FISHERY RESOURCES

Of

THE UNITED STATES OF AMERICA

By

The Fish and Wildlife Service

United States Department of the Interior

Edited by Lionel A. Walford

Designed under the supervision of the Bureau of Graphics,
Office of War Information.

THE SECRETARY OF THE INTERIOR
WASHINGTON 25

February 2, 1945.

My dear Mr. Vice President:

I have the honor to submit herewith a report on a survey of the fishery resources of the United States and its possessions, pursuant to Public Law 302, 78th Congress, S. J. Res. 112, approved May 14, 1944.

In making this study, the Fish and Wildlife Service of the Department of the Interior has attempted to distill, from a massive volume of statistical, biological, and industrial data, the essential facts needed to see clearly and objectively the present condition of our national aquatic resources and of our conservation of them. It is concluded from the study that throughout its entire history the Federal Government has never given adequate care to these resources.

The recommendations derived from the conclusions are stated as very general principles. These are intended to guide the formulation of specific programs which will enable the United States to take intelligently the leadership in world aquatic industries that seems about to be thrust into its hands. Because the range of American fishing interests will broaden on a vast scale after this war, these programs must be made flexible and remain so. This Department proposes to submit to the Congress for its consideration, in future months, suggestions for specific legislation covering Federal functions in economic, technological, and biological aspects of the development, utilization, and maintenance of the fishery resources. These will be based on the material presented in this report.

Sincerely yours,

Harold L. Ickes

Secretary of the Interior.

Hon. Harry S. Truman,

President of the Senate.

Enclosure 304.

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Enclosure 303.

PREFACE

THE TERM "FISHERY RESOURCES" is used in this book with a broad application. It includes the populations of the fishes and other organisms useful to men, the environment that makes life possible for them, the industry that exploits and utilizes them, and our knowledge about them by which we can conserve their productivity. This book aims to survey the present status of all these aspects of those fishery resources that are used or are available for use by United States anglers and commercial fishermen. It is planned primarily for the Congress, at its request, with the idea of giving to busy people, in condensed fashion, a perspective on its subject.

The book touches on all the important aquatic species utilized by United States fishermen (i. e., all those of which 2 million pounds or more are caught annually) and on many of the less important ones. It also points out the more obvious of our latent fishery resources which remain to be developed and, in this respect, may well serve as another guidepost in the veteran reemployment program.

Geographically, the scope of the book includes the waters within and to the offing of the continental United States and its territories; and also the waters of other nations or international waters where United States fishermen operate.

The distribution maps are intended to show in a general way the ranges over which the various species are frequently caught; not the extreme ranges indicated by occasional rare finds, and not the local particulars of distribution.

The common names given in the text are those having, in the opinion of the authors, the widest usage. For various reasons, scientific names generally do not appear in the text but are listed in the table of contents, along with synonyms of the common names.

The pictures of the fishes are included to show, in an informal way, what the fish look like. Though they are not scientific drawings for identification purposes, they are anatomically accurate, being based entirely on published drawings or photographs.

The statistics given in the book are generally in rounded figures. Usually they represent averages of several pre-war years, occasionally a typical recent year, or in certain cases the most recent year for which statistics are available.

The word *conservation* which appears throughout the book fell out of fashion among fishery workers several years ago, because it seemed to connote saving and abstention from utilization. In order to make clear that conservation is quite compatible with utilization, attempts were made to introduce a number of substitutes, among them "utilization for wise use," "optimum catch," "wise usage," and "fishery management." Unfortunately, the public failed to adopt these phrases—at least we never see them except in official documents—and continues with *conservation*, which remains the most convenient and widely understood word for its purposes. It is therefore used in this book and with the following comprehensive meaning:

Conservation of fishery resources is public control, based on scientific knowledge, designed to insure the highest continuous production at lowest cost that these resources can yield without impairing their productivity; and it is designed further to effect the fullest, most widespread use that can be obtained from the catch.

It is the purpose of this book to examine the fishery resources, one by one, in order to arrive at a judgment of the present status of fishery conservation in this country, and to draw such conclusions and make such recommendations as are indicated by this judgment.

The text and statistics are from material collected by the staff of the Fish and Wildlife Service, and are based on data developed by this Service or appearing in published works. The book was designed in collaboration with the Office of War Information, and it is a pleasure to acknowledge the creative inspiration which the Graphics Bureau of that agency furnished. The lay-outs were executed by Henry Buchanan and Harry Kamien; and the illustrations were drawn by Katherine Howe. The entire volume reflects the painstaking assistance of the Honorable Augustus E. Giegengack, the Public Printer.

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***THE INTERIOR OF THE UNITED STATES** contains such large fish-producing areas as the Great Lakes and the Mississippi River. In addition, the numerous smaller lakes, ponds, streams, and creeks add up to an impressive acreage, furnish food and sport to millions of people. The total estimated 1942 commercial catch from United States fresh waters (excluding sea-run fishes): 175 million pounds.*

ALASKA, whose principal industry is fisheries, is the chief production center of salmon, most valuable fishery resource of the United States. It is also an important source of herring, halibut, sablefish, and clams. The breeding grounds of the fur seal are in Alaska. The continental shelf of the Northwest is a vast area rich in untapped resources, offers great opportunity for development and expansion of bottom fisheries.

Alaska catch, 1943: 577 million pounds.

THE NORTH PACIFIC STATES' most important fisheries are for salmon, halibut, sharks, albacore, crabs, and oysters. In recent years an otter trawl fishery for flounders, rockfishes, and lingcod has been developing rapidly. Shore industries are based on canning, curing, packaging of fresh and frozen fish and shellfish, and the manufacture of fish-liver vitamin oils.

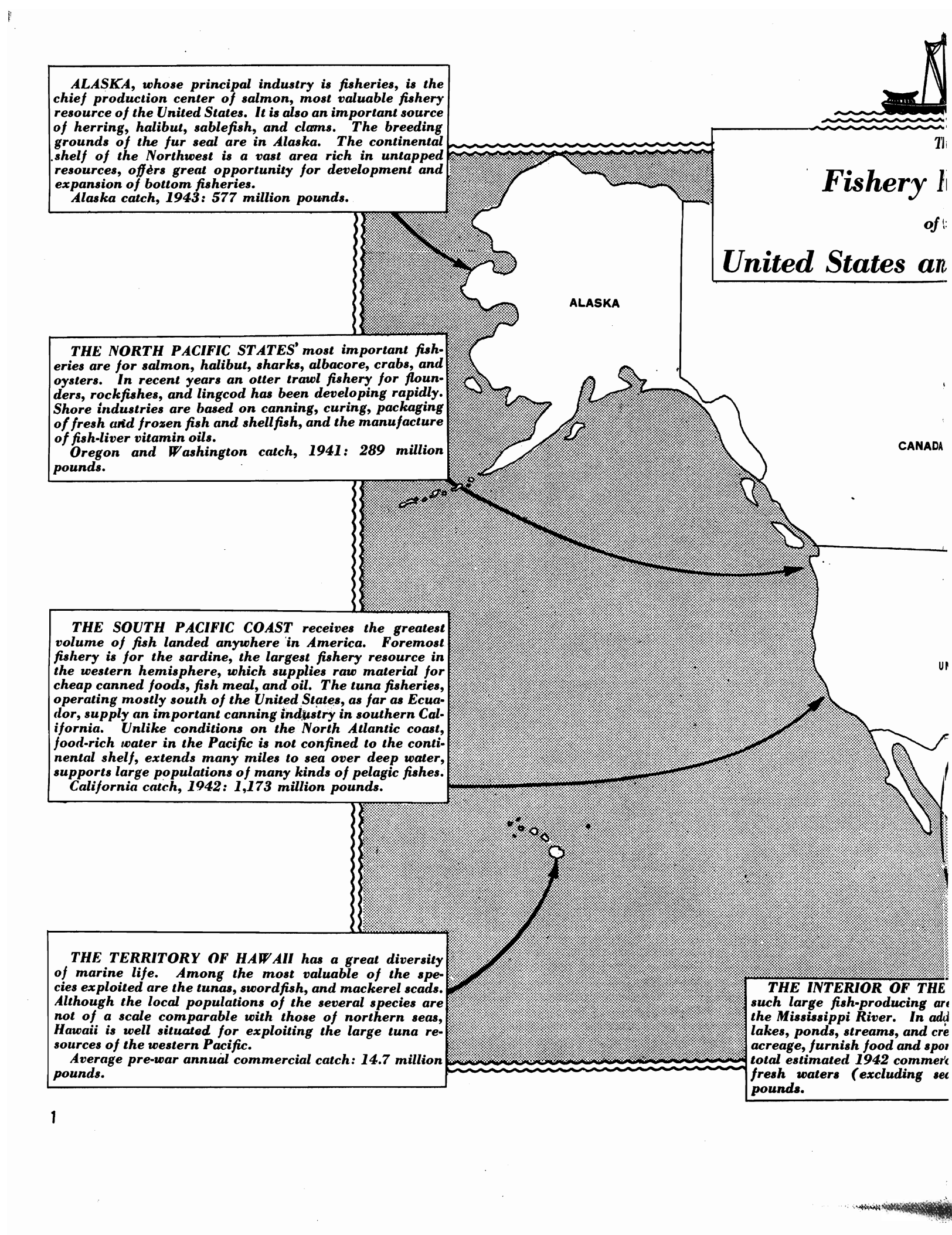
Oregon and Washington catch, 1941: 289 million pounds.

THE SOUTH PACIFIC COAST receives the greatest volume of fish landed anywhere in America. Foremost fishery is for the sardine, the largest fishery resource in the western hemisphere, which supplies raw material for cheap canned foods, fish meal, and oil. The tuna fisheries, operating mostly south of the United States, as far as Ecuador, supply an important canning industry in southern California. Unlike conditions on the North Atlantic coast, food-rich water in the Pacific is not confined to the continental shelf, extends many miles to sea over deep water, supports large populations of many kinds of pelagic fishes.

California catch, 1942: 1,173 million pounds.

THE TERRITORY OF HAWAII has a great diversity of marine life. Among the most valuable of the species exploited are the tunas, swordfish, and mackerel scads. Although the local populations of the several species are not of a scale comparable with those of northern seas, Hawaii is well situated for exploiting the large tuna resources of the western Pacific.

Average pre-war annual commercial catch: 14.7 million pounds.



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THE NORTH ATLANTIC region is characterized by a wide continental shelf, which in some places extends out from the coast for hundreds of miles. Large areas of the shelf rise to form submerged plateaus, called banks, on which lives a vast population of bottom-living fishes. Most important among them are the haddock, rosefish, cod, flounders, and pollack. These are taken mostly by otter trawls, which are dragged across the ocean floor by motor-powered vessels. In addition to the bank fishes are such valuable pelagic species as herring and mackerel. Fisheries for lobsters, clams, oysters, and scallops provide a livelihood for thousands of New Englanders. A large New England shore industry is devoted to filleting, packaging, and quick-freezing the bank fishes. New England catch, 1942: 676 million pounds.

THE MIDDLE ATLANTIC STATES are the most important producing center for oysters, blue crabs, menhaden and shad, alewives, and striped bass. Large quantities of flounders, butterfish, croaker, scup, "sea trout," and whiting are taken close inshore in summer with pound nets, offshore in winter with trawls. The most important shore fishery industries in this area are the packing of shucked oysters and fresh-cooked crab meat and the manufacture of fish meal and oil. This section leads the country in the production of smoked fish.

Middle Atlantic and Chesapeake catch, 1940: 684 million pounds.

THE SOUTH ATLANTIC AND GULF STATES are the seat of the largest shrimp fishery in the world. This crustacean lives on the floor of the continental shelf, is taken almost entirely with otter trawls operated from motored craft. Other important fishes are mullet taken largely on the west coast of Florida; menhaden, used in manufacture of meal and oil; alewives, sea trout, red snapper, and Spanish mackerel. Among the shellfish other than shrimp, oysters and crab are most important. The United States sponge fishery is centered on Florida's west coast.

The packing of fresh and frozen fish and shellfish, the manufacture of fish meal and oil, and the canning of shrimp and oysters are the most important shore industries.

South Atlantic and Gulf catch, 1940: 576 million pounds.

UNITED STATES contains
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PUERTO RICO and the VIRGIN ISLANDS have no very extensive fishery resources. Tropical bank and reef fishes, like snappers and basses, are taken all year 'round, and tunas, mackerels, and jacks during their seasonal migrations.

1940 catch: 3.7 million pounds.

Pacific Fishery Resources SALMONS

PACIFIC SALMONS ARE THE MOST VALUABLE FISHERY RESOURCE BELONGING TO THE UNITED STATES. They yield around 600 million pounds of fish a year, 85 percent of which is used to manufacture the largest pack of canned fish produced in this Nation. About 100 million pounds are sold fresh, frozen, smoked, or cured. Close to 90 percent of the United States production and 55 percent of the world production of salmon comes from Alaska, where the resource is more valuable than any other. Indeed, 70 percent of Alaska tax revenues come from salmon industries.

The salmons are among the most popular sport fishes of the world. Although statistics are not available, the sport catch runs into millions of pounds annually.

Salmon are caught with traps, purse seines, gill nets, haul seines, and by trolling. All these kinds of gear are subject to legal restrictions, which vary from place to place.

Salmon canneries utilize more of the fish than any other fish-canning industry, the loss in canning averaging only 33 percent. On the other hand, the waste is less utilized than in any other canning industry. A small amount of roe is prepared for bait or for caviar. Part of the waste is used for making oil and meal, but the bulk of it is thrown away. Here as well as in all the various processes of handling salmon, technological developments are needed to enhance efficiency, minimize loss through waste, and improve the products.

THERE ARE FIVE KINDS OF SALMON IN THE EASTERN PACIFIC: The red, sockeye, or blueback; the king, chinook, or spring; the coho or silver; the pink or humpback; and the chum, keta, or dog. A sixth one, found only on the Asiatic side, is the masu.

PACIFIC SALMON SPEND A LARGE PART OF THEIR LIVES IN THE OCEAN, THEN ENTER FRESH WATER TO ASCEND STREAMS AND SPAWN. The availability of suitable spawning grounds, more than anything else, controls their distribution and abundance. Whatever unfavorable conditions, short of lethal ones, may prevail in the lower reaches of a stream, so long as the stream gives clear passage to good spawning grounds, it supports salmon. Spawning areas must have bottoms covered with gravel of a certain size range, and clear water flowing at a moderate and reasonably constant rate. Exact requirements vary according to species. Pink and chum salmon find suitable grounds generally not far from the ocean, often not more than a mile away; kings and cohos generally ascend the larger streams and go farther; reds can inhabit only streams having access to lakes.

Little is known about the ocean life of salmon. They scatter widely, generally keep to cold water, and feed on plankton and small fishes.

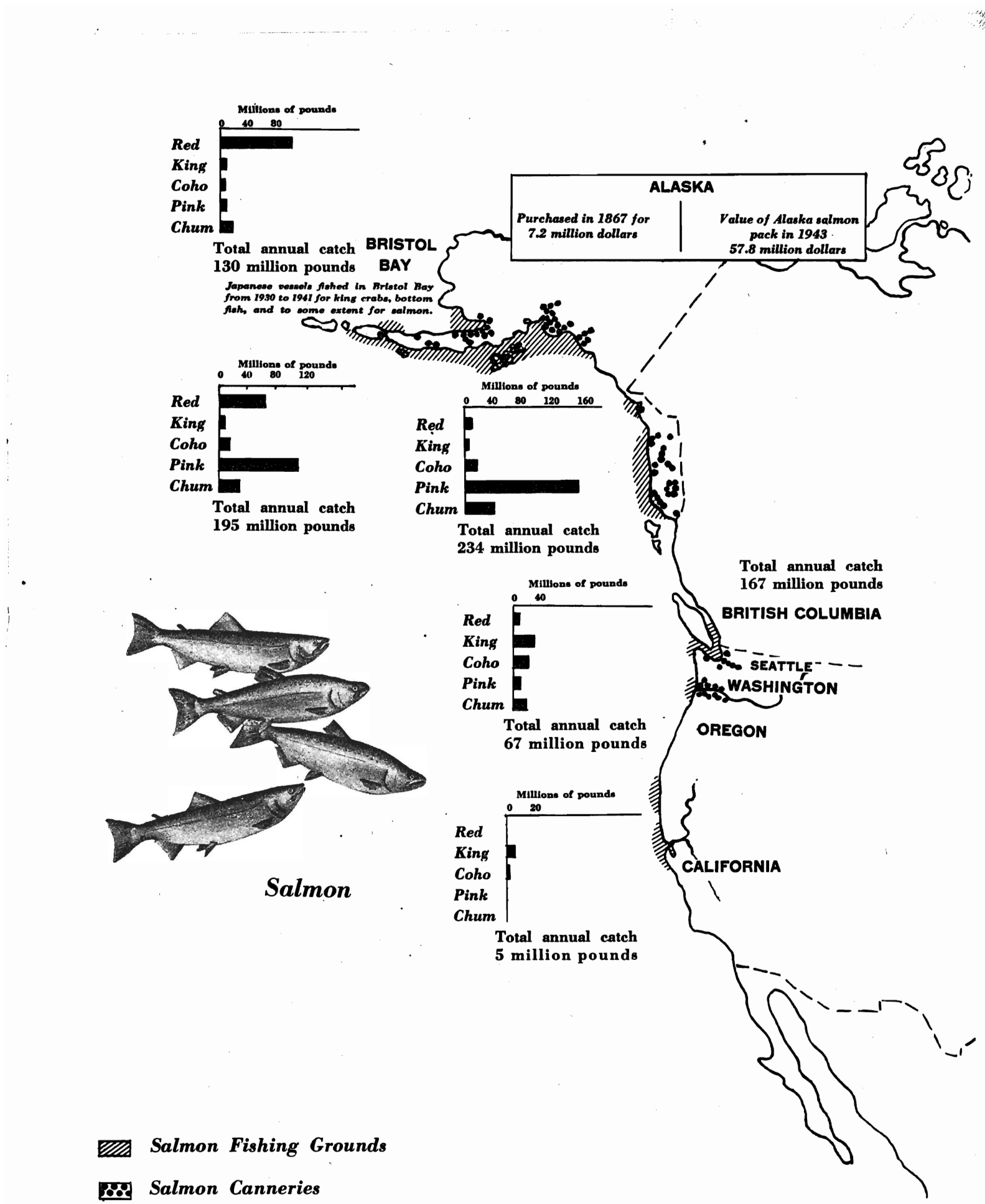
THE SPAWNING SEASONS OF THE SALMONS VARY, but, in general, last from late summer to early winter. As the fish approach sexual maturity, they reassemble and swarm up the rivers of their birth until they find a place to spawn. There they pair off, and each pair builds a nest or depression in the gravel of the stream bed, and spawns over a period of several days. All Pacific salmon die after their single spawning season.

The eggs incubate, buried in the gravel, during the fall and winter. They hatch early in spring, and for about 2 months thereafter the babies live off the yolk in the sac which remains attached to the belly. When that is used up, the young fish, now called fry, struggle up through the gravel and begin searching for food.

Pink and chum salmon now proceed almost immediately to the ocean, but the other species generally stay in fresh water from 1 to 4 years before migrating to sea. After reaching the ocean, they remain there 2 to 5 years, according to species and latitude. All pink salmon spawn at 2 years of age, cohos and chums at 3 to 5, red and king salmon at 4 to 7 years.

SALMON HAVE ENEMIES THROUGHOUT LIFE: The eggs are eaten by most of the diving birds, sea gulls, terns, and by trout and other fishes. Young salmon are eaten by ducks, osprey, cormorants, gulls, and terns, and by various fresh-water fishes. They also often die from starvation and disease. In the ocean they fall prey to sea lions, seals, killer whales, and many kinds of large fish. Then they must run the gantlet of man's fishing gear. On their way upstream, and while on the spawning grounds, they are preyed upon by eagles, sea gulls, bears, and wolves. Those finally spawning are appropriately called the "escapement."

STATUS OF THE SALMON RESOURCES: By 1913, all the important Pacific salmon-producing areas were being intensively fished, and the annual catch reached 500 million pounds. Since then, intensified fishing has increased the catch in certain Alaska areas somewhat; but for the most part, the size of the stocks now limits the catch, which fluctuates from year to year accordingly. Even though expansion of the fishery to new grounds cannot be expected to increase the catch materially, and though new dams and irrigation diversions may curtail the catch in some areas, *intelligent management of the resources, based on scientific knowledge, would increase the over-all production in Alaska by at least 50 million pounds, worth some 10 million dollars annually.*


Millions of pounds
0 40 80
Red
King
Coho
Pink
Chum
Total annual catch
130 million pounds
BRISTOL BAY
Japanese vessels fished in Bristol Bay from 1930 to 1941 for king crabs, bottom fish, and to some extent for salmon.
ALASKA
Purchased in 1867 for 7.2 million dollars
Value of Alaska salmon pack in 1943 57.8 million dollars
Millions of pounds
0 40 80 120
Red
King
Coho
Pink
Chum
Total annual catch
195 million pounds
Millions of pounds
0 40 80 120 160
Red
King
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Total annual catch
234 million pounds
Total annual catch
167 million pounds
BRITISH COLUMBIA
Millions of pounds
0 40
Red
King
Coho
Pink
Chum
Total annual catch
67 million pounds
SEATTLE
WASHINGTON
OREGON
Millions of pounds
0 20
Red
King
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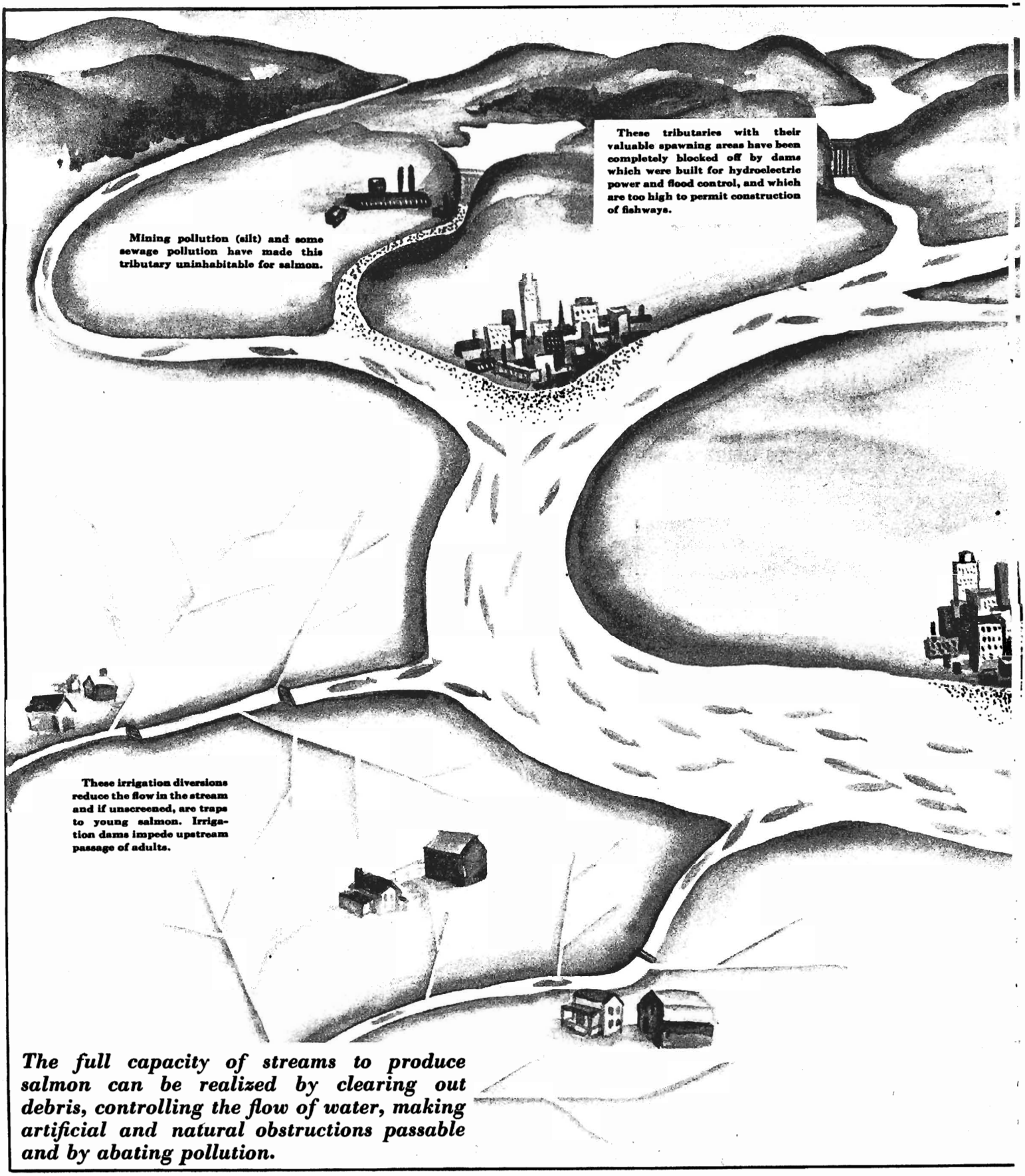
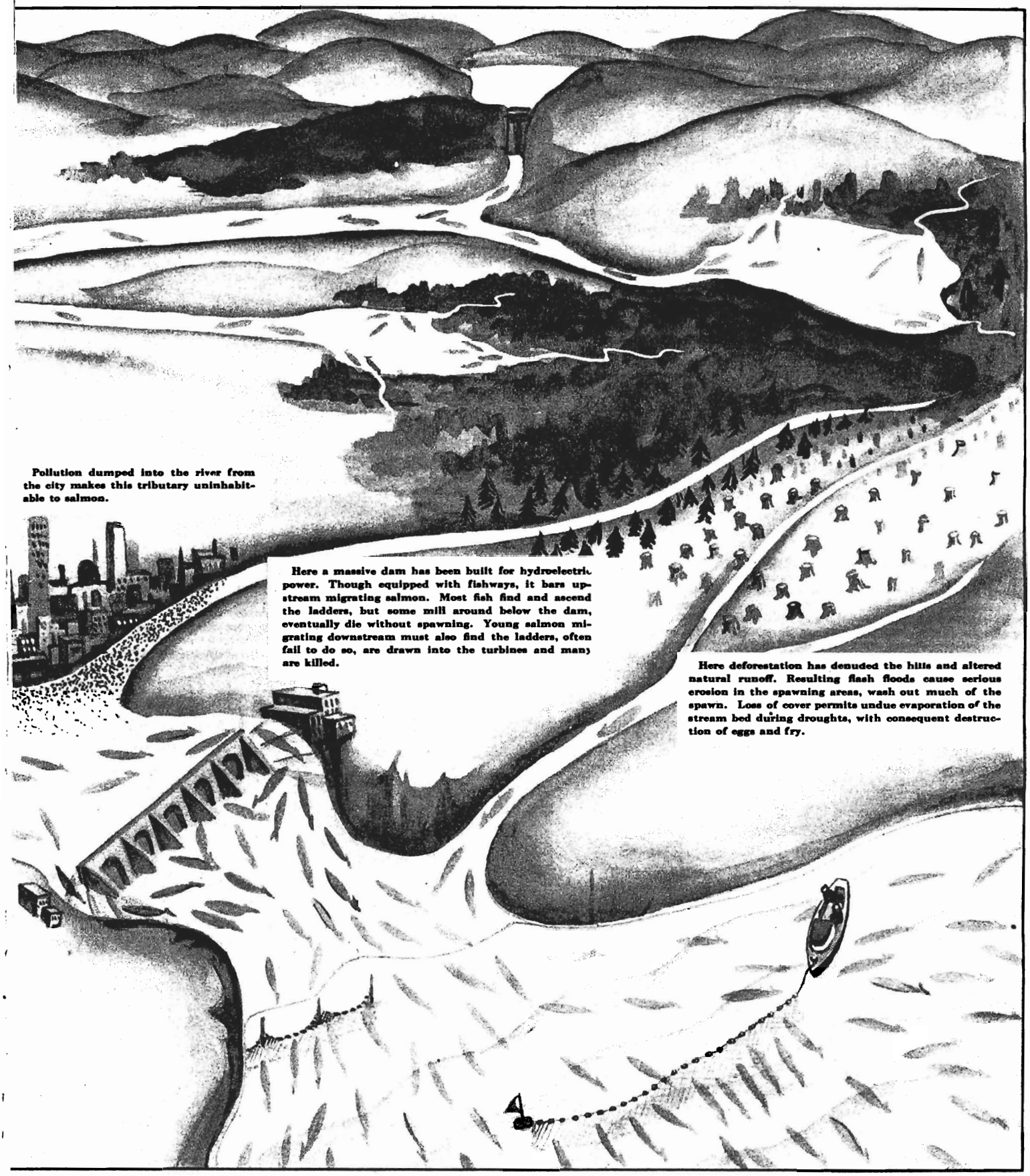
Total annual catch
5 million pounds
CALIFORNIA
Salmon
Salmon Fishing Grounds
Salmon Canneries



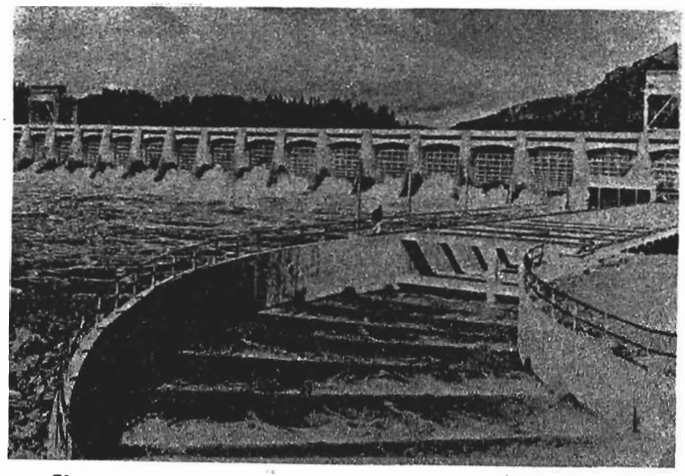
The full capacity of streams to produce salmon can be realized by clearing out debris, controlling the flow of water, making artificial and natural obstructions passable and by abating pollution.



Pollution dumped into the river from the city makes this tributary uninhabitable to salmon.

Here a massive dam has been built for hydroelectric power. Though equipped with fishways, it bars upstream migrating salmon. Most fish find and ascend the ladders, but some mill around below the dam, eventually die without spawning. Young salmon migrating downstream must also find the ladders, often fail to do so, are drawn into the turbines and many are killed.

Here deforestation has denuded the hills and altered natural runoff. Resulting flash floods cause serious erosion in the spawning areas, wash out much of the spawn. Loss of cover permits undue evaporation of the stream bed during droughts, with consequent destruction of eggs and fry.



Showing a portion of the Bonneville Dam and one of the three fish ladders. With regard to the river, the picture looks upstream toward the spillway sections; with regard to the fish ladder, it looks downstream. This is because there is a 180-degree turn in the ladder where it approaches the dam. The fish enter the ladder at a collecting point just in front of the dam.

In the Pacific Coast States, the encroachment of civilization seriously interferes with salmon resources. Among the many unfavorable conditions brought on by population and industrial growth, the most harmful to salmon are pollution, deforestation, irrigation diversions, and dams. Consequence: The outlook for enlarging salmon resources in the Pacific States is not promising. Indeed, they can be maintained at their present subnatural level only by constant vigilance and the utmost care.

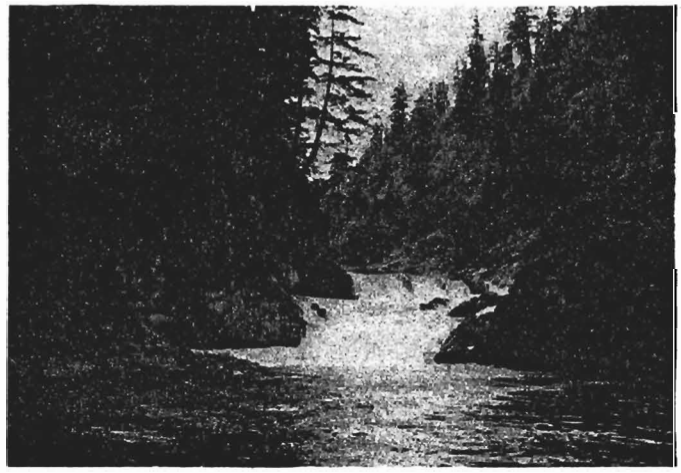
SALMON HATCHERIES, begun in 1870 with a firm conviction that they would solve all conservation problems, enlarge salmon runs and sustain them at high abundance level, failed to produce these anticipated results. The best that can be said for many of the hatcheries operated in former years is that they were only slighly more efficient than nature. Consequently, all of the hatcheries in Alaska have been abandoned and the operations of those in the States have been greatly modified.

Yet artificial propagation of salmon has its uses. Indeed, under certain circumstances, salmon culture has been necessary to conservation practice, particularly for restoring runs in those many streams where the salmon population has become so far depleted that it cannot reestablish itself naturally, or in other streams having natural obstructions that can be removed or so modified as to make new spawning grounds available and therefore restocking feasible.

WHENEVER A DAM BLOCKS OFF SPAWNING GROUNDS, THE SALMON MUST BE HELPED AROUND OR OVER IT by one or more of a number of devices, called fishways, of which the commonest type for salmon is the fish ladder. These vary greatly in design according to the height of dam, size of stream, foundation conditions, etc. Fish ladders are similar to cascades, usually consist of a succession of rectangular pools, varying from 6 to 40 feet across, with a difference in elevation between pools of 1 to 2 feet. Sometimes more artificial means are used, such as locks, similar in principle to navigation locks, or bucket hoists, or tank trucks.

The problem of attracting the salmon to the entrance of a fishway increases in difficulty with increasing disproportion between the flow of water passing over the dam and that going through the fishway. The effectiveness of a fishway in attracting fish is enhanced sometimes by providing expanded or multiple entrances and contriving to pass through these an auxiliary supply of water, thus totalling a much greater volume than that passing down the fishway proper.

EQUALLY DIFFICULT, AND TOO OFTEN IGNORED, IS THE PROBLEM OF GETTING THE YOUNG SALMON FINGERLINGS DOWNSTREAM over the dam on their way



This is an example of a place where stream improvement is needed. The run of chinook salmon that enters this stream is limited to the spawning area below the falls. Construction of a fishway at this site would greatly increase the available spawning area and therefore the productive capacity of the stream.

to the ocean. Intakes to power and irrigation diversions and hazardous spillways may be screened to keep the young fish out, *if* the quantity of water and velocity of flow are not too great. *But* no method has yet been devised of keeping fingerlings out of spillways and turbines of the larger power projects such as are proposed for the main Columbia River, or out of deeply submerged outlets of storage reservoirs. This is why hope of getting salmon over Grand Coulee and Shasta Dams, to and from their natural spawning grounds, has been abandoned in favor of a necessarily costly program of artificial propagation below these structures.

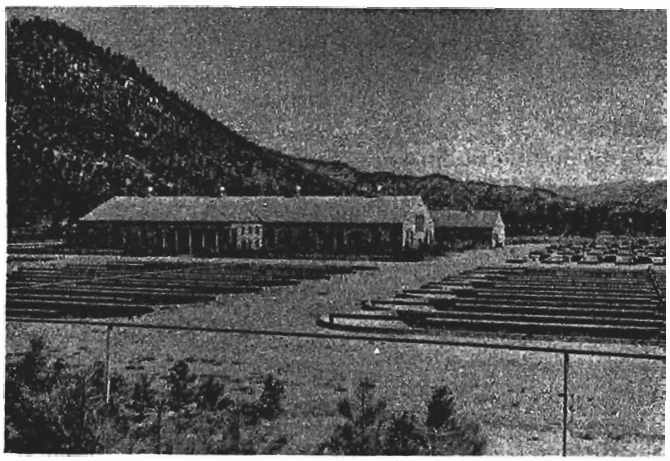
LEGISLATIVE CONTROL OF SALMON IN ALASKA, AS OF ALL FISHERY RESOURCES IN THE TERRITORY, is under the jurisdiction of the Federal Government. Laws and regulations define fishing areas, prescribe maximum and minimum size limits on certain types of gear, prescribe opening and closing dates for the fishing season and provide for weekly closed periods; they prescribe maximum catch quotas in certain areas and in general so regulate the fishery that the maximum catch may be taken without endangering future yields.

Regulations for the salmon fisheries in the States are established by the State governments. They are comparable to those in Alaska, but vary from State to State, sometimes with consequent lack of unified management. All three Pacific States have departments of fisheries which carry on scientific fishery investigations, patrol the fishing grounds to enforce the regulations, and collect catch statistics.

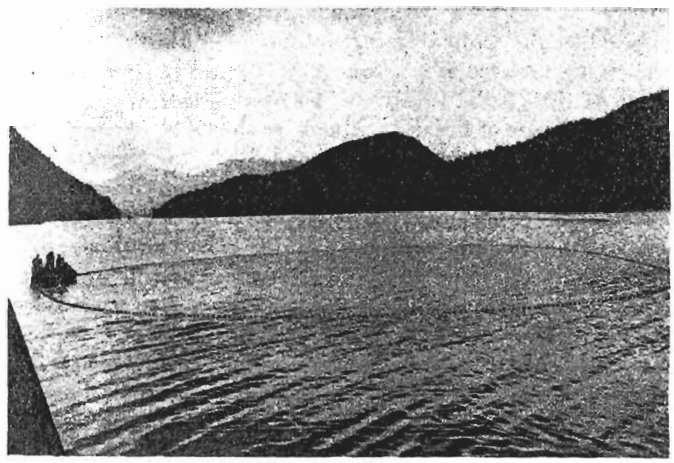
THE CROP OF SALMON CAN BE PREDICTED. A year class of salmon is available to the fishery only in its last year of life, and only during the rather short period of change from ocean to stream life. The fish not caught are lost forever to the fishery, for they all die after they have passed through the fishing grounds to the spawning area. True, enough fish must be allowed to spawn in order to reproduce the run, but beyond a certain point any additional spawners may not increase the number of offspring. Too many spawners may overcrowd the spawning grounds, with resulting low production and survival of offspring. Thus to sustain maximum production, the fishery should take *all* the fish over the number required for the spawning stock, but it should not take *more* than that number. To know how many the fishery can take it is necessary to predict the size of the runs, which varies from year to year. Management of the fishery in its highest sense, i. e., getting the most out of the resource that it has to give, depends on the accuracy of this prediction.

TO PREDICT THE SIZE OF A CROP THIS MUST BE DONE: (1) The number of spawning parents, i. e., the seed stock, must be counted or estimated as the fish pass upstream to the spawning grounds; (2) the relative number of hatched young must be counted or estimated as they migrate downstream to the ocean; (3) this information must be integrated with certain quantitative data on stream and oceanic conditions which are known to affect the survival of salmon. All this must be done *for each stream's population* separately and it must be done *every year.*

Continued crop prediction in Alaska would result in enlarging many of the runs; it would assure maintenance of the entire Alaska salmon resource, and it would permit increasing the total commercial catch of salmon. It requires, however, a minimum of 12 field laboratories strategically located, and fully equipped for year-round work. There is now only one such laboratory.



Leavenworth Hatchery, showing buildings and fish ponds



Purse seining for salmon, Yes Bay, Alaska

Pacific Fishery Resources SARDINES

THE WORLD'S PILCHARDS

SARDINA
pilchardus

SARDINOPS
neopilchardus
ocellata

Pilchards, like other herring-like fishes, are called sardines when canned. Some authorities refer to them as the "true" sardines. They are found in temperate coastal waters where surface sea temperatures average 50° to 70° F.

SARDINOPS
sagax
caerulea
melanosticta

THE PACIFIC SARDINE OR PILCHARD RESOURCE IS UNIQUE. It supports the largest fishery in the western hemisphere—nearly 25 percent of all fish caught in the United States are sardines; it is the cheapest source of protein food for human consumption; it is the most important source of fish meal and oil which are vital in the nutrition of poultry and other livestock. It yields the largest volume ofcanned fish produced in the United States (exclusive of Alaska); and is an important source of vitamins A, D, B_1 and G (B_2).

THE PACIFIC SARDINE IS A PELAGIC FISH, traveling in the upper layers of ocean in schools or shoals of varying size from a few tons to hundreds of tons of fish. The characteristics of the sea water rather than the sea bottom direct their movements and because these characteristics are constantly changing, the sardines constantly move. They do this vertically as well as horizontally, so that at times schools travel at the surface, at other times far below, and the luck of fishermen fares accordingly.

Sardines spawn from January through June, mostly in March and April in the open sea as far out as 300 miles though generally 50 to 200 miles offshore. The eggs are fertilized in the open water. Great fecundity offsets high infant mortality, each female laying about 35,000 eggs in a batch, and as many as three batches in one season. The eggs hatch in about 3 days, and the babies drift helplessly with currents and tide until after they absorb their yolk and become free-swimming. They feed then, as they do throughout life, on minute organisms, plant and animal, which live suspended in the sea water and are collectively called plankton.

Though initially of tremendous numbers, the brood is rapidly thinned out in the struggle for existence. The conditions affecting this struggle for existence, such as food supply and submarine climate, fluctuate constantly, and cause great fluctuations in the infant survival rate. These variations are later reflected in the commercial catch when the young grow to adulthood.

As the juvenile sardines grow their swimming efforts become stronger, and they congregate in schools like those of their parents. When from 3 to 5 inches long, they migrate toward shore, where they remain to feed for a time. While there they are caught in large numbers by fishermen for tuna bait. The known main nursery grounds are off Southern California and Lower California, Mexico; areas of fluctuating, though generally of lesser importance extend northward to British Columbia.

When the sardines have grown to about 7 inches in length, they begin to leave their inshore nursery grounds and take up the pelagic offshore life of adults. Then they make their first appearance in the regular commercial fishery. The fish do not all enter the commercial catch at the same length; only a

small percentage of the sardines as short as 7 inches are available to the fishery, and none that small are wanted. By the time the fish are 10 inches long, however, practically 100 percent of them become available to the fishery and are aggressively sought. The youngest fish are found first in the fishing regions nearest the spawning areas, and later in the more remote grounds. Sardines become sexually mature at about 7 to 10 inches in length, $\frac{1}{10}$ to $\frac{1}{4}$ of a pound in weight, and at 1 to 3 years of age. According to scale studies, the natural full life span is something over 10 years; a few specimens of 13 years have been collected.

Tagging experiments by the research agencies of California, Oregon, Washington, and British Columbia have proved conclusively that some sardines migrate from California to British Columbia, and vice versa. The exact extent and nature of these migrations, however, are difficult to study and are still imperfectly understood. Present available evidence indicates a northward, feeding movement in spring and summer and a southward movement toward spawning grounds in fall and winter. The fish appear to migrate increasing distances as they grow larger.

Owing to fluctuations in infant mortality, the size of year broods varies greatly from year to year. These changes are probably the consequence of changing food supply, among other things, which is accompanied by fluctuating saltiness of the sea water and perhaps by other things about which little is yet known. Fisherman's luck depends not only on these fluctuations, but also on weather, being better during warmer years than in cooler ones. The mechanism of this phenomenon, recently discovered, is yet to be worked out. The catch of sardines is influenced not only by these natural conditions, but also by fishing intensity; i. e., by the amount and type of gear used and the length of time it is used.

THE ULTIMATE EFFECTS OF FISHING ON THIS AS ON ANY STOCK CAN BE—(1) reduction in total number of fish in the stock, producing a smaller yield for a given amount of fishing effort; (2) reduction in the average size of the fish in the stock, thus necessitating catching more fish to sustain the tonnage; (3) decimation of the spawning stock to below a safe level, finally leading to successively smaller annual catches. The first effect starts in some degree, even though slight, as soon as *any* fishing effort is applied, and so far has not been extensive enough to be serious in the sardine fishery. The second effect has evidenced itself. Sardines have been in recent years averaging smaller and younger than formerly. For the third effect, the necessary marine research was discontinued with the start of World War II. It indicated one of the primary fields for future research on this resource.

Under present fishing intensities probably as much as half the adult sardines are caught annually, on the average. The majority of sardines are less than 4 years old, few last longer than 7 years. Such a young stock has both advantages and disadvantages. Among the former are a rapid growth rate and apparently a high rate of replacement. The only important disadvantage at present seems to be the relatively small size of the fish. When exceptionally small fish are brought in, as sometimes happens under current conditions, the fish plants experience difficulty in processing the catch. If small fish became extremely common the industry would have the problem of adjusting itself to a new and perhaps difficult condition.

THE SARDINE RESOURCE CAN BE SOUNDLY MANAGED only after determining what *continuing* yield in total tonnage, in catch per unit of effort and in sizes of fish, can be expected from various fishing intensities. To accomplish this, it is necessary to separate the effects imposed on the size of the stock by man's fishing from those imposed by Nature's complexly interrelating systems of influences. This involves analyses of statistical records on the fishery as well as on all phases of the sardine's life and its environment.

The several Pacific coast States and the Fishery Research Board of Canada have long collected fishery statistics. In addition, with the help of the United States Fish and Wildlife Service, they maintain a sampling system for keeping record of sizes, ages, sex, and weights of the fish composing the catch; and continuously analyze these data.

Most seriously lacking are adequate observations *at sea* of oceanic conditions as they affect reproduction, habits, and catch. The conservation agencies of California, Oregon, and British Columbia have studied migration, by tagging. The Fish and Wildlife Service has made several partial surveys of spawning and ocean conditions affecting the survival of spawn and fry in a very limited section of the tremendous spawning grounds; it has also made some preliminary studies of the weather's effects on fishing luck. These studies merely furnish background demonstrating the necessity for much more intensive and extensive observations on the living sardine popula-

50 million pounds of canned product worth $14.3 million

155 million pounds of meal worth $5.8

104 million pounds of oil worth $9.2 million

7 million pounds stickwater concentrate

An unknown quantity used for bait to catch 100 to 150 million pounds of tuna and about 50 million pounds of mackerel

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tion and on the marine world which it inhabits.

LEGISLATIVE CONTROL OF THE SARDINE RESOURCE is in the hands of several Coast States, province of British Columbia, and the Dominion of Canada. In British Columbia, Washington, and Oregon, sardine fishing is unrestricted; and general restrictions on the use of fishing gear in certain areas do not materially affect the sardine fishery. In California, general restrictions on the use of gear, especially in certain areas, have little direct effect on the exploitation of the resource. There are closed seasons, not on fishing, but on the *use* of sardines for canning and reduction, which tends to restrict the large-scale operations in the industry to the fall and winter months when the fish are of best quality and the catch is most reliable. This restriction promotes efficiency in operation of processing plants and boats. It has little effect on sustaining the yield or protecting the resource; it simply allows more fish to be caught for a given amount of effort and more processed product to be obtained from the tonnage caught, than if the fishery were spread over the entire year.

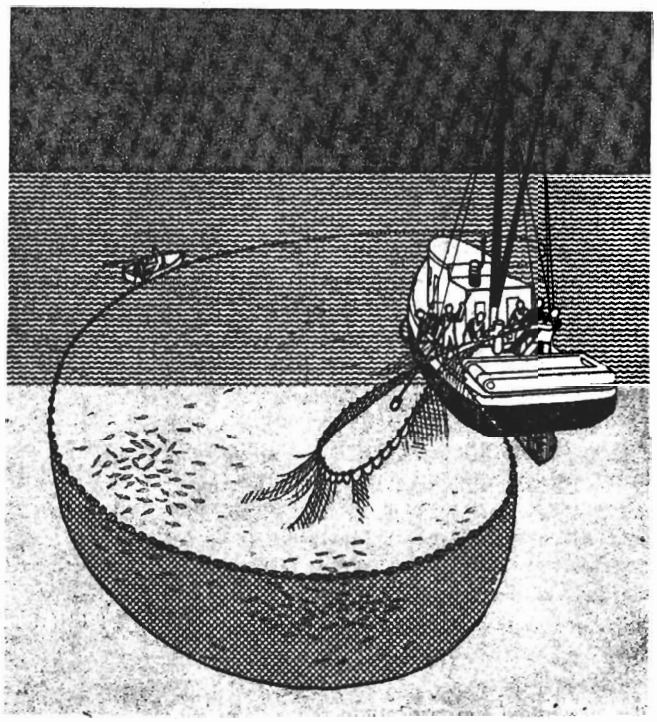
More specifically directed toward sustaining the yield (through avoidance of over-utilization) is California's regulation of the *use* of sardines. Sardines may be used for reduction only under these conditions: A certain percentage of the sardines received for canning may be reduced; and further, the Fish and Game Commission may grant permits to reduce fish if such use does not tend to deplete the species and if it would promote the economic utilization of the fish resource.

Under this law the Fish and Game Commission has authority to limit the catch of sardines to the amount which the resource can support. But this authority is effective for its purpose only so long as the canning process does not require more fish than the resource can support, and only so long as the industry in the other Pacific States remains minor.

Currently (season of 1944–45) the Fish and Game Commission is granting permits to use 5,000 tons of sardines for reduction in each of 80 plants; a total of 400,000 tons. Canning (including 32½ percent allowable for reduction) probably will use 250,000 tons of sardines. Thus the framework of regulation permits a take of 650,000 tons for major industrial purposes in addition to the take of unknown tonnage for bait and other minor uses.

The catch will probably not exceed 600,000 tons with the current intensity of fishing. In other words, the exploitation pressure is not likely, this season, to reach the point where legislative restriction would be a limitation. And current regulation is significant only as it might affect the resource in postwar years when manpower and boat shortages no longer constrain production. For proper management through these years the administrative agencies must know what the resource can sustain.

PRESENT STATUS OF THE SARDINE RESOURCE. Utilization of the sardine resource on a large scale began with the war of 1914–18 as a canned-fish industry. Adoption of the screw press in the 1920's enabled utilization, first, of cannery waste for the manufacture of fish meal and oil, subsequently, of whole fish for this purpose; and the reduction process has proved to be often more profitable than the canning process. There is now practically no limit to the amount of finished product that can be absorbed. The field for marketing sardine products is as wide as the markets for protein foods, for fats of all kinds, and for protein concentrates now



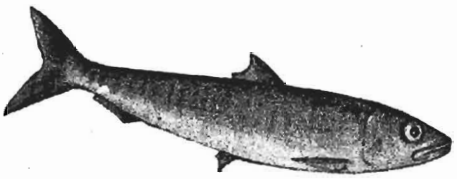
Purse seining

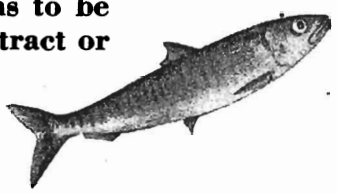
critically essential in poultry and animal feeds.

The evolution in utilization of sardines was accompanied by an evolution in fishing method. Lampara nets and small boats gave way to purse seines and boats comparable in size and far surpassing in catching ability the halibut schooners or North Atlantic trawlers. Where a night's catch of 10 to 20 tons had once been usual, loads of 100 to 200 tons are now commonplace. Correspondingly the annual take of sardines has grown from something less than 200 thousand tons to about 500 thousand tons.

It is neither certain that the evolution in this industry has ended nor clear what the next development will be. The low price commanded by the products of the industry, however, is an important control. The value of sardine oil governs the industry's price structure, and since it must compete in a market with lard, tallow, cottonseed oil, etc., the fish must be caught very cheaply. At present, even under wartime conditions, fishermen get only 11 mills a pound for sardines. Therefore, the fish must remain abundant enough to support a high and profitable average catch per man.

Each new stage in development has meant a greater drain on the resource. So far there is no clear evidence that the drain is greater than the resource can stand. The fishery appears to be stabilized at a catch of 500,000 tons a year. It is not definitely known whether reproduction is replacing all of this catch or whether the catch is maintained in part by drawing on accumulated reserves. But the fact that the fish *now being caught* were spawned several generations (of sardines) *after* the catch had reached 500,000 tons suggests that reproduction has so far been replacing the annual take of the fishery.





This area has been intensively surveyed, is known to cover spawning grounds of prime importance. The extent of spawning northward and southward remains to be explored, probably shifts, may contract or expand, from year to year.

Some sardines, generally the larger fish, migrate northward in summer and return to southern grounds in winter.

Distribution

Fishing Grounds

Major known spawning area

Pacific Fishery Resources

MACKERELS

THE MACKEREL FISHERY, having its center in southern California, is one of the major fishing industries of the Pacific Coast. Used mostly for canning (the pack has averaged over a million cases a year during the past 10 years, being exceeded only by salmon, pilchard, and tuna), mackerel are, nevertheless, a valuable fresh food. Two kinds of fish support the industry: The Pacific mackerel and the horse mackerel. Of the two, only the former is a true mackerel; the latter belongs to the family of jack fishes, of which the yellowtail is the best known. The yearly catch of Pacific mackerel averaged 81.5 million pounds, and the income to fishermen from this catch, 1.2 million dollars during the 5-year period ending with 1943. The catch of horse mackerel averaged 5.0 million pounds a year, with a value of $85,000 a year to fishermen. About 95 percent of the total mackerel catch was landed in the San Pedro area.

IN ADDITION TO ITS USE FOR CANNING, the Pacific mackerel is also salted and smoked commercially. The smoked product is particularly appetizing, but advertising and market development are needed to enhance the demand. The quality of canned Pacific mackerel could be improved. The present product, packed to sell cheaply, faces strong competition from similar inexpensive canned fishery products. Horse mackerel, considered by epicures to be superior to Pacific mackerel, has been canned only in recent years. Large quantities are sold in fresh-fish markets. Small amounts are smoked and salted. Before the war it was used in making canned pet food.

MACKEREL IS IMPORTANT AS A SPORT FISH in point of volume caught by anglers, especially from pleasure fishing barges. As game they are less highly valued than such fish as barracuda, yellowtail, or sea bass, but they are quite acceptable when the more desirable varieties are not available. Furthermore, there are no legislative limitations placed on the sport catch of either species of mackerel.

MACKEREL ARE CAUGHT COMMERCIALLY WITH PURSE SEINES AND BY THE SCOOP METHOD. The pilchard fleet, using purse seine or ring nets, catch a rather large proportion of the mackerel landed and almost all of the horse mackerel. This fleet at San Pedro fishes either for pilchard or mackerel, bringing in whichever happens to be available. The scoop method of fishing mackerel has become more important, during the past few years, than seining. Practiced on rather small boats of 4- to 12-ton capacity, the method consists of scooping the fish into the boats after attracting them by chumming with ground-up fish. Much of the fresh market mackerel is supplied by a small boat fleet using set lines and hand lines. In the fresh-fish trade, horse mackerel is valued somewhat higher than Pacific mackerel, as many persons consider its flesh to be of better quality.

THE PACIFIC MACKEREL FISHERY HAS GROWN SPECTACULARLY WITHIN THE PAST 20 YEARS. Until 1927, mackerel had been used primarily in the fresh-fish trade. About three to four million pounds a year had been utilized regularly, and continue to be utilized through this outlet. With the development of canning techniques during 1927, however, mackerel became the object of a great fishery practically overnight. Thus an industry that had canned less than 300 cases in 1926 packed nearly 600,000 cases during 1929 and 1¾ million cases during 1935.

TO CONSERVE THIS RESOURCE there are certain State legislative regulations. These are, at present, less concerned with the resource itself than with the way in which it is utilized. There are no closed seasons, no restrictions on gear, or limitations on the quantity that can be caught. On the other hand, no part of the catch can be used for reduction except the trimmings and offal remaining from the canning operation.

SCIENTIFIC INVESTIGATION of the Pacific mackerel, carried on since 1929 by the California Division of Fish and Game, has shown the spawning season to extend from late April to August, principally from the middle of May to early July. Known spawning grounds are located south of Point Conception, with heavier spawning off Lower California, Mexico, than off California. Fish begin spawning when 2 years old (12 to 13 inches in length). Tagging experiments have demonstrated migration of Pacific mackerel to the San Pedro area, both from Monterey and from Lower California. It remains to be determined what part of the whole population of Pacific mackerel is now being exploited. The horse mackerel has not been the subject of a biological study, and we have no fund of knowledge on this valuable resource.

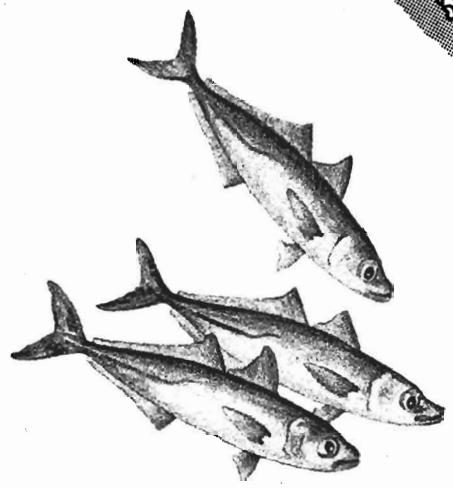
IN 1943

37.4 Million Pounds Were Canned. Product Worth 4.3 Million Dollars.

3.5 Million Pounds Were Sold in Fresh Fish Markets, Worth 0.5 Million Dollars.

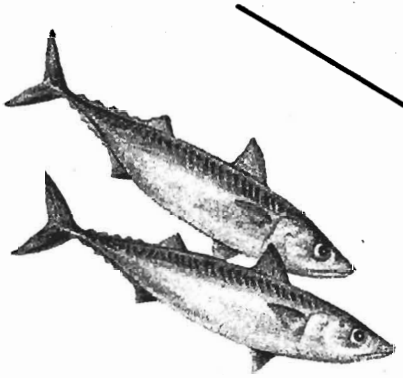
8.0 Million Pounds of Meal Manufactured, Worth 0.3 Million Dollars.

3.1 Million Pounds of Oil Manufactured, Worth 0.2 Million Dollars.

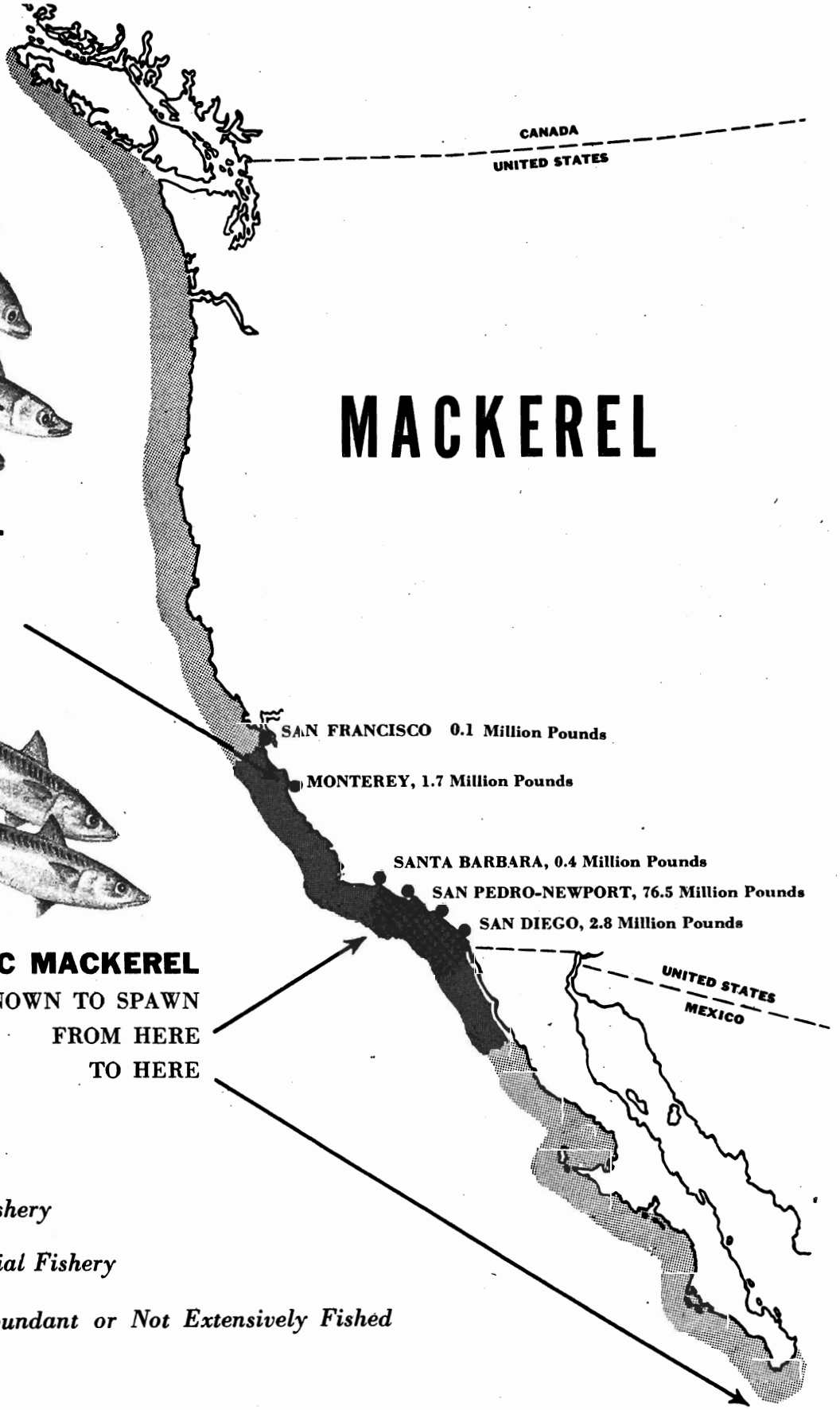


MACKEREL

HORSE MACKEREL
OCCUR FROM
MONTEREY TO CHILE



PACIFIC MACKEREL
ARE KNOWN TO SPAWN
FROM HERE
TO HERE



Area of Major Fishery

Area of Commercial Fishery

Present. Not Abundant or Not Extensively Fished

Pacific Fishery Resources HERRING

PACIFIC HERRING: Since man first began harvesting the wealth of the sea, he has found the herring to be among his most valuable marine resources. Because its range includes nearly all the temperate waters of the northern hemisphere, it has been readily available to large masses of people. Herring are found in dense schools, consequently are easily captured. This makes them a cheap source of excellent and nourishing food. They have been found to be ideal for processing into meal and oil, the former to be used as food for livestock, the latter for the host of purposes to which animal fat has been found adaptable. These uses have greatly enhanced the value of herring in recent years. In addition to these direct uses, herring are of tremendous importance in the economy of the ocean, for they are food for a multitude of larger fishes and mammals which are valuable to man. The United States catch of Pacific herring fluctuates widely, in the last 8 years between 44 and 208 million pounds

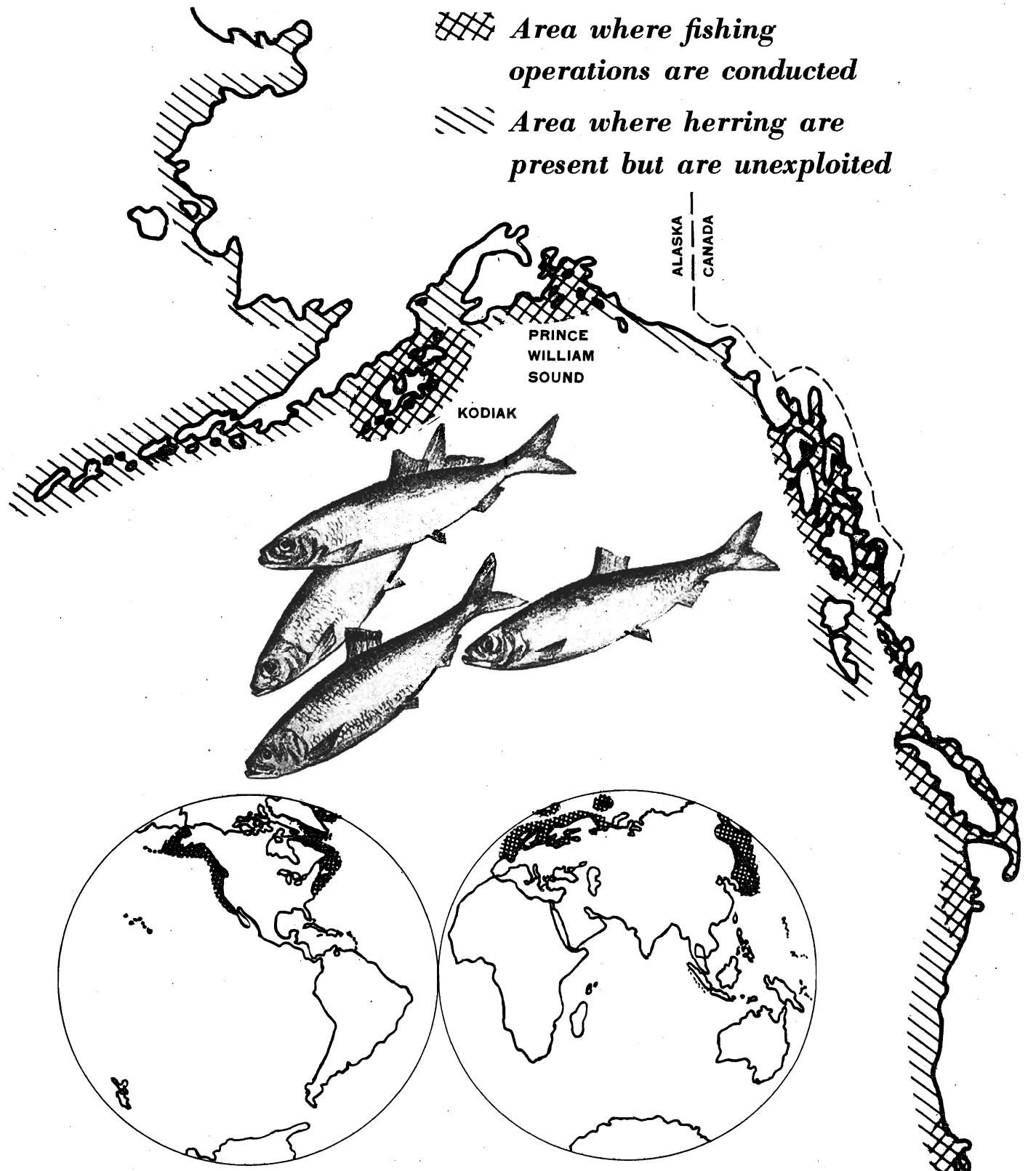
The Pacific herring is found from San Diego on the south to Nome in the north and west, and is of major commercial importance throughout British Columbia waters and as far west as Kodiak in Alaska. The fish spawn from winter in the south into late June in the north, depositing their eggs on kelp and other marine growths along selected portions of the shoreline. The young emerge in ten to twenty days, depending on temperature. Little is known of the habits or movements of the young herring from the time of hatching until they join the schools of adults. Part of the brood matures in their third year; most mature in their fourth or fifth year and a few not until their sixth year. On attaining maturity they spawn each year for the remainder of their life span. While the average age of the herring in Alaska is five to six years, many survive to their tenth year and beyond, and occasional individuals live to be twenty.

WHAT IS DONE TO SUSTAIN THE YIELD OF HERRING: The Alaska herring fishery has had a history characterized by great expansion in production capacity and fishing effort, followed by periods of scarcity of herring, with consequent economic distress to the industry. The first efforts to stabilize the fishery involved restricting the length of the fishing season. Unfortunately, this limitation failed of its purpose because the industry, being unwilling to sacrifice immediate gain for ultimate advantage, merely increased the size of the fleet and improved the fishing gear to circumvent the restrictions.

To correct this situation, a system of quota limitations on the total catch has been substituted for the limitations on season and areas. Each district is now allotted a tonnage quota regardless of the fishing effort expended there. This quota, which is adjusted from year to year, is based on predicted abundance as determined by biologists of the United States Fish and Wildlife Service. It is set to permit the maximum catch compatible with the need of maintaining an adequate spawning reserve. Canada maintains a comparable system of quota control; Oregon, Washington, and California, where herring is relatively unimportant, make no quotas but impose certain other restrictions intended to conserve the resource.

HOW THE CROP IS PREDICTED. The abundance of herring varies widely from year to year owing to widely fluctuating infant mortality. Thus some broods are very much more fortunate than others in escaping the many dangers ready to destroy the young. When the offspring of a brood become old enough to enter the fishery, they may, if numerous, bolster the abundance to a high level or, if scarce, fail to contribute enough to replace the adults removed by fishing and natural mortality. The result is a decline in abundance. Years of plenty follow when one exceptionally successful or two or more moderately successful hatches occur in the stock.

Because all of the individuals of a brood are not taken during their first year in the fishery but remain available for several years, it is possible to evaluate probable abundance in advance of a fishing season by maintaining accurate records, over a period of years, of the percentage contributed by each of the several broods in the catch. By this method it becomes possible to appraise the relative success of each brood which contributed to the catch and so evaluate the contribution to be expected from it in the coming season. With this information it is possible to estimate, within reasonable limits, the amount of herring that may be removed from the stock without encroaching on the spawning reserve necessary to maintain the value of the resource.



THE WORLD PRODUCTION OF HERRING

European production, including Iceland	*3,000 million pounds*
Eastern coast of North America	*225 million pounds*
Western coast of North America	*350 million pounds*
Japanese production	*700 million pounds*
Siberian production	*Unknown*

Pacific Fishery Resources SHARKS

SHARKS have a long history of uselessness to man. If they were ever given credit for having value, it was as scavengers of the sea. To fishermen they were a nuisance; to the public they were a great legend of ferocity. Attempts to popularize shark meat for food were never very successful, and only small quantities were landed for sale in the fresh-fish markets. Small quantities were taken for fins. In 1927 the Fishery Research Board of Canada discovered that the liver of the dogfish (a small shark) has a vitamin-A potency 5 to 10 times as great as that of the standard grade of cod-liver oil. This knowledge was not made use of in the United States until about 1936, when a fishery for sharks for the purpose of obtaining their livers started on a small scale. About 1938 it was discovered that the liver of the soupfin shark far exceeded that of the dogfish in potency of vitamin A. The new industry grew rapidly and in 1941 landed 40 million pounds of sharks worth 4.6 million dollars. More recent catch statistics are not yet available.

GROWTH OF THE PACIFIC COAST SHARK FISHERY

Year	*Pounds landed*	*Value*
1937	2.5 million	0.03 million dollars
1938	8.1 million	0.14 million dollars
1939	11.6 million	0.20 million dollars
1940	12.9 million	0.52 million dollars
1941	40.0 million	4.60 million dollars

Meanwhile, a few other kinds of sharks among the several species inhabiting the Pacific coast have proved to have livers of high potency, though none of them averages as high as the soupfin in this respect. Among these sharks are the hammerhead, the gray smooth-hound, the brown smooth-hound, the bay, and the great blue shark. Livers of lower vitamin potency are also taken from the leopard and bonito sharks, and from other so-called "junk" species, as well as from the closely related ratfish.

Shark fisheries have been established in Mexico and Central America, and the livers are sold to United States buyers for export into this country. In 1943 the west-coast production of oil from domestic and imported shark livers totaled 65 trillion units of vitamin A. About 54 percent of this was from soupfin sharks, 20 percent from dogfish, the rest from other species. Statistics for 1944, not yet complete, indicate that dogfish rather than soupfin are now the principal source of vitamin A. This may reflect reduced abundance of soupfin.

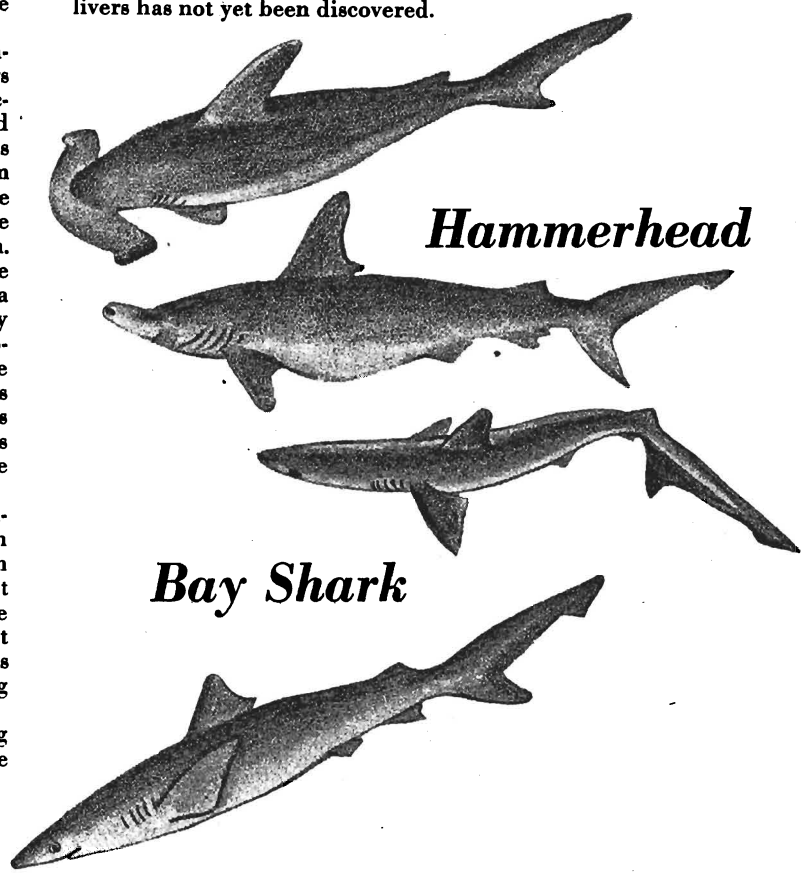
Before 1939 most of the sharks taken in California were caught by hand and set lines or by otter trawls and paranzella nets. The fishing off Washington and Oregon was principally by set lines. Later, drift and anchored gill nets were introduced in the soupfin shark fishery and have proved to be highly successful. More recently the trawl fleet, which has expanded so greatly in the northern ground-fish industry, has taken great quantities of dogfish and extended its activities into Hecate Strait in British Columbia and to the extreme southern part of Alaska.

In Washington and Oregon only a part of the catch is utilized, for the carcasses of most of the sharks caught are thrown overboard and only the livers are saved. California law, on the other hand, requires that fishermen deliver to port not only the livers but also the carcasses. There the meat of some sharks is filleted and sold in the fresh-fish market; some of it is smoked (soupfin is a particularly choice species); some is made into fish meal. At least one plant is manufacturing leather from shark skins.

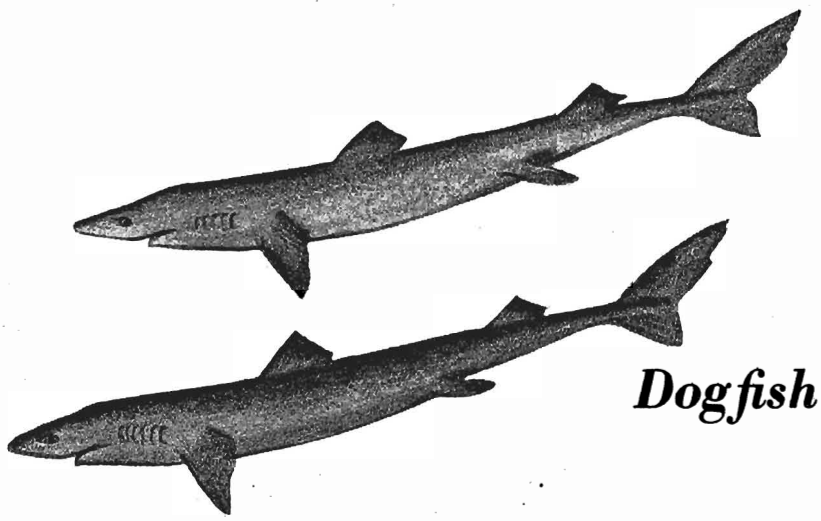
Shark fishing has much the same character as prospecting during a gold rush. Prices have been fabulously high; some fishermen have made fortunes, others have lost their stake. The tendency is to look on this fishery as a temporary thing that will collapse when the resource becomes exhausted or when the demand fails. There is no necessity for the first of these two events to happen, or likelihood that the second will occur, though the present craze for vitamins may very well moderate in the future. It seems likely that in the Pacific States this resource has about reached the limit of its capacity, beyond which further expansion is not possible. However, there are many large areas in Alaska where shark populations have not yet been exploited.

At the beginning of this new industry there was very scanty information about the sharks. It was known that the different species vary widely in habits. Some lay eggs, others bear their young alive; some swim at the surface, others live on the bottom; some feed entirely on fish, others on plankton. Thus, to find the facts needed to insure perpetuation of this resource on a profitable basis, it would be necessary to study each of the important commercial species separately. Usually, biological studies on a fishery resource do not begin until after the resource has been exploited for many years. In this case, however, studies were begun on soupfin sharks and dogfish *early* in the history of the industry. The fishery conservation agencies of Washington, Oregon, and California, and the Fishery Research Board of Canada have participated. The United States Fish and Wildlife Service has cooperated in a limited way so far as its facilities have permitted. Results of these studies have not yet been made public.

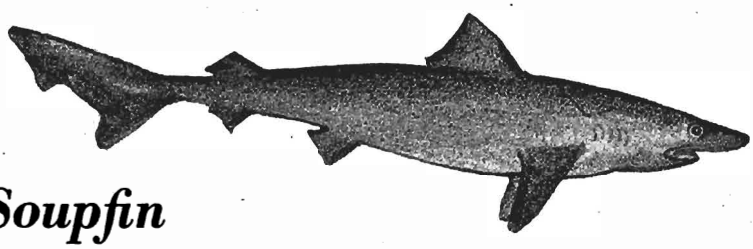
The potency of vitamin A varies widely in the soupfin (5,000 to 500,000 U. S. P. units per gram; average 110,000) and also in dogfish (1,000 to 60,000 U. S. P. units per gram; average 13,000). It tends to be higher in males than in females, higher in larger fish than in smaller ones, and higher in winter than in summer. In both species the sexes school separately during certain seasons of the year, and at certain times fishermen catch mostly males. Whatever peculiar process goes on in these sharks to concentrate and store vitamin A in their livers has not yet been discovered.



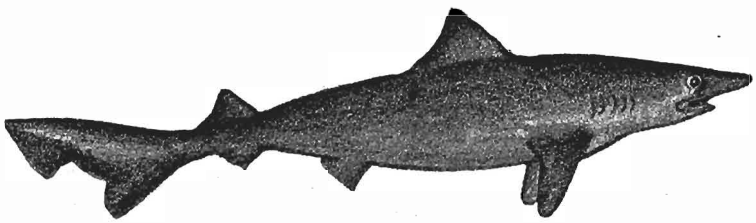
Pacific Fishery Resources SHARKS

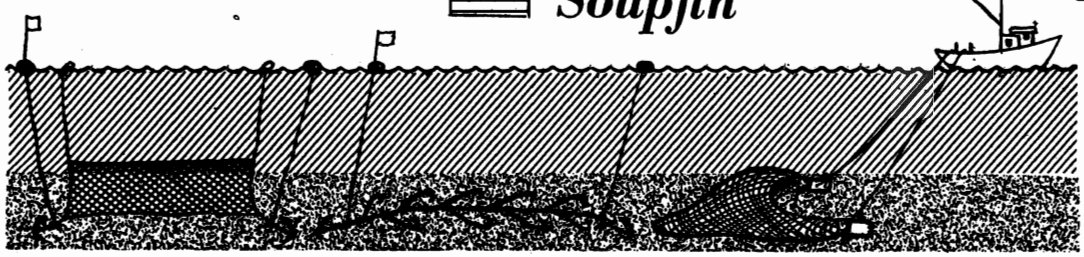


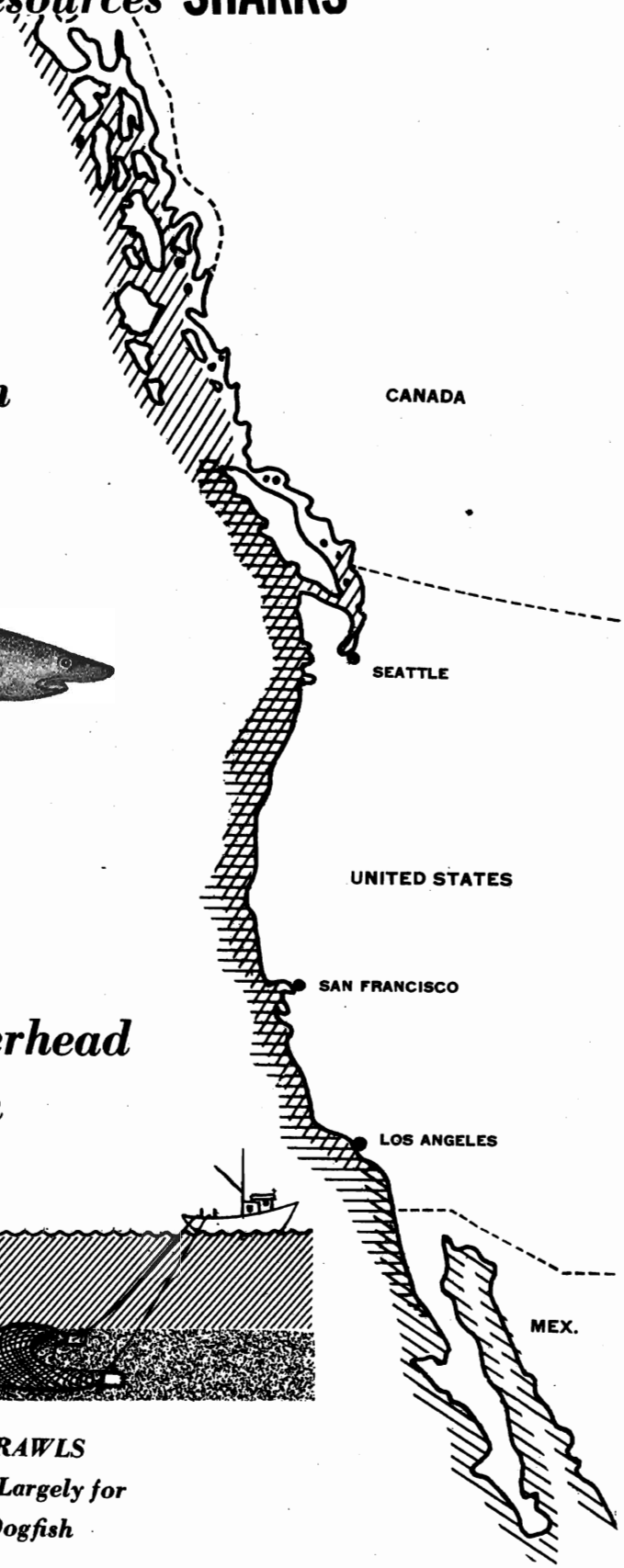
Dogfish



Soupfin







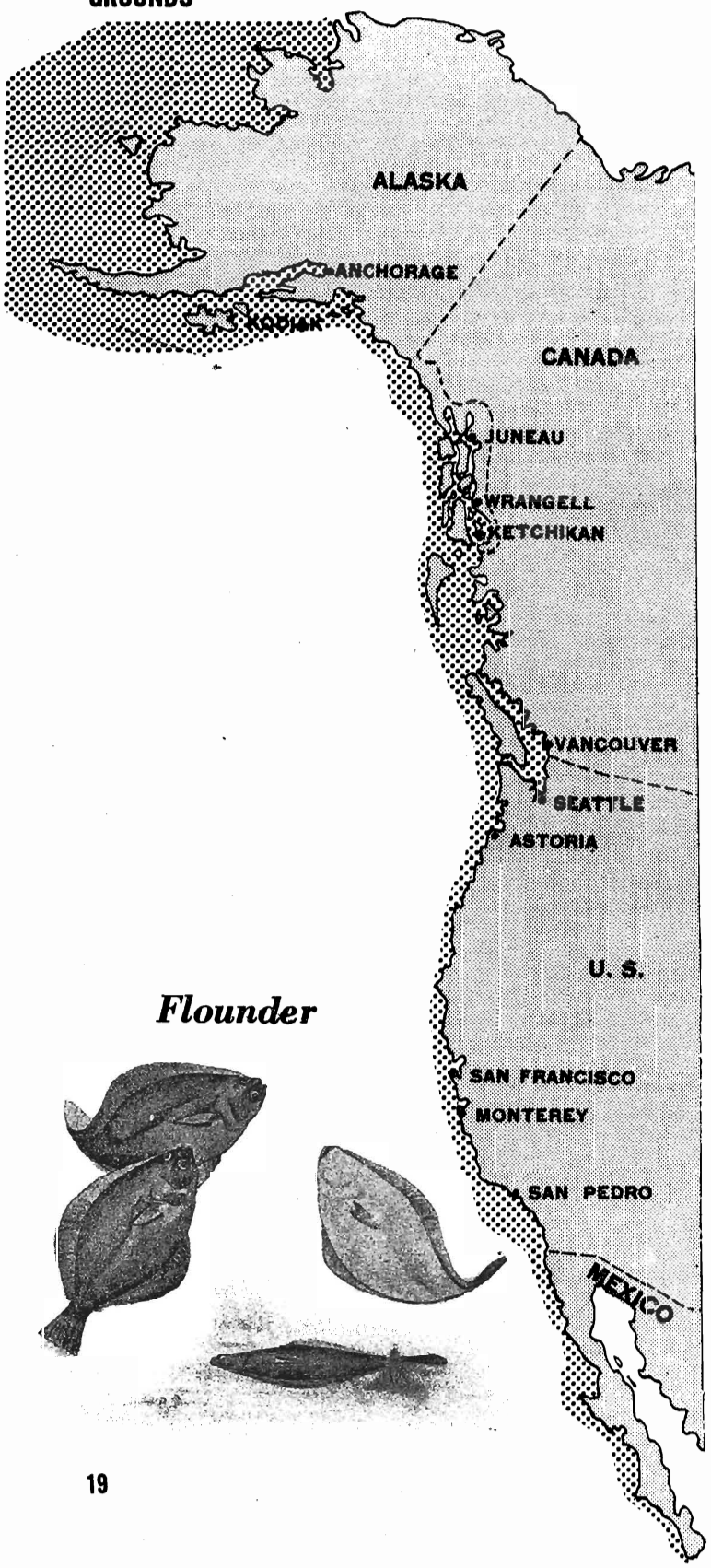
GILL NETS
Used Mostly for Soupfin

SET LINES
Used for Soupfin and to Some Extent for Dogfish

TRAWLS
Used Largely for Dogfish

Pacific Fishery Resources GROUNDFISHES

SOLE AND FLOUNDER FISHING GROUNDS



Flounder

SOLES OR **FLOUNDERS** ARE THE BACKBONE OF THE PACIFIC COAST GROUNDFISH* RESOURCES. There are several kinds of these valuable fishes. They know no political boundaries, being continuously distributed from the Arctic Ocean on the north to the Gulf of California on the south, and within the territory of four countries: United States, Canada, Russia, and Mexico.

This is still one of the few great under-exploited fishery resources remaining to us; indeed, it is only partially explored. At least one great population is not even touched: The yellowtail flounder, which is of no commercial significance at present, was found by the Alaska Crab Investigation to be more abundant in the Bering Sea than any of the very valuable soles taken commercially farther south.

The petrale or round-nosed sole is at present the most important in Pacific coast catches and the most highly valued by the trade. It is a large fish, averaging around 20 inches in length, and is therefore convenient to fillet. Next in importance is the pointed-nosed, "point," or "English" sole. This is somewhat smaller in size than the petrale, averaging about 18 inches.

Somewhat less important are the starry flounder, rex sole, arrow-toothed sole and California halibut.

SINCE SOLES OR FLOUNDERS ARE CAUGHT MAINLY BY TRAWLING, THE FISHING GROUNDS FOR THEM ARE LIMITED TO THE AREA IN WHICH TRAWLS CAN BE USED. To date little successful trawling has been done in depths greater than 100 fathoms. The unexploited grounds cover about 600,000 square miles of ocean, while the exploited areas only about 60,000 square miles. Although some trawlers are now fishing in depths as great as 135 fathoms, and have gear capable of fishing to 200 fathoms, these developments will cause only a slight extension of the trawlable banks. The reason for this lies in the rapid dropping off of the ocean floor into abyssal depths. This generally occurs within only a few miles of the 100-fathom line.

In the past, fishing has been limited to banks near population centers, since the majority of flounder fillets are eaten fresh and do not keep particularly well unless frozen. This has precluded any large scale exploitation of fishing grounds north or south of the Pacific coast of the United States. Methods of refrigerating the catch aboard the fishing boats have been developed, now permitting the delivery of fish in excellent condition from more distant points. Also, the development of methods of handling frozen and packaged fillets will make it possible to install processing plants in Alaska, whence the finished product may be shipped to the United States.

AMONG THE UNEXPLOITED GROUNDS, THOSE OF ALASKA ARE PARTICULARLY PROMISING. They cover a large area, greater even than the famed trawling grounds of the North Sea. A survey made by the United States Fish and Wildlife Service in 1941 for the purpose of developing an Alaska king crab fishery incidentally revealed the extent of the flounder resources of the Bering Sea and other Alaskan waters. In hauls made primarily to catch crabs, the average take of flounders was 1,100 pounds per haul. This is over

*Groundfish are fish which characteristically live on the bottom.

twice the average catch per haul in the well-developed trawl fishery of Puget Sound, Washington. The extensive grounds of Hecate Strait are close to the area of present fishing operations, and the next expansion of the fishery will probably take place there. Although this region lies entirely off British Columbia, most of its waters are more than 3 miles from shore and therefore come within the scope of high-seas fisheries as they are now defined.

TECHNICAL IMPROVEMENTS IN HANDLING, PREPARATION, PRESERVATION, AND MARKETING, HAVE ACCOMPANIED DEVELOPMENT OF THE SOLE FISHERY. The new filleting plants in Astoria and Seattle are equipped with efficiency improving features in construction and operation such as are not found on the Atlantic coast. Because filleting is an expensive method of preparation, technologists and engineers are developing machinery to reduce the cost and enhance the yield.

TO SUSTAIN THE MAXIMUM YIELD, legislation now governing flounder fishing is of three general types: (1) Complete closure of certain areas to trawl fishing, (2) closed seasons in some regions, and (3) the setting of certain minimum sizes of mesh for the netting used in trawls. All present laws are devised and administered by the States in whose waters the fishing takes place.

The first two types of laws are often designed to protect other species of fish as well as soles, with the idea that the trawl is a basically destructive form of gear.

Regulation of mesh size is advocated by many responsible fishery investigators, and is of course intended to prevent the waste of small fish and to take advantage of growth. The former point is especially significant because many of the small flounders caught in small-mesh trawls are thrown away. Allowing fish to grow to a larger size takes advantage of the rapid increase in weight which is attained by most fish in their early years, and in addition allows them to reach maturity so that they may become the progenitors of future generations.

The regulations now in force of necessity are a patchwork resulting from the individual efforts of the various State legislatures. Laws imposed in one region may be circumvented by going to another. This situation can be mitigated only by planning laws to benefit the resource as a whole.

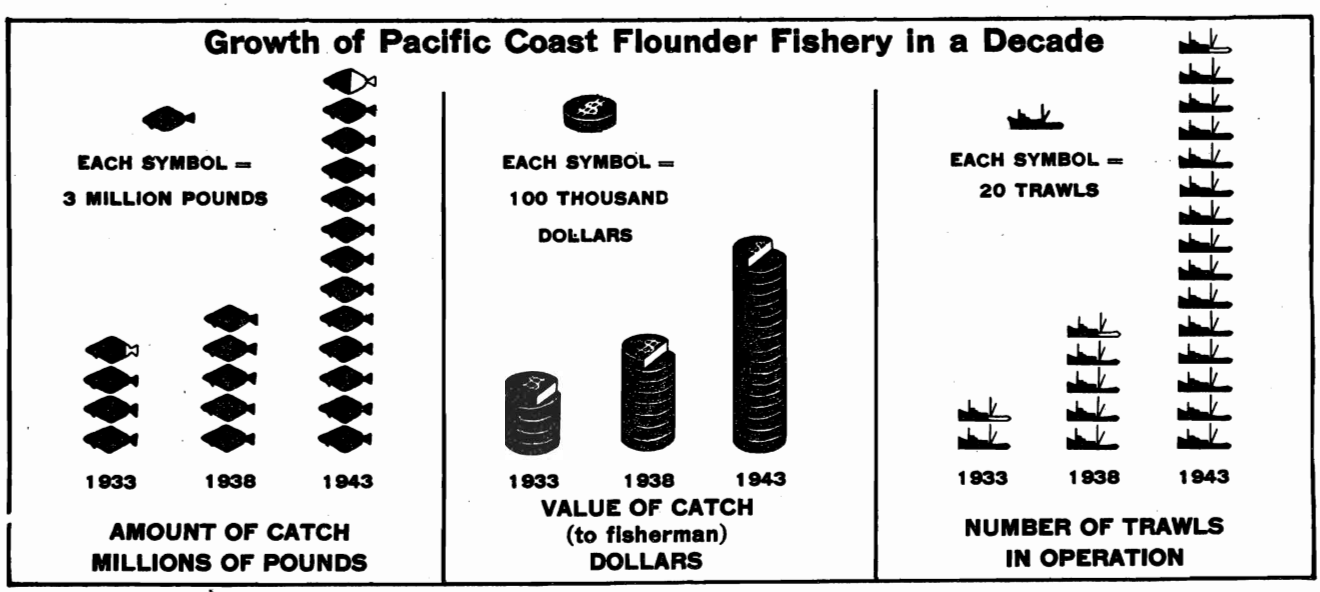
WHAT WE KNOW ABOUT THIS RESOURCE: The majority of what is now known about the biology of the soles or flounders has been discovered by the investigators of the State of Washington Department of Fisheries and the California Division of Fish and Game. Research to date has not been extensive, since it is only recently that the sole fisheries have attained their large size.

Most Pacific coast flounders lay their eggs in the winter and early spring, each species spawning quite generally over the area of its distribution. The eggs are pelagic, floating freely in the sea water. The newly hatched larvae are symmetrical, like other fishes, but as they grow one of the eyes migrates to the side occupied by the other; other distortions develop, and the fish lives and swims with its blind side to the ground.

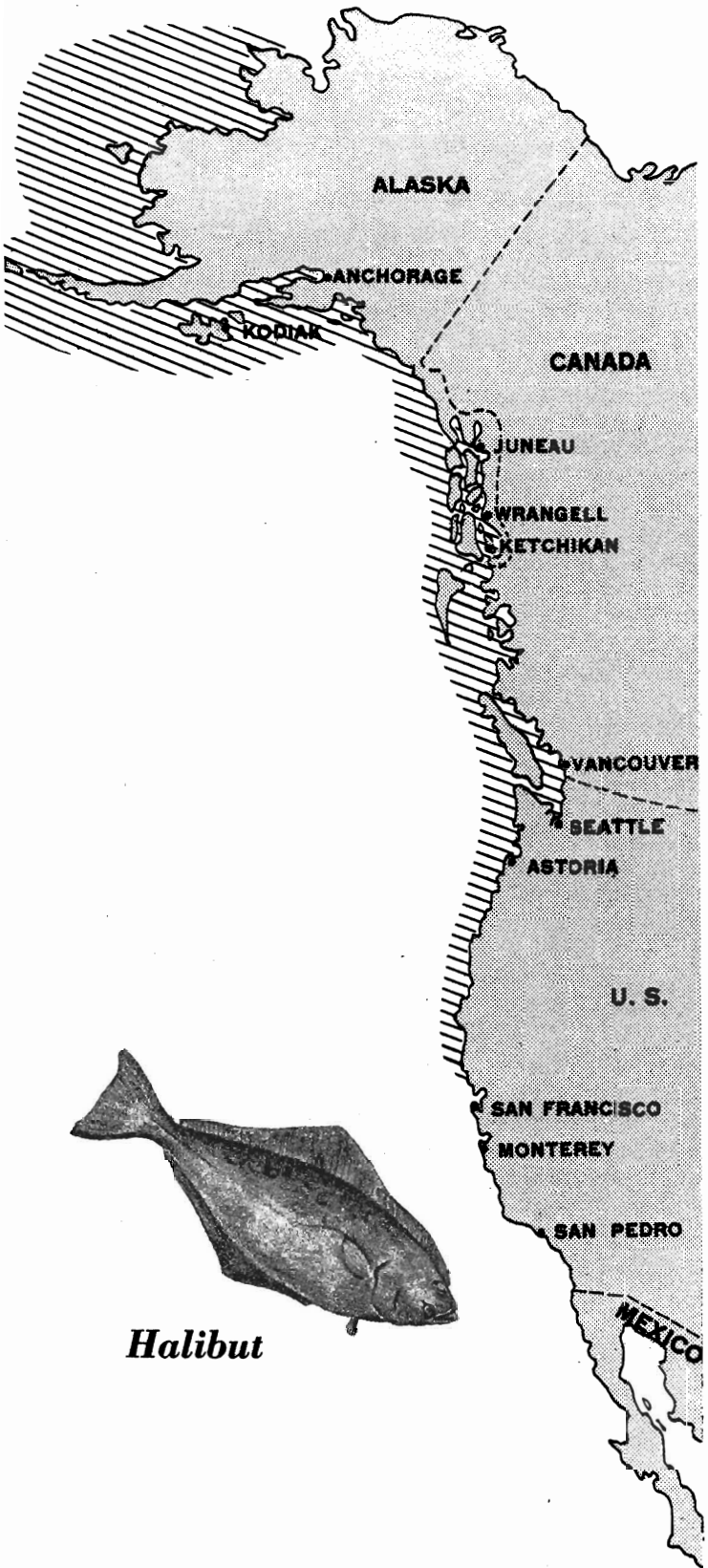
The two species most important commercially, the round-nosed or petrale sole and the pointed-nosed or English sole, reach maturity at an age of about 3 years, and at lengths of about 10 inches and 8 inches, respectively.

Tagging, done in California by the California Division of Fish and Game, indicates that flounders migrate considerable distances. For instance, tags inserted in fish off San Francisco have later been recovered near Eureka. This finding is important in connection with possible future conservation policies, because it suggests that the flounder stock can be composed of intermigrating groups of fish. If so, it will obviously be impossible to make useful regulations on a local basis.

WE STILL DO NOT KNOW ENOUGH TO INSURE MAXIMUM YIELD: There is at present a paucity of biological information concerning the flounder resources of the Pacific coast. We have yet to know what is the present condition of each species in relationship to the fishery. Is it being exploited at, above, or below its maximum level of continuous productivity? We must establish enough information concerning the life history *of each species* by which to guide the fishery to efficient and wise utilization of this resource. This involves determining, among other things, the rates of growth, duration of life, spawning grounds, routes of migration, and mortality rates. All of this information can be gathered only by carrying on investigations for a period of years, on a coastwise scale.



Pacific Fishery Resources GROUNDFISHES



Halibut

THE PACIFIC HALIBUT IS A CLASSIC EXAMPLE OF A RESOURCE WHICH, AFTER UNDERGOING EXTREME DEPLETION, HAS BEEN RESTORED THROUGH CAREFUL REGULATION. As a result of the rapid development of an intensive fishery between 1910 and 1930 the stocks of halibut in the north Pacific declined alarmingly; since 1930 management based on adequate investigation by the United States and Canada has increased abundance and stabilized the fishery at a relatively high level of production.

The halibut is a giant flounder of northern seas, found in the north Pacific, the north Atlantic, and the Arctic Oceans.

The oldest halibut fishery in the United States, that of the north Atlantic banks, has declined from a former catch of around 14 million pounds a year to one of about 1 million pounds. By contrast, the catch in the north Pacific banks is about 50 million pounds.

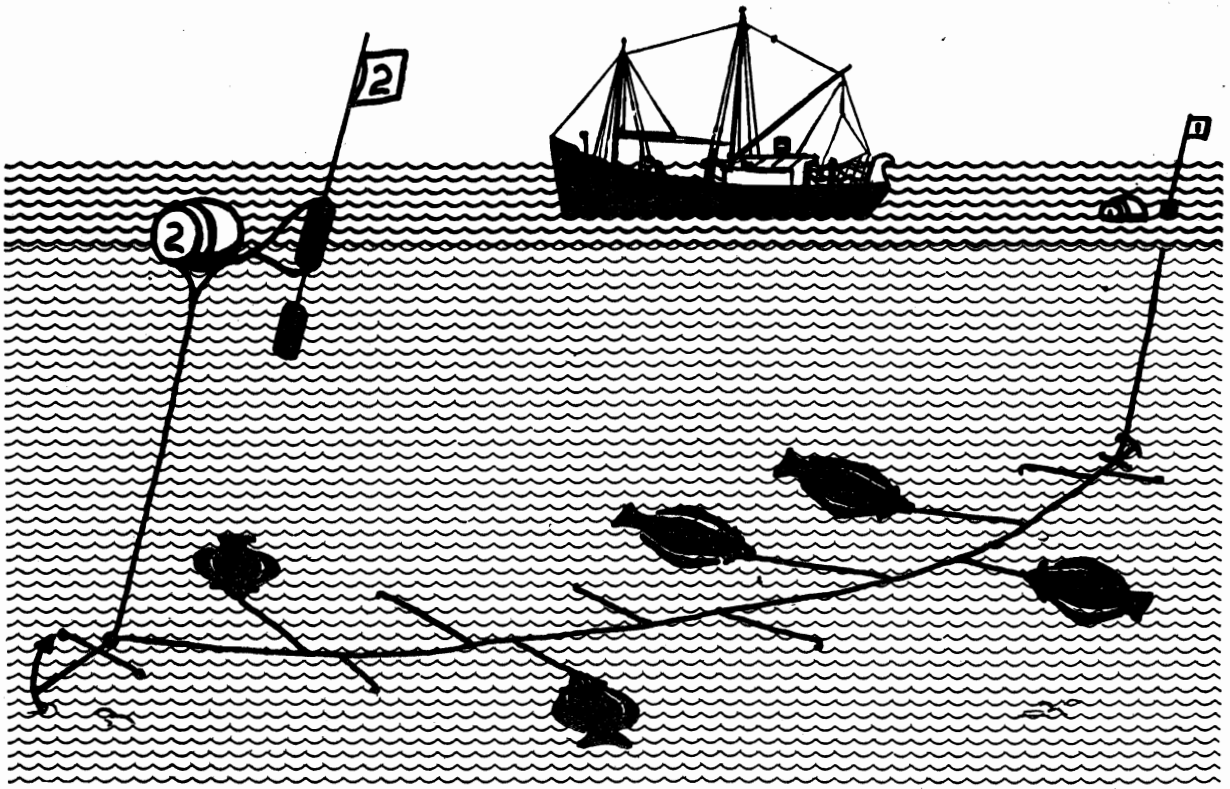
The halibut is a slow growing species, especially subject to depletion. In general, it reaches commercial size at 5 years, matures at 12, under favorable conditions may perhaps live for half a century. In American Pacific waters, female halibut, which are larger than the males, reach weights of 150 to 200 pounds. Atlantic halibut commonly grow to be 300 to 450 pounds, have been known to reach 700 pounds.

Halibut live on banks extending from shore to about 250 fathoms deep. They are caught with long lines made up in units called skates, each approximately 1,800 feet long, carrying 5-foot lines at intervals of about 13 feet. Vessels run up to 100 feet in length, are manned by crews of about 8 to 12 men. A halibuter may be on the banks 2 to 3 weeks on a single voyage.

Halibut is sold mostly as fresh or frozen fish. Canning has recently started on a small scale. The fish are cleaned and iced upon capture; after delivery to the port they are either re-iced for shipping fresh or are frozen. Part of the catch of United States vessels is shipped through Seattle, part through Canadian ports from which it is shipped in bond to the United States. Halibut is marketed widely throughout the country; largest sales, however, are probably east of the Mississippi and north of St. Louis.

The taking of halibut livers for vitamin oils began in 1932; in 1938 a market developed for the viscera, which was found to contain vitamin-rich oil. The annual utilization of the liver and viscera has since increased steadily and in 1942 the value of these products amounted to nearly 1 million dollars.

THE HISTORY OF THE HALIBUT FISHERY has been characterized by rapid mechanization of the industry and by progressive expansion of fishing grounds as areas near the home ports became depleted. From a local fishery in Puget Sound, halibut fishing spread north along the coast of British Columbia, reaching Cape Spencer by 1910, soon changed from an inshore to a deep-sea fishery with the discovery of populous banks in deeper waters from the Queen Charlotte Islands to Cape Ommaney. By 1913 halibut vessels were working well out along the Alaska Peninsula. The present fishery covers



2,200 miles, from northern California to Bering Sea.

Early halibut fishing was from dories carried by sailing vessels or steamers; later, offshore fishing was conducted by gasoline-powered vessels from which the gear was set directly, permitting the use of many more units of gear per man and making fishing possible in rough weather. Diesel engines supplanted gasoline about 1921 and again the fishery reached out into new grounds. Development of cold storage facilities provided means of caring for heavy catches. Lacking any check by legal restrictions, the halibut fishery continued to increase in intensity.

As early as 1916, decreasing abundance in several areas brought requests for international cooperation in fishery regulations. In 1924 a treaty between the Governments of Great Britain and the United States established the International Fishery Commission for the investigation of the halibut. In 1930 this convention was rewritten to provide regulatory powers, and it was further extended in 1937.

Investigations of the nature and condition of the stocks of halibut frequenting different parts of the coasts were made by the Commission, which also developed means for preserving and rebuilding the population. It was found that the stocks south and west of Cape Spencer were separate populations and in different stages of depletion. Spawning halibut were very scarce south of Cape Spencer, where the annual catch of fish had decreased from 60 million pounds in 1912 to 22 million in 1930 and 1931, despite greater fishing effort. Even on the more recently fished grounds west of Cape Spencer, the catch had fallen, between 1915 and 1930, to about one-fourth the original return per unit of fishing effort. Total Pacific coast landings had fallen from 69 million pounds in 1915 to 43 million in 1931 and it was demonstrated that the halibut were being removed from the banks by the fishery more rapidly than they were being replaced by reproduction and growth.

Under the authority of the treaty of 1930 the Commission divided the coast into four areas, and thenceforth annually set a quota on the number of pounds of halibut that could be taken during the season. When the quota was reached the season was closed. As a supplementary measure two areas where small fish predominated were entirely closed to fishing.

UNDER REGULATION THE ABUNDANCE OF HALIBUT HAS INCREASED MARKEDLY ON ALL GROUNDS. The catch per unit of gear has increased as much as 112 percent since 1930.

Control of the fishery during the past 13 years has resulted in an annual yield now 10 million pounds greater than under unrestricted fishing immediately preceding regulation, and perhaps 20 million pounds greater than the fishery would be taking now had unrestricted fishing continued.

Pacific Fishery Resources GROUNDFISHES

SABLEFISH OR BLACK COD, UNLIKE OTHER GROUNDFISHES, is not dry meated, but is one of the richest and fattest of American fishes. The flesh is firm, white, and flaky, with a full, rich flavor. Yet in spite of these excellent qualities, this species has been long neglected by the fishing industry and the public.

The largest part of the catch now is made by long lines; but, with the expansion of trawling, considerable quantities are now being taken in otter trawls. Like the lingcod, it is taken incidentally with the halibut catch. However, halibut fishing is highly restricted by governmental action, and to spread the limited total catch as evenly as possible, the individual boats voluntarily restrict themselves as to the number of trips they make each season. Under these conditions, fishermen fill their holds with the more valuable halibut, and discard their incidental catches of sablefish and lingcod. Recent relaxation of certain regulations of the International Fisheries Commission has already had a favorable effect on landings of sablefish. Public demand for sablefish has not been sufficient to stimulate a fishery, and market development studies are required to induce greater utilization of this valuable resource.

Sablefish is marketed fresh, frozen, salted and hot-smoked or "barbecued." Smoked sablefish is considered a delicacy by epicures. The salted fish does not oxidize readily, in spite of the high fat content, and is a favorite product among Scandinavian-Americans. Although experiments in canning this fish have so far been unsuccessful, it is believed that further research will produce favorable results. Indications are that the sablefish has possibilities as a quick-frozen, packaged product. The liver is a good source of vitamin A, and also the viscera, according to recent studies.

THE PACIFIC COD IS ONE OF THE FEW POTENTIAL FISHERY RESOURCES REMAINING TO BE UTILIZED. At present this very close relative of the famous codfish of the Atlantic—the two species differ in only slight respects—supports only a small fishery in a small part of its range. Yet, the Pacific banks are larger and of greater potential production than the Grand Banks off the coast of Newfoundland. As a result of a peak demand during World War I there was a boom in cod fishing in the Pacific, and the catch rose to about 30 million pounds annually from 1914 to 1918. In the post-war depression of 1921–22 it declined to 9 million pounds, gradually rose to 24 million in 1926, declined to 16 million pounds in 1927, remaining at approximately that level for the next 10 years. In 1938 the San Francisco fleet left the cod fishery, which then declined to a level of 10 million pounds, where it remained until 1942. In that year the cod fishing grounds became a war theater; most of the vessels were taken for war purposes. and only one vessel was able to fish. Because of these difficulties of operation, the catch of cod fish during the war period has been greatly reduced.

Various reasons may explain the low production in recent pre-war years, especially the lack of demand for salt cod. The fact is, however, that the productive grounds are in the Gulf of Alaska and in Bering Sea, where no local processing facilities are available. The catch must be transported thousands of miles for processing and marketing. When plants are established near the fishing grounds and improved transportation facilities become available, this resource can be more fully utilized.

While cod is thought of principally as a dry-salt fish, some is preserved as stockfish [1] by air drying; some is made into fillets and some sold in the fresh-fish market.

The development of new products, better marketing techniques, modern plants, and adequate transportation, would enable the fishermen to dispose of quantities comparable to those now taken in the Atlantic. The commercial production of quick-frozen Pacific cod should contribute much to accomplishing this result.

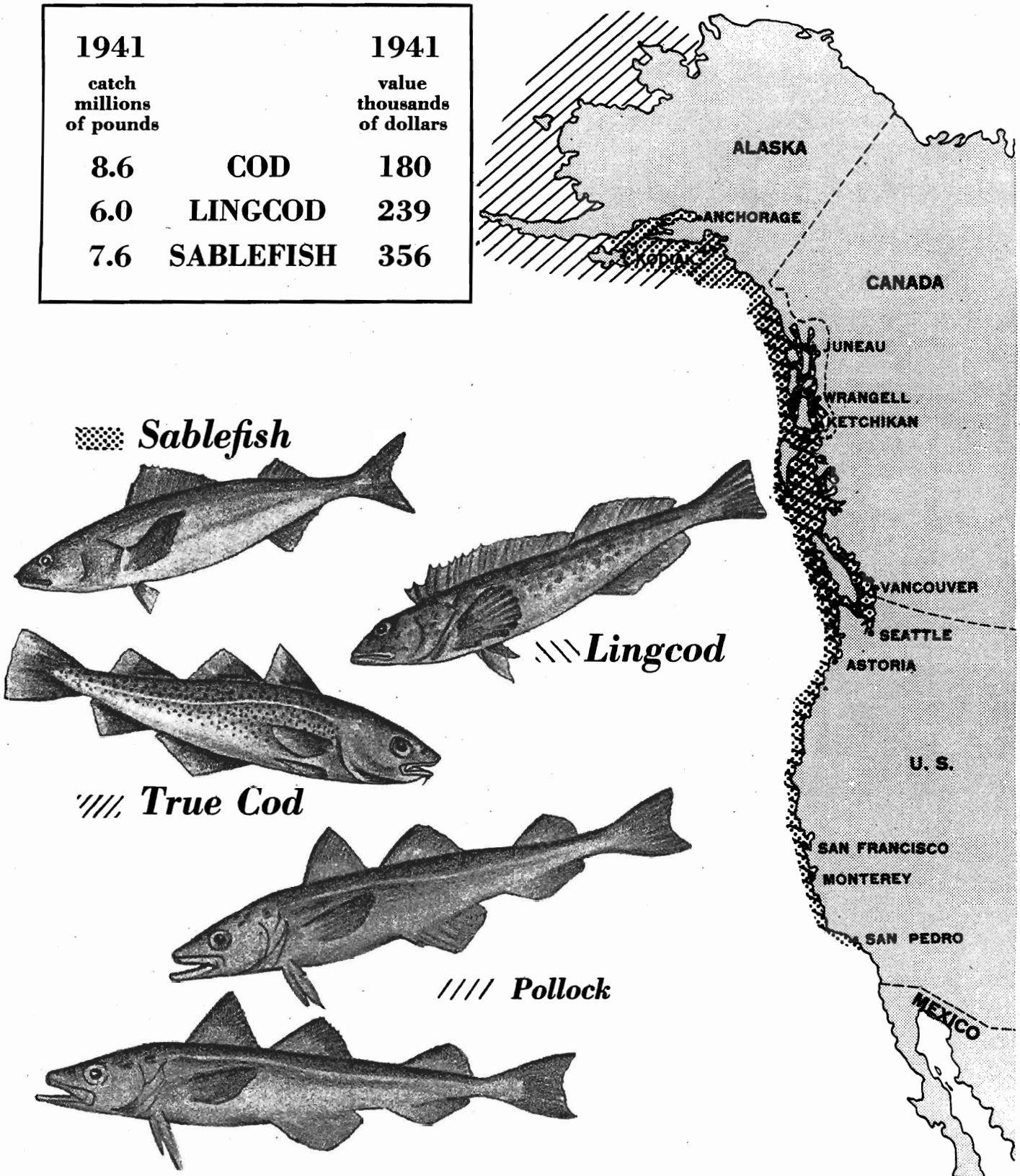
LINGCOD OR CULTUS, LIKE THE OTHER GROUNDFISH RESOURCES OF THE PACIFIC, HAS BEEN UNDER-UTILIZED. This species has never been the object of a special fishery, but has always been an incidental catch of halibut fishermen, or of market fishermen. The recent great expansion of the Pacific trawl fishery has contributed substantially to landings of lingcod.

As with other groundfishes, filleting is becoming the predominant method of preparation for market, though steaking is still used widely, and some is prepared as smoked fillets. Lingcod does not make a particularly good salt fish, and investigations to date do not indicate that it is suitable for canning. Research should be extended, however, to develop new products from this under-utilized species. The livers are extremely valuable, the oil having a high vitamin A content, a fact which accounts in part for the recent increase in catch.

Lingcod are found from near shore out to depths as great as 200 fathoms. Southern British Columbia seems to represent the center of distribution of the species. Here the spawning season is from December through March. During these winter months the lingcod migrate toward the shore, and lay their eggs in crevices between rocks. A single female may produce from 60,000 to 500,000 eggs. Like the young of the true cod, the juvenile lingcod remain close to shore, later migrating outward. The favorite habitat of the adult fish in British Columbia waters appears to be a rocky bottom where there is considerable current.

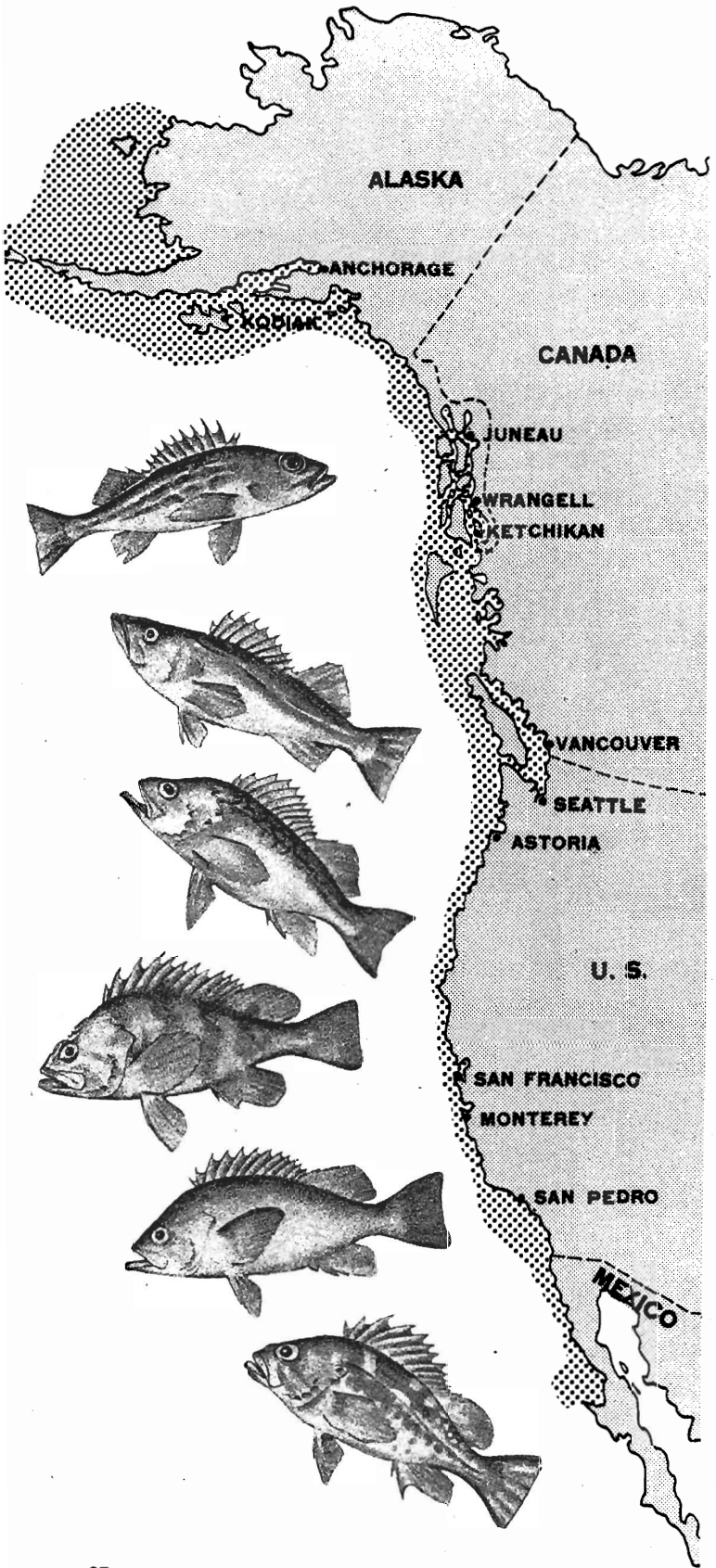
[1] Stockfish is used in making "Lutefisk," a favorite Scandinavian dish for the Christmas and New Year holidays.

1941 catch millions of pounds		1941 value thousands of dollars
8.6	COD	180
6.0	LINGCOD	239
7.6	SABLEFISH	356



***POLLOCK** has a distribution similar to that of cod, is equally abundant, and is of excellent quality. It is not fished commercially, hence this resource is entirely wasted.*

Pacific Fishery Resources GROUNDFISHES



ROCKFISHES: MORE THAN 50 KINDS OF ROCKFISHES INHABIT THE PACIFIC COAST FROM LOWER CALIFORNIA, MEXICO, TO THE BERING SEA. These all belong to a single family, and because they are all very much alike—they are all more or less spiny about the head, and most of them are more or less red in color—there is great confusion in their names. Because of some fancied resemblance of certain of them to cod, they are frequently called "rock cod." They vary greatly in size, some of them reaching a length of three feet, though from one to two feet is commoner.

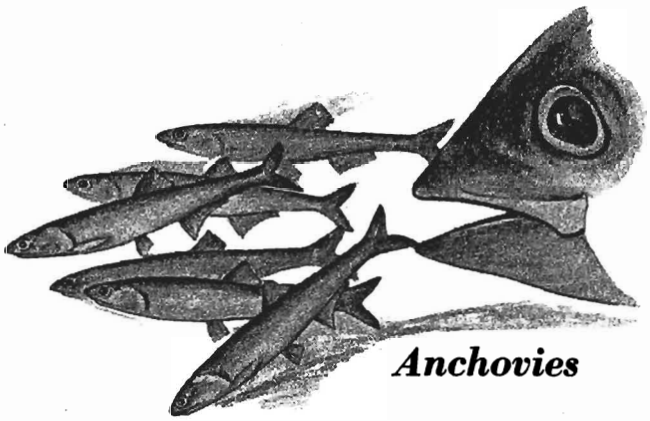
Although they do not at present support a major commercial fishery on the Pacific coast, the rockfishes constitute one of the most valuable groups of fish in the fresh markets. The recent great expansion of the Pacific trawl fishery has resulted in a tremendous increase in the catch of rockfish. Whereas in 1940 the landings for the entire Pacific coast totaled 5 million pounds worth $187,000 to the fishermen, the trawl catch alone in 1943 was over 12 million pounds, valued at almost $500,000. Rockfish are sought by anglers, too; about half a million pounds were caught by them in California during 1940. What might one day happen to the rockfish fishery of the Pacific coast is suggested by what has happened on the Atlantic coast, where in a few years the catch of the rosefish (one of the rockfishes) has increased from almost nothing to 150 million pounds a year.

Most rockfish is sold in the fresh fish markets. Some is filleted, packaged, and quick-frozen. Results of experiments give promise that rockfish could be canned successfully.

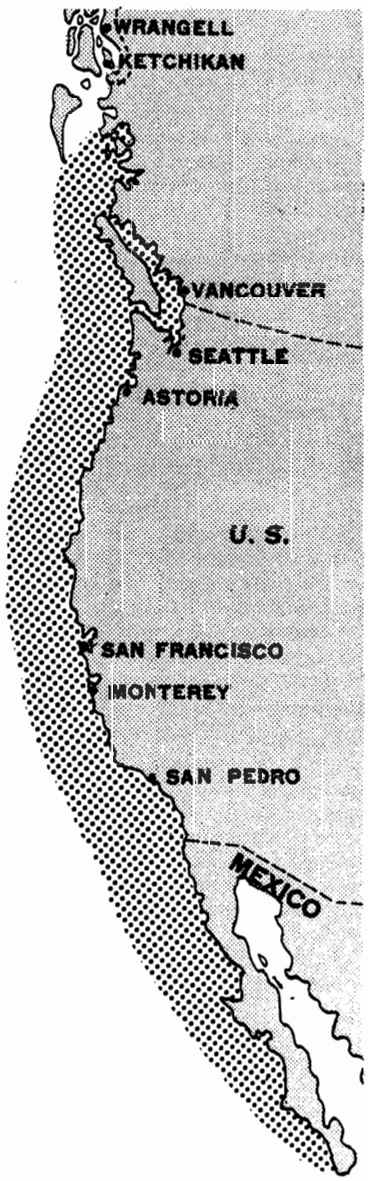
Until recently, rockfish were caught mostly with hand lines or set lines. Trawls now are gradually becoming more important in this fishery. Besides the usual otter trawls, special "balloon trawls" are used in some areas. This type is operated without leads, the weight of the otter boards and the net itself being enough to prevent surfacing. Fishermen claim the greater buoyancy thus achieved prevents stirring up the clouds of mud which are believed to frighten the rockfish away from ordinary trawls.

As their name implies, rockfish prefer rocky bottoms for their habitat. They spawn in spring and summer; each female produces from 30,000 to 100,000 eggs. Rockfish are ovoviviparous; that is, the eggs are fertilized internally. Apart from these facts, little is known of their biology; and much investigation would be required if it were necessary to have a basis for formulating a conservation program.

Pacific Fishery Resources ANCHOVIES



Anchovies



ANCHOVIES ARE AN UNTAPPED RESOURCE: Among four species found on the Pacific coast, one of them, the northern anchovy, is distributed widely enough and is abundant enough to be of potential commercial importance. This anchovy is found from the Queen Charlotte Islands, British Columbia, on the north, to Cape San Lucas, Lower California, on the south, and an unknown distance to sea—probably less than three hundred miles. It is a pelagic fish, typically moving in schools, and feeds on plankton.

This is an almost virgin population of fishes, approaching in numbers, if not in weight, the vastness of the pilchard population. Minor amounts are reduced, canned, or salted in California, but this production has not been consistent and has been experimental in nature. Similar or greater quantities are used as bait by sport fishermen and by commercial tuna fishermen. Unknown amounts are landed mixed with pilchards and are thrown into reduction. All of these amounts are negligible in terms of the total population.

OF THE FEW REMAINING LATENT FISHERY RESOURCES OF THE PACIFIC COAST, THE ANCHOVY SEEMS CAPABLE OF YIELDING THE GREATEST RETURNS. Assuming that anchovies and pilchards are present in equal numbers, rough estimates indicate that an anchovy fishery might yield as much as 125,000 tons annually. Were it not for the pilchard, this resource would probably be utilized. That it is not now utilized is due to several factors: (1) Anchovies are not as desirable as pilchards when processed in the same manner. (2) Anchovies, being smaller, are "gilled" in the nets which are used to take pilchards. Gilled fish are removed only at the cost of much extra work and cause excessive rotting of the net. (3) Anchovies are delicate, suffer more damage in the boats, and with the present methods cannot be carried as far nor in such quantities as pilchards.

In order to establish an anchovy fishery, it would first be necessary to develop on a profitable basis, (1) methods of catching anchovies, (2) methods and machinery for canning them, (3) methods of producing oil and meal from them. It would also be necessary to develop a larger market for them.

There is now a minor industry in curing California anchovies, Spanish style, at Monterey. It is claimed that while the quality of the domestic product is good, anchovies from France, Italy, Portugal, and Spain are imported and sold at prices with which we cannot compete. In addition, the market for products of this type is limited and was created by the imported anchovies, which have therefore been favored.

The anchovy has an oil content much lower than that of the pilchard. Therefore it is not now considered to be a profitable raw material for reduction purposes, since much of the profit in fish reduction is in the manufacture of oil.

VERY LITTLE IS KNOWN ABOUT ANCHOVIES. Certain information has been collected incidental to the study of other fishes and certain inferences may be drawn from what is known about similar species. The eggs and larvae are known, but the extent and quantity of spawning are not. The major spawning area is not definitely known. Results of oceanographic work indicate that it probably lies in part, at least, in that region off southern California which is bordered by the Channel Islands on the north, and the International Boundary on the south, and which extends some 100 to 150 miles to sea. Nothing is known about the northern anchovy's movements, or about its growth rate, life span, mortality rate, or responses to environment.

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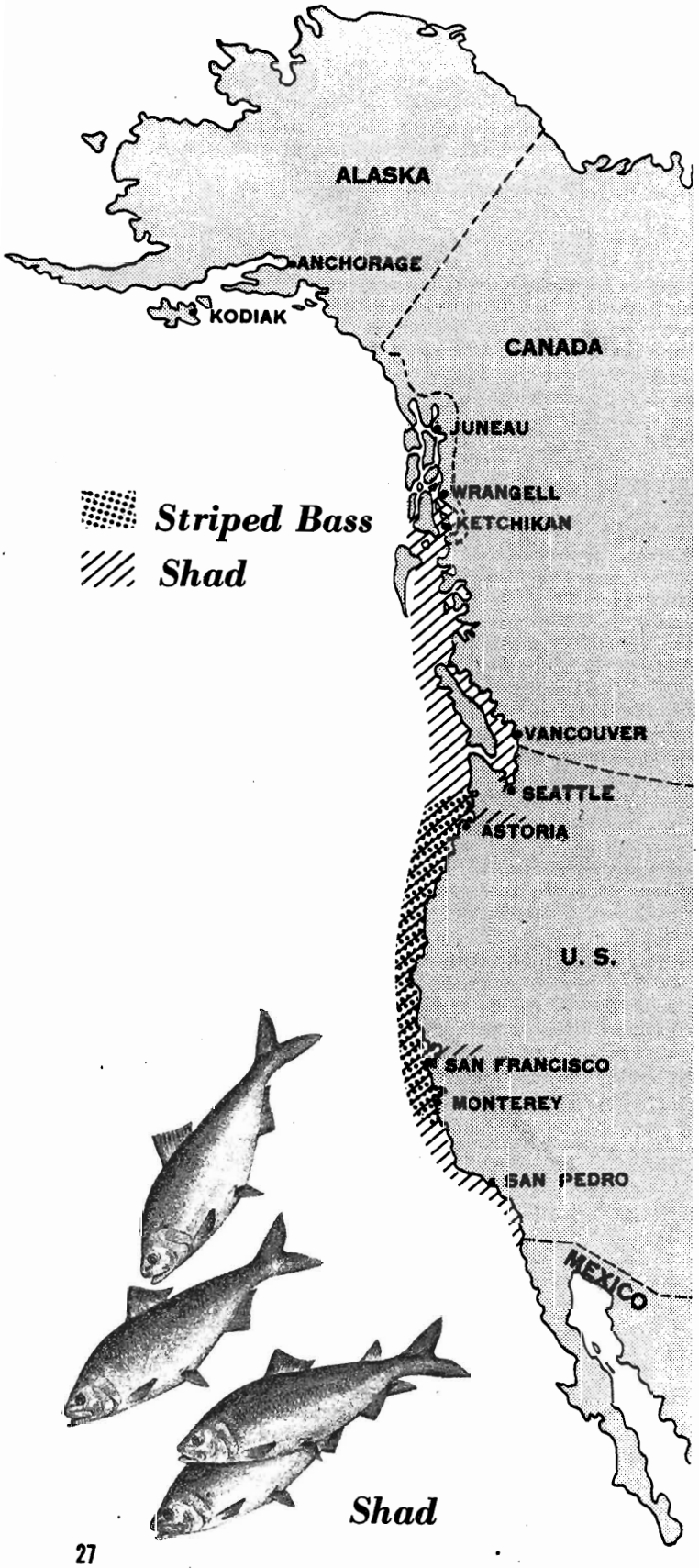
Pacific Fishery Resources STRIPED BASS



STRIPED BASS, like shad, is a native of the Atlantic coast, introduced in Pacific waters in the 1870's, and now successfully established along an extensive coast line. The San Francisco Bay region, where the striped bass was introduced in 1879, was the center of a productive commercial fishery from about 1890 to 1935; in the latter year legislation was enacted which reserved the species for game fishing.

The commercial catch prior to 1935 generally fluctuated around half a million to a million pounds annu ally. Since 1935 sportsmen have taken 6 to 10 million pounds of striped bass a year.

Pacific coast sportsmen fish for striped bass near the mouths of rivers, in slow-moving streams, and in sloughs. They use rod and reel or hand lines cast from boat or shore, or trolled. California law forbids selling, exporting, or importing striped bass. Licensed commercial fishermen who take striped bass incidental to fishing for shad or salmon are required to return all but one to the water.

In the San Francisco Bay region striped bass spawn in the spring and summer in fresh and brackish waters of the Sacramento and San Joaquin deltas. From their first to their fifth year, the fish grow to be around 4, 11, 14, 18 and 20 inches long. Most females mature when 5 years old.

Dam construction projects in the Central Valley of California may change the character of the feeding and spawning grounds of the striped bass through their effect on water flows and salinity. For the protection of the resource, these effects should be investigated, along with the preliminary engineering studies of each project.

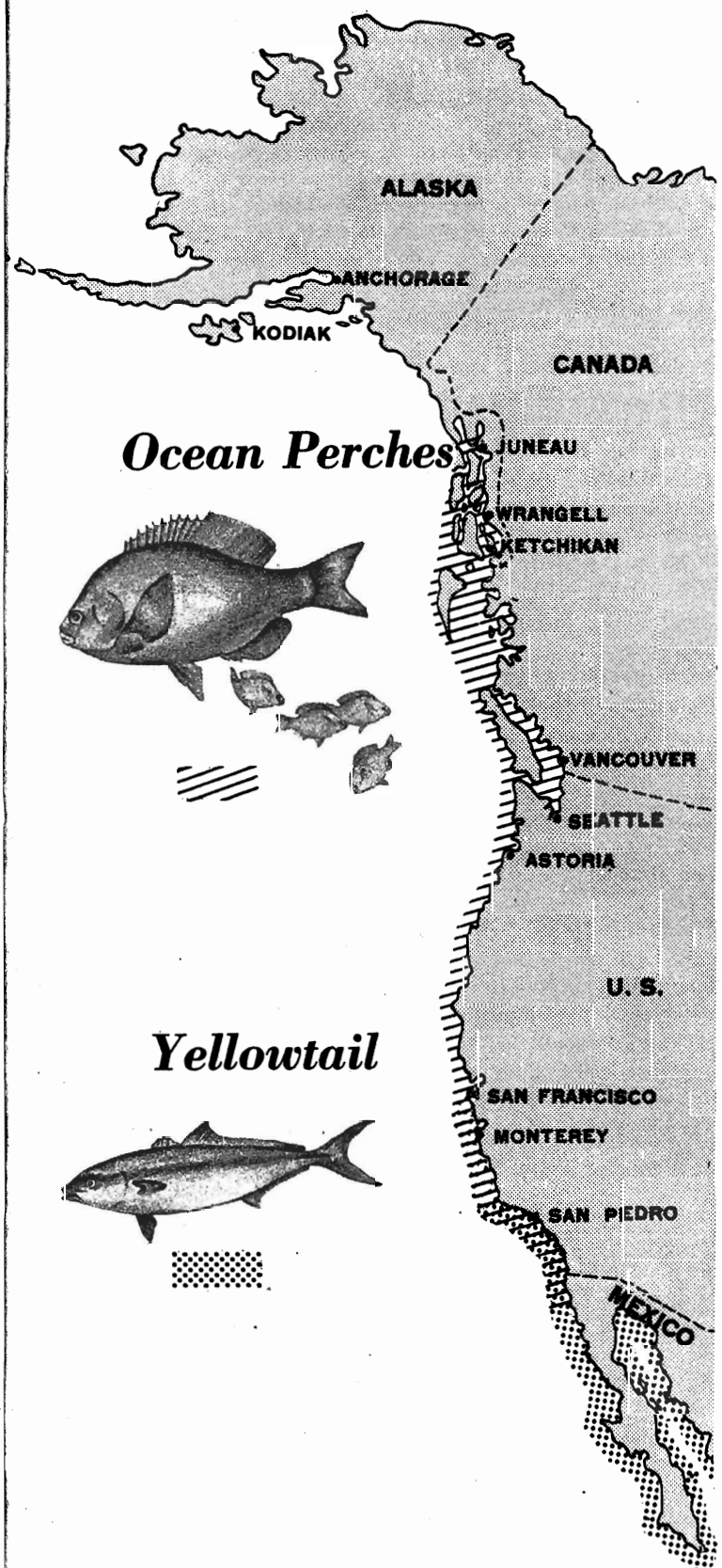
THE SHAD IS A NON-NATIVE SPECIES, brought to the Pacific coast from the Atlantic, which has thrived so well in its new surroundings that it is now established along 3,000 miles of Pacific coast line and supports a small commercial fishery.

First plantings of shad were made in the Sacramento River in 1871, first runs of mature shad entered the river in 1877, and shad appeared as a market fish in the San Francisco Bay area within a decade after the original transplantation. By 1914 the catch had risen to its peak of 7 million pounds; it has since declined to average about 2 million, more through economic causes than a scarcity of fish. San Francisco Bay, the Sacramento and San Joaquin Rivers remain the center of the Pacific shad fishery; in Washington and Oregon most shad are caught in the Columbia River. In all these areas the shad and salmon fisheries are closely related, shad being taken in the same gear, by the same fishermen, and in general during the same period of the year as salmon.

The shad is almost entirely a commercial species, of little interest to sportsmen. Even as a market fish it has not attained a standing on the Pacific coast comparable with its importance in Atlantic States. Canned shad roe, processed in Sacramento, San Joaquin, and Columbia River regions, is, however, the highest-priced canned-fish product of the Pacific coast. Incidental to the canning of shad roe, the whole fish is sometimes canned salmon style, and in recent years a lightly smoked, kippered shad has been developed.

Shad are caught in drift gill nets and haul seines as they approach or enter the coastal rivers to spawn, from March to June. During the balance of the year they live offshore. Their habits are presumably very similar to those of the Atlantic coast shad (*which, see*). No study has been made to determine the actual condition of the Pacific shad population; there are indications, however, that, unlike the Atlantic shad, it is still increasing in abundance. Reclamation projects proposed for the lower Sacramento and San Joaquin River systems might destroy quantities of shad eggs and young and so threaten a reversal of this trend.

Pacific Fishery Resources MARKET FISHES



Ocean Perches

Yellowtail

THE OCEAN PERCHES, OF WHICH THERE ARE NO FEWER THAN 18 SPECIES, BELONG TO A PECULIAR FAMILY OF FISH, WHICH IS ALMOST AS TYPICAL OF THE WEST COAST AS THE REDWOOD TREES. They are not related to fresh-water perch though one species does inhabit some California rivers. The common ones are 8 to 15 inches long.

From a quarter to a third of a million pounds of the various species are landed on the west coast by commercial fishermen and the unrecorded sport catch may be as large or larger. The commercial catch is made with beach seines, lampara nets, or gill nets, depending upon local conditions. Sportsmen catch them with hook and line from sandy beaches and rocky points all along the coast.

The peculiarity of the ocean perches is that they bear living young that are perfectly formed and sizeable, independent little fish at birth. Some are a fifth as long as their mothers. Apart from this fact, virtually nothing is known of their biology, or of their abundance as it is affected by fishing effort or seasons.

Sale is prohibited during a certain period of the year in California and there are minimum mesh-size regulations in Washington; but otherwise the catch is not regulated. Sportsmen can take them at any time and in any numbers. They are utilized commercially entirely in the fresh-fish market.

YELLOWTAIL ON THE PACIFIC COAST OF THE UNITED STATES IS PRIMARILY A GAME FISH, VALUED AMONG ANGLERS ALMOST AS HIGHLY AS TUNA. Sportsmen in southern California catch something like a million pounds in a year from pleasure fishing boats and barges; and commercial fishermen take less than a third that quantity. At the same time, a commercial fishery for yellowtail is carried on in waters south of the United States, producing a catch reaching as high, in some years, as 10 million pounds, a quantity worth, at present, over a third of a million dollars. Because yellowtail is taken by fishermen primarily interested in tuna, and therefore is either an incidental catch or a substitute for tuna, the landings fluctuate widely from year to year, depending on how successful tuna fishing is in Mexico.

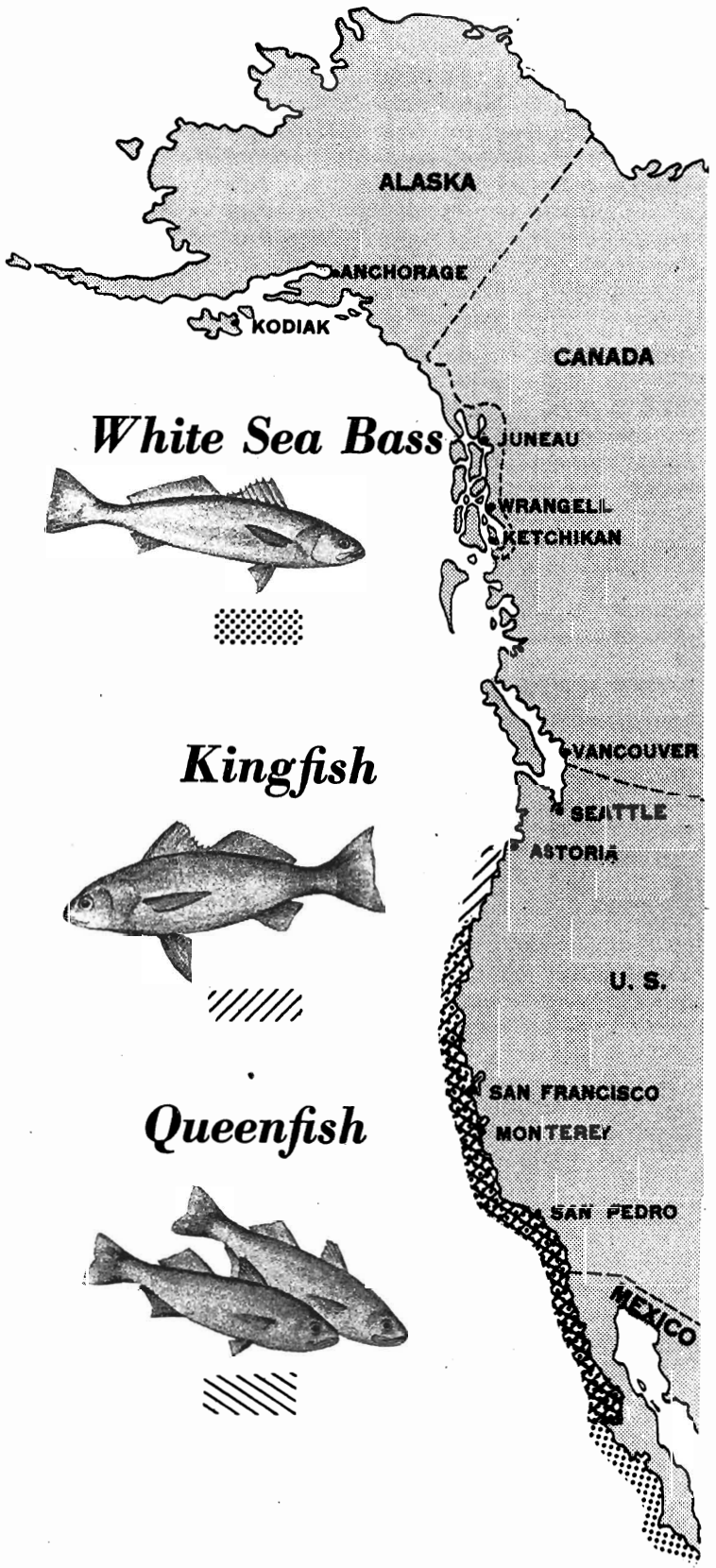
In the United States, yellowtail is caught commercially with hook and line from small live-bait boats; in Mexico, it is largely taken by purse seines, a gear prohibited to the yellowtail fishery in the United States. Anglers catch yellowtail by trolling, or by live-bait fishing with hook and line.

This fish is utilized commercially in the fresh-fish markets. It is also canned, being processed in a tuna-style pack that sells more cheaply than tuna. The average annual pack for the period 1939–43 was 66,000 cases.

The yellowtail resource is highly protected by State legislative control, which severely restricts commercial fishing as to quantity that may be landed and gear that may be used. The result of these restrictions is that the total U. S. catch of yellowtail is now only a small fraction of what it was in the mid-1920's.

There is no knowledge of the biology of this resource. Age, growth rate, size at maturity, migrations are unknown. It is not known whether the Mexican and United States yellowtail populations intermingle. The relation between the fishing intensity and the size of these populations is likewise unknown.

Pacific Fishery Resources MARKET FISHES



THE WHITE SEA-BASS IS THE PACIFIC COAST COUNTERPART OF THE ATLANTIC COAST WEAKFISH. It is closely similar to that fish in appearance and quality. It appears to be a less abundant resource than barracuda or yellowtail, and is relatively unimportant, at present, yielding an annual commercial catch of something over three-quarters of a million pounds, and sport catch of about 200 thousand pounds. In the early 1920's, this resource supported a commercial fishery of fair importance, that landed between two and three million pounds a year. Statistical analysis of the catch per unit of effort, conducted in 1930 by the California Division of Fish and Game, indicated a declining abundance, and severe legislative restrictions were imposed on the fishery. These include closed seasons, bag limits, gear prohibitions, and size limits.

The fish are taken commercially with gill nets, and with hook-and-line; taking with purse seines or other round-haul nets is prohibited by California law. The catch is utilized entirely in the fresh-fish trade.

Anglers prize the white sea-bass highly, for it furnishes good food as well as good sport. They are rather large fish, weighing up to 50 pounds, and having both "spirit" and a tender mouth from which the hook is easily torn, tax the angler's skill. Anglers take them principally with hook-and-line, using live bait.

Little is known about the biology of white sea-bass. It spawns during the summer months for the first time when 24 to 28 inches long. Although nothing is known of their migration, fishermen believe there is a coastwise movement of some sort. Age and rate of growth, and relation between fishing and abundance, are all unknown.

KINGFISH AND QUEENFISH, two species with regal names, are small croakers, usually 8 to 10 inches long. Both are sold as kingfish, which species actually makes up about 95 percent of the catch.

They are caught commercially with lampara (round-haul) nets principally along sandy shores of Southern California, and rather small amounts in Monterey Bay and northward. They take a baited hook readily.

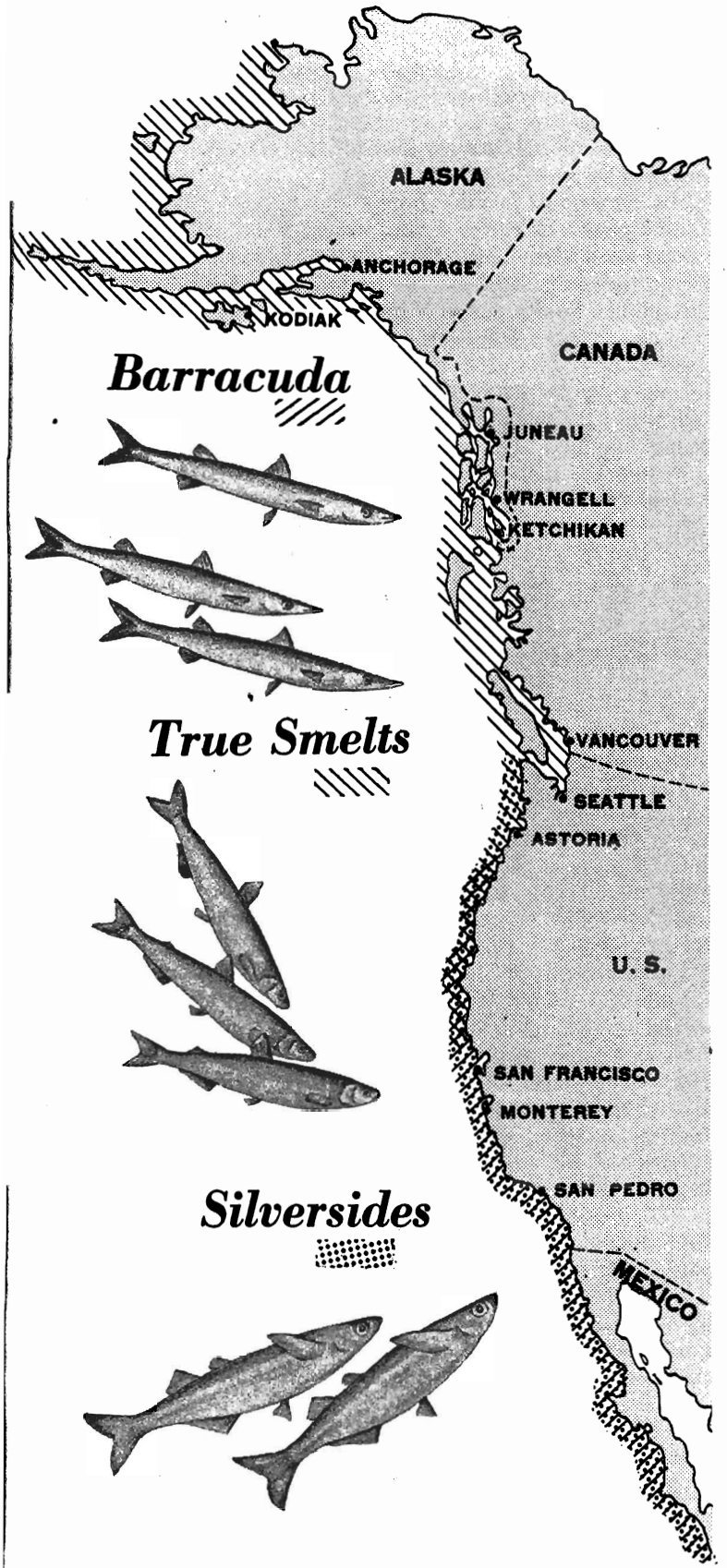
About a half million pounds are sold in the fresh-fish markets annually, and most of the catch is landed in the winter months when boats are not concentrating on more valuable summer fish such as barracuda or tunas. Though not greatly sought after for sport, great numbers are landed by pleasure fishermen. The young, especially of queenfish, seined from bays and sloughs, are sold to sportsmen for live bait.

Kingfish breed in the winter months and queenfish in the summer. Otherwise, their habits appear quite similar. They occur together in shallow water along sandy shores, where they often swim in mixed schools just off the bottom. They feed on crabs, shrimps, worms, or mollusks, and occasionally fish.

The taking of these fish is not regulated but the limited demand keeps the catch small.

Pacific Fishery Resources

MARKET FISHES



BARRACUDA ON THE PACIFIC COAST IS AN ABUNDANT, SCHOOLING, PELAGIC FISH; ONE OF THE LEADING MARKET SPECIES, AND ONE OF THE MOST FREQUENT CATCHES OF SUMMER ANGLERS. Commercial landings run close to four million pounds a year, are worth about a quarter of a million dollars. About two-thirds of this catch are taken off the coast of the United States, the remainder off the coast of Mexico. For several years anglers have caught almost as much as commercial fishermen, their annual catch being estimated at something over three million pounds.

Commercial fishermen catch barracuda off the United States by trolling, live-bait fishing, and gill netting. They catch them off Mexico mostly with purse seines, a gear prohibited to the United States barracuda fishery by California State legislation. Almost the entire commercial catch is utilized in the fresh-fish markets; some is salted, and some is used as an ingredient in a canned-fish pudding packed for the oriental trade.

Anglers catch barracuda by trolling, live-bait fishing or jigging with artificial lures, usually from pleasure-fishing boats and barges.

Barracuda occur in Mexican waters throughout the year; they appear off the coast of the United States during the early spring, and depart during the autumn, usually in October. They occur characteristically in large schools, generally within 8 to 10 miles off shore. They spawn during the summer; the young fish grow rapidly, attaining a length of around 14 inches at the end of their first year. From the end of their second to sixth years, they average about 20, 25, 28, 30, and 32 inches respectively. They spawn for the first time during their second year, and have a maximum life span of something over 10 years. There is no knowledge, at present, of the relation between fishing and the abundance of this resource.

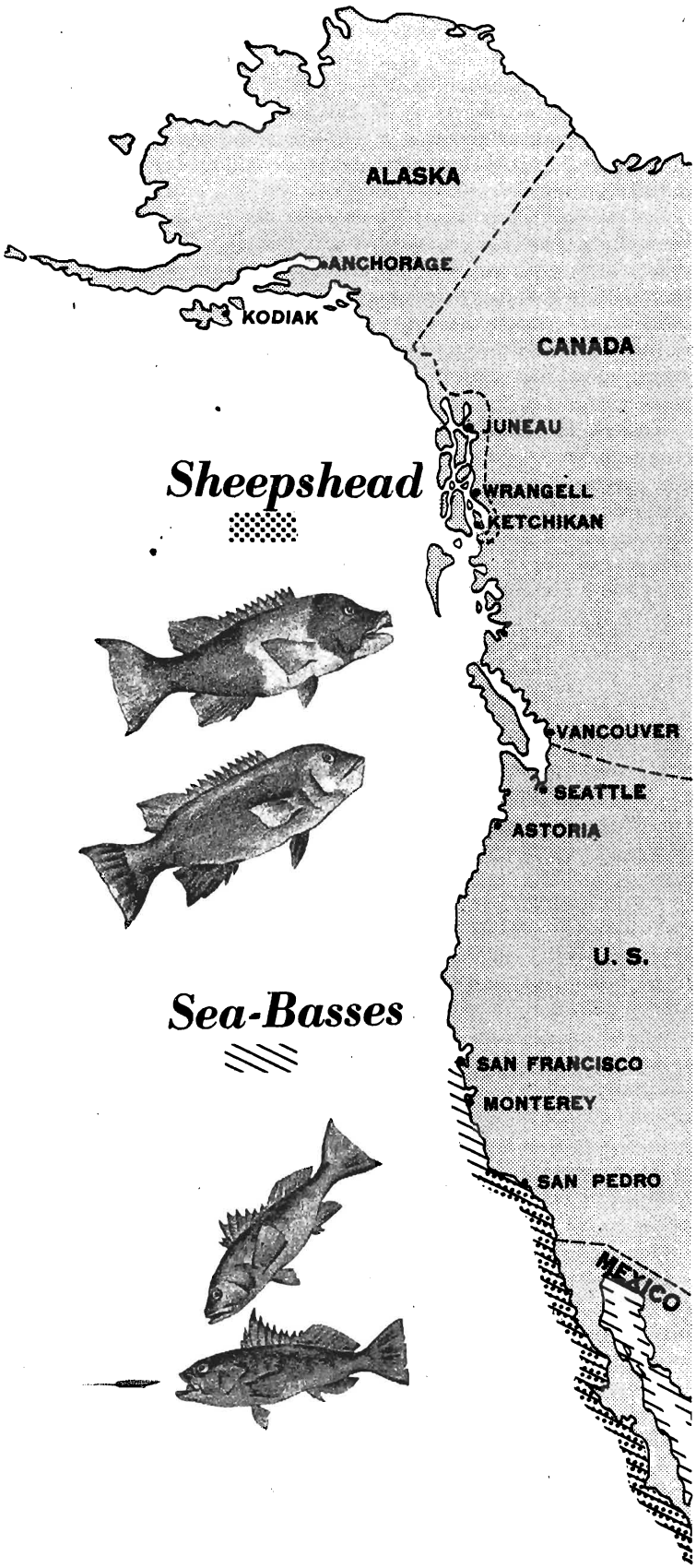
Size limit, imposed on the commercial fishery only, and gear restriction, are at present the chief means of protecting this species.

SMELTS AND SILVERSIDES SUPPORT IMPORTANT COMMERCIAL FISHERIES on the Pacific Coast, producing 3 or 4 million pounds annually. These fishes are of two distinct and unrelated types: The true smelts, which are anadromous (i. e., they ascend rivers and streams to spawn); and the silversides, which are ocean-dwelling entirely.

Eulachon, or Columbia River smelt, which supplies two-thirds or more of the total smelt catch, are caught with gill nets, dip nets, or are scooped up with any makeshift gear as the dense schools ascend streams to spawn. Most of the other smelts, and some of the silversides are taken with dip nets or seines in the surf, the time of day and the tide determining the species caught. In central California, schools of silversides, mostly jacksmelt, are caught with circle gill nets, principally in bays. In southern California most of the catch is made with round-haul nets and seines. Sportsmen catch jacksmelt with hook and line and other smelts with dip nets. Grunion attract many people to the beaches where they may be picked up by hand when they spawn on the wet sand at high spring tides. The commercial catch of grunion is small.

Eulachon are protected by various regulations as to fishing days, gear, and closed areas. Grunion are protected by a closed season and gear restrictions, and jacksmelt and bay smelt by size limits.

Pacific Fishery Resources MARKET FISHES



PACIFIC SHEEPSHEAD ARE CAUGHT COMMERCIALLY WITH HAND OR SET LINES FISHED ON THE BOTTOM NEAR ROCKS OR KELP BEDS. Most of the catch is made by a few boats that specialize in this fishery, but some is landed incidentally with rockfish and other market fishes. Partly because of their good flavor, they are popular with anglers, 43,000 pounds being taken from party boats and barges in an average year.

The commercial landings have varied between 60,000 and 370,000 pounds since the fishery started to expand in 1925, but the fluctuations seem to be caused by the number of boats fishing for them rather than the abundance of fish.

Nothing is known of their biology except that they eat shellfish, among other things, and frequently rob spiny-lobster traps. For this crime a sheepshead usually pays in full by becoming lobster bait. Male sheepshead are vivid crimson and black; the female is dull red. They attain a weight of about 15 pounds.

Neither the sport nor the commercial catch is at present limited by law.

SEA-BASSES, OF WHICH THERE ARE SEVERAL KINDS ON THE PACIFIC COAST, FIGURE PROMINENTLY IN THE CATCH OF MISCELLANEOUS FISH MADE BY SMALL BOATS WORKING FOR THE FRESH-FISH MARKETS. One of the most important of these fish is the black sea-bass, a large species, seldom caught when under 50 pounds in weight, and reaching up to 600 pounds. Something over half a million pounds of this species are landed annually, the greater part of the catch being made off Lower California, Mexico, with set or hand lines. A small catch is made off southern California. As a game fish, it is noted more for its size than its fighting qualities. Commercially, this fish is sold entirely in the fresh-fish markets, filleted.

Taken along with black sea-bass in Lower California, are cabrilla and grouper, two closely related fish, which do not extend as far north as California. They are becoming important market fish under the name of "golden bass." Slightly less than one-half a million pounds of these are landed in the United States annually. They are filleted and sold in the fresh-fish markets.

Rock bass are small fish, seldom larger than 18 inches in length, which are common along the coast of southern California. These are more important as game fish than as market fish. The total angler's catch is close to a million pounds a year, while the commercial catch is only a quarter of this. Anglers catch rock bass with hook and line, usually using live bait. Commercial fishermen use a variety of gear, of which hand and set lines, traps, and gill nets are most effective, and they take rock bass only incidentally while fishing for other species.

Nothing is known of the biology of sea-bass; nothing of their abundance, and nothing of the relation between fishing intensity and their abundance.

Pacific Fishery Resources CLAMS

CLAMS.—More than 35 species of edible clams live on the Pacific coast, but only 5 are commercially valuable, and of these, one, the razor clam, accounts for 65 percent of the total annual catch. The razor clam, whose thin shell is sharp enough to cut the fingers of diggers, occurs from Lower California to western Alaska, and is most abundant in Washington and in central Alaska wherever flat, sandy beaches with surf are located. Thanks to its powerful foot, which it uses for digging, it is fast moving for a clam. Razor clams are dug at low tide with a long narrow-bladed shovel. Most of the catch is canned. A small part is marketed fresh as shucked, cleaned meats. The meats have also been quick frozen and packaged on a small scale, a process which is expected to increase in volume in the post-war period. Considerable quantities of razor clams are now used for bait by the crab fishermen. With the recent expansion of the crab fishery, this adds considerably to the strain on this resource.

Next in importance to the razor clam are HARD-SHELLED CLAMS, of which the most important are the BUTTER CLAM and the LITTLE NECK CLAM. These live on rocky, muddy beaches from California to Alaska. Because they stand shipment well, most of them can be sold fresh, either in the shells or shucked. By far the greatest production of hard-shelled clams is in Washington. They are dug with a fork at low tide, and occasionally in water several inches to a foot deep. Production in Alaska has been increasing recently and could continue to do so if the cost of marketing clams could be reduced.

The species next in importance is the PISMO CLAM, which occurs in California and Oregon. It is the most important of the clams taken in California, is now taken in moderate quantities, was once exceptionally abundant. This is a large heavy-shelled clam found on sandy ocean beaches. It is dug in the same way as are hard-shelled clams. The entire catch is sold in the fresh-fish markets.

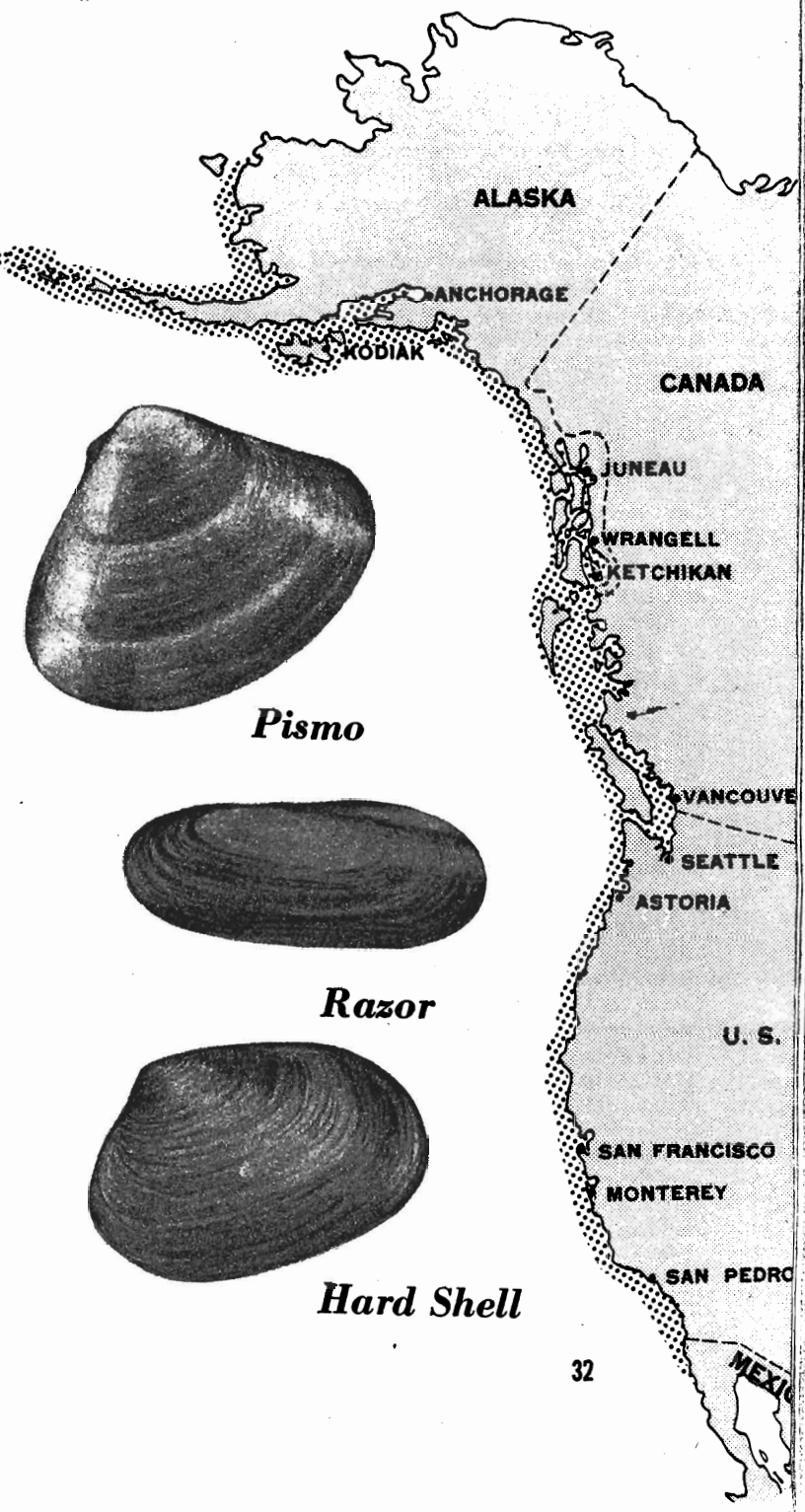
Recently a Mexican fishery for Pismo clams has developed in Lower California. There the meats are shucked into 5-gallon cans and exported under refrigeration to Los Angeles, where they are canned as minced clams. Production amounted to 10,000 cases in 1943.

A small quantity of soft-shelled clams is taken in Oregon, Washington, and California. This clam, accidentally introduced to the Pacific coast with shipments of eastern oyster spat about 1880, is now distributed from San Francisco to British Columbia. It is found only in sheltered bays where the soil is firm or tenacious. It lends itself admirably to farming and is highly valued as a table mollusk.

Total Pacific coast clam production in 1940 was about 3 million pounds of shucked meats, worth between two and three hundred thousand dollars.

WHAT IS DONE TO SUSTAIN THE YIELD: To aid in sustaining the yield of clams in the States and the Territory, a number of scientific studies have been made on the biology of the various species and on the causes of their fluctuations in abundance. These investigations have led to a clearer understanding of the problems involved in maintaining the populations and have been the basis of numerous regulations governing the fishery. In Alaska razor clams are protected by minimum-size limits and in some areas by quotas setting the number of pounds that can be removed from a given region during a year. These measures are very effective in protecting the beds, *and in assuring a steady yield to the industry*. For hard-shelled clams, regulations on size limit and gear restrictions are in force. Similar regulations apply in Washington, Oregon, and California, with such local variations as local conditions require. In some areas commercial clamming is prohibited to sustain the supply for amateurs who dig for their personal food. Amateurs also are subject to certain restrictions.

Unfortunately, State regulations on clamming are often not firmly enforced. Amateur diggers frequently ignore restrictions and occasionally even peddle portions of their catches. In some places the razor-clam supply has become seriously curtailed and exploitation is in need of a careful and enforced management. The desirability of using this clam as bait should be carefully considered and a substitute bait for crabs sought.



Pacific Fishery Resources CRABS

CRABS OF SEVERAL KINDS INHABIT THE PACIFIC COAST WATERS OF CONTINENTAL UNITED STATES, but only one, the Dungeness, is utilized commercially to any considerable extent. The king crab and Tanner crab in the Gulf of Alaska and Bering Sea, and the various rock crabs of more southerly waters remain a practically untouched resource of unknown value and extent.

In spite of this vast unutilized supply, the United States imported before the war, mostly from Japan, about 10 million pounds of canned crab a year. This constituted 95 percent of the canned crab consumed in this country. In the 10 years prior to World War II the Japanese sold to the United States over 27 million dollars worth of canned crab. Toward the last, practically all of this imported pack consisted of king crab, a large part of which was taken in waters adjacent to the west coast of Alaska, and packed in floating canneries.

Although American fishermen and canners made several pioneer ventures into canning king crab, the prospective and exploratory nature of the operations tended to discourage private enterprise.

As Japanese fishermen encroached more and more into this resource, Americans became increasingly aware that they were failing to utilize their own wealth. Consequently, the Federal Government in 1940 authorized the United States Fish and Wildlife Service to investigate the extent of the Alaska crab population.

This study demonstrated the large size of the king crab resource, located numerous grounds which would support commercial fishing during certain seasons of the year, showed the uses of different types of gear in the fishery, and developed satisfactory methods of canning king crab. Further development of this fishery is of great importance to the crab-canning industry of the North Pacific.

THE FISHERY FOR DUNGENESS OR MARKET CRABS STARTED AROUND SAN FRANCISCO BAY, where, as early as 1890, 1 to 2 million crabs were taken each year. At first the crabs were caught from sheltered bays and inlets; but later, as the fishery expanded, from the more exposed coastal areas. In recent years the catches in Oregon and Washington have equalled or exceeded the annual production in California and an appreciable catch is made in both southeastern and central Alaska. The 1941 total Pacific coast production was near to 16 million pounds of Dungeness crab, yielding about 4 million pounds of meat.

In the States, most of the crab catch is marketed fresh or frozen. In Alaska virtually the entire catch is canned. The production of canned Dungeness crab can increase in the future as the market is developed and methods of catching and processing are improved.

A FEMALE DUNGENESS CRAB, DURING HER LIFETIME, MAY PRODUCE BETWEEN 3 AND 5 MILLION EGGS. The fertilized eggs are carried under the abdominal flap for several months. Upon hatching, the minute young are more or less free swimming, and unlike the parents in form. Finally, after successive moultings, they assume the adult form and a life on the sea bottom. Completion of these changes requires nearly a year, at the end of which time the young crab measures 1 inch across the "shell." The growth rate declines as the crab matures, and moulting, the characteristic growth process of crustacea, becomes an annual event that occurs during the summer or fall months.

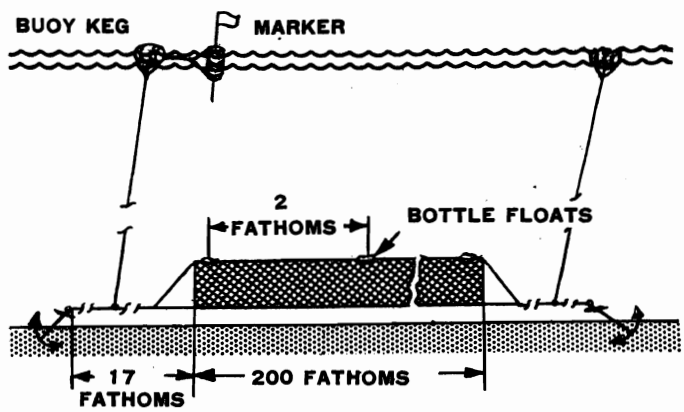
Female Dungeness crabs mature in about 4 years. They then measure 4 inches across the "shell." Males may require an additional moult, or 5 years, to reach maturity. In the vicinity of Puget Sound the average life span is approximately 8 years.

LITTLE IS KNOWN ABOUT KING CRABS. In general they have a life history similar to that of the Dungeness, but frequent deeper water, being usually found in 10 to 40 fathoms in the spring and in 30 to 70 fathoms in the fall. The adults moult from February to May, the males usually earlier in the season than the females. Tagged king crabs have been recovered as much as 300 miles away from the point of tagging.

FISHING HAS DEMONSTRATED THAT CRABS ARE ABUNDANT not only in the eastern Bering Sea, but also the south side of the Alaska Peninsula, around Kodiak Island, and in Prince William Sound. All that is needed to develop this potentially valuable resource is to perfect methods of fishing and processing so that the canned product can be sold to the consumer at a reasonable price. Progress has been made in this respect, and since the beginning of the war several companies have put up experimental packs in central Alaska. As crab meat must be processed quickly in order to avoid discoloration and spoilage, the floating cannery is essential to the effective exploitation of the extensive crab resources in Alaska. These self-contained units operate directly on the fishing grounds and are supplied by a number of fishing boats. In addition to providing a means of processing the crabs, they provide storage space and transportation to the home port for the completed pack.

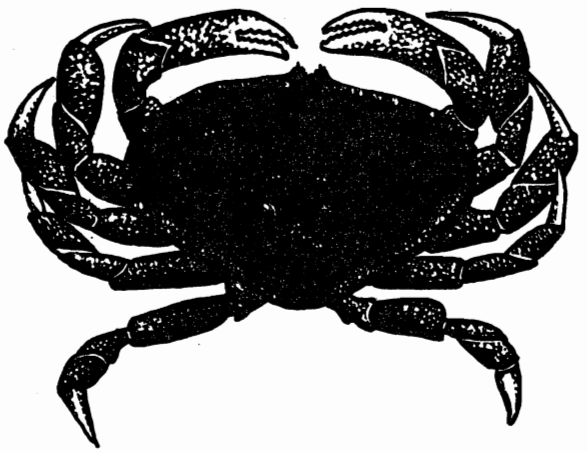
Large-scale development of the king crab fishery in Alaska should be accompanied by the research needed for rational management of the fishery to insure getting up to, but not beyond, the most that the resource has to yield. This means learning growth rate and age of maturity for establishing minimum size limits. It means determining whether the population of crabs is intermigrating or is composed of local, independent units; i. e., whether regulations are to be coastwise or local in scope. It means determining seasons when crabs need special protection or when they are commercially undesirable. It also means determining quantitatively the relation between fishing rates and productivity of the resource.

A TANGLE NET FOR KING CRAB

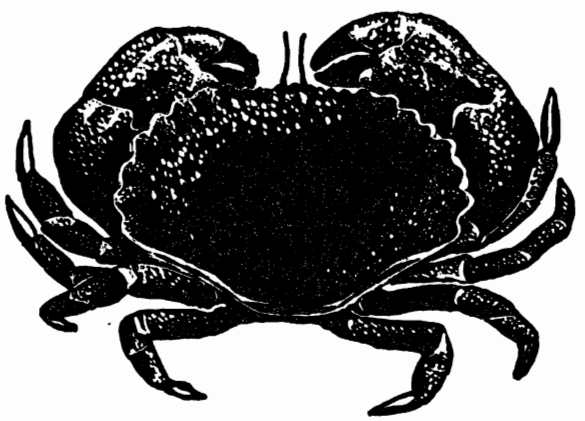


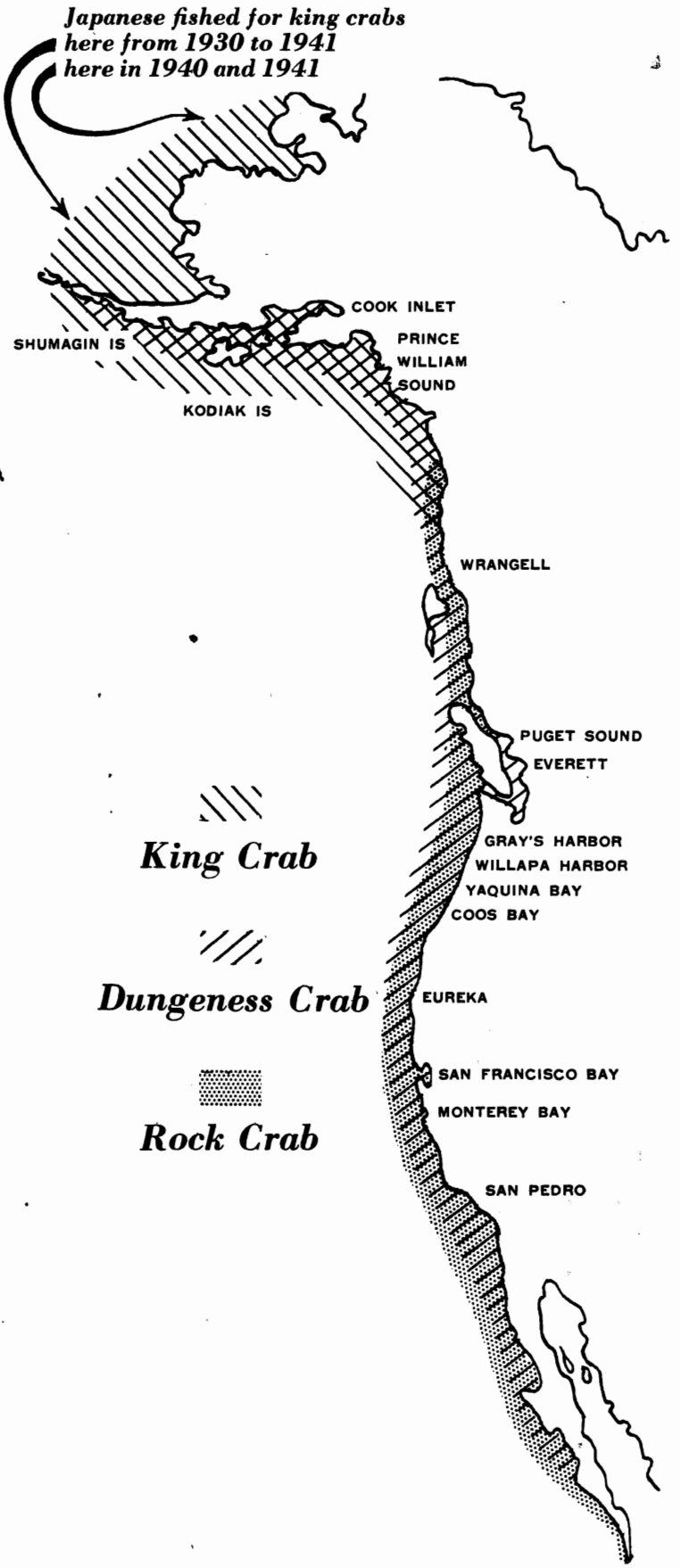
King Crab

Dungeness Crab

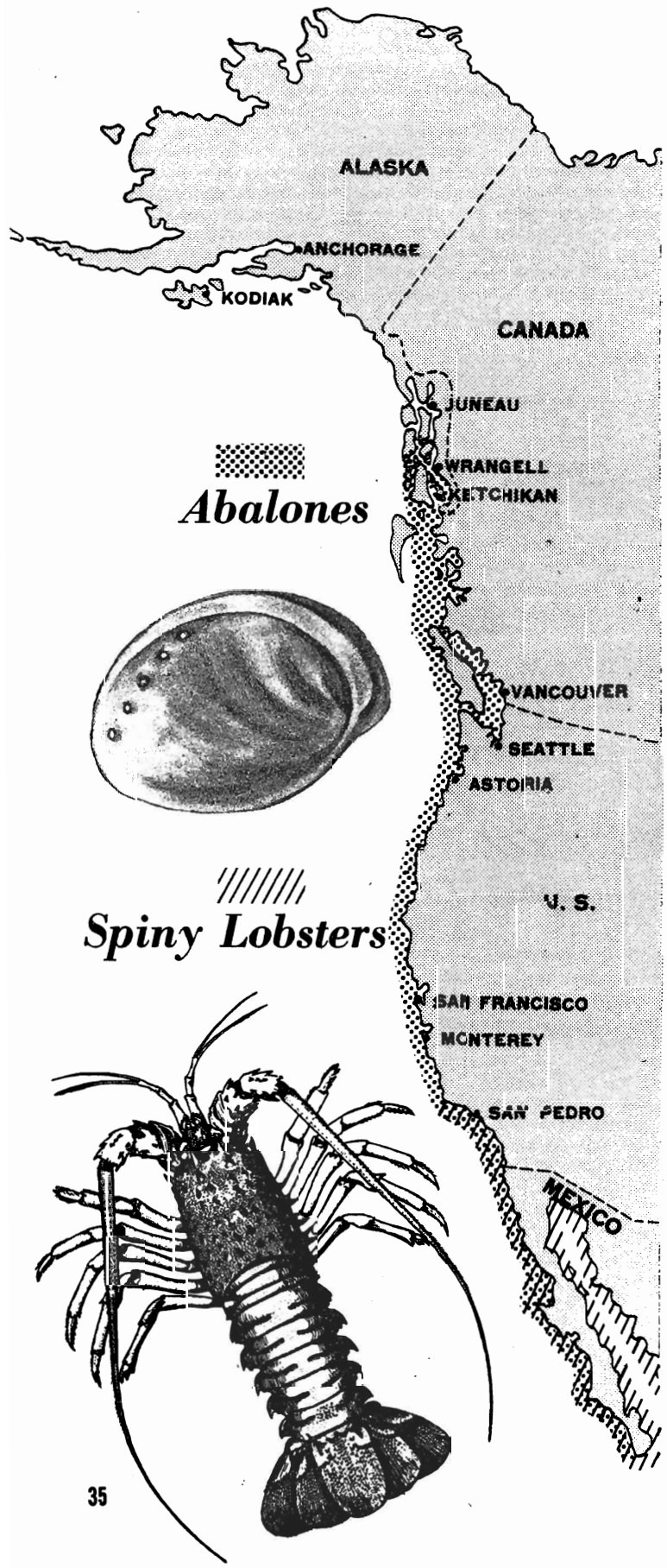


Rock Crab





Pacific Fishery Resources SHELLFISH



PACIFIC SPINY LOBSTERS ARE FOUND FROM SOUTHERN CALIFORNIA TO CHILE. United States fishermen catch around a million pounds a year, of which about four-fifths are taken off the Mexican coast. In addition, almost the same quantity, caught by Mexican fishermen, is imported into this country annually. The entire catch is marketed as fresh or frozen meats.

Spiny lobsters are caught in crate-like traps or pots which usually have two funnel-shaped openings at the top. These are baited with various kinds of fish, weighted, and sunk on rocky inshore bottoms, and their position marked by means of attached floating buoys. After a suitable interval, the trap is lifted, the lobsters sorted according to legal size, and placed in receivers similar to crab live-boxes.

Little is known about this resource. Lobsters live among rocks and beneath kelp. They are believed to feed at night. The females produce their eggs in May and June, carry them, during incubation, attached to the inner branches of their swimmerets. During this period of 9 or 10 weeks the females hide in rocky places near shore. The eggs hatch into free-swimming larvae which are quite unlike the adult lobster in shape. The larvae have been found as far as 150 miles off-shore. After successive moults, they eventually attain the form characteristic of their species, and descend to bottom. They grow throughout life by periodic moults. In this process, the body shrinks away from the "shell"; the "shell" splits and the body emerges. It then remains soft for a time while it swells up and forms a new "shell." Lobsters have various enemies, among them sheepshead, black sea-bass, and octopus.

State laws impose closed seasons and size limits, and limit the manner of utilization.

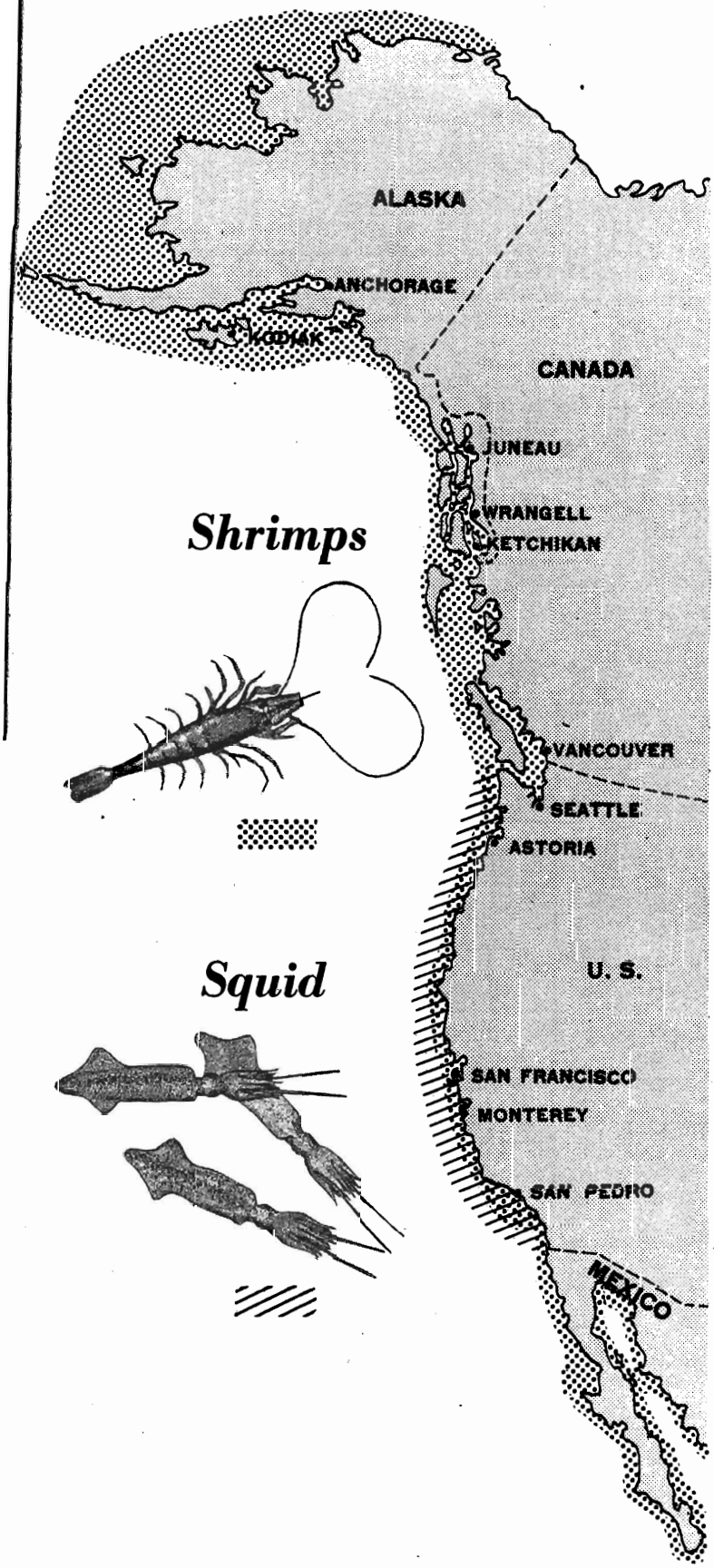
THE ABALONE IS A SINGLE-SHELLED MOLLUSK which inhabits rocks, adhering with a large, powerful muscle or foot. It is found from the inter-tidal zone seaward as far as abalone divers have explored. Six species are known from Lower California, Mexico, to Alaska. The United States commercial catch is concentrated in California, where in 1940, 345 thousand pounds of meats were taken, valued at close to $93,000.

The total catch is marketed as fresh meats, the large muscle being cut into transverse slices, pounded, and sold as steaks. Abalone shell, being coated inside with mother-of-pearl, has long been valuable for ornamental purposes. The Indians of the Pacific northwest and Alaska used the shells for personal adornment, for inlay work in their household furniture, and for money. Today the shells are made into a wide variety of articles, such as tourist trade novelties, buttons, knife handles, and jewelry.

Abalones were the object of important commercial fisheries in California as early as 1880, when the value of the catch was tenfold what it is now. The meat was dried and smoked, exported to Hawaii and China. In later years it was canned. Unhappily, the resource did not prove to be self-sustaining enough to endure such a drain as was put to it, and it became necessary to restrict the fishery. In California, size limits are now set which probably permit several spawning seasons before abalone can be taken. Closed seasons are established, and commercial fishing is regulated according to local conditions. The method of utilizing the meat is highly restricted and abalones may not be transported out of the State. Amateur abalone fishermen are subject to bag limits, but are numerous enough to keep accessible rocks well cleaned.

Too little is known about the biology of abalones for establishing a program of restoring depleted colonies. Since the adults, and perhaps also the young, move little, restoration would probably be a slow and highly localized problem.

Pacific Fishery Resources SHELLFISH



SHRIMPS occur along the Pacific coast from central America northward into the Bering and Arctic Seas, but commercial fisheries for them are carried on only in four widely separated areas. United States fisheries are located in San Francisco Bay (production in 1940, 1.08 million pounds), Puget Sound (1940 production 0.55 million pounds), and in the Petersburg and Wrangell areas of southeastern Alaska (1940 production 3.50 million pounds.) A Mexican fishery, of rather recent development, is located in the Gulf of California, produced around 6 million pounds in 1943. A large part of this quantity was exported to the United States.

It is believed that exploratory fishing in Alaska would result in the discovery of important new shrimping grounds there in addition to the rather small areas now exploited. Such explorations should be accompanied by technical studies to reduce operational costs and to develop new products.

PACIFIC SHRIMP ARE TAKEN WITH TRAWLS. The otter trawl is coming into use in these fisheries, but the beam trawl has been the most important gear. This is a bag-shaped net held open at the mouth by a beam 16 to 60 feet long, with shoes or runners fastened to each end. In San Francisco Bay most shrimp fishing is done with a bag net generally called the Chinese shrimp net.

The Alaska shrimp catch is marketed almost entirely as fresh-cooked meat. A small amount is canned, and other small quantities are sold as frozen-cooked meat and whole-cooked shrimp in the shell. Drying was attempted in Alaska, but owing to unsuitable climate, was unsuccessful. The Puget Sound catch is sold entirely as whole-cooked shrimp in the shell. The bulk of the California shrimp catch is sold as cooked meat or whole-cooked shrimp; and, under restricted conditions, some quantities are sun-dried.

Shrimps of the United States Pacific commercial catch are small, generally not much over 2 inches long. Many species have been identified, but only five are significant commercially.

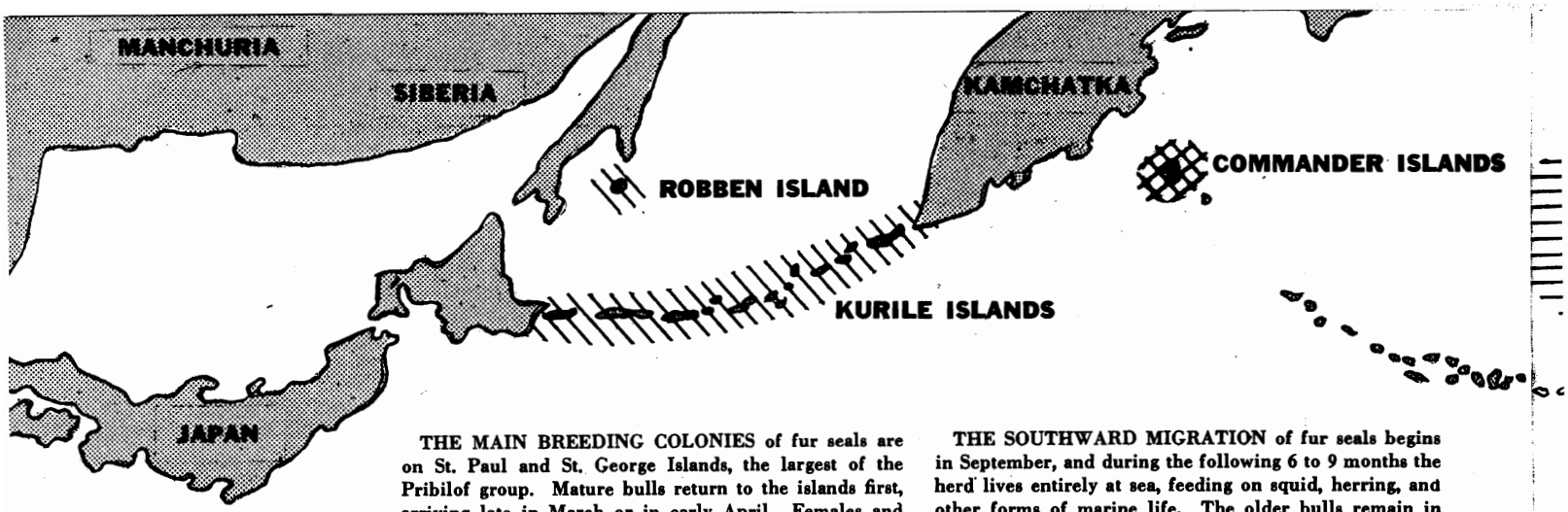
SQUID is a pelagic, densely schooling edible mollusk, of much potential value, but so far little utilized in this country. Various species occur along the entire Pacific coast of the Americas. Although small quantities are delivered and sold fresh in most of the important fishery centers of California, Oregon, and Washington, the only squid fishery of any importance is at Monterey, Calif., where 90 percent of the catch is landed.

Formerly, most of the catch was dried for the Oriental trade. This market has not been available for several years, and now only a small part of the catch is dried, small but increasing amounts are canned, and much of the catch is frozen and sold locally or shipped to markets in the eastern part of the United States or to South America. The squid is an appetizing food, but owing to its curious appearance it has not been widely appreciated. Among people of Oriental or Mediterranean origin, it has been recognized for the delicacy that it is. It is now slowly gaining in general favor, and is served ever more frequently in good sea-food restaurants of the Pacific coast.

Squid are caught with round-haul nets or small purse seines at night when the dense schools can be spotted by the luminescence which they stir up. A light may be used to attract them and make the school more compact. Some of the smaller purse seine vessels turn to squid fishing after the sardine season is closed.

Practically nothing is known about their abundance, migrations, habits, or growth. The catch fluctuates widely between half a million and 2 million pounds a year, reflecting, in part, varying economic conditions, and in part, varying availability.

There are no restrictions on the sale or catching of these mollusks. They are utilized in a very small segment of their range, so the resource is almost untouched.



THE MAIN BREEDING COLONIES of fur seals are on St. Paul and St. George Islands, the largest of the Pribilof group. Mature bulls return to the islands first, arriving late in March or in early April. Females and young bulls come later, the main body in May and June. Usually within a few days after her arrival, each female gives birth to a pup weighing about 12 pounds, and mating soon follows. The period of gestation is slightly less than a year. Fur seals on the breeding grounds are associated in family groups known as harems, consisting of one bull and about 40 cows. Because these animals are polygamous it is possible to kill the surplus "bachelors" or immature males without affecting the number of young that are born.

THE SOUTHWARD MIGRATION of fur seals begins in September, and during the following 6 to 9 months the herd lives entirely at sea, feeding on squid, herring, and other forms of marine life. The older bulls remain in the vicinity of the Aleutian Islands or in the Gulf of Alaska, while the younger males and the females go farther south, some as far as southern California.

The Russian fur-seal herd comes ashore on the Commander Islands. It is believed to number less than 100,000 animals. The migration routes of the western Pacific and Pribilof seals are believed to be entirely distinct.

Japanese-owned fur seals come ashore on the Kuriles and on Robben Island in the Okhotsk Sea. The size of the colonies is severely limited by the small area of the breeding grounds, which are mostly narrow, rugged reefs.

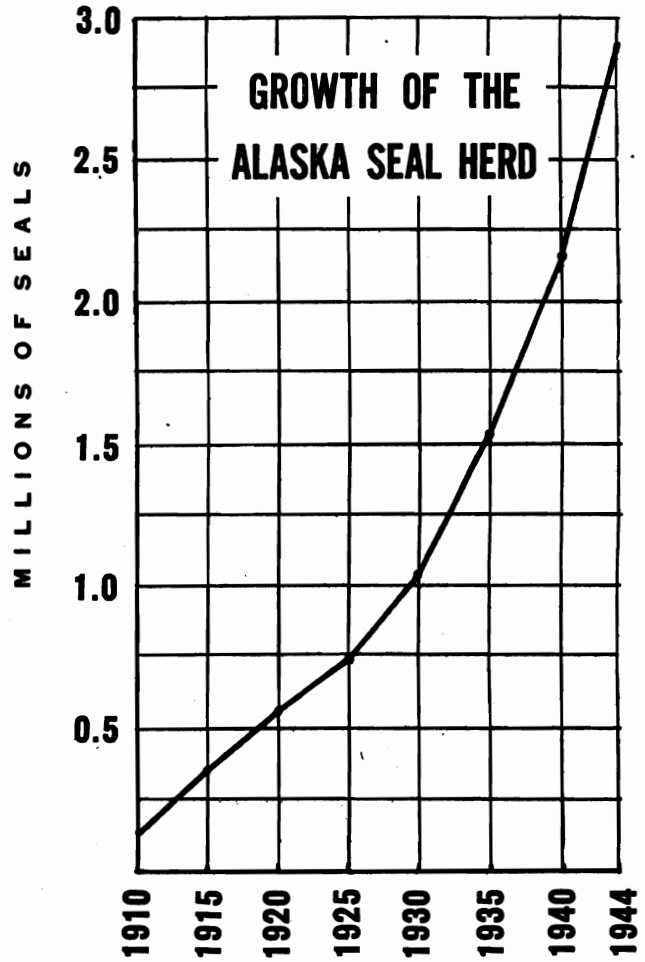
The FUR SEAL *Resource*

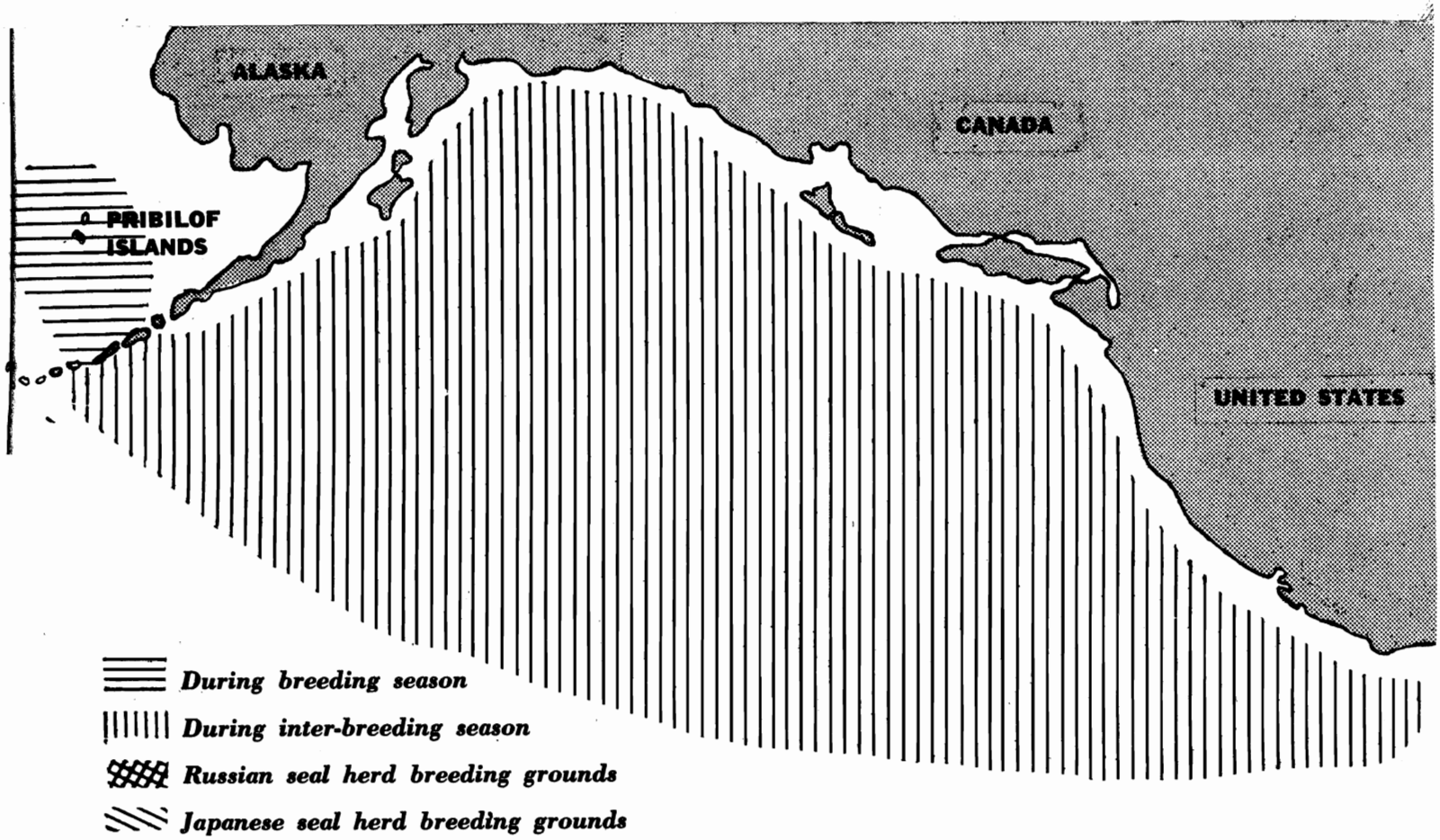
THE NORTH AMERICAN FUR SEAL HERD, COMPRISING 80 PERCENT OF ALL THE FUR SEALS IN THE WORLD, IS NATIONAL PROPERTY, exploited under the direction of and for the profit of the Federal Government. Since 1910 seal skins and, more recently, seal meal and oil, have brought into the Federal treasury over 8 million dollars.

THIS IS AN EXAMPLE OF A RESOURCE THAT WAS DEPLETED BY IMPRUDENT FISHING, AND RESTORED THROUGH GOOD MANAGEMENT. When the United States purchased Alaska in 1867 the number of seals in the herd was close to 3 million animals. During the next 43 years an intensive fishery at sea by American, British, and Japanese nationals, plus sealing on the breeding grounds by Americans, reduced the herd almost to extinction. The annual catch consequently declined from 165,000 in 1868 to 17,000 about 1900. This was chiefly the consequence of pelagic sealing, or killing the seals in the water, which often resulted in the death not only of mother seals but also of their pups through starvation.

IN ORDER TO REBUILD THIS RESOURCE, the United States Government took it over in 1910. The next year pelagic sealing was outlawed by an agreement known as the North Pacific Sealing Convention, reached by the United States, Great Britain, Russia, and Japan. To compensate for their refraining from pelagic sealing, the treaty allotted to both Great Britain and Japan 15 percent of the fur-seal skins taken annually on the Pribilofs. Russia was a signatory of the treaty only in the interest of the seal herds on her side of the Pacific.

FUR-SEALING OPERATIONS ARE CONDUCTED CHIEFLY IN JUNE AND JULY, at which time the family groups occupy the rookeries and the immature males are more or less completely segregated in adjacent areas called hauling grounds. From these hauling grounds the male seals selected for killing, chiefly 3-year-olds, are driven inland a short distance. Killing of the seals is under immediate direc-





tion of Fish and Wildlife Service agents and is done by Aleuts who live on St. Paul and St. George Islands. After the killing the skins are removed, then cured, dressed, dyed, and finished by a private company under contract with the Government. After processing, the skins are sold at a public auction held twice a year in St. Louis, and the net proceeds are turned over to the Treasury.

Processing of the byproducts, meal and oil, takes place on the Pribilof Islands. The meal is used as a constituent of poultry feed, and the oil has many industrial uses.

Since the United States Government assumed control, the fur-seal herd has grown from 130 thousand animals to nearly 3 million.

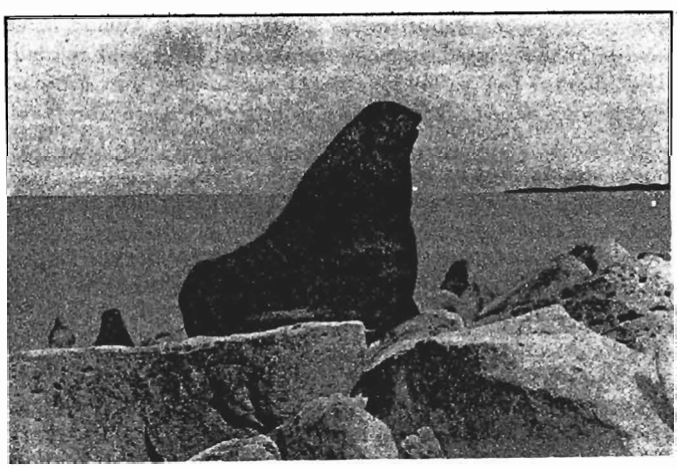
MANAGEMENT UP TO THIS POINT HAS BEEN PLANNED WITH A VIEW TO RESTORING A NEARLY EXTINCT HERD; the present need is for scientific study and planning to insure maximum utilization of a herd which may be approaching the optimum size under changed conditions.

Plans for an extensive investigation of the migratory and feeding habits of fur seals, and their relationship to the fisheries and other economic interests, were interrupted at the outbreak of war, when the vessel purchased for the purpose was requisitioned for military use, and the scientists assigned to the work were detailed to other activities.

It is of vital importance to the United States from the standpoint of international relations, revenue from products of the herd, and perpetuation of a valuable natural resource that the investigations interrupted by war be undertaken at the earliest practicable time after the end of hostilities and preparatory to entering negotiations for a new fur-seal treaty.

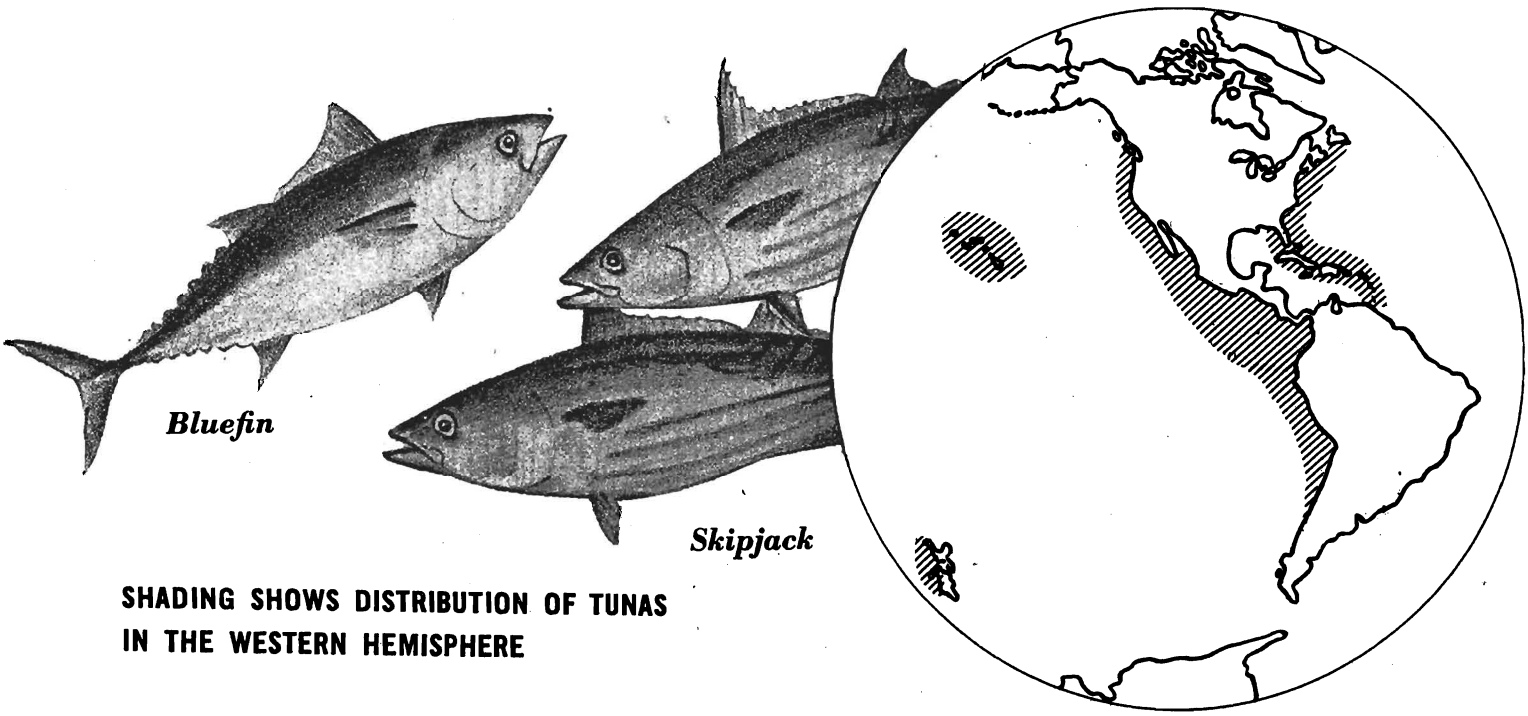
The fur-seal treaty of 1911 was abrogated by Japan on October 23, 1941, the Japanese claiming that the seals were damaging their fishing industry. A provisional agreement signed by Canada and the United States in December 1942 affords protection of the fur-seal resource until a new treaty can be negotiated.

Fur seals on the beach, St. Paul, Alaska



A breeding bull Pribilof Islands

World Fishery Resources TUNAS



SHADING SHOWS DISTRIBUTION OF TUNAS IN THE WESTERN HEMISPHERE

THE TUNAS ARE A WORLD RESOURCE, ranging over vast distances and migrating across oceans; and they are the object of important fisheries in many countries whose shores they visit. United States citizens have a large stake in this marine wealth, for tunas support a canning industry in this country second in value only to that of salmon, and they are of great recreational value to thousands of anglers.

On the Pacific coast of the United States tuna fishermen have landed about 158 million pounds of fish a year, on the average, during the past 5 years. Virtually the entire quantity was utilized by the canning industry to produce 64 million pounds of canned fish. In addition, the "waste" was made into about 20 million pounds of meal and 1.5 million pounds of fish oil. The livers are used for the manufacture of high-potency vitamin oils. Besides their use in industry, the tunas are a favorite quarry of western sportsmen. Four kinds of Pacific fishes landed in the United States are permitted to be sold as tuna: The bluefin, the yellowfin, the albacore, and the skipjack. The bonito, which, like tuna, is a member of the mackerel family, and the yellowtail, *which, see,* are put up in a tuna-style pack, but may not be labeled "tuna."

On the Atlantic coast, the tunas have a dark, coarse flesh and seem to be less desirable for canning than their Pacific relatives; therefore commercial fisheries have not developed. On the other hand, they reach their largest size there and probably serve their highest value as game fish; and they are pursued by sportsmen from Florida to Nova Scotia.

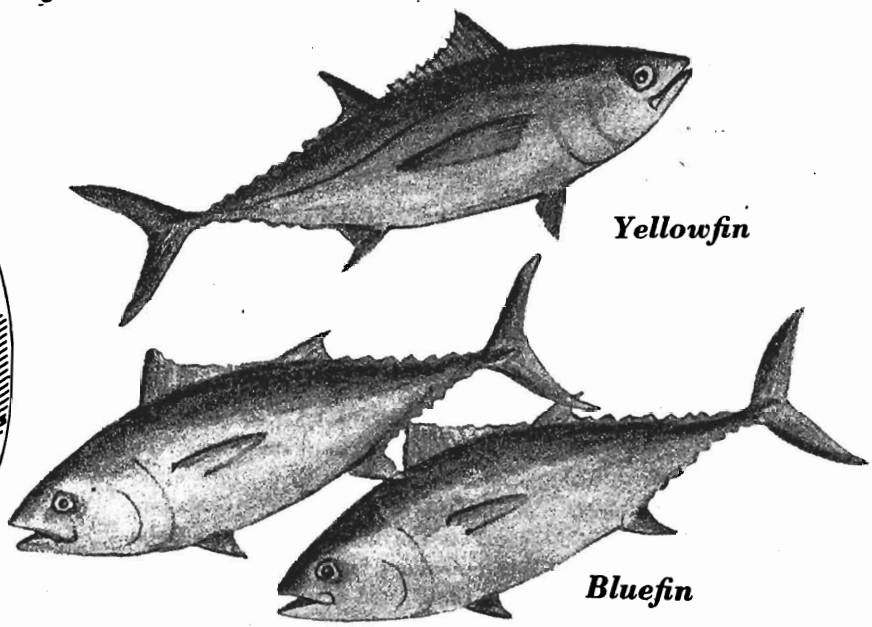
THE WORLD'S ANNUAL CATCH OF TUNA, IN NORMAL TIMES, WAS CLOSE TO 675 MILLION POUNDS. The United States took about 23 percent of this total, Japan about 68 percent of it. Japan's fisheries extended over vast distances of the Pacific, and her production came to 460 million pounds a year, almost three times the United States catch. She exported to the United States annually between 1 and 2 million dollars' worth of canned tuna and a large amount of frozen fish for canning in this country. The Japanese fishery is believed to have been carried on around the Japanese islands and southward to the Philippines; also in the area of the mandated islands. Saipan is said to have been the center of a Japanese tuna fishery.

In normal times some canning was done in the Philippines, but was believed to be far short of the total capacity of the tuna resources of those islands. Development of tuna industries in Australia and New Zealand to exploit the resources of the South Pacific have not yet gone far. In Hawaii, before the war, tuna made up about 60 percent of the landings of deep-sea fishermen, averaging around 7 million pounds a year. This fishery was dominated by Japanese nationals. In Peru and Chile some tuna-canning industries have recently started. To sum the Pacific situation: It appears that Japan's domination of tuna fisheries in the western Pacific will be challenged from many quarters after the war and that American tuna fisheries may therefore be given an impetus to expand greatly.

In the Caribbean region and the adjacent northern coast of South America tunas are used to a limited extent, chiefly in the fresh-fish market. Experimental canning is being carried on in the Barbados. The tuna fisheries of the Mediterranean countries are the oldest in the world, go far back into antiquity. Yet they produce less than 10 percent of the world's total catch of these valuable fishes.

TUNA FISHING is pursued on the high seas bordering the American continent clear down to equatorial waters 2,500 miles from home ports. American tuna clippers are vessels 80 to 150 feet long; cost, before the war, $75,000 to $300,000.

World Fishery Resources TUNAS



SHADING SHOWS DISTRIBUTION OF TUNAS IN THE EASTERN HEMISPHERE

They carry crews of 10 to 19 men and are equipped for voyages of 4,000 to 6,000 miles, lasting as long as 90 days. They have live tanks which hold 10 to 15 tons of live bait, and their hold capacity ranges from 125 to 225 tons or more. They are equipped for brine-freezing the catch.

On the way to the fishing grounds, a tuna vessel stops to fish for bait, which consists of small sardines, anchovies, or smelts. These are kept alive in tanks of circulating water. On the fishing grounds, the tuna are located by observation or are attracted by lures trolled behind the ship. When a school of tuna is sighted and reached, live bait is thrown over to attract the fish around the boat. The men fish from platforms which are attached outside the gunwales, using bamboo rods and short heavy lines. The barbless hook, covered with white feathers, is called a squid, jig, or striker. The tuna, driven to a frenzy of excitement by the live bait, strike indiscriminately, seize the squids, and are quickly jerked on to the deck of the boat. When the fish run large, two, three, or even four men may work together with separate rods attached to a single line.

In 1940 almost 70 percent of the tuna catch was made by this method, about 25 percent was made by purse seines (from sardine vessels fishing for tuna during seasons closed to sardine fishing), and the balance by trolling. The catch by trollers is increasing with the growth of the albacore fishery off Washington and Oregon.

WHAT WE DO NOT KNOW ABOUT THE TUNAS: In spite of the great value and antiquity of tuna fisheries, very little is known about these fishes. Our knowledge of tunas in the Pacific is particularly negative. We don't know where or when the Pacific tunas spawn or the size or age that they must attain before first spawning. We don't know how large any of the populations of tuna are, or what fraction of them is being exploited. Certainly the rate of exploitation has been greatly increased within the past few years, and it will probably further increase in the future. We know little about the migrations of tunas. They are oceanic fishes not limited to the continental shelf, migrate great distances. Since they pass in and out of the territorial waters of many countries, the tunas are truly a world resource. The extent of their migration is not known, should be made the subject of intensive investigation. There are indications that albacore migrate across the Pacific, bluefin across the Atlantic. It seems likely the yellowfin and skipjack travel similarly vast distances. Thus an intense fishery in remote regions might adversely affect our own fishing if the tunas belong, even in part, to populations shared by many nations. What effect, for example, does the rapidly expanding Japanese tuna fishery have on our own? Until some of these problems are solved, no intelligent conservation program can be initiated. Any program to be effective must be on a large scale and must not be restricted to any local area; indeed, it must cover the entire range of the distribution of each species.

TO CONSERVE THE TUNA RESOURCE OF THE PACIFIC, minimum and maximum size limits are placed on tunas in California. These have an economic rather than a conservation basis, since the industry finds it unprofitable to handle very small or very large fish. To protect sport-fishing interests, some areas in southern California have been closed to commercial tuna fishing. No sound measures of conservation can be effected, however, without knowledge of tunas' biology; and no truly effective means of insuring the income from these valuable resources can be instituted without the full collaboration of all the countries that share in them.

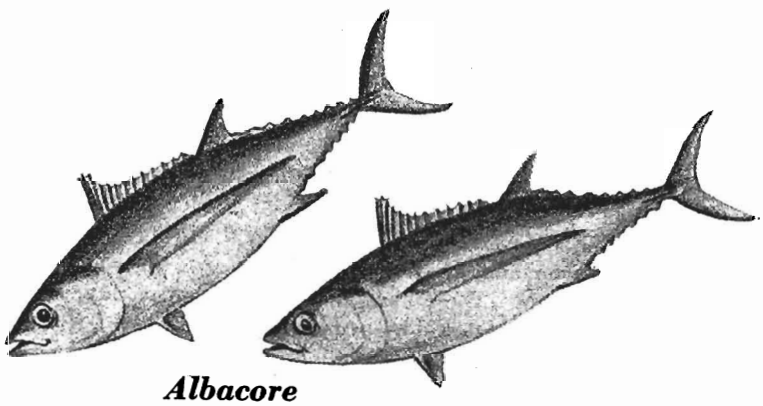
World Fishery Resources TUNAS

THE YELLOWFIN TUNA, mainstay of the West Coast tuna industry, is caught more or less throughout the year in tropical and subtropical waters between southern California and the latitude of Galapagos Islands, off Ecuador. Nearly the entire catch is taken south of the United States. most of it south of 20° north latitude. Total catch of this species has averaged about 84 million pounds annually in recent years. The fish taken by commercial fishermen range in size between 7½ and 150 pounds, average 30 to 40 pounds. This species is important in the Japanese fishery; it seems to be less abundant in the Atlantic than in the Pacific.

SKIPJACK, smallest of the commercial tunas, is probably the most abundant; it is also the least valuable per pound in the United States market. About 45 percent of the world's catch of tuna, and about one-fifth of the United States catch (35 million pounds), is of this species. In Japan, and also in Hawaii, skipjack is the most important of the tunas. It is also of some importance in the Mediterranean Sea. In the area covered by the United States fishery, it has a distribution similar to that of yellowfin, is taken in the same manner, by live bait fishing. Skipjack caught commercially average 8 to 10 pounds.

THE BLUEFIN TUNA has a more northerly distribution than either yellowfin or skipjack, gets bigger than any of the other tunas. On our Atlantic coast, where it is fairly common from Maryland to Newfoundland during a few months of the year, the bluefin may reach a weight of 1,500 pounds, the largest size attained by this species anywhere in the world. Schooling bluefin of 65 pounds or less are common in the vicinity of New Jersey and Long Island; the larger fish, of 400 pounds or more, called horse mackerel, predominate in the north on both the American and the European side of the Atlantic. During recent years small quantities have been taken by commercial fishermen with hook-and-line, harpoons, or nets. It is a favorite of anglers, who catch it by trolling.

In California the bluefin is a famous game fish and an important commercial species, yielding a catch which has averaged around 14 million pounds in the last 5 years. The catch is seasonal (May until December) and erratic. The fish average 20 to 40 pounds in weight, rarely exceed 150 pounds. Commercial fishermen take them mostly with purse seines, anglers mostly by trolling. The bluefin of our Pacific coast may spend part of their lives in Japan, where 100 million pounds a year were taken in the 1930's; also in other western Pacific regions, including Australia, where a tuna fishery is just getting under way. Our Atlantic tuna may spend part of its life cycle in Europe, where large catches are made by French, Portugese, and Italian fishermen.



Albacore

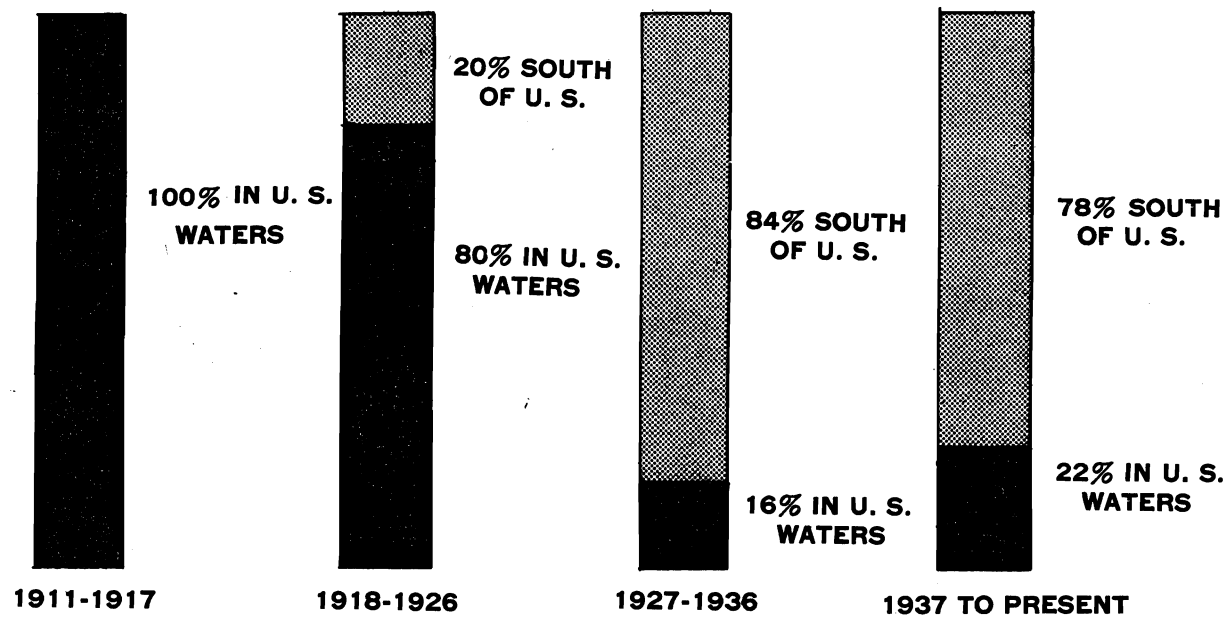
ALBACORE has the whitest meat of all the tunas; therefore it is the most valuable in the United States market, selling at a much higher price than any other species. An average of 18 million pounds has been caught annually over the past 5 years, most of it with trolled jigs and by live-bait fishing. The supply of albacore has fluctuated widely. From 1919 to 1925 the catch varied from 13 million pounds to 22 million pounds; in 1926 albacore failed to appear in abundance on the California coast, and less than 3 million pounds were caught. From then on through the next 12 years the albacore fishery almost ceased to exist, for during most of that period the annual catch was below a million pounds. To partially satisfy the demand for this excellent fish, large quantities of frozen albacore were brought in from Hawaii and also from Japan. At last, in 1938, the albacore "came back" to the United States west coast and has been abundant every year since. In 1943, 36 million pounds were caught, the largest quantity in the history of the fishery. Until 1936 the fishery had been confined to the California coast, but in that year the fish appeared on the Oregon coast in abundance; a fishery started there and has since spread northward to British Columbia. The causes of the disappearance of the albacore and its subsequent reappearance with an apparently extended distribution have never been discovered.

Albacore generally make their appearance on our coast in the spring or early summer, disappear in fall or winter.

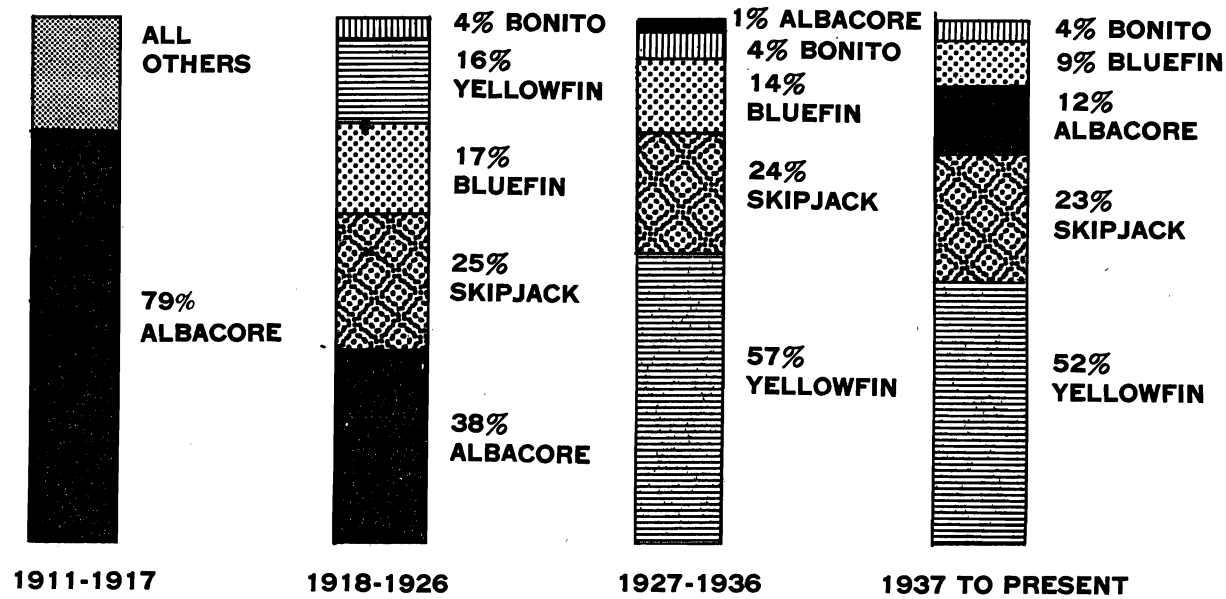
Pacific albacore with ripe eggs have been taken only in Hawaii, never on either the American or the Japanese coasts. According to studies made by the Oregon Fish Commission, the albacore population visiting the west coast of the United States and also Japan is composed entirely of two or three ages of fish, rarely if ever includes very young or very old fish (i. e., sizes smaller than 20 inches or larger than 40 inches).

BONITOS, members of the same family as the tunas, are often taken by tuna fishermen and canned tuna style. The cans must be labelled "bonito." Several species of bonito are known; they apparently are more localized in their distribution and less migratory than the tunas. Bonito is not in great demand by the canneries and the catch (which has averaged 7 million pounds a year in the last 5 years) is only a small fraction of the capacity of the resource. They are small fish, averaging only 6 to 8 pounds, are considered inferior in quality to tuna, and bring a lower price canned. Nothing is known about the biology of bonito populations.

PROPORTION OF WEST COAST TUNA CATCH TAKEN OFF U. S. COAST AND SOUTH OF THE U. S. DURING DEVELOPMENT OF TUNA FISHERY



PERCENTAGE OF EACH KIND OF TUNA IN CATCH DURING DIFFERENT PERIODS OF DEVELOPMENT OF WEST COAST TUNA FISHERY



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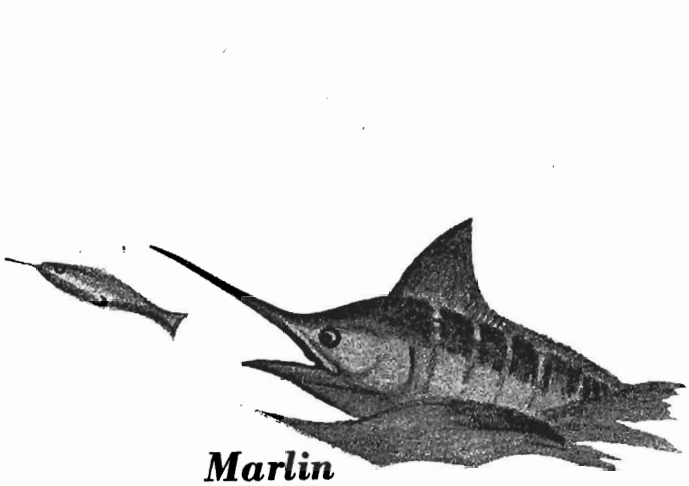
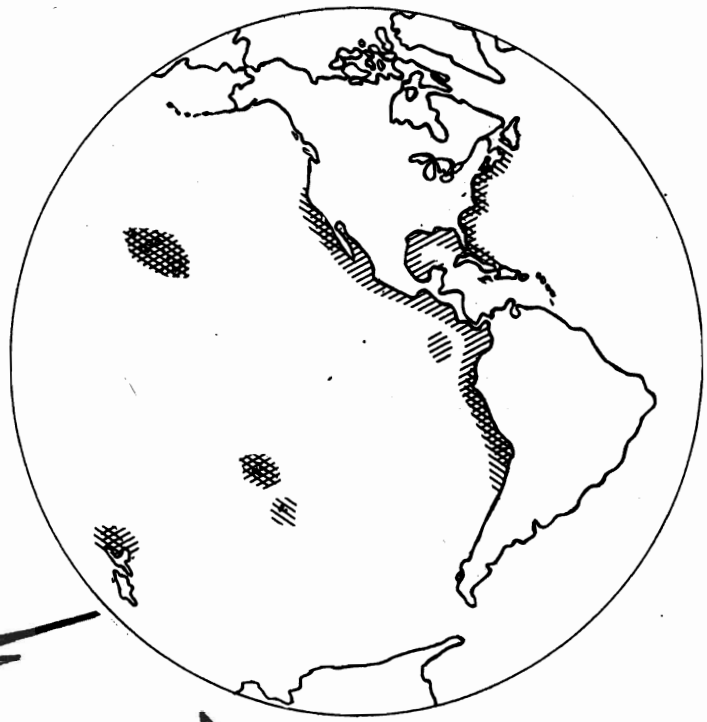
World Fishery Resources SWORDFISH and SPEARFISHES



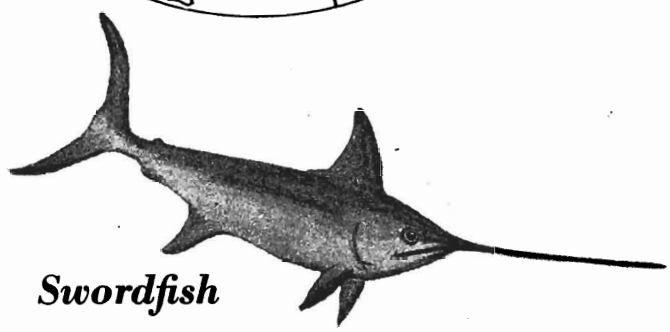
Marlin

Sailfish



Marlins
Sailfishes

Swordfish



Swordfish

THE SWORDFISH, CALLED BROADBILL BY ANGLERS, to distinguish it from marlins, is a resource of world-wide distribution. As a food fish it is one of the most precious, the demand for it far exceeding the supply. In 5 pre-war years American fishermen took an average of 2.2 million pounds annually off the Atlantic coast, 700,000 off the Pacific. In addition, an average of 1.6 million pounds was imported from Canada and 2.4 million pounds from Japan; and an unrecorded quantity, probably around 30,000 pounds a year, was shipped in from Hawaii. Swordfish are marketed entirely as fresh or frozen fish. It is among the highest-priced fish on the American market. Oil taken from the liver has a vitamin A content of high potency.

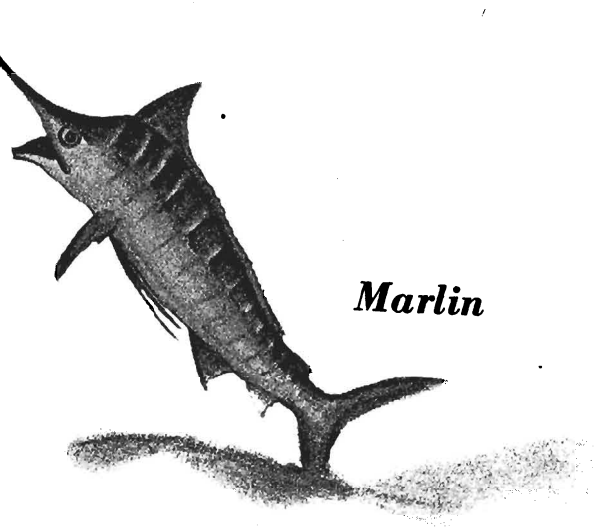
To anglers swordfish is probably the richest trophy obtainable; it is an exceedingly difficult game fish to catch with rod and reel, and the most expensive, for it requires a special kind of boat and special equipment. The best-known angling grounds are the Block Island district on the east coast and the Channel Islands region on the west coast. In normal times some enthusiasts go to such distant places as Nova Scotia, Peru, or Chile, where good grounds are located.

Very little is known about swordfish. They are found close to our coasts only in large sizes. Very young specimens have been reported from the Gulf Stream off Florida to Cuba, but breeding grounds have not been located on this side of the Atlantic. Both eggs and young have been taken from the Mediterranean, and young swordfish are common around Hawaii.

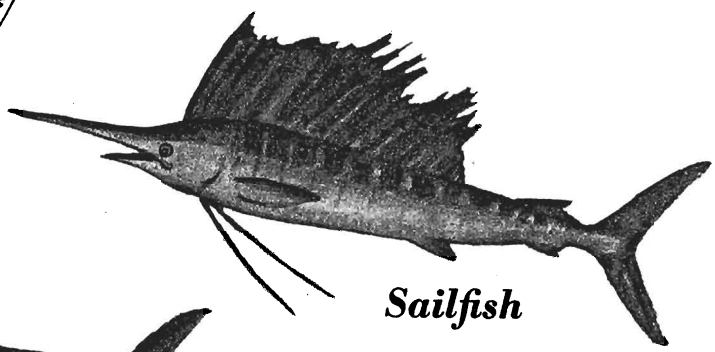
Probably, like tuna, they migrate vast distances across the oceans, but the course and extent of these migrations are unknown. Nothing is known about the growth, age, or abundance of swordfish. No important questions about the swordfish can be answered without scientific research on a trans-oceanic and international scale, with talent and facilities contributed by all the countries sharing this resource.

MARLINS ARE BIG-GAME FISHES OF WARM SEAS, FOUND ON BOTH COASTS OF THE UNITED STATES, AND IN HAWAII, AND PUERTO RICO. Like the swordfish and the tunas, they are distributed around the world, are found in many tropical and subtropical countries, and probably migrate over great distances. Big-game anglers find marlins to be spectacular fish on rod and reel, take them by trolling with artificial lures, or with cut bait, live bait, or with whole flying fish. The techniques of marlin fishing are highly specialized, require special equipment, boats, and highly skilled boatmen. The sport is therefore an expensive one. Nevertheless it is a great attraction to pleasure fishermen on both coasts, and thousands of men earn their living operating

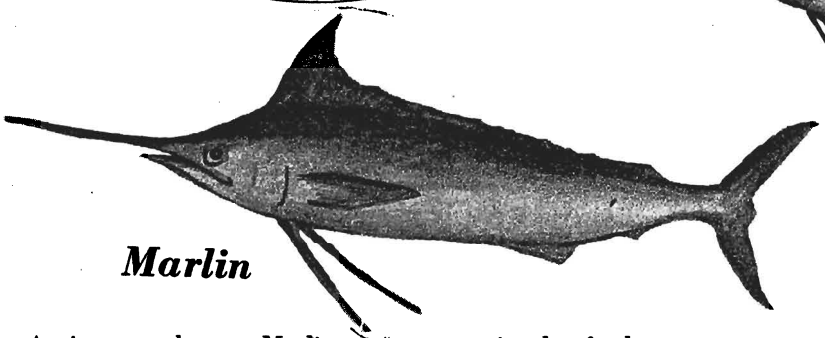
World Fishery Resources SWORDFISH and SPEARFISHES



Marlin



Sailfish



Marlin

or equipping party boats. Marlin are not appreciated as food in the United States and are not utilized there commercially. In the West Indies there is a good market for all that can be caught.

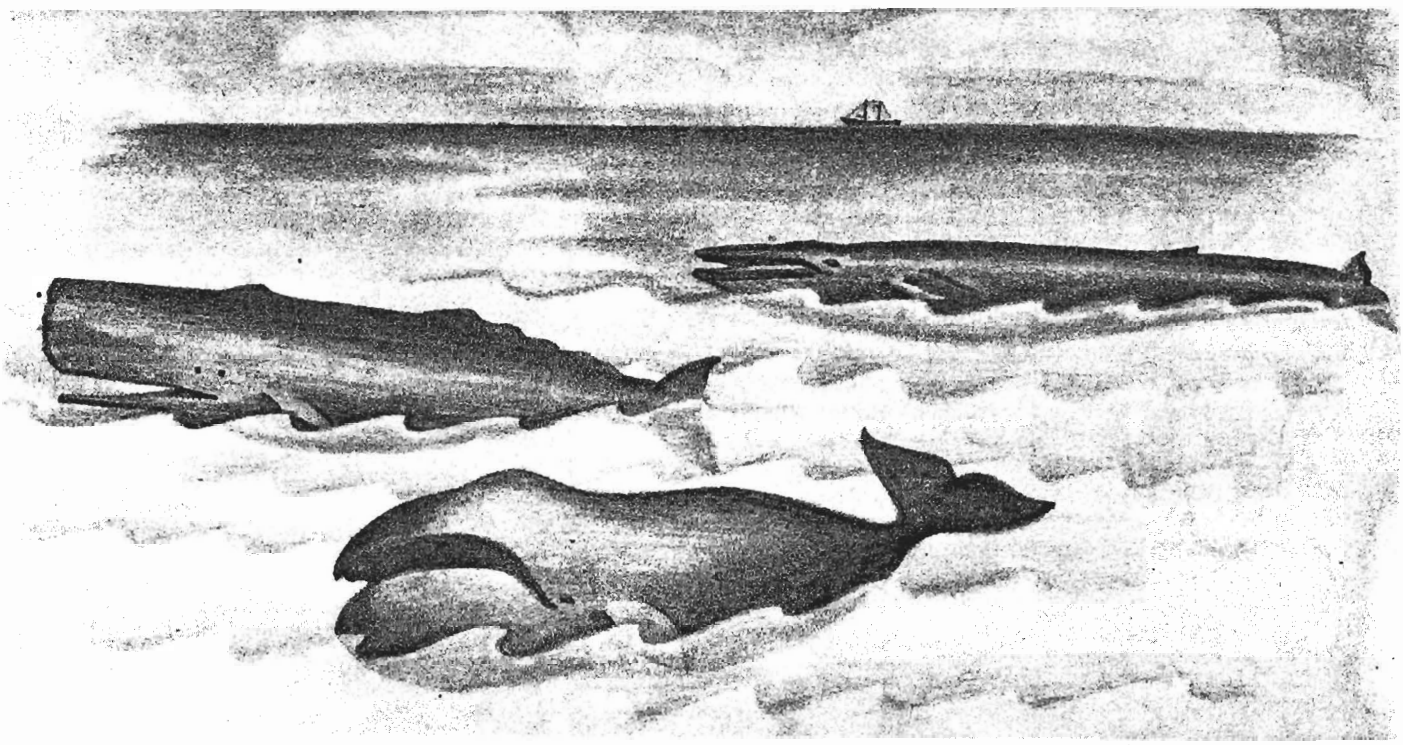
On the Atlantic coast two kinds of marlin occur, the white and the blue; they are found from Maine to South America. The best-known fishing grounds are Long Island to Virginia, Palm Beach to Panama, and around the British West Indies. On the Pacific side, the striped marlin extends from southern California to Mexico, and the black marlin ranges from Mexico southward. Santa Catalina Island is the most important United States center for big-game fishing in this range; better grounds are along the Mexican coast and southward. Hawaii provides excellent marlin fishing.

Little is known about marlins. The American Museum of Natural History has long collected data on all the big-game fishes, has observed that marlins eat small fishes and squids. Neither eggs nor larvae have ever been collected from American waters; the only small specimens ever reported are one of 5 pounds, taken in the Gulf Stream off Miami Beach, Fla., and another of 6¾ pounds, taken off Cat Cay, British West Indies. This is the sum of our knowledge on the biology of marlins. Adequate studies on these species would have to be on a scale as great as the habitat of the fishes; it would have to extend across the oceans and be carried on with full collaboration of the many nations that profit from these valuable resources.

SAILFISHES ARE CLOSELY RELATED TO THE MARLINS, like them are big-game fishes found in warm seas around the world, including both coasts of the United States, Hawaii, and Puerto Rico. Anglers catch them by the same methods used for marlins, consider them as great a trophy. In the Atlantic, where they generally run 35 to 100 pounds in weight, they have been found as far north as Massachusetts, but are commonest from Florida southward. The best fishing grounds are from Stuart, Fla., to Palm Beach and around the British West Indies. On the Pacific side, they are found in much larger sizes than in the Atlantic, specimens of 100 to 125 pounds being not uncommon. They are found from southern California southward through Mexico and Central America, as well as around the South Pacific Islands and along the Asiatic coast. Sailfish are not appreciated for food in this country; Florida law permits anglers to have their legal catches made palatable by smoking. As little is known about sailfishes as about marlins. They are said to spawn off the South Atlantic and the Gulf coasts in summer. Any fruitful study on them would have to be on a large scale and international in scope.

Distributional data given by Francesca La Monte, American Museum of Natural History.

World Resources WHALES



WHALES ARE A WORLD RESOURCE, WHICH, THROUGH PROFLIGATE EXPLOITATION, HAS BECOME DANGEROUSLY CLOSE TO EXTINCTION. Once it was the most important marine resource of our Nation. In the middle of the last century, the whaling industry engaged some 735 boats, and 40,000 people. It represented an investment of 40 million dollars, and involved an annual take of whales worth about 8 million dollars. In 1943 there were engaged in this country three boats and 59 people; the investment was something less than 1 million dollars, and the year's catch was worth $44,000.

These figures tell the story of the death of a great industry through at least three causes. First, the whaling resources had been grossly mismanaged; second, the rise of the petroleum industry seriously reduced the domestic market for whale oil; third, United States industry has failed both to develop new products from whales and to keep abreast of new methods of whaling. Meanwhile, other countries, notably Norway, have maintained highly profitable whaling industries by improving effectiveness of fishing methods, by developing new whale products, and by completely utilizing the catch.[1] So profitable was whaling to these countries that exploitation of the resource was prosecuted on an imprudently lavish scale, and the resource was brought close to the brink of exhaustion. This is an excellent example of the consequences of failure to manage a renewable resource.

Whale oil is used principally for soap making, with glycerine as a byproduct; also in Europe for the manufacture of edible fats such as margarine, and to a lesser extent for currying leather, manufacturing fibre dressing, face cream, unguents, and ointments. Some of the lower grades are used for the lubrication of machinery, and these are also utilized by steel manufacturers. In addition to oil, a whale of average size will yield three tons of meal for cattle, hog, or chicken food, and over a ton of guano. The chief market for whalebone is in Paris, where it is used to make mattress stuffing, artificial osprey feathers, and the artificial hair of barrister's wigs. Fine threads of whalebone are woven into silken fabrics and some of the coarser grades are used in the manufacture of brushes.

Dr. Remington Kellogg, of the United States National Museum, in discussing the history of whaling has said: [2]

"For more than 1,000 years the whaling industry has been organized and the chase has been prosecuted each year as energetically as the available equipment would permit. Year after year whaling has taken toll in excess of the rate of reproduction, and one region after another has been depleted.

"The rise, climax, and decline of the whaling industry has been reenacted time and again as the result of overfishing for particular kinds of whales. Sooner or later the operations are shifted from the exhausted ground to some more promising new field, and here the process is repeated. In the closing days of each field, the financial losses to firms and individuals operating whaling vessels have been tremendous. Scarcity of whales caused their pursuit to be abandoned in one region or another during the past 3 centuries, though in more recent

[1] If new products and new uses for whales could be developed in the United States, perhaps a whaling industry might be revived here. Canned whale steaks are packed in Newfoundland. Norway and other European countries refine and hydrogenate whale oil so that it can be used for edible purposes. A number of other new whale products developed in other countries might be cited. In the United States, however, such products are made from other sources, and whaling is not profitable here in normal times even if whales were plentiful.

[2] Modified from an address delivered at the eleventh annual meeting of the American Society of Mammalogists, April 9, 1929, at Ann Arbor, Mich.

years they have been indiscriminately slaughtered wherever opportunity presented.

"Species that have been commercially depleted or nearly exterminated in any given region never later show any marked recovery, even though there may be a long period of comparative immunity. There is a well-founded belief that when a species has been exterminated in any given region it does not return to that place in any appreciable numbers, even after long periods during which it has not been molested. Experience has shown that there should be a breeding reserve in excess of natural losses, and that overfishing sooner or later passes the danger point beyond which there is no recovery."

In 1930, Dr. Kellogg wrote:

"We are now witnessing what may be the last phase in the history of whaling, for with the present exploitation of the Ross and Antarctic Seas, no more unexplored fields are left to be conquered. The order of events, that will surely follow is clearly predictable . . ."

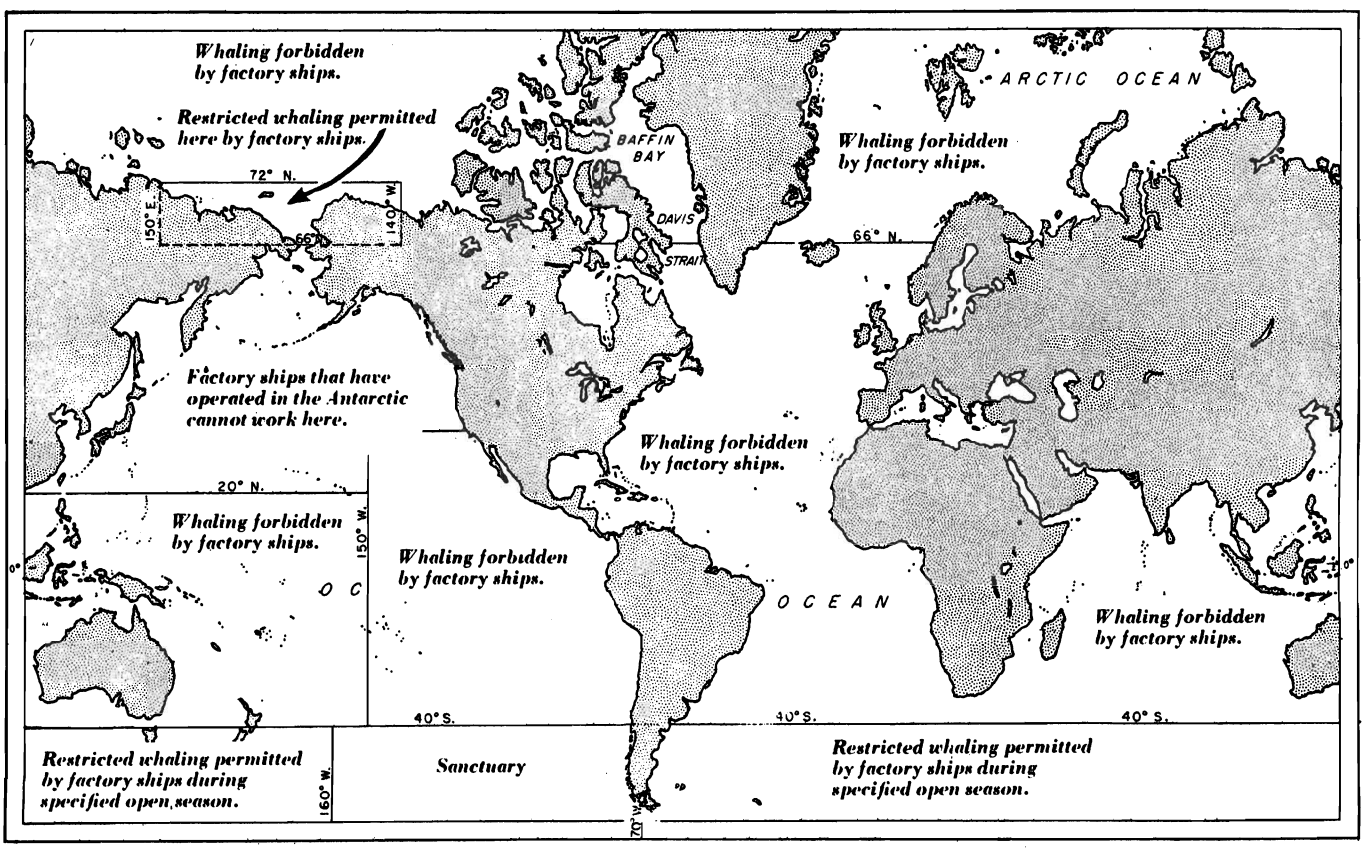
This bleak situation led the Economic Committee of the League of Nations to call together a committee of experts to consider the feasibility of international regulation of the whaling industry. Dr. Kellogg then wrote: [1]

"The draft convention prepared at this conference, after having been modified in certain minor respects, was ratified by 17 countries and acceded to by 8 others. This convention, however, did not come into force until January 16, 1935. By its provisions, full protection was given to all kinds of right whales; the taking or killing of calves, and females accompanied by calves, was prohibited; and the fullest possible use of the carcasses of all whales was required.

"In 1937, the International Conference for the Regulation of Whaling was held in London. 'Stringent regulations,' or 'game laws' covering the minimum legal size for whales of each species, and prohibiting the killing of females accompanied by calves, as well as all right and gray whales, were drafted for approval by the governments of South Africa, Argentina, Australia, Germany, Great Britain, Eire, New Zealand, and the United States. This agreement came into force as regards the United States on May 18, 1938. Under the terms of this agreement, factory ships are barred from operation on the calving grounds of whales, and are obliged to make the fullest possible use of the whole carcass. Some minor modifications were written into the Protocol of June 1938, including the protection of the decimated stocks of humpbacks in Antarctic waters and the establishment of an Antarctic whale sanctuary between the Ross Sea and Cape Horn."

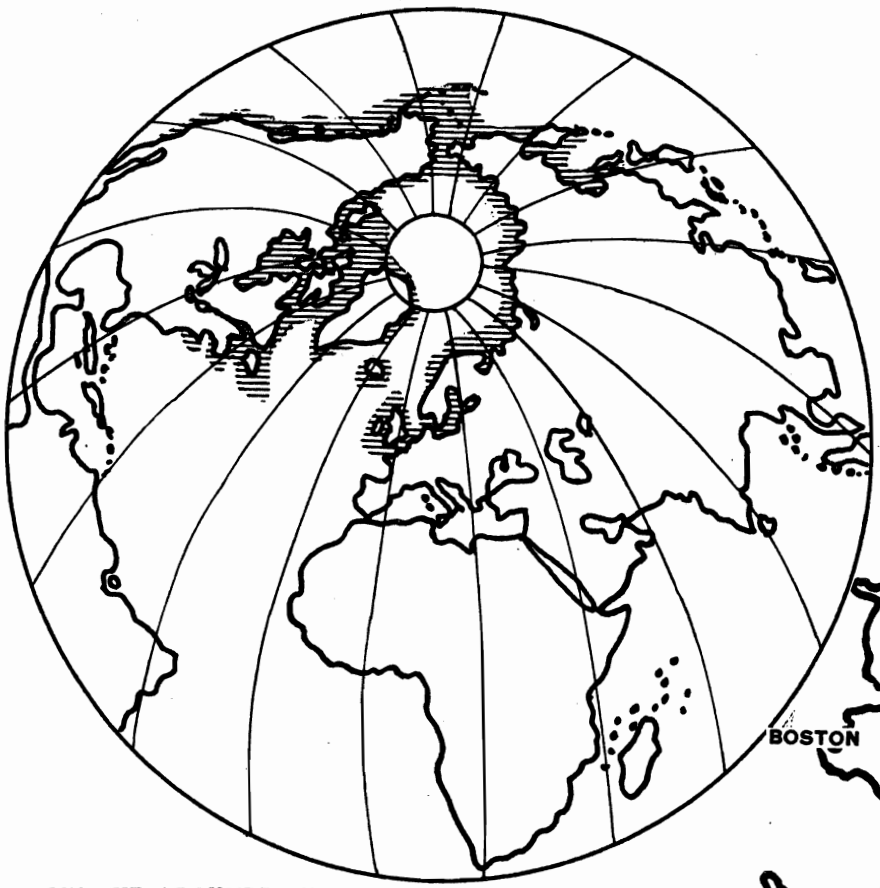
The participating nations share enforcement of the treaty's terms. Whaling vessels must be licensed by their respective governments. In the United States this function is performed by the Fish and Wildlife Service. Each factory ship must be accompanied by a law enforcement officer of its own nationality. The United States Coast Guard fulfills this duty on American vessels. How effective these regulations may be in restoring and perpetuating the whale resources remains for the future to prove.

[1] Proceedings Eighth American Scientific Congress, Vol. 3: 466, 1942.



According to Article 8 of the International Agreement, land stations can be operated anywhere except in the Sanctuary, but only for 6 continuous months in each year

Atlantic Fishery Resources GROUNDFISHES



HOW THE GROUNDFISHES OF NORTHERN SEAS ARE DISTRIBUTED

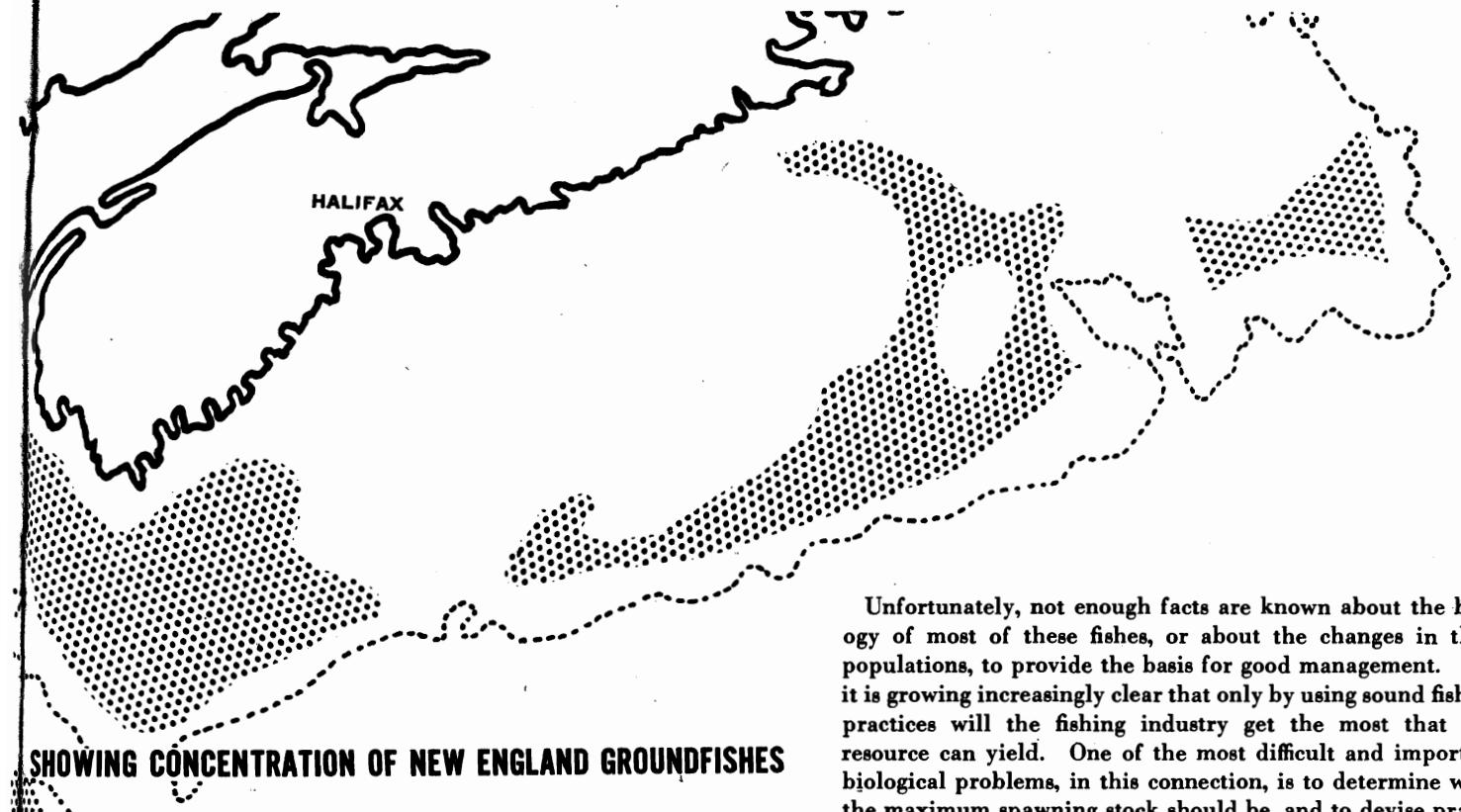
GROUNDFISH IS THE TERM APPLIED TO MANY KINDS OF FISHES THAT LIVE ON OR NEAR THE BOTTOM. They are the object of a special fishery, are caught mostly with otter trawls; also with line trawls and sink gill nets. Taken together, they are the most important marine resource of New England, and the third most productive and valuable in the United States. The principal groundfishes are haddock, rosefish, flounder, cod, whiting, pollock, and hake. The fishery yields a catch of 500 to 600 million pounds annually, worth about 25 million dollars to fishermen.

This country is but one of a number of nations drawing from the North Atlantic groundfish resource. Fishermen of Canada, Newfoundland, France, Portugal, and Spain, collectively take even more than the United States catch.

From 80 to 90 percent of the United States catch is marketed as fresh or frozen fish. Small quantities are salted or smoked. A canning industry has been growing, producing canned fish cakes, fish balls, fish chowder, canned finan haddie, and canned smoked halibut. Filleting waste has been used for making canned pet food, and also fish meal. The most important byproduct made from groundfish is liver oil.

North Atlantic groundfish can live only in food-rich, cool water, on the continental shelf, are thus confined to depths shallower than 100 to 150 fathoms. Beyond those contours, the bottom deepens rapidly to 1 or 2 miles; the water becomes too warm, too barren, and otherwise unsuitable for them. The area available to them, however, is vast. The banks inhabited by these groundfish populations range 1,000 miles

Atlantic Fishery Resources GROUNDFISHES



SHOWING CONCENTRATION OF NEW ENGLAND GROUNDFISHES

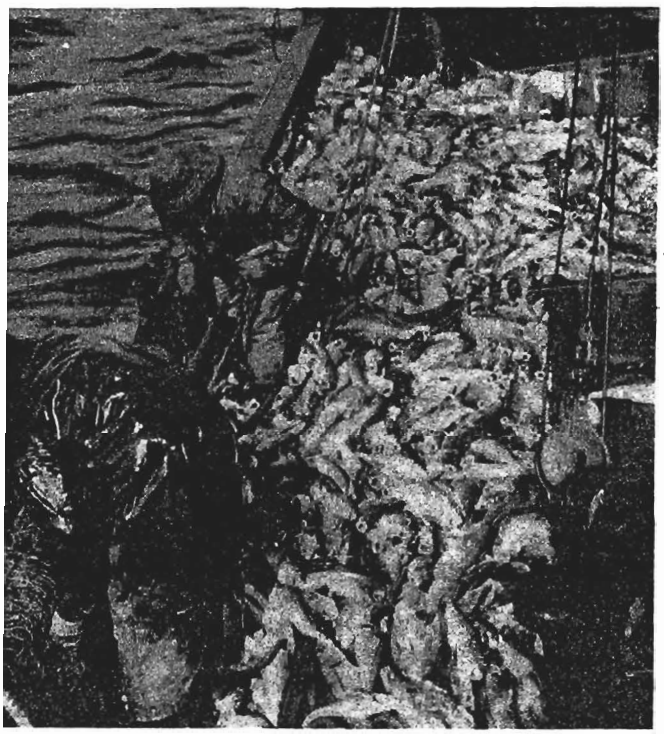
from Long Island to Newfoundland and are 260 thousand square miles in area, which is as large as all the coastal States from Maine to North Carolina.

Tides and currents are violent in this area, but the pattern of the latter is favorable to keeping the groundfishes' drifting eggs and larvae on the banks in areas conducive to survival. Extreme temperatures vary from near to freezing in winter to something over 68° in summer, but in the most favorable and thickly populated parts of the New England banks, they range from about 38° to 55°.

Groundfish catches are nearly twice as large during the spawning seasons and summer as in winter, probably because the fish then school more densely to spawn and to feed.

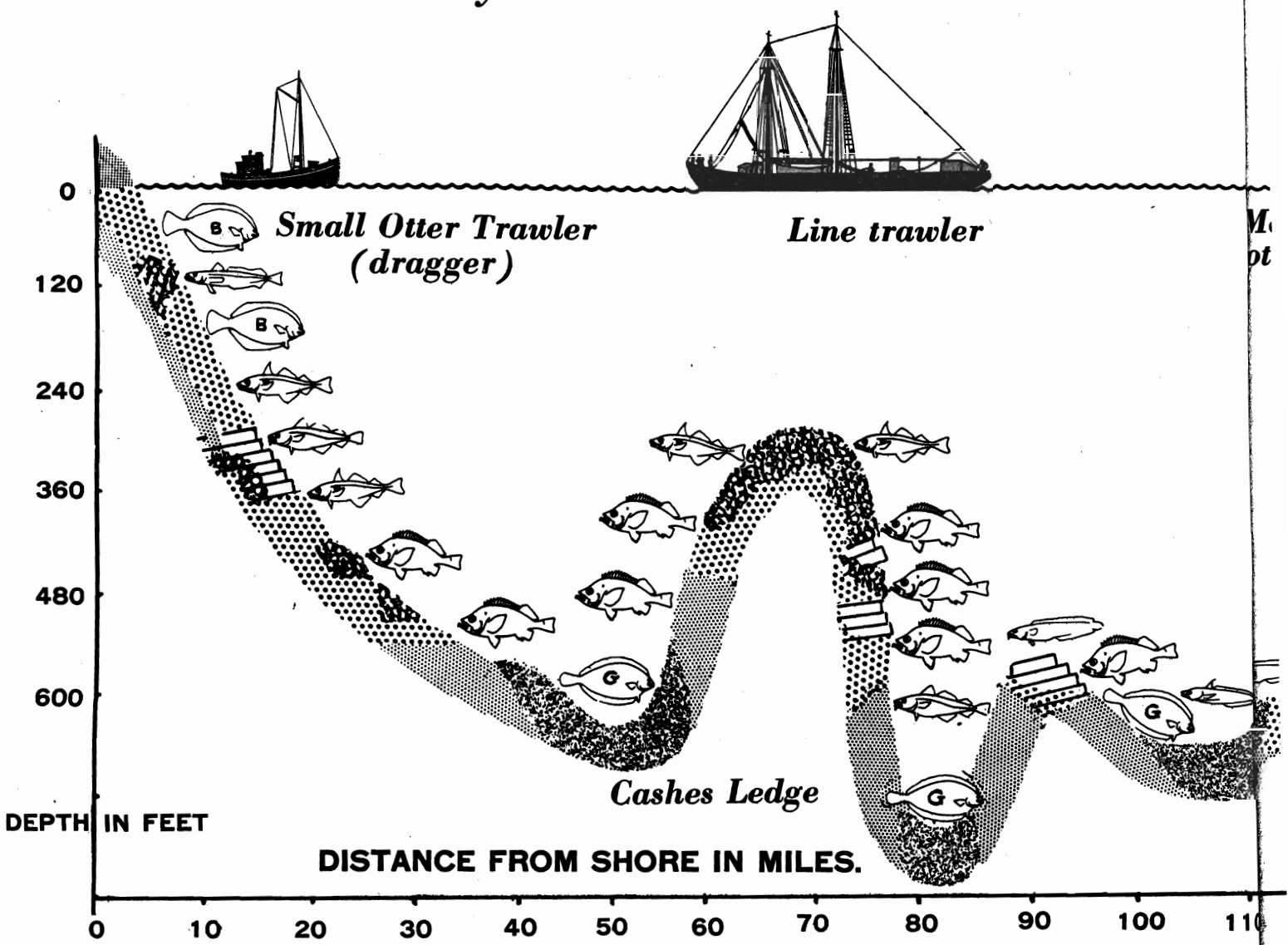
Few species of groundfish have been proved to be overfished to the point of "depletion." True, many of them have become scarcer in certain localities, but this fact is not necessarily alarming, for in a new fishery some reduction in the catch usually occurs after the accumulated stocks are caught off. Among populations that have become seriously reduced is the halibut, which has declined faster than any other Atlantic fishery resources in the last 50 years, as a consequence of the intensive fishery. Likewise the haddock stock of the New England banks is demonstrated to have been severely reduced by intensive fishing. Other species, among them rosefish and blackback and yellowtail flounders, are probably being fished up to or beyond their most productive level.

Unfortunately, not enough facts are known about the biology of most of these fishes, or about the changes in their populations, to provide the basis for good management. Yet it is growing increasingly clear that only by using sound fishing practices will the fishing industry get the most that this resource can yield. One of the most difficult and important biological problems, in this connection, is to determine what the maximum spawning stock should be, and to devise practical measures that will insure it without unnecessarily restricting the fishery.



New England trawler with part of catch on deck.

Atlantic Fishery Resources GROUNDFISHES



Ledges

Boulders

Sand

Gravel

Mud

Haddock

Cod

White Hake

Pollock

Whiting

Cusk

Rosefish

G—Gray sole

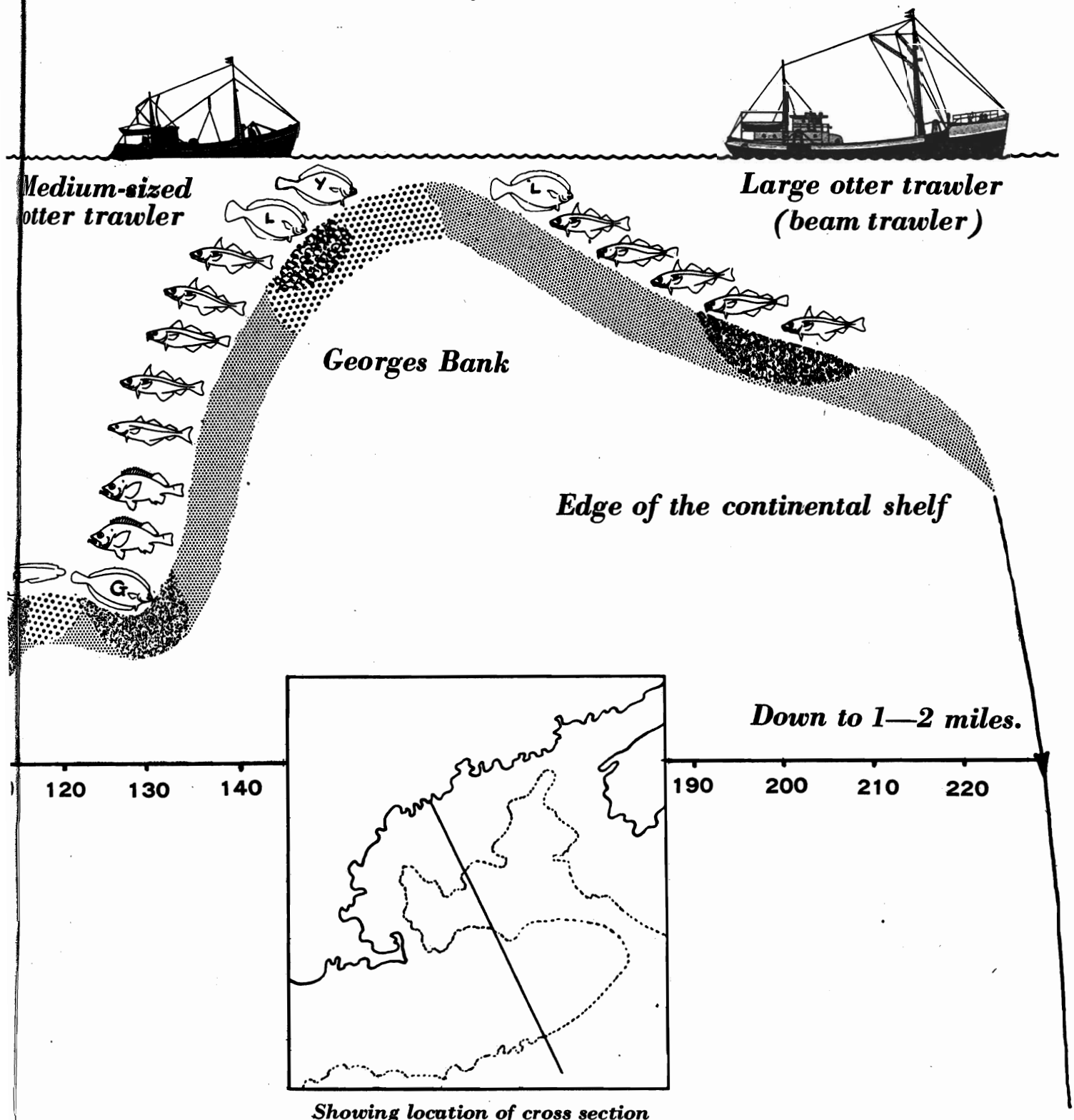
L—Lemon sole

Y—Yellowtail flounder

B—Blackback flounder

CROSS SECTION OF THE GULF OF MAINE, SHOWING DISTR

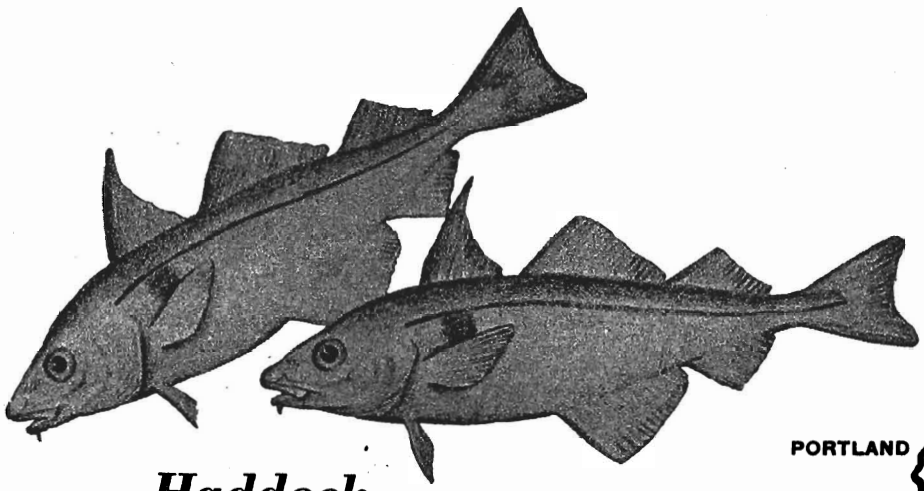
Atlantic Fishery Resources GROUNDFISHES



Showing location of cross section

BUTION OF GROUNDFISH BY DEPTH AND TYPE OF BOTTOM.

Atlantic Fishery Resources GROUNDFISHES



Haddock

SHADING INDICATES WHERE HADDOCK ARE CONCENTRATED ON NEW ENGLAND BANKS

HADDOCK IS THE MAINSTAY OF THE UNITED STATES OTTER TRAWL FISHERY and is the most valuable of all the North Atlantic coast fisheries. At peak production in 1929 the haddock resource yielded nearly 260 million pounds. Owing to reduced abundance brought on by intensive fishing, the average pre-war catch was down to about 150 million pounds a year, worth nearly 12 million dollars at recent prices.

Over 90 percent of the catch of haddock is by otter trawls, the remainder mostly by line trawls. Small amounts are also taken with anchored gill nets. Most of the haddock is sold as fresh or frozen fillets, some as cleaned fresh fish. Close to a million pounds are smoked and sold as finnan haddie; in addition, two million pounds of this product are imported from Canada each year. Some haddock is canned as fish flakes and some as fish chowder.

THE HADDOCK OF THE NORTHWEST ATLANTIC MAKE UP A COMPLEX OF POPULATIONS, of which at least three main groups are recognized, inhabiting, respectively, the New England Banks, the Nova Scotian Banks, and the Newfoundland Banks. The fish vary between groups as to growth rate, spawning time, migratory habits, fluctuations in size of stock, and other biological features. Knowledge about these populations is growing as United States Fish and Wildlife fishery investigations progress, but is still incomplete.

Haddock spawn for the first time when 3 or 4 years old and 2 to 3 pounds in weight. The spawning schools gather during February to April or later in favorable areas on the banks, usually where the water is from 30 to 60 fathoms deep. The eggs are spawned into the surrounding water, are fertilized there, and drift passively in the currents while they incubate.

Atlantic Fishery Resources GROUNDFISHES

They hatch in 2 to 4 weeks, and the larvae, and subsequently the young fish, continue to drift for 2 or 3 months before beginning their bottom existence. If adverse currents carry the drifting young to areas where the water is too deep or conditions are otherwise unsuitable, the young perish. The most important nursery grounds in the New England Banks are on southeast Georges Bank at 50- to 60-fathom depth. Haddocks' migrations during their first year are very limited but increase as they grow older and larger.

The haddock populations on the New England and Nova Scotian Banks are to a great extent independent of each other, for there is no considerable exchange between these banks of haddock eggs or of young haddock, either during their drifting stages or during the first years of their life on the bottom. Occasional and limited migrations between these banks have been observed for older fish. Tagging experiments and other evidence indicate that the haddock found along the coast of Maine during the spring and summer come mostly from Georges Bank, so that success of the Maine fishery is dependent on the size and condition of the haddock population on Georges.

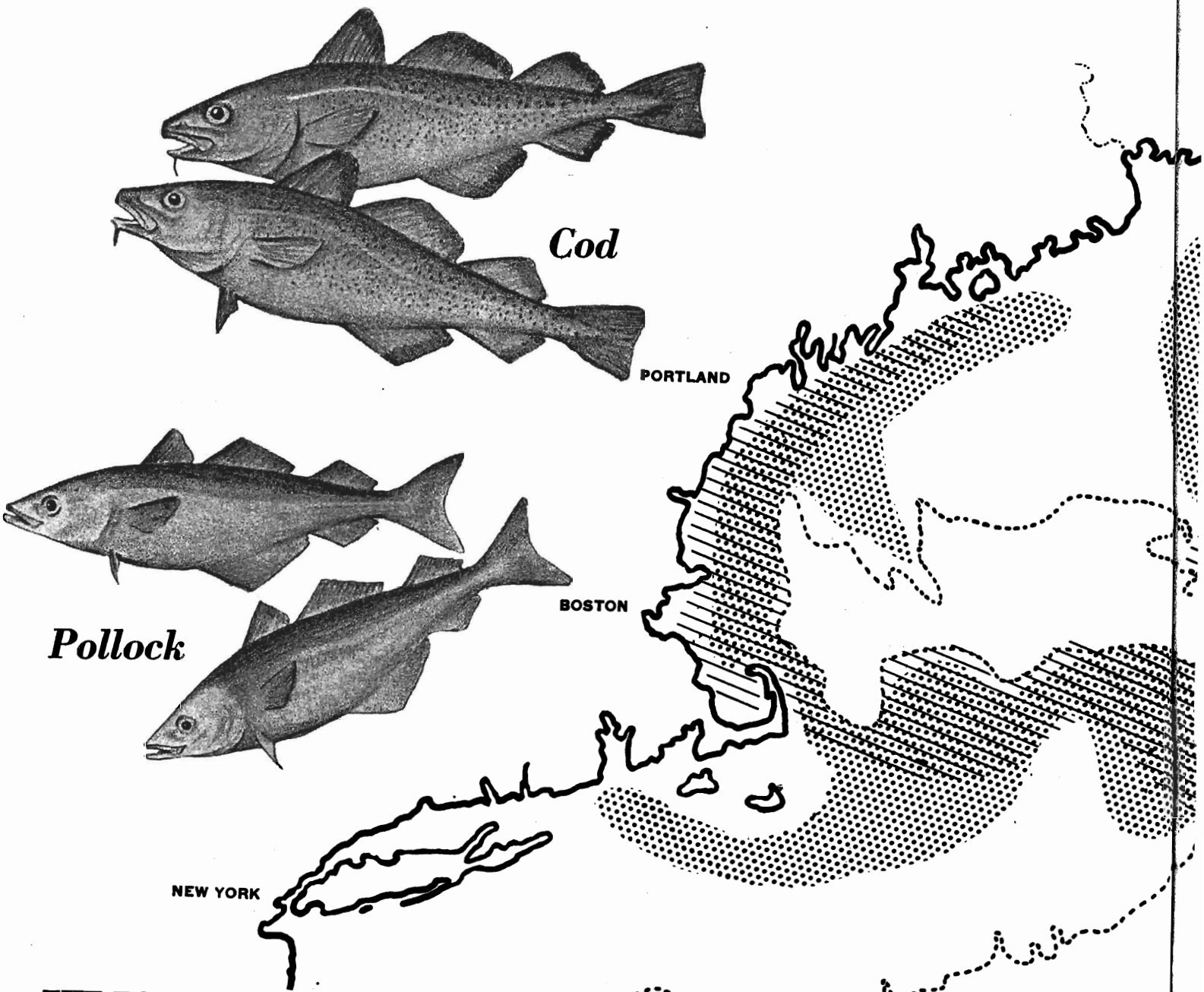
THE HADDOCK CATCH HAS DECLINED in spite of improvements in fishing gear, because stocks of fish on the banks have become reduced by heavy and destructive fishing to the point where there are too few spawning fish. Fish and Wildlife Service studies show that at present only about a third as many marketable-sized haddock live on the New England Banks as during earlier years. They also show that the fleet is now taking many more small fish than formerly. The number of haddock caught weighing less than 2 pounds made up 9 percent of the catch in 1928, 47 percent of the catch in 1941.

Discovery of the effect of these changes on the haddock stock and its continued productivity has been an important outcome of Fish and Wildlife Service investigations on haddock. Outstanding conclusion of these studies is that *the spawning stock of haddock should be nearly double its present size to provide for an adequate production of young. Fish smaller than 2 pounds* should be left in the ocean to take advantage of the growth period of their lives. This measure alone would increase the catch by 15 percent or more. In rebuilding the haddock stocks, the goal should not be to achieve the tremendous numbers found in the early days, for it has been demonstrated that when the adults are too numerous they seriously compete with the young for food, causing a heavy juvenile mortality.

THE CATCH OF HADDOCK FROM THE NEW ENGLAND BANKS CAN BE INCREASED about 50 million pounds or more by protecting fish smaller than 2 pounds and maintaining the spawning stock at the required level. It is believed this could be accomplished by adopting recommended changes in the otter trawl nets and by establishing a minimum commercial size. Some fishermen, boat owners, and dealers have volunteered to cooperate in adopting these proposed measures, but observance has been neither universal, uniform, or constant, and results have not been satisfactory.

The Fish and Wildlife Service has carried on studies of the haddock resource for several years, chiefly on Georges Bank. Conclusions indicating how the yield may be increased need now to be tested, improved in accuracy, and extended to other banks. This requires survey work at sea to determine the distribution and magnitude of unfished stocks of haddock, to study the young before they reach commercial size, to further investigate young-fish-saving gear, and to improve the accuracy of measuring the sizes of the populations and of individual year broods.

Atlantic Fishery Resources GROUNDFISHES



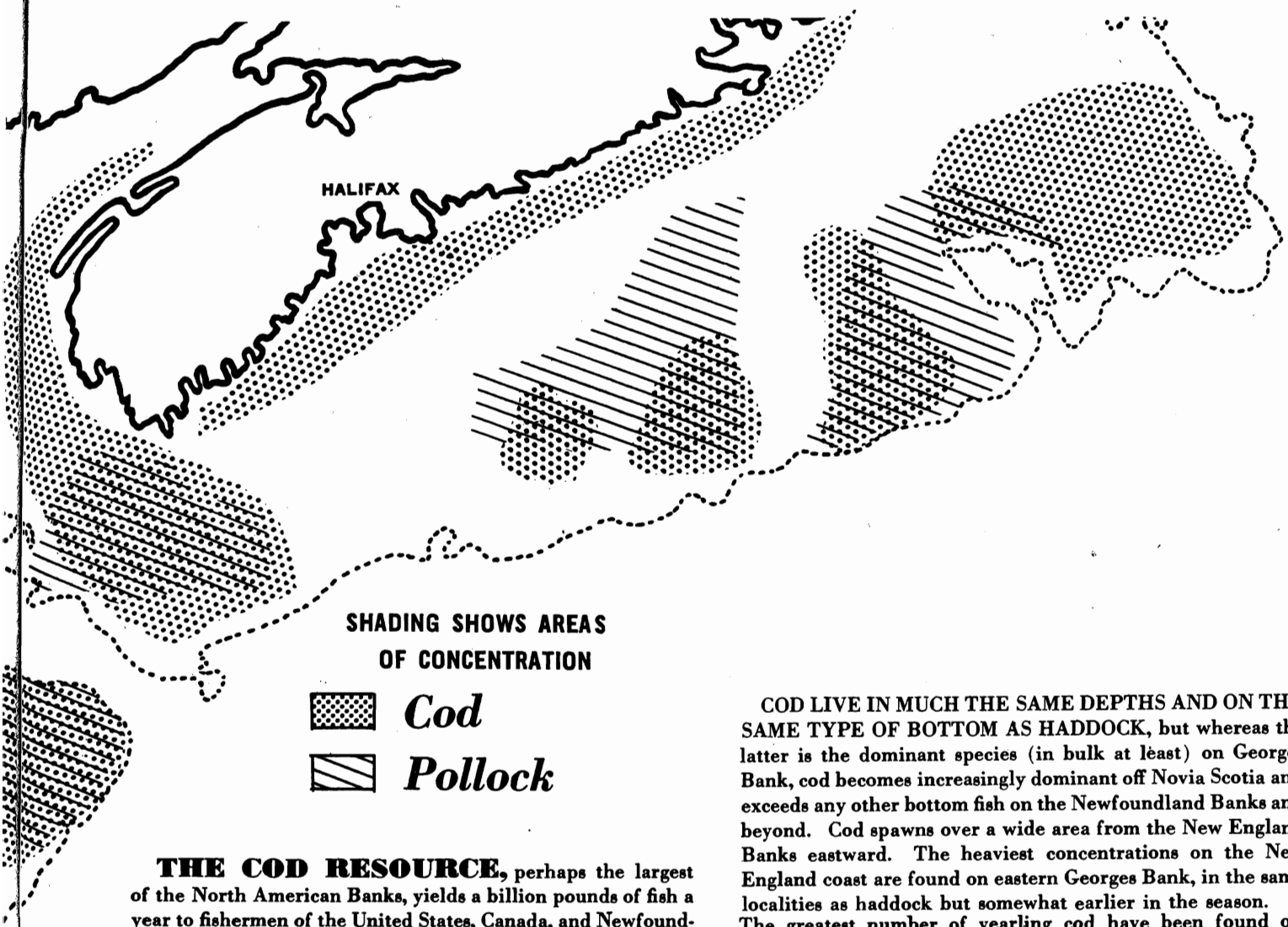
THE POLLOCK, OFTEN CALLED BOSTON BLUEFISH, has increased in importance in recent years. Just before the war about 38 million pounds were caught annually, about 67 percent of it with otter trawls, about 25 percent of it with anchored gill nets, the rest with purse seines, lines, floating traps, and pound nets.

Pollock is prepared as fresh and frozen fillets, is salted, and a small amount is smoked. It makes a good dry salt fish, though the color is not as white as dried cod. In the last few years some pollock has been canned commercially as fish flakes.

Important as the species is to the United States fishing industry, we know little about its biology, or extent of the resource in American waters.

POLLOCK SPAWN OFF THE MOUTH OF MASSACHUSETTS BAY, from October through February. The egg is buoyant and is slightly less than one-twentieth of an inch in diameter; it hatches in 6 to 9 days, depending on temperature, and the larvae are less than one-fifth of an inch long. The young drift near the surface for several months, then gradually settle to the bottom. In the Bay of Fundy, pollock average 5 to 6 inches by the second spring and about 12 inches by the third spring. By the fourth summer, that is at 3½ years of age, the fish are from 14 to 18½ inches long. The growth rate in the Gulf of Maine and along the Massachusetts coast is not known.

Atlantic Fishery Resources GROUNDFISHES



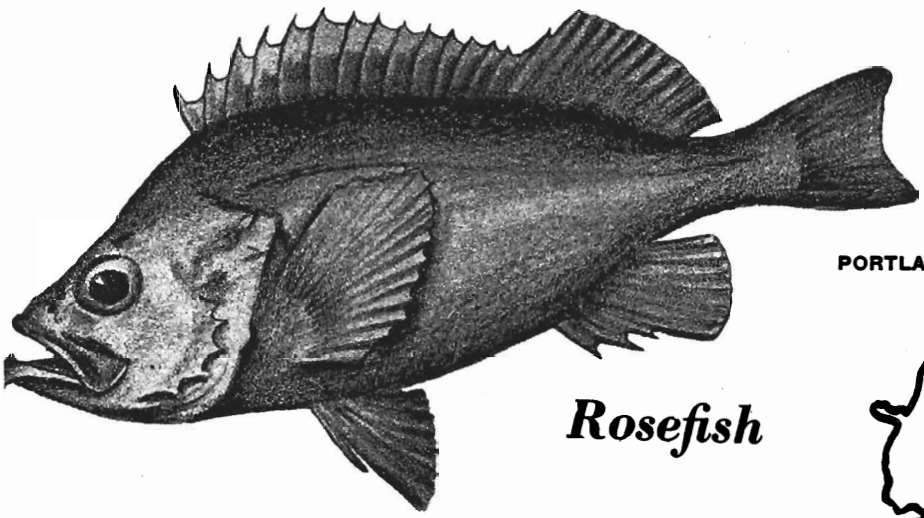
THE COD RESOURCE, perhaps the largest of the North American Banks, yields a billion pounds of fish a year to fishermen of the United States, Canada, and Newfoundland. In the last century when salting was the only economical way of preserving fish for widespread distribution, the cod supported the largest fishery of the United States because it salts particularly well. The development of refrigeration and of the filleting industry, however, brought the haddock into prominence in the 1920's since haddock were more plentiful on the nearby grounds and more suitable for filleting than cod; and because the demand for salt fish was declining in this country, cod became less sought after by United States fishermen. Today the annual catch is around 85 million pounds.

The biggest part of the United States catch of cod is taken with otter trawls; the balance with lines, sink gill nets, floating traps, and pound nets. Most cod is marketed as fresh and frozen fillets and steaks, and a small quantity is salted and smoked. Other products are pickled cod tongues and canned fish flakes. The skins from the salted fish are made into a high-quality glue. Liver oil made from the livers of haddock, cod, hake, pollock, etc., is one of the principal sources of vitamin D. It also has a number of industrial uses.

COD LIVE IN MUCH THE SAME DEPTHS AND ON THE SAME TYPE OF BOTTOM AS HADDOCK, but whereas the latter is the dominant species (in bulk at least) on Georges Bank, cod becomes increasingly dominant off Novia Scotia and exceeds any other bottom fish on the Newfoundland Banks and beyond. Cod spawns over a wide area from the New England Banks eastward. The heaviest concentrations on the New England coast are found on eastern Georges Bank, in the same localities as haddock but somewhat earlier in the season. The greatest number of yearling cod have been found on southeast Georges Bank in somewhat deeper water than the older fish. On Georges Bank young cod grow to about 7½ inches in their first year, and reach 15 to 16 inches at 2 years of age. Growth on the Nova Scotian Banks, which are farther north, is slower than on Georges Bank. Cod grow to enormous size, the largest recorded specimen measuring over 6 feet long and weighing 211 pounds. However, the commercial catch is made up principally of fish weighing 2½ to 25 pounds.

It is not known to what extent the cod populations found in the Gulf of Maine, on Georges Bank, and on the Eastern Banks are independent, but these fish are known to move about more than haddock. The catch per day's fishing has varied widely over the past 10 years. It is not known whether these variations reflect changes in the population, migrations, or a shifting of the primary objective of the fishery between haddock and cod. An understanding of measures needed to obtain maximum utilization of this resource must await a basic study of the cod populations and the conditions which govern their yield.

Atlantic Fishery Resources GROUNDFISHES



Rosefish

ROSEFISH CATCH, PRE-WAR YEARS

1930	*118,000 pounds*
1935	*17,157,000 pounds*
1940	*85,270,000 pounds*
1941	*145,400,000 pounds*

THE ROSEFISH OR REDFISH SUPPORTS A FISHERY THAT HAS GROWN SPECTACULARLY IN RECENT YEARS. In 1933, when only 264 thousand pounds were caught, it ranked one hundred and thirtieth in volume of production among the United States fisheries. In 1941 over 145 million pounds were caught, which ranked it second in volume only to haddock among New England fishes. This remarkable growth came as a result of the development of new markets and utilization of the rosefish by the filleting industry.

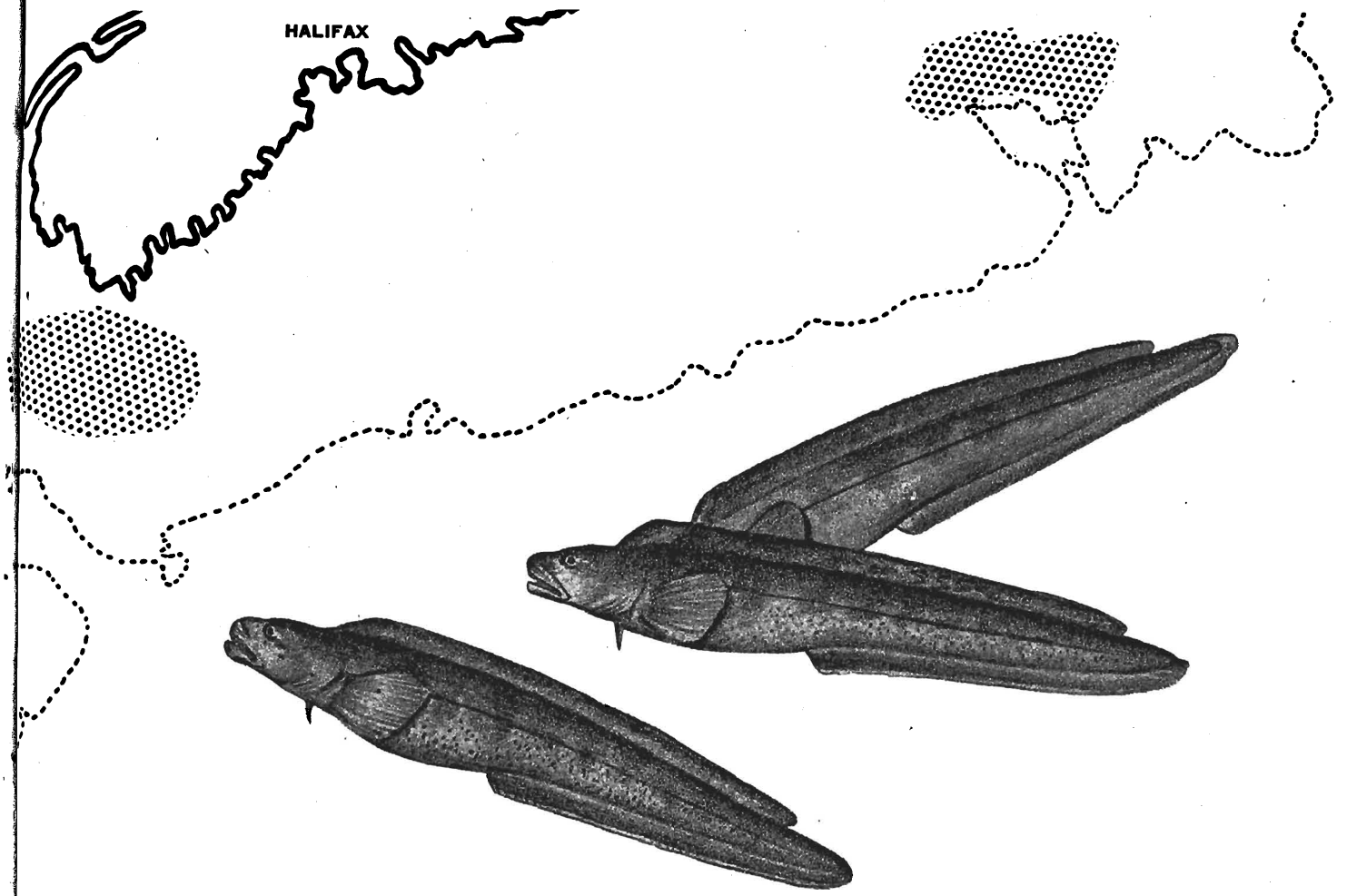
Practically the entire catch is taken by otter trawls in depths of 50 to 125 fathoms. Fishing is carried on throughout the year, but only during daylight hours, for the fish scatter or rise off the bottom at night.

Rosefish is one of the few commercial species giving birth to live young instead of eggs. The young are spawned from June until September and are abundant at or near the surface throughout the summer. The fish grow slowly at a rate of about an inch a year until around their eleventh year, when they mature. Little is known about their migrations, but there is some evidence that the larger fish move about over considerable distances so that an intensive fishery on one ground will affect the rosefish populations on others.

The rapid expansion of the rosefish fleet and catch has resulted in a considerable decline in the yield from the nearby grounds as the accumulated stocks of older fish were caught. In order to supply the market the fleet has expanded operations to progressively more distant grounds and is concentrating to an increasingly greater extent on small fish. The Fish and Wildlife Service has recently begun a study of the effect of these developments on the productivity of the rosefish resource. It is working to develop practical measures which will protect the smaller fish and otherwise provide conditions necessary for the maximum continuous yield from this fishery.

OCEAN POUT is very abundant locally, both inshore and on the outer banks. Ordinarily very small quantities of this species are landed, but wartime demands stimulated the landing of four million pounds by otter trawlers in 1943 and in 1944. Most of this quantity was taken from February to May close to New Bedford and Provincetown, Mass., and a large part of it was filleted. It is doubtful that this fish would find a large market in normal times, but it is an easily accessible source of food during periods of emergency.

Atlantic Fishery Resources GROUNDFISHES



Ocean Pout.

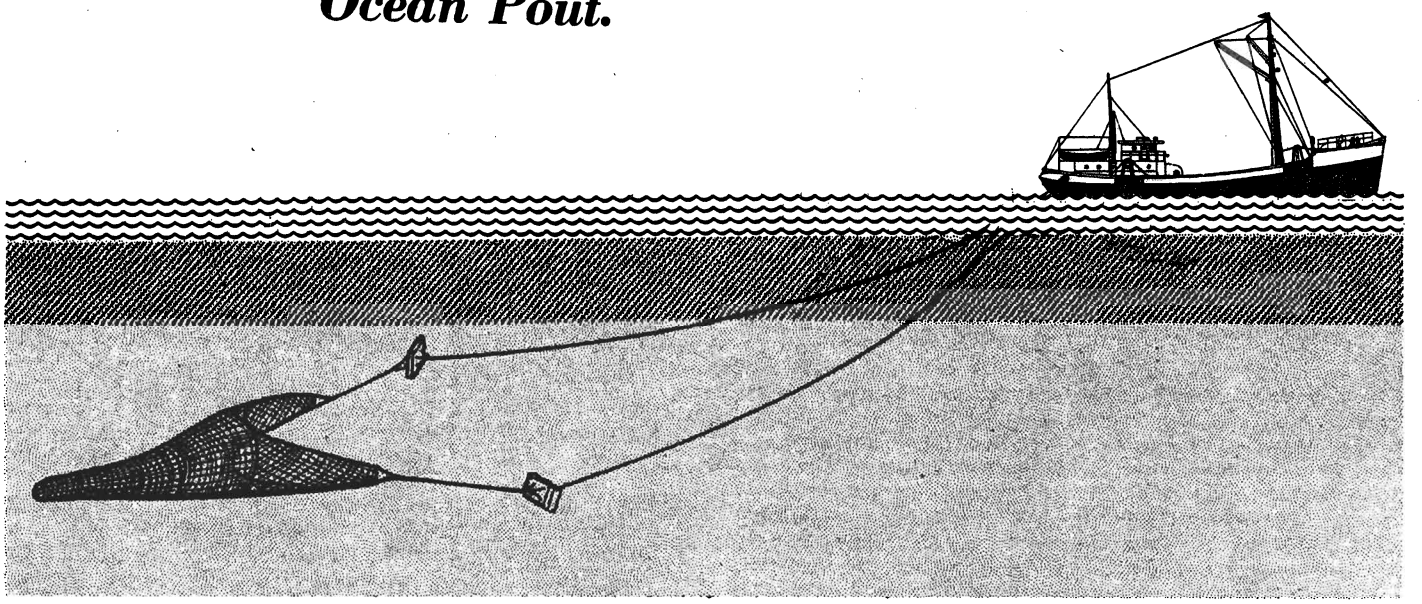
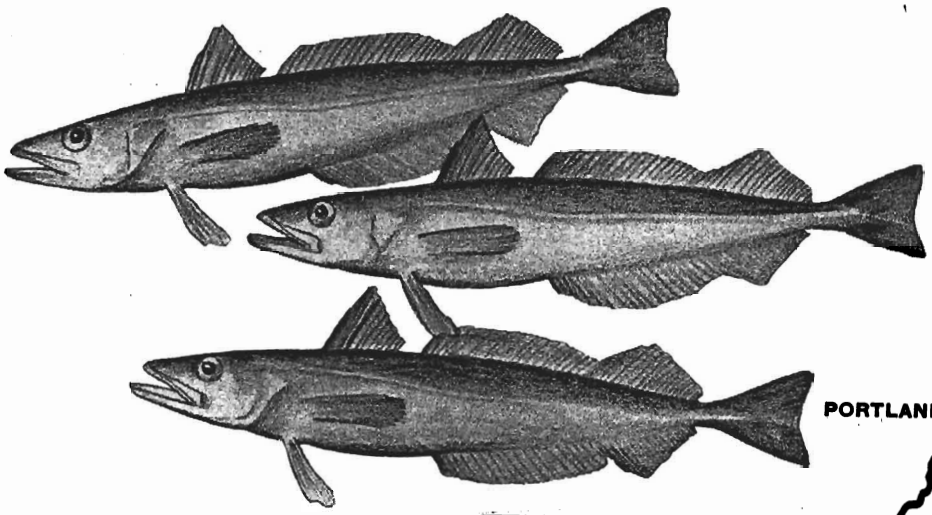


Diagram of an Otter trawl in operation.

Atlantic Fishery Resources GROUNDFISHES



Whiting

SHADING SHOWS AREAS OF CONCENTRATION

Whiting

Hake, Cusk

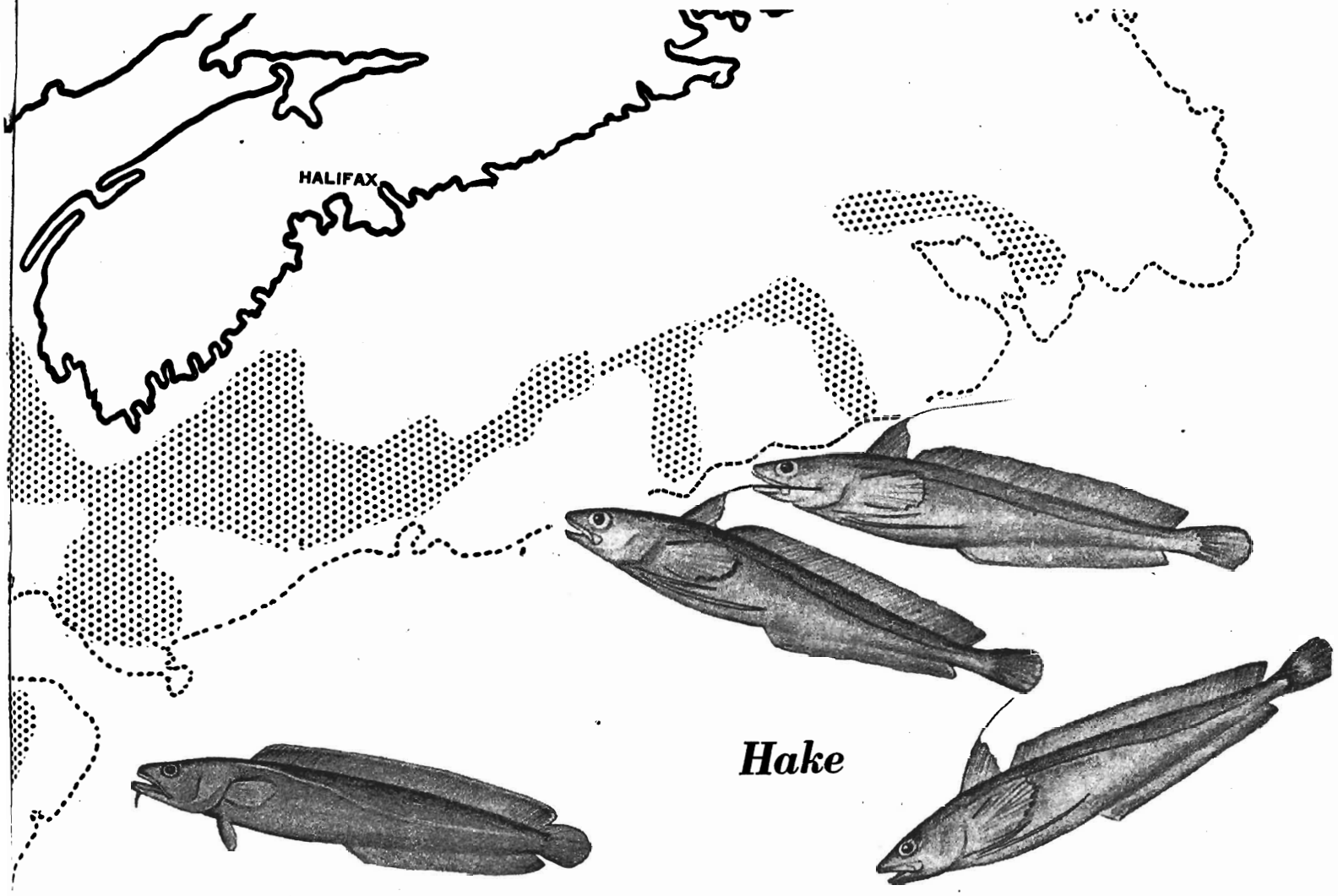
WHITING OR SILVER HAKE ARE TAKEN COMMERCIALLY FROM SABLE ISLAND TO SOUTH CAROLINA. In the Gulf of Maine they are a summer fish, appearing first in the Cape Ann-Massachusetts Bay region in March and becoming increasingly abundant as the waters warm. Off Long Island, they are common throughout most of the year, being taken offshore by otter trawlers from November through March, and inshore by pound netters from April through July. Off North Carolina they are caught in the winter trawl fishery. They are also caught with floating traps, anchored gill nets and even in purse seines. Otter trawlers, particularly of the Gloucester, Boston, and Provincetown fleets have taken increasing amounts of whiting, and the catch has consequently risen from 14 million pounds in 1930 to 50 million pounds in 1940.

The bulk of the catch is cleaned and skinned, then frozen and packaged; it is sold as pan-dressed, split, or filleted whiting. It is popular in the Middle West, especially Kansas City, where it is used in fried-fish sandwiches. Before the war some whiting and waste from filleting and skinning was canned for pet food.

NOTHING IS KNOWN regarding the extent of the population, the rate of growth, or the size at maturity of whiting, nor are more than fragmentary data available regarding nursery grounds. Whiting spawn from June through September. The eggs and subsequently the larvae drift in the currents. The young fish descend to bottom probably when 1 to 1½ inches long. Whiting are found on sandy and pebbly bottoms from the shoreline to a depth of about 300 fathoms.

Fishermen report that this fish is becoming scarcer, with former highly productive grounds now barely furnishing a day's fishing.

Atlantic Fishery Resources GROUNDFISHES



Hake

Cusk

HAKE is a name applied to several species of closely related fishes found from Newfoundland to Cape Hatteras. Two of these are taken commercially: THE WHITE HAKE, which, until very recently made up almost the entire catch, and THE RED HAKE, which had remained unutilized until wartime shortages created an unusual demand for fish in 1943 and 1944. Something over 22 million pounds of hake are now caught annually, close to 66 percent of it with line trawls, and most of the balance with otter trawls and anchored gill nets. Hake is sold fresh, frozen, salted, dried, and as smoked fillets. The air bladders are dried and used for making isinglass; the livers are collected for vitamin oils.

White hake grows to 20 to 30 pounds, but the average sized fish landed is 5 pounds or less. Red hake average a pound to two, and though of good flavor, are so soft bodied they do not keep well. Very little is known of the biology of hakes or about the extent to which the supply is being utilized. The fishery for both of these species could probably be expanded if the market warranted.

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THE CUSK is a member of the cod family and is taken in deep waters of more than 60 fathoms, the catch usually being incidental to cod fishing. Unlike most other bottom fishes, it does not school but is of solitary habit. The cusk is more important in European fisheries than it is likely to become on this side of the Atlantic, where it has never been abundant.

United States fishermen in 1940 took nearly eight million pounds of cusk. Most of the catch is made off the New England coast during the winter and spring, with small quantities landed at other seasons. More than 90 percent of the catch is made with line trawls; the balance with anchored gill nets, otter trawls, and hand lines.

Although the cusk may grow to a length of 3 feet and a weight of 30 pounds, the commercial catch consists mostly of fish 1½ to 2 feet in length, averaging 5 pounds or so in weight.

The cusk is marketed largely as fresh and frozen sticks and fillets. Some cusk fillets are smoked and sold as "finnan haddie." Until World War I almost the entire catch was salted; a small amount is still preserved in this way.

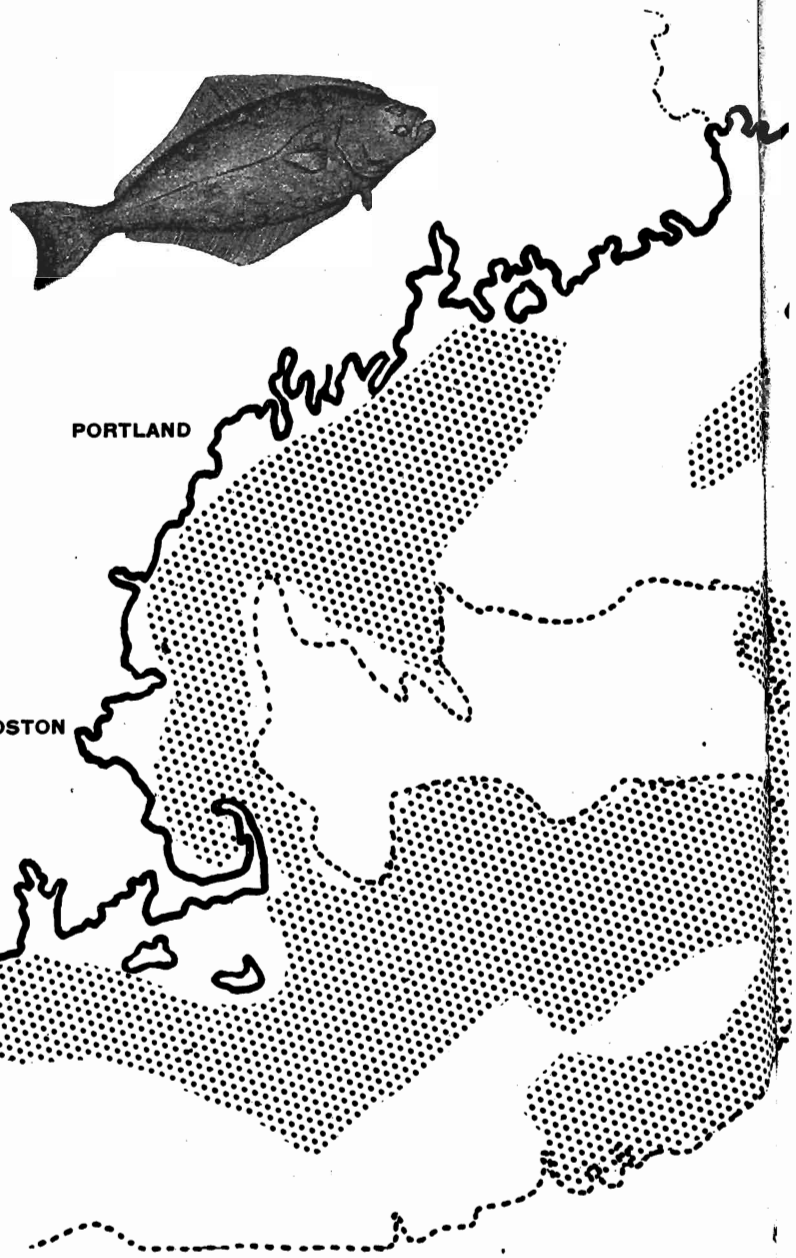
Very little is known about the biology of the cusk on the New England coast and practically nothing about the size and extent of the cusk populations and potential catch.

Atlantic Fishery Resources GROUNDFISHES

THE **FLOUNDER RESOURCE** of the North Atlantic yields about 80 million pounds a year and ranks about fourth in volume in the New England catch. Until recent years it was hardly touched, for the small mouths of many of the species saved them from the hooks of line trawls and no considerable market existed for some of the most abundant species. In 1900, for example, only 4.5 million pounds were landed. The introduction of the otter trawl and development of the filleting industry stimulated growth of the flounder fishery. Today about 97 percent of the catch is taken with otter trawls, the balance chiefly with line trawls. Most of the flounder catch is utilized by the fillet industry. A small amount of flounder is smoked; and some flounder roe is canned.

FLOUNDERS AND THEIR FLATFISH ALLIES ARE A UNIQUE GROUP OF FISHES. A newly hatched flounder swims erect like any other fish and has eyes on both sides of its head. As the young fish develops, however, one eye migrates around the head to a location next to the other eye and the fish begins to swim on its side. The body becomes much flattened, the eyed side develops color, the blind side remains white. Nearly all members of the same species are twisted in the same direction; hence flounders are designated as right-handed or left-handed, depending on which side possesses the eye and color.

All species of flounders are carnivorous, but most possess such small mouths that their diet must consist solely of small, bottom-living, invertebrate animals such as shrimps, mollusks, starfish, and worms. They spawn from midwinter to midsummer, but mostly in the spring.



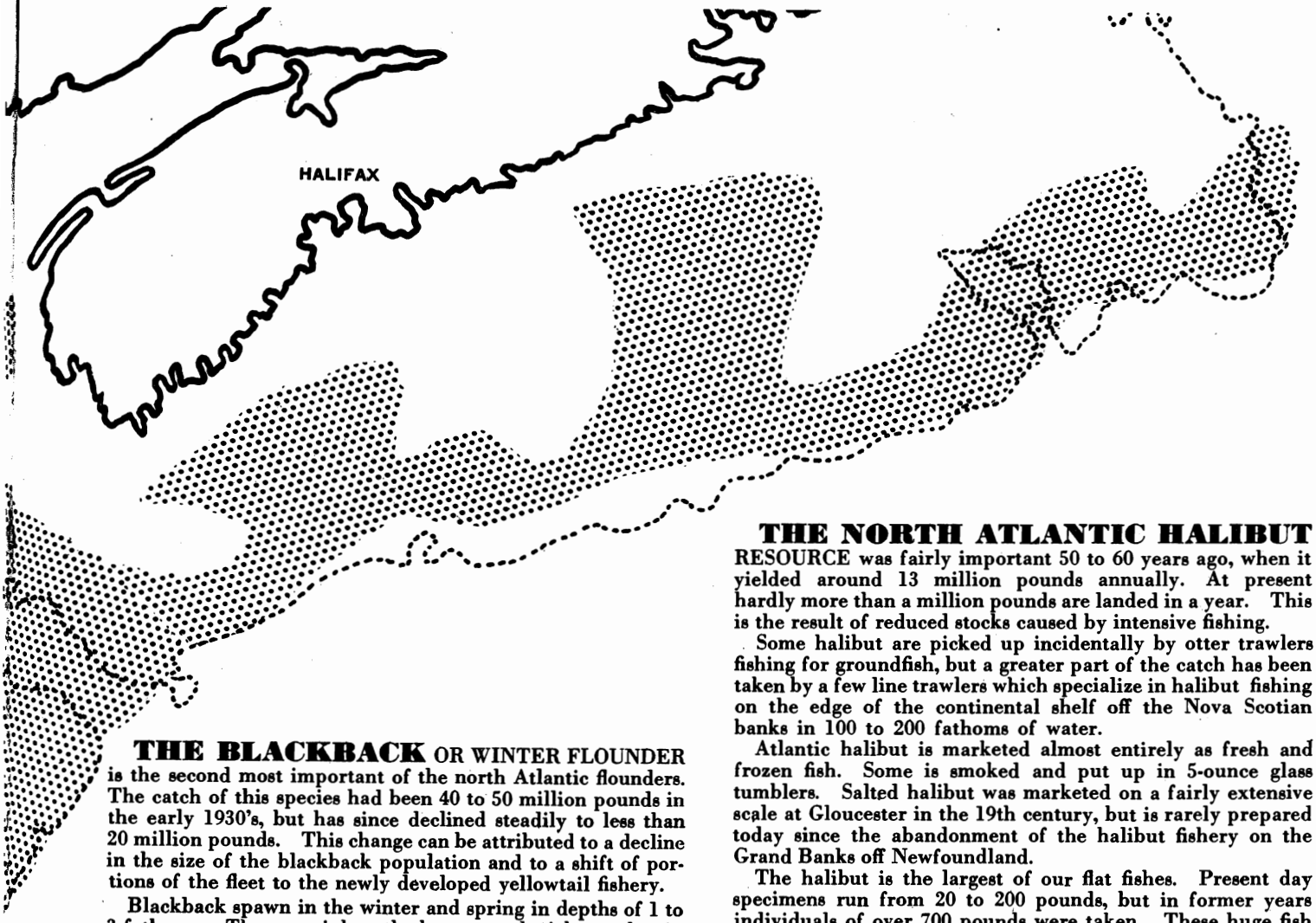
YELLOWTAIL IS THE MOST IMPORTANT OF THE NORTH ATLANTIC FLOUNDERS. Prior to about 1935 it was considered a trashfish and was landed in small quantities at very low prices. With the decline of the blackback fishery, the small otter trawlers turned to yellowtail fishing and the public learned of the excellent table qualities of this species. This led to the development of a flounder fillet industry at New Bedford and the expansion of the yellowtail fishery. In 1942 the landings of yellowtails were about 65 million pounds, surpassing those of all other flatfishes.

Since 1942 this fishery has yielded progressively smaller catches, although the intensity of fishing and the demand for yellowtail have increased. Unfortunately, we do not have enough knowledge about this resource by which to prescribe intelligent conservation measures for the fishery. Preliminary data on the biology, commercial catch, and abundance are being obtained. Much additional information is required on stocks, natural mortality, rate of growth, and effect of fishing on the stock.

Yellowtail are found in 10 to 50 fathoms of water. Like most flounders they spawn in the spring, mostly during May, along the southern New England coast. The eggs drift a short time with the currents and the young fish descend to the bottom when about ½ inch long. Yellowtails mature when 10 to 12 inches long and about 3 years old. The adults subsist mostly on small invertebrate animals such as shrimps, mollusks, worms, starfish, etc.

Tagging experiments have shown that yellowtail migrate seasonally. The appearance and disappearance of yellowtail schools and changes in the sex ratio and size composition indicate rather complex movements yet to be studied.

Atlantic Fishery Resources GROUNDFISHES



THE BLACKBACK OR WINTER FLOUNDER is the second most important of the north Atlantic flounders. The catch of this species had been 40 to 50 million pounds in the early 1930's, but has since declined steadily to less than 20 million pounds. This change can be attributed to a decline in the size of the blackback population and to a shift of portions of the fleet to the newly developed yellowtail fishery.

Blackback spawn in the winter and spring in depths of 1 to 3 fathoms. The eggs sink to the bottom and stick together in small clusters. The fish grow rapidly and become sexually mature at 8 to 10 inches and 3 to 4 years of age. The fish are relatively nonmigratory, moving only to cooler waters outside the bays in summer and back to inside waters in winter.

The rapid growth rate helps the blackback to persist under the intensive fishery. The nonmigratory habit, however, means that conservation measures must be more or less localized to fit local units of the blackback populations. To obtain better utilization of the existing supply of this resource, a minimum size limit of 10 inches has been recommended for certain waters of Long Island, New York. Allowing the fish to grow before catching them will in itself increase fishermen's tonnages and also increase the number of spawning adults.

LEMON SOLE OR GEORGES BANK FLOUNDER is a fish closely related to the winter flounder; indeed, it may be only a race of blackback flounder rather than a distinct species, though this is a matter of dispute. In any event, the trade uses the name lemon sole for individuals of both kinds which weigh over 2½ or 3 pounds. This size limit varies among dealers and among cities. About three million pounds sold under this name are caught annually. True lemon sole seem to be limited in their distribution to Georges Bank.

THE NORTH ATLANTIC HALIBUT RESOURCE was fairly important 50 to 60 years ago, when it yielded around 13 million pounds annually. At present hardly more than a million pounds are landed in a year. This is the result of reduced stocks caused by intensive fishing.

Some halibut are picked up incidentally by otter trawlers fishing for groundfish, but a greater part of the catch has been taken by a few line trawlers which specialize in halibut fishing on the edge of the continental shelf off the Nova Scotian banks in 100 to 200 fathoms of water.

Atlantic halibut is marketed almost entirely as fresh and frozen fish. Some is smoked and put up in 5-ounce glass tumblers. Salted halibut was marketed on a fairly extensive scale at Gloucester in the 19th century, but is rarely prepared today since the abandonment of the halibut fishery on the Grand Banks off Newfoundland.

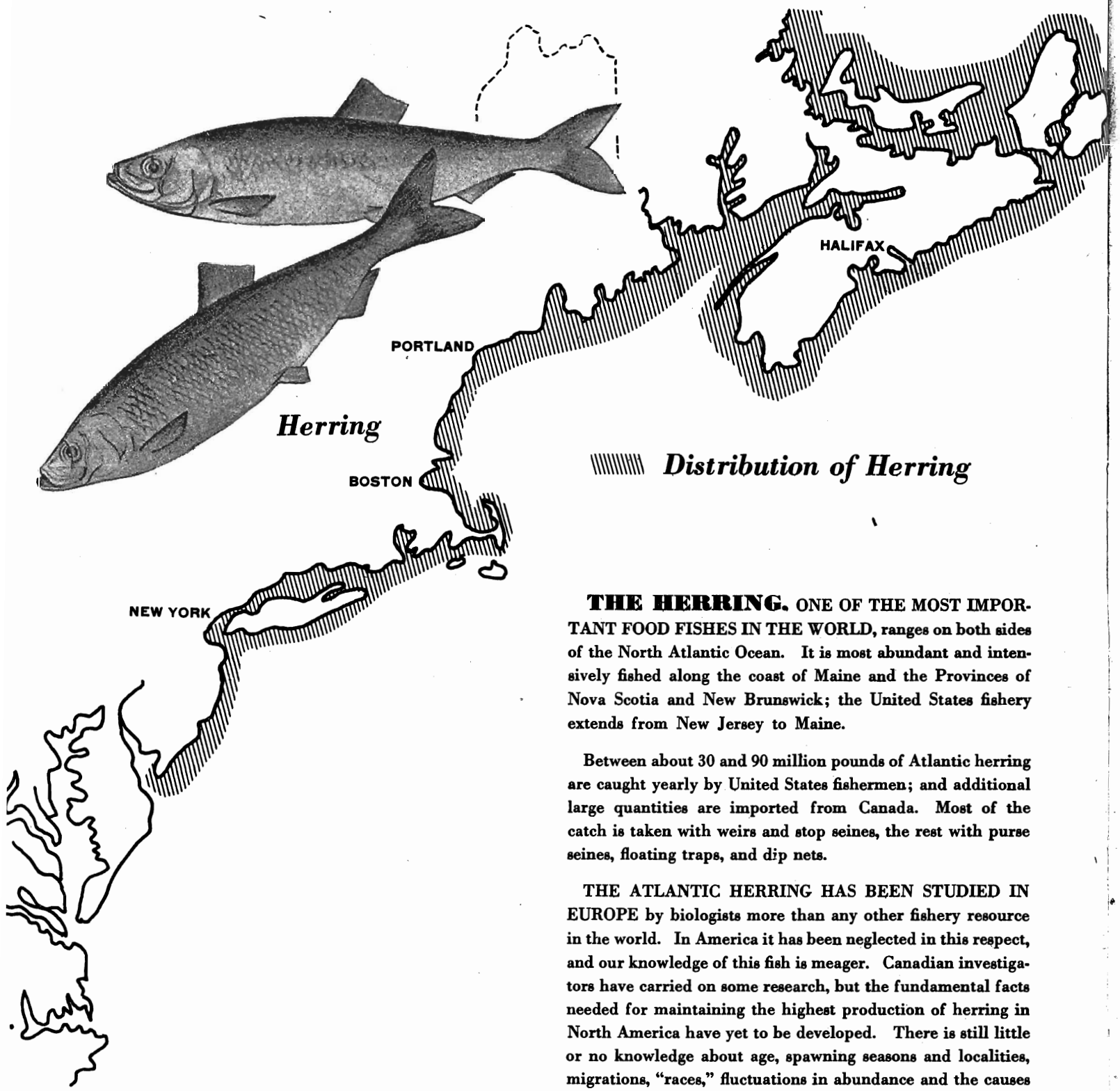
The halibut is the largest of our flat fishes. Present day specimens run from 20 to 200 pounds, but in former years individuals of over 700 pounds were taken. These huge fish are exceedingly voracious and their diet consists of various kinds of market and other fishes. If halibut are ever to be restored to the New England waters in anything like the numbers present in colonial days, it seems inevitable that a sizable share of the cod, haddock, whiting, and hake which now support important fisheries, will be required to feed them.

GRAY SOLE is one of the deeper water flounders found principally on soft, muddy, and clay bottoms in 25 to 120 fathoms of water. About 8 million pounds are caught annually, most of it by the large otter trawlers incidentally with their catches of haddock and cod.

It is marketed almost entirely as fillet of sole. Practically nothing is known about this resource on which to base an opinion as to the possibility of increasing production.

SEA DAB IS A DEEP WATER FLOUNDER taken mostly on sandy bottoms in 15 to 60 fathoms by large otter trawlers as an incidental catch while fishing for cod and haddock. About 4.5 million pounds are landed annually. It is mostly filleted and marketed as fillet of sole. Virtually nothing is known of the biology of this fish, or of the production possibilities.

Atlantic Fishery Resources HERRING

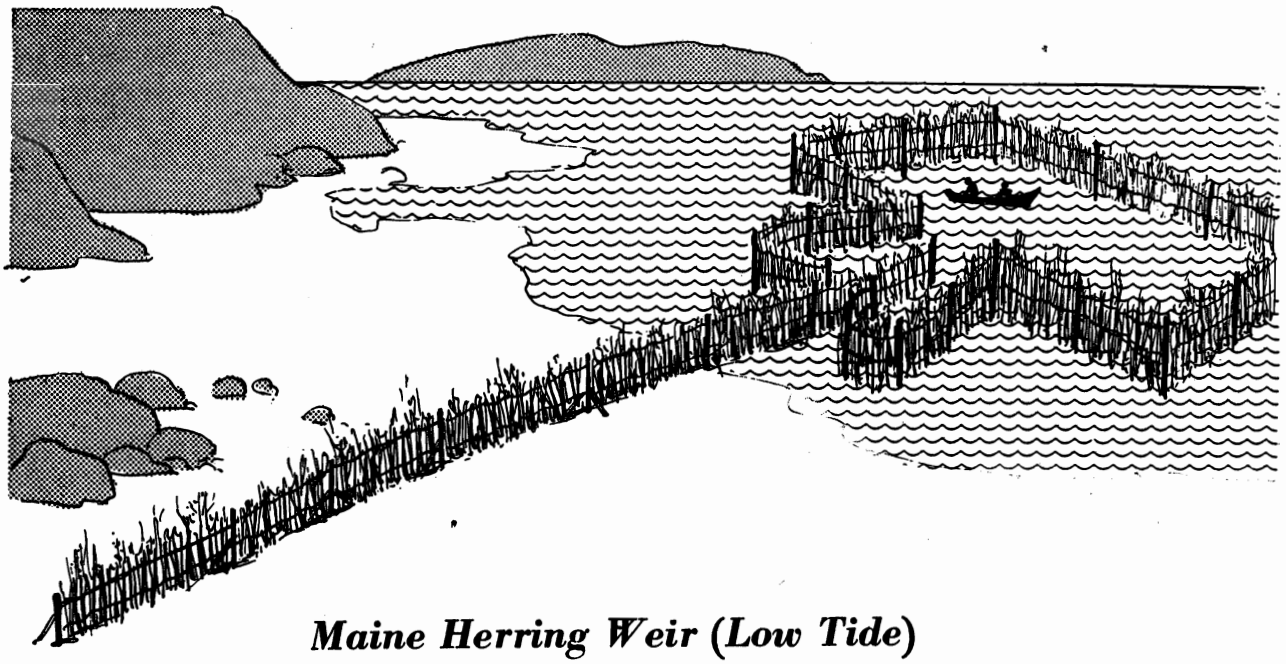


THE HERRING. ONE OF THE MOST IMPORTANT FOOD FISHES IN THE WORLD, ranges on both sides of the North Atlantic Ocean. It is most abundant and intensively fished along the coast of Maine and the Provinces of Nova Scotia and New Brunswick; the United States fishery extends from New Jersey to Maine.

Between about 30 and 90 million pounds of Atlantic herring are caught yearly by United States fishermen; and additional large quantities are imported from Canada. Most of the catch is taken with weirs and stop seines, the rest with purse seines, floating traps, and dip nets.

THE ATLANTIC HERRING HAS BEEN STUDIED IN EUROPE by biologists more than any other fishery resource in the world. In America it has been neglected in this respect, and our knowledge of this fish is meager. Canadian investigators have carried on some research, but the fundamental facts needed for maintaining the highest production of herring in North America have yet to be developed. There is still little or no knowledge about age, spawning seasons and localities, migrations, "races," fluctuations in abundance and the causes thereof, and about the effect of the fishery on the size of the stock.

Atlantic Fishery Resources HERRING



Maine Herring Weir (Low Tide)

Between the Gulf of Maine and Block Island, herring spawn in summer and fall, along the shore. The eggs are adhesive, sink to the bottom, and stick to whatever objects they meet. They incubate for several weeks, longer in colder water than in warmer. The growth rate of the young in New England waters is not known; but in the Bay of Fundy they reach about 5 inches in length when 1 year old, and 10 inches when 3 years old.

Schools of small herring occur along the inshore areas from spring to fall, usually disappear during the winter. The appearance of these schools is erratic, both in time and place. Occasionally one inshore section of the coast may swarm with herring, while another nearby area may be barren of them. There is yet no knowledge by which to explain or predict such fluctuations.

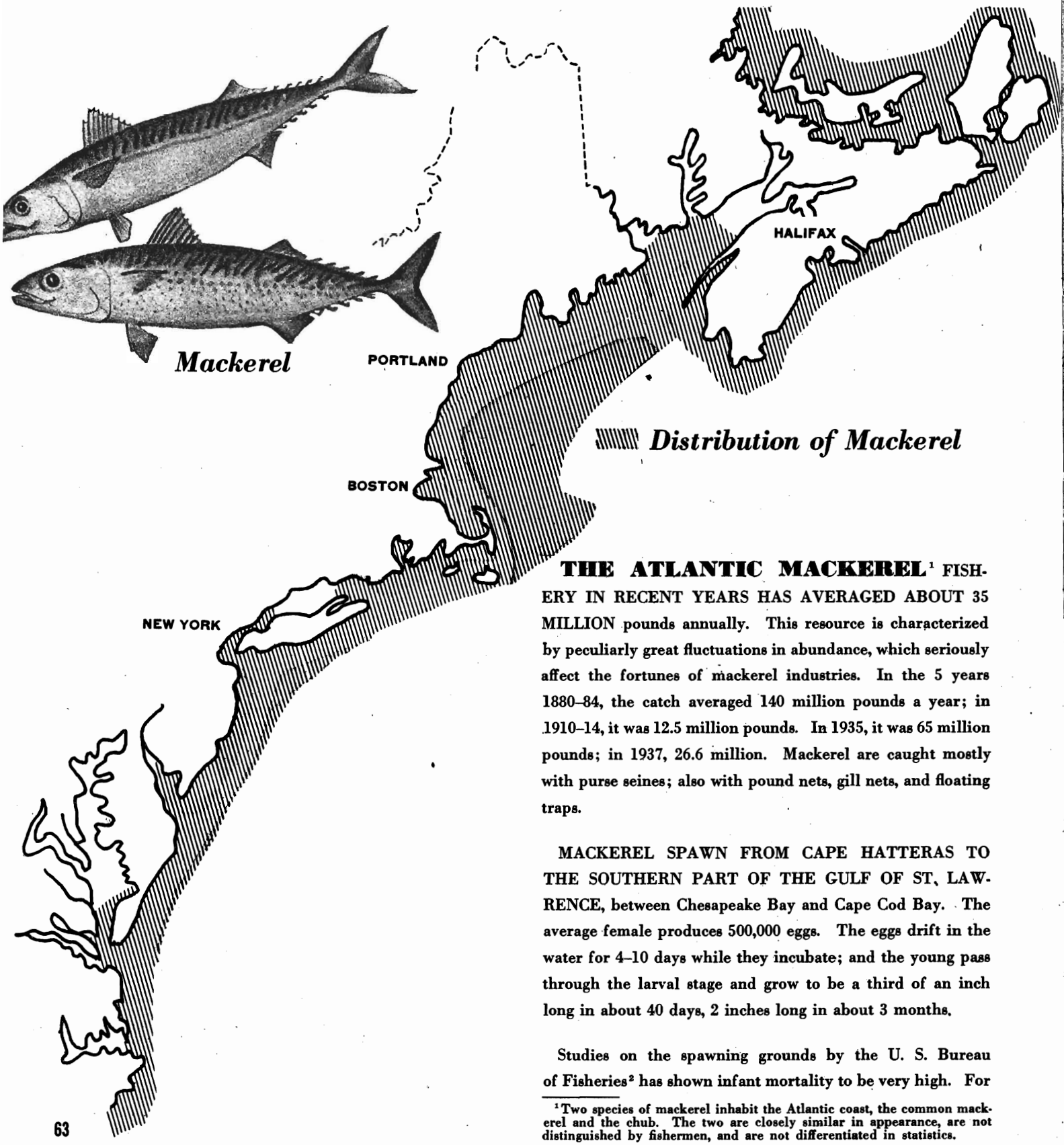
In general, the herring in Maine is subject to an intensive fishery during its first few years of life, but normally is not caught in large numbers after it reaches over 10 inches in length, for only the smaller sizes are demanded by the canneries.

The productivity of the United States North Atlantic sardine or herring industry is rarely limited by the available supply of fish. Occasionally, fish are scarce, as in 1938 when the Maine herring catch was only 16 million pounds, but ordinarily the production of any year is more or less an index of the demand for the canned product. During years when the fish are very abundant the sardine pack does not increase accordingly; however, when a scarcity of fish appears, the pack is necessarily small. In normal times the industry operates considerably below capacity. The domestic market for canned Maine sardines is limited, since this pack must, on the one hand, compete with the high quality product of other countries where the costs of labor and materials are lower than ours, and, on the other hand, with the low-price, mass-produced sardines canned on the Pacific coast.

Since 1940 Government demand has provided a market for the New England sardine fishery and about 3 million cases have been packed annually. After the war the industry will probably again be faced with increased foreign and domestic competition and limited domestic consumption.

Improved methods of processing and standardization of the pack have tended to improve the quality of the domestic product, and perhaps advertising and other efforts to increase the demand would be of great benefit to the industry.

Atlantic Fishery Resources MACKEREL



THE ATLANTIC MACKEREL[1] FISHERY IN RECENT YEARS HAS AVERAGED ABOUT 35 MILLION pounds annually. This resource is characterized by peculiarly great fluctuations in abundance, which seriously affect the fortunes of mackerel industries. In the 5 years 1880–84, the catch averaged 140 million pounds a year; in 1910–14, it was 12.5 million pounds. In 1935, it was 65 million pounds; in 1937, 26.6 million. Mackerel are caught mostly with purse seines; also with pound nets, gill nets, and floating traps.

MACKEREL SPAWN FROM CAPE HATTERAS TO THE SOUTHERN PART OF THE GULF OF ST. LAWRENCE, between Chesapeake Bay and Cape Cod Bay. The average female produces 500,000 eggs. The eggs drift in the water for 4–10 days while they incubate; and the young pass through the larval stage and grow to be a third of an inch long in about 40 days, 2 inches long in about 3 months.

Studies on the spawning grounds by the U. S. Bureau of Fisheries[2] has shown infant mortality to be very high. For

[1] Two species of mackerel inhabit the Atlantic coast, the common mackerel and the chub. The two are closely similar in appearance, are not distinguished by fishermen, and are not differentiated in statistics.

[2] Now Fish and Wildlife Service.

Atlantic Fishery Resources MACKEREL

IN 1940, IT IS ESTIMATED THAT:

1.8 million pounds were canned.
2.5 million pounds were filleted.
6.0 million pounds were salted or smoked.
30.3 million pounds were sold fresh or frozen.

The annual pack of canned mackerel has since increased nine times over the above figure in response to wartime demands, is expected to return to former levels after the war.

example, in 1932, of every million eggs spawned, only four young fish survived the first 3 months. That was apparently a year of unusually high mortality, owing either to an abnormal scarcity of feed or to unfavorable winds which drifted the young away from grounds favorable to survival. The fish grow rapidly, and spawn for the first time when 2 years old and 12 to 16 inches long.

They first appear in March and April off Chesapeake Bay, and progressively later off the middle Atlantic and southern New England coast. In late June and July they travel around Cape Cod into the Gulf of Maine and also appear off western Nova Scotia. In September the return migration begins and mackerel reappear south of Cape Cod, where a few may be taken through December and January.

Violent year-to-year variations in the catch are at least partly the result of wide variation in the size of annual broods. This variation is further increased by the fact that there are two types of year broods, one of which makes an important contribution to the fishery for many years while the other soon disappears. Fluctuations in catch are also caused by variation in habits of the fish, resulting from changing environment. For example, in 1937, even though scientific evidence indicated a large supply of mackerel in the North Atlantic, fishermen could not locate them, and the catch was the lowest in many years. That summer was noted for its warm, calm weather which resulted in unusually high surface temperatures along the New England coast. These conditions may so have affected the mackerel's distribution and movements that the fish could not be located and captured by the usual forms of gear.

VARIATIONS IN THE AVAILABILITY OF MACKEREL MAKE THIS FISHERY AN UNUSUALLY GREAT GAMBLE, even for the traditionally uncertain fishing industry. The fisherman must gamble when he outfits for spring, and the dealer must gamble in developing and maintaining an adequate market geared to the supply. Consequently it is hard to handle at good prices any great increase in the catch. This appears to be the chief factor in recent years limiting the size of the fleet and consequently the catch. There is still too little knowledge on this resource by which to set a course of action that will materially increase the total mackerel population or reduce the magnitude of the annual variations.

Where it is impossible to control natural phenomena affecting man's well-being, sometimes anticipation of the magnitude and range of their occurrence will be of value. A foreknowledge of the size and availability of the mackerel runs during the approaching summer would assist the fisherman in making his decision concerning conversion to mackerel fishing and would enable the dealer to anticipate his requirements and potential supplies of fish.

Attempts have been made to utilize the results of the mackerel studies to predict the coming year's catch. In normal years the predictions were realized with a fair degree of accuracy, but unusual conditions which developed in 1937 and to a lesser extent in 1939 caused the catches to drop far below the predicted amounts. If the cause of these deviations can be determined, it may be possible to develop a predicting service of material assistance to the mackerel industry.

Atlantic Fishery Resources SALMON

ATLANTIC SALMON IS AN EXAMPLE OF A RESOURCE WHICH, THROUGH NEGLIGENCE, IS NOW ALMOST LOST TO US. Once salmon were abundant in nearly every river tributary to the Atlantic north of the Hudson. Only those rivers were without this splendid fish that had no suitable spawning grounds or were blocked off by natural falls. Today, remnants of Atlantic salmon runs in the United States are found only in a few rivers in eastern Maine. This natural resource has been brought to such a sad condition chiefly by impassable dams; also by pollution from industrial developments, by overfishing with traps and gill nets in the narrow estuaries of the rivers, and by destruction of seaward-migrating young salmon in water diversions to power-plant canals, turbines, etc.

IF THE ATLANTIC SALMON RESOURCE IS TO BE RESTORED as much as present conditions permit, as it certainly should be, these forces of destruction must be corrected. This requires an analysis of the present condition of the streams. All dams and water diversions must be located and studied, the former to determine whether and how each could be modified to permit the salmon to surmount it, the latter to determine how each could be blocked off to keep salmon out. The locus, extent, and effect of pollution must be surveyed and methods developed for its abatement.

Even though all dams be provided with fish ladders and all diversion ditches be screened, many of the streams have so changed from their primeval character that they may now be quite unsuitable for salmon. A consequence of industrialization and land cultivation is deforestation. This destroys the native biological equilibrium. Without a water-retaining mechanism, summer temperatures soar and stream flow slows; and without a soil retainer, silt covers the gravel of stream beds which salmon require for spawning grounds. A stream so modified may harbor a population of warm-water fishes with which salmon could never compete in the battle for existence.

TO INCREASE, BY MANAGEMENT, THE SIZE OF PRESENT RUNS IN STREAMS where salmon still survive, it is necessary to count the number of spawners each year, the number of their offspring down-stream migrants, and the number of returning adults. The interrelations between these quantities must be determined as well as the effect on them of the several destructive forces, including fishing.

Restoration of runs in rivers where salmon are now extinct presupposes restoration of suitable salmon habitats, i. e., stream improvement. Eggs must then be obtained from other streams and scientifically hatched, reared, and planted.

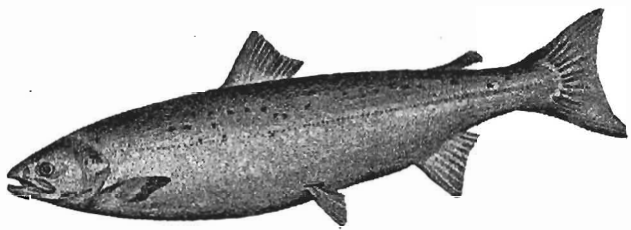
With present limited knowledge of the conditions existing in North Atlantic Rivers, it is unfeasible to estimate the extent to which sport and commercial fisheries can be developed. Nevertheless, there is no doubt that with proper study and stream improvement large salmon runs reaching thousands and perhaps hundreds of thousands of fish can be developed in many rivers from eastern Maine to the Hudson.

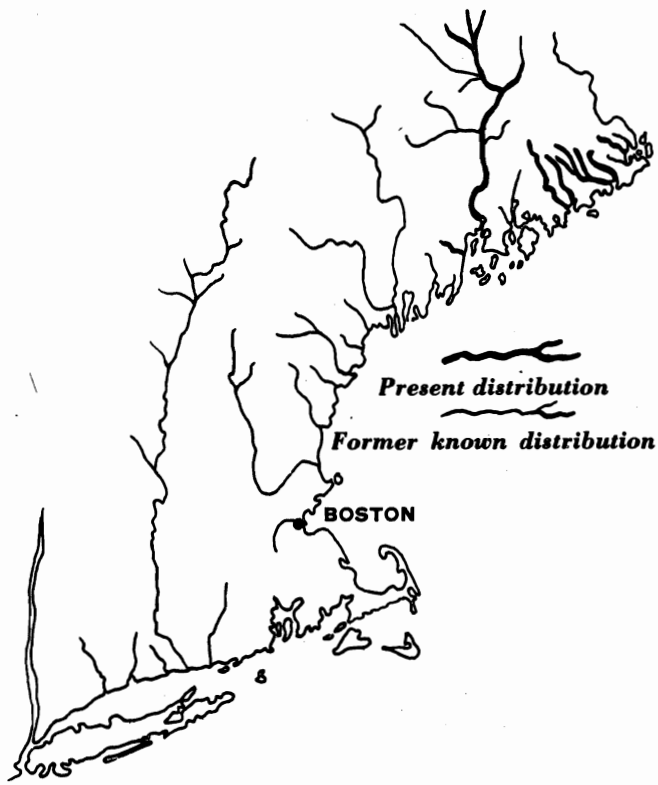
Certain species of Pacific salmon have been introduced to determine whether they will thrive in certain rivers in combination with Atlantic salmon and in small rivers poorly suited to Atlantics. Experiments so far have been confined to the silver salmon, an excellent game fish weighing over ten pounds.

THE EGGS ARE DEPOSITED IN GRAVEL IN NOVEMBER, hatch in 5 to 6 months. For about four weeks after hatching the fish lives on the food in its yolk sac. Then it pushes its way out of the gravel, becomes free-swimming, hides from predators behind boulders in quiet places just below the riffle areas. The current transports to the babies food consisting of small fish and crustaceans. During its stream life the young salmon is known as a parr, grows slowly, is characterized by black bars or parr marks running vertically down the sides, and by bright red spots. Enemies are pickerel, bass, eels, trout, kingfishers, mergansers. After the end of the third winter the parr loses its bright markings and takes on a glistening silver dress. It is then called a smolt, is five to six inches long. It migrates to sea from late spring to early summer, and remains there for 2 years.

The smolt grows rapidly in the sea, feeding on launce, herring, and capelin, among other things.

From June to late October of their fifth year the adults return, weighing now 8 to 16 pounds. After spawning, most of the spent fish return to sea. A few stay in the rivers over winter to return to sea in the spring.





Atlantic Fishery Resources ALEWIFE

ALEWIVES, OR RIVER HERRING, members of the herring family, enter the coastal rivers of eastern United States in the spring and return to the ocean after spawning. During their short sojourn in the streams they support one of the principal river fisheries of the Atlantic coast with an annual yield of nearly 30 million pounds. The most important fisheries for alewives are in the Chesapeake Bay area, the South Atlantic States, and New England, in the order named.

The canning of alewives and their roe is the chief seafood-canning industry of the Atlantic coast from Massachusetts to Georgia. Only a small amount of the catch is eaten fresh, much of it is salted, another and possibly larger share is cured in salt and vinegar for use in making such special herring products as bismarck herring and rollmops. Some are smoked. Byproducts are dry scrap for fertilizer, oil, and pearl essence from the scales.

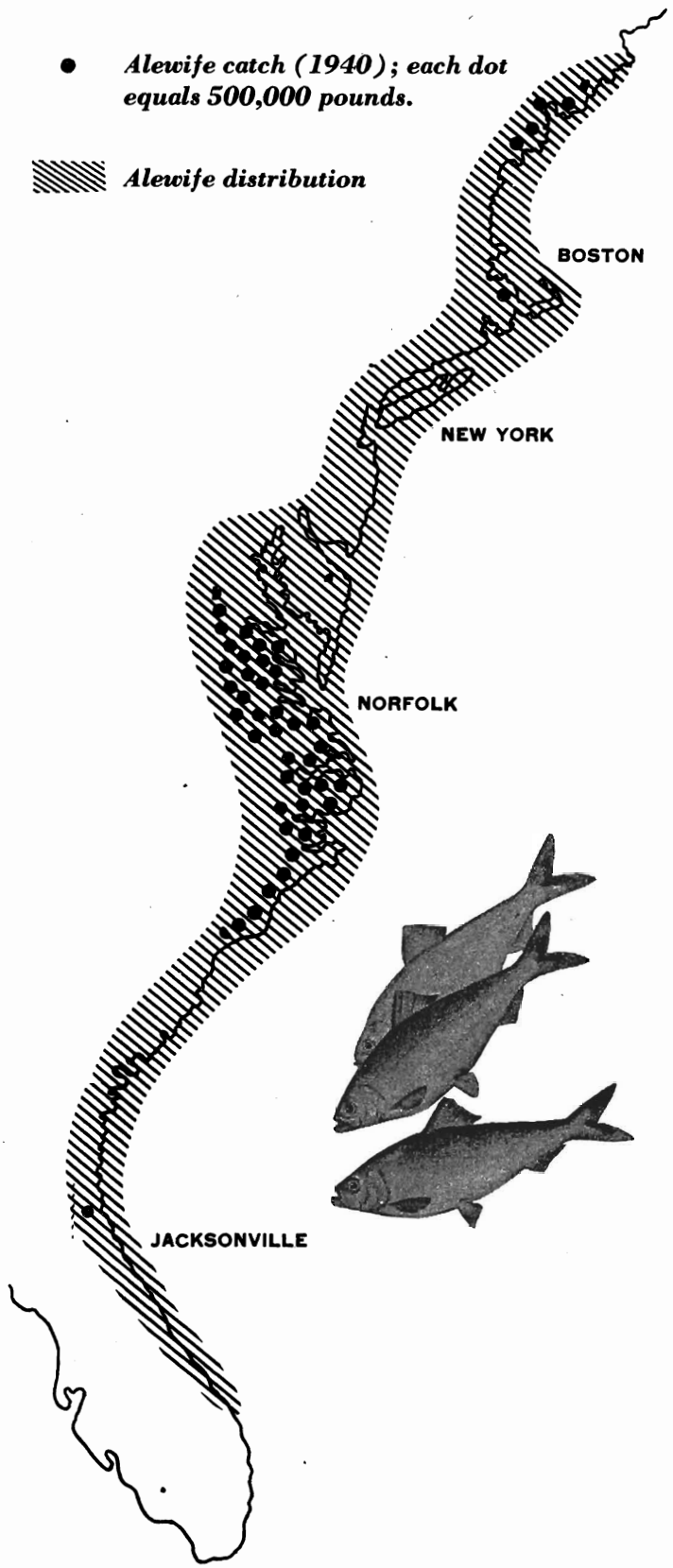
The alewife fisheries are supported by two species with overlapping ranges, the "true" alewife or branch herring found from Nova Scotia and the Gulf of St. Lawrence to the Carolinas, and the blueback, found from the Bay of Fundy to Florida. Fishermen usually do not distinguish the species. In general, however, the branch herring predominates in the catch in the North Atlantic area; the blueback in the Chesapeake Bay and South Atlantic States.

The spawning runs of alewives begin in March in Chesapeake Bay and in April in New England. The fish usually arrive in tremendous numbers, move upstream to the spawning grounds during the daylight hours, and return to the sea almost immediately after spawning. The young hatch in 2 to 6 days, depending on the temperature, develop rapidly, and in the fall descend to salt water as 2- to 4-inch fish.

In New England alewives are caught chiefly with dip nets during the spawning migration. Pools are constructed about the mouths and in the lower part of the streams, and the fish are led into them by nets and stone diversions and are then easily captured. In Chesapeake Bay most of the catch is taken by pound nets.

THE ALEWIFE IS ANOTHER EXAMPLE OF A RESOURCE which has declined sharply through mismanagement. Although depletion has occurred in all areas, it has been most severe in New England, and the causes there are better understood. These are lack of fishways to pass the fish over dams, poorly designed fishways, and excessive fishing.

In New England the size of the alewife runs is limited chiefly by the extent of the lake area available for the young, the largest runs all originating from lakes of fair size. In order to maintain as large a run to a stream as the lake area permits, sufficient adults must be allowed to escape the fishery for spawning. All obstructions must be equipped with adequate fishways, providing for the safe passage of both upstream and downstream migrants, and these fishways should be inspected periodically to keep them in good repair. To carry out this program it will be necessary to determine, by careful experiment, the number of spawning fish required in each stream to maintain the maximum runs. Runs may be established in streams where they are now lacking, by planting spawning adults.



Atlantic Fishery Resources SHAD

SHAD are a great American delicacy and among the most famous of our table fishes. They spend part of the year in the ocean and enter fresh water in the spring to swim up the rivers for spawning. Once they were among the most abundant fish along the coast, and 50 years ago the commercial production of shad was surpassed only by that of cod and salmon. Now, in contrast, the catch ranks thirtieth among the fisheries of the United States.

THE HISTORY OF THE SHAD RESOURCE HAS BEEN ONE OF BAD MANAGEMENT: The colonists who came to America in the seventeenth and eighteenth centuries found the shad in such abundance that they thought the runs were inexhaustible. With great nets, some nearly a mile long, they caught more shad migrating up river to spawn than they needed for food, sold them for as little as a dollar a wagonload to fertilize fields. By the middle of the nineteenth century severe depletion of the runs was reported in all the principal fishing areas. Artificial propagation was developed in an attempt to restore the runs to their former abundance. More than a billion larvae were released from the hatcheries between 1880 and 1910.

The earliest record of a total annual catch of shad from the various runs is for 1880, when only 17 million pounds of shad were taken. The catch increased rapidly to 50 million pounds by 1896.

This increase was attributed to artificial propagation. The possibility of its being connected with improvements in fishing methods and increased fishing intensity was overlooked. After 1900 the catches in all the rivers declined to the point where hatcheries experienced difficulty in securing enough eggs to maintain a large enough output of larvae for planting in the streams. The fishing intensity had grown out of proportion to the size of the resource.

DECLINE OF SHAD RUNS. Although the early phases of the decline of the shad fishery are not documented by records of annual production, the later phases after 1896 are clearly shown by published statistics of the decreasing annual catches. Since there is a separate race of shad indigenous to each river the rate of decline differs somewhat from river to river, but there are features of similarity in the declines of many runs. Most striking was the sudden drop in production for all rivers between 1896 and 1908—from 50 to 26 million pounds. The decline since 1908 has been more gradual but no less definite; and the catch totaled only 10 million pounds in 1940.

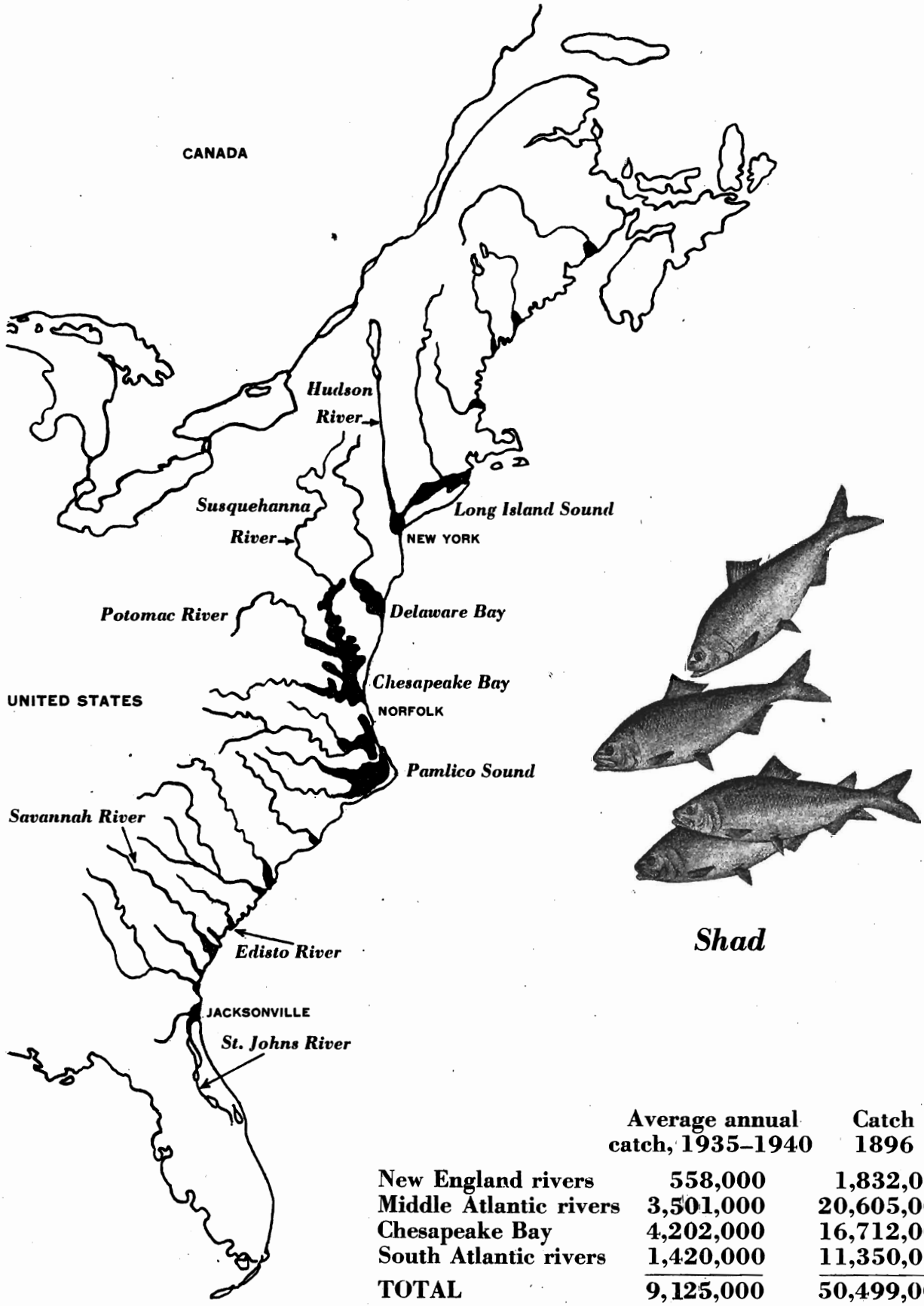
THERE WERE THREE MAIN CAUSES FOR THE DECLINE: OVERFISHING, POLLUTION, AND ERECTION OF DAMS. OVERFISHING was the most destructive of these causes because it was operative in all the rivers and bays over a long period of years. POLLUTION only became an important factor with the industrialization of sections adjacent to shad streams. Pollution is detrimental to shad in several ways. It reduces the dissolved oxygen content of the water and introduces toxic substances especially harmful to the young. The flesh of the adult fish takes on an unpleasant oily flavor from polluted water which reduces their market value. DAMS erected across the rivers on or below the spawning grounds have reduced natural reproduction. Shad have failed to ascend fish ladders installed for them in existing dams. It is possible, however, that suitable ladders may be designed eventually that will reopen spawning grounds long shut off by power dams.

SHAD RUNS CAN BE INCREASED, as has been demonstrated in the Hudson River since 1935. There, by the simple expedient of fishing shad at a moderate instead of an excessive rate, enough spawning adults have been spared to rebuild the runs by natural reproduction. In 1944 Hudson River fishermen took less than 40 percent of the run, *yet they caught more pounds of shad than at any previous time when fishing rates were much higher.*

In Chesapeake Bay, where the catches of shad had continued to decline, the fishery took over 90 percent of the run in 1938. Owing to manpower shortage since the war this figure has been reduced to about 77 percent. During World War I a similar reduction in fishing rate was followed by increased catches from 1920 to 1931. Unfortunately, then, the fishing intensity, i. e., quantity of gear used, was permitted to increase, with consequent destructive effects on the resource. So gains made during the war period of moderate fishing were lost and catches declined still further from 1932 to 1942. In 1941, Maryland alone, of the two States responsible for the Chesapeake Bay fishery, adopted a management plan by which licensed fishermen and the gear employed by them were limited.

METHODS OF UTILIZING THIS RESOURCE CAN BE IMPROVED. As shad runs are built up, shad products should be developed and improvements made in methods of handling and marketing in order to reach a wider market. Retailers in small communities who now receive only occasional lots of poor quality fish must be assured of regular shipments of high quality. This in return requires a study of retailing equipment. Many retailers are not equipped to hold fish in good condition.

Several new shad products have already been developed. Shad has been canned on the Columbia and Sacramento Rivers for some years, but, as it was packed salmon style and has a soft texture and pale color, it competed only with the cheapest salmon. One of the new canned products is smoked or "kippered" shad. This has a firmer texture, a deeper color, and a more pronounced smoky flavor and is selling as a fancy-grade product. Canned-shad fillets wrapped in parchment paper may be broiled and eaten without fear of the bones which are entirely softened in the canning process. A new frozen product is also possible—filleted, boned shad. This has been prepared successfully on an experimental basis.



Shad

	Average annual catch, 1935–1940	Catch 1896
New England rivers	558,000	1,832,000
Middle Atlantic rivers	3,501,000	20,605,000
Chesapeake Bay	4,202,000	16,712,000
South Atlantic rivers	1,420,000	11,350,000
TOTAL	9,125,000	50,499,000

Atlantic Fishery Resources SHAD

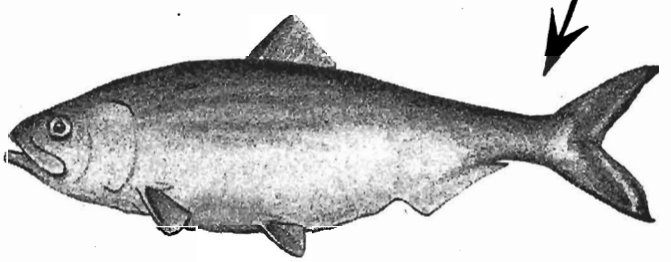
Larvae—One-half to four-fifths inch long.

About 2 weeks after hatching the larval shad is one-half to four-fifths inch long, but bears little resemblance to its parents. After several weeks, however, they transform to become more fishlike in appearance with full scalation. During this period they live in rivers, feed on minute crustaceans and other small forms of aquatic life.

Fingerlings—3 to 5 inches long.

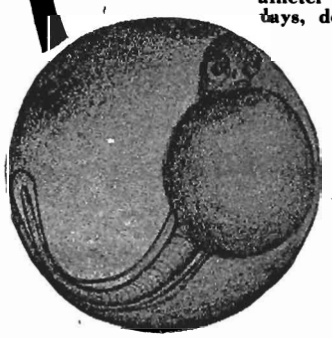
Having spent their first summer on the fresh-water nursery grounds, in the autumn the young shad, then 3 to 5 inches long, migrate down the rivers and out into the ocean. They do not return until they have grown to sexual maturity. The ocean habitat of the shad has never been discovered. A few young shad are caught with schools of whitebait during winter along the shores of Long Island, and small catches have been made with herring off the coasts of Maine and Massachusetts, but the main body of fish evades all types of nets wherever they have thus far been fished. Perhaps the shad seek deep-water feeding grounds offshore from the rivers of their origin, possibly in the Gulf Stream, where temperatures vary little from one season to the next.

Adult shad—fish 12 to 24 inches long—return to the fresh-water spawning grounds of the rivers of their nativity to deposit their spawn. Some of the males, or "bucks," return when 3 or 4 years old and females, or "roes," come in a year or two later, although a few may stay out until they are 7 or 8 years old before making their first spawning migration. So consistently do shad return to spawn in the rivers where they were hatched that a separate race has developed in each river.

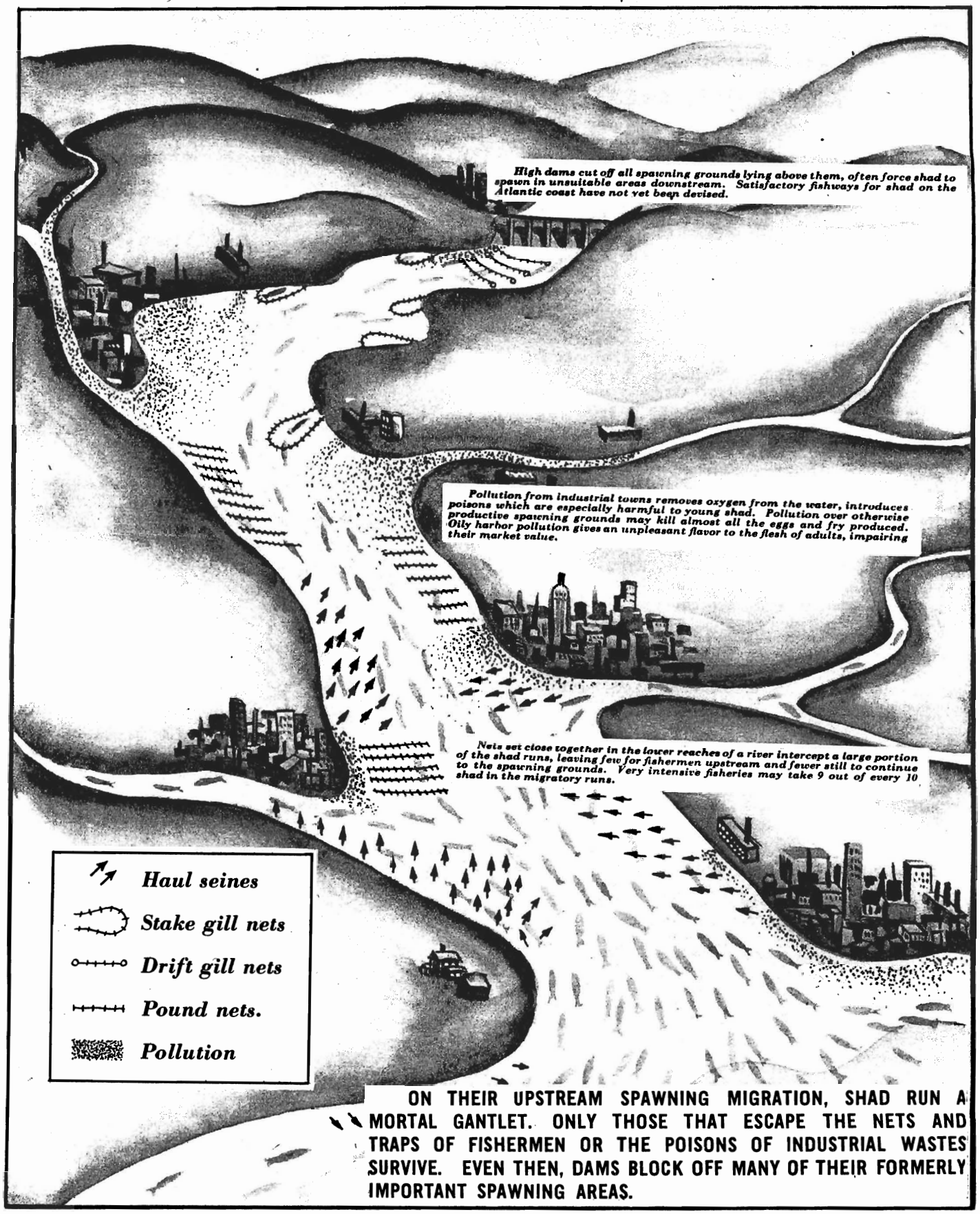


Adults—12 to 24 inches long.

The eggs are deposited on the spawning grounds in the fresh-water sections of the rivers during the spring, after the water has warmed to 54° F. The eggs are about one-eighth inch in diameter and usually hatch in 4 to 8 days, depending on the temperature.



Egg—One-eighth inch in diameter.



ON THEIR UPSTREAM SPAWNING MIGRATION, SHAD RUN A MORTAL GANTLET. ONLY THOSE THAT ESCAPE THE NETS AND TRAPS OF FISHERMEN OR THE POISONS OF INDUSTRIAL WASTES SURVIVE. EVEN THEN, DAMS BLOCK OFF MANY OF THEIR FORMERLY IMPORTANT SPAWNING AREAS.

Atlantic Fishery Resources, MENHADEN

THE MENHADEN, in a sense, is the Atlantic counterpart of the Pacific sardine. It, too, is a member of the herring family, and though its population is very much smaller than that of its Pacific coast relative, it is nevertheless a large one. Unlike the Pacific sardine, the menhaden is used almost exclusively in the manufacture of meal and oil; only small quantities are canned.

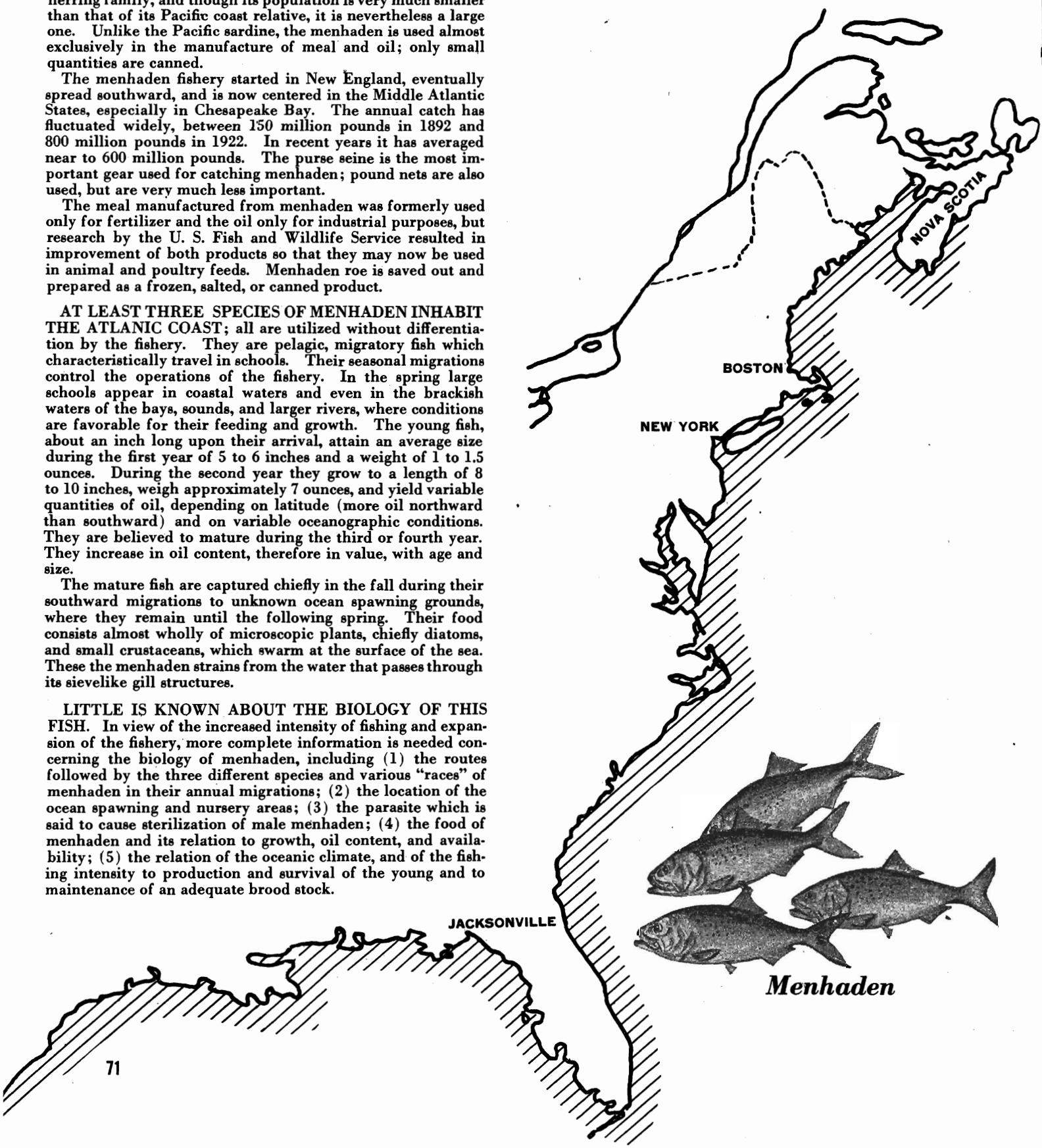
The menhaden fishery started in New England, eventually spread southward, and is now centered in the Middle Atlantic States, especially in Chesapeake Bay. The annual catch has fluctuated widely, between 150 million pounds in 1892 and 800 million pounds in 1922. In recent years it has averaged near to 600 million pounds. The purse seine is the most important gear used for catching menhaden; pound nets are also used, but are very much less important.

The meal manufactured from menhaden was formerly used only for fertilizer and the oil only for industrial purposes, but research by the U. S. Fish and Wildlife Service resulted in improvement of both products so that they may now be used in animal and poultry feeds. Menhaden roe is saved out and prepared as a frozen, salted, or canned product.

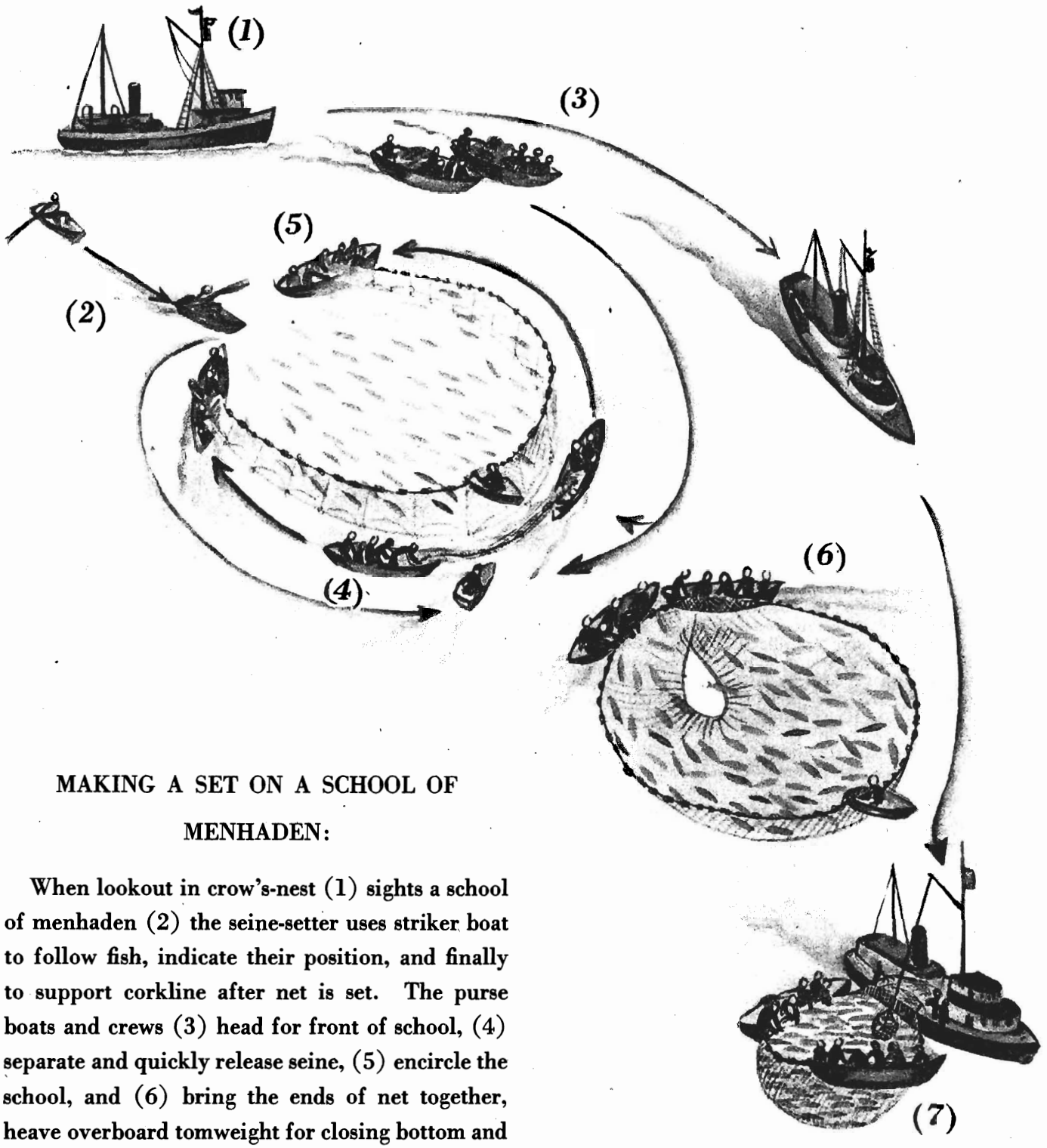
AT LEAST THREE SPECIES OF MENHADEN INHABIT THE ATLANIC COAST; all are utilized without differentiation by the fishery. They are pelagic, migratory fish which characteristically travel in schools. Their seasonal migrations control the operations of the fishery. In the spring large schools appear in coastal waters and even in the brackish waters of the bays, sounds, and larger rivers, where conditions are favorable for their feeding and growth. The young fish, about an inch long upon their arrival, attain an average size during the first year of 5 to 6 inches and a weight of 1 to 1.5 ounces. During the second year they grow to a length of 8 to 10 inches, weigh approximately 7 ounces, and yield variable quantities of oil, depending on latitude (more oil northward than southward) and on variable oceanographic conditions. They are believed to mature during the third or fourth year. They increase in oil content, therefore in value, with age and size.

The mature fish are captured chiefly in the fall during their southward migrations to unknown ocean spawning grounds, where they remain until the following spring. Their food consists almost wholly of microscopic plants, chiefly diatoms, and small crustaceans, which swarm at the surface of the sea. These the menhaden strains from the water that passes through its sievelike gill structures.

LITTLE IS KNOWN ABOUT THE BIOLOGY OF THIS FISH. In view of the increased intensity of fishing and expansion of the fishery, more complete information is needed concerning the biology of menhaden, including (1) the routes followed by the three different species and various "races" of menhaden in their annual migrations; (2) the location of the ocean spawning and nursery areas; (3) the parasite which is said to cause sterilization of male menhaden; (4) the food of menhaden and its relation to growth, oil content, and availability; (5) the relation of the oceanic climate, and of the fishing intensity to production and survival of the young and to maintenance of an adequate brood stock.



Menhaden



MAKING A SET ON A SCHOOL OF MENHADEN:

When lookout in crow's-nest (1) sights a school of menhaden (2) the seine-setter uses striker boat to follow fish, indicate their position, and finally to support corkline after net is set. The purse boats and crews (3) head for front of school, (4) separate and quickly release seine, (5) encircle the school, and (6) bring the ends of net together, heave overboard tomweight for closing bottom and guiding purseline as it is hauled in to purse the net. The crews haul in ends and bottom of net, concentrate the fish in the center portion of seine, which (7) is placed against the side of menhaden steamer and the catch brailed into the hold.

Atlantic Fishery Resources SHORE FISHES

THE SHORE FISHES OF THE AREA FROM CAPE COD TO CAPE HATTERAS comprise a natural resource of approximately 60 species, including exclusively marine fishes as well as those that enter fresh water to spawn. A dozen or more of the shore fishes have considerable commercial value; many others are popular with the salt-water anglers.

Much of the shore-fish resource is composed of migratory populations of fish that move from offshore, southern wintering areas to inshore, northern grounds in the summer. Formerly these fish were taken only during the summer in inshore waters; since 1930, however, an intensive winter fishery by otter trawls has been carried on in the offshore region extending from approximately 80 miles off New York City to the latitude of Cape Hatteras. Croakers, scup, weakfish, and summer flounder predominate in the catch of the winter trawl fishery.

Principal types of gear used in the Middle Atlantic shore fisheries are otter trawls (vessels fishing otter trawls usually are called draggers in this area), pound nets, and seines. Most of the catch is consumed in the coastal States—chief markets being New York, Philadelphia, Baltimore, Washington, and Richmond—but some species are shipped to interior sections.

Commercial landings run to about 750 million pounds a year, bring fishermen about 8½ million dollars. The quantity of fish taken by salt-water anglers is unknown, but undoubtedly of considerable magnitude, as is the monetary and recreational value of the sport fisheries.

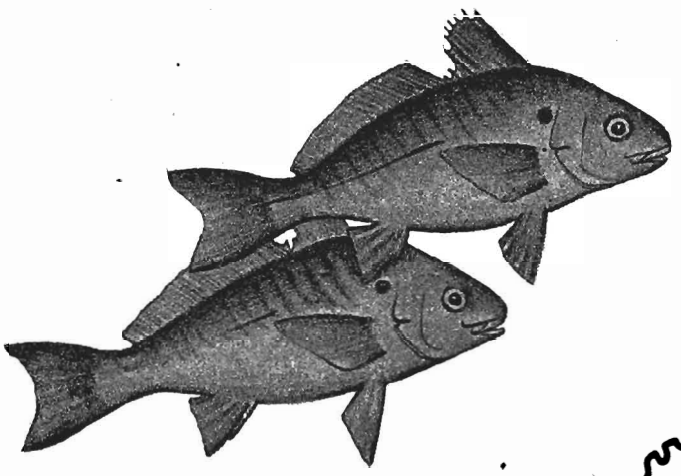
The migratory habits of the Middle Atlantic shore fishes demand Federal and interstate cooperation in conducting basic studies of the resource and interstate cooperation in the proper utilization of the supply. Joint exploitation of a common stock of fish by commercial fishermen and anglers also presents social and economic problems which require cooperation and recognition of the legitimate rights of each group of fishermen.

To protect and develop the shore fisheries of the area it is important (1) to adjust fishing intensity to the size and potential productiveness of the stock, (2) to prevent production in excess of market demand during periods of unusual abundance, (3) to improve methods of refrigeration, transportation, processing, and marketing in order that the most effective utilization may be made of this resource.

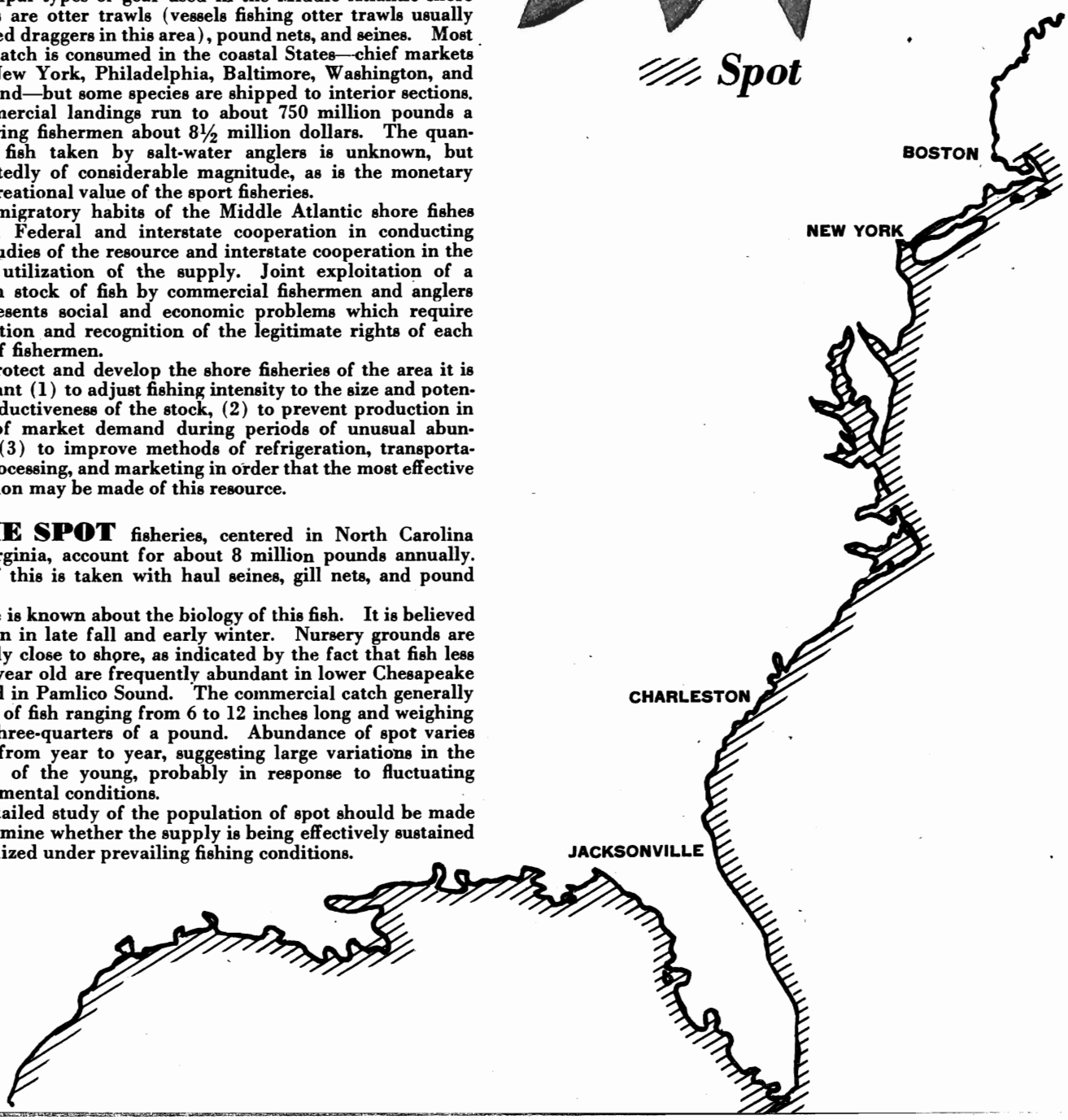
THE SPOT fisheries, centered in North Carolina and Virginia, account for about 8 million pounds annually. Most of this is taken with haul seines, gill nets, and pound nets.

Little is known about the biology of this fish. It is believed to spawn in late fall and early winter. Nursery grounds are probably close to shore, as indicated by the fact that fish less than 1 year old are frequently abundant in lower Chesapeake Bay and in Pamlico Sound. The commercial catch generally consists of fish ranging from 6 to 12 inches long and weighing up to three-quarters of a pound. Abundance of spot varies widely from year to year, suggesting large variations in the survival of the young, probably in response to fluctuating environmental conditions.

A detailed study of the population of spot should be made to determine whether the supply is being effectively sustained and utilized under prevailing fishing conditions.



Spot



Atlantic Fishery Resources SHORE FISHES

SCUP OR PORGIES are caught in the summer in the inshore waters of New Jersey, New York, and Rhode Island, and during winter in the offshore waters from the Jersey Capes southward to Cape Hatteras. The annual catch of the commercial fisheries in recent years has been about 20 million pounds, of which a little over half is normally taken in the winter trawl fishery. About 75 percent of the catch is made with otter trawls, the remainder with pound nets, floating traps, and purse seines. The winter fishery is carried on solely with otter trawls. Principal markets for scup are New York City, Philadelphia, and Norfolk.

Sport-fishing activities for this species are concentrated during the summer along the New Jersey beaches and the inshore and bay regions of Long Island, N. Y.

Scup spawn in the inshore waters and bays of New Jersey, Long Island, and southern New England from May to August, but chiefly in June. The same coastal areas serve as nursery grounds. Scup reach an average length of about 4 inches at the end of the first summer, and by the fifth year have attained an average length of 10 inches and an average weight of three-fourths of a pound. The maximum length reported is 18 inches. Most of the commercial catch consists of fish ranging from three-fourths to one and one-half pounds.

Scup move northward and toward shore in the spring, southward and offshore in fall.

The yield of scup fluctuates widely. During the past 20 years the trend of the catch, especially in New Jersey and New York, has been generally upward, as a result of (1) several years of unusually successful spawning; (2) increase in the number of otter trawlers and other types of vessels; (3) improvements of fishing gear and development of the balloon net.

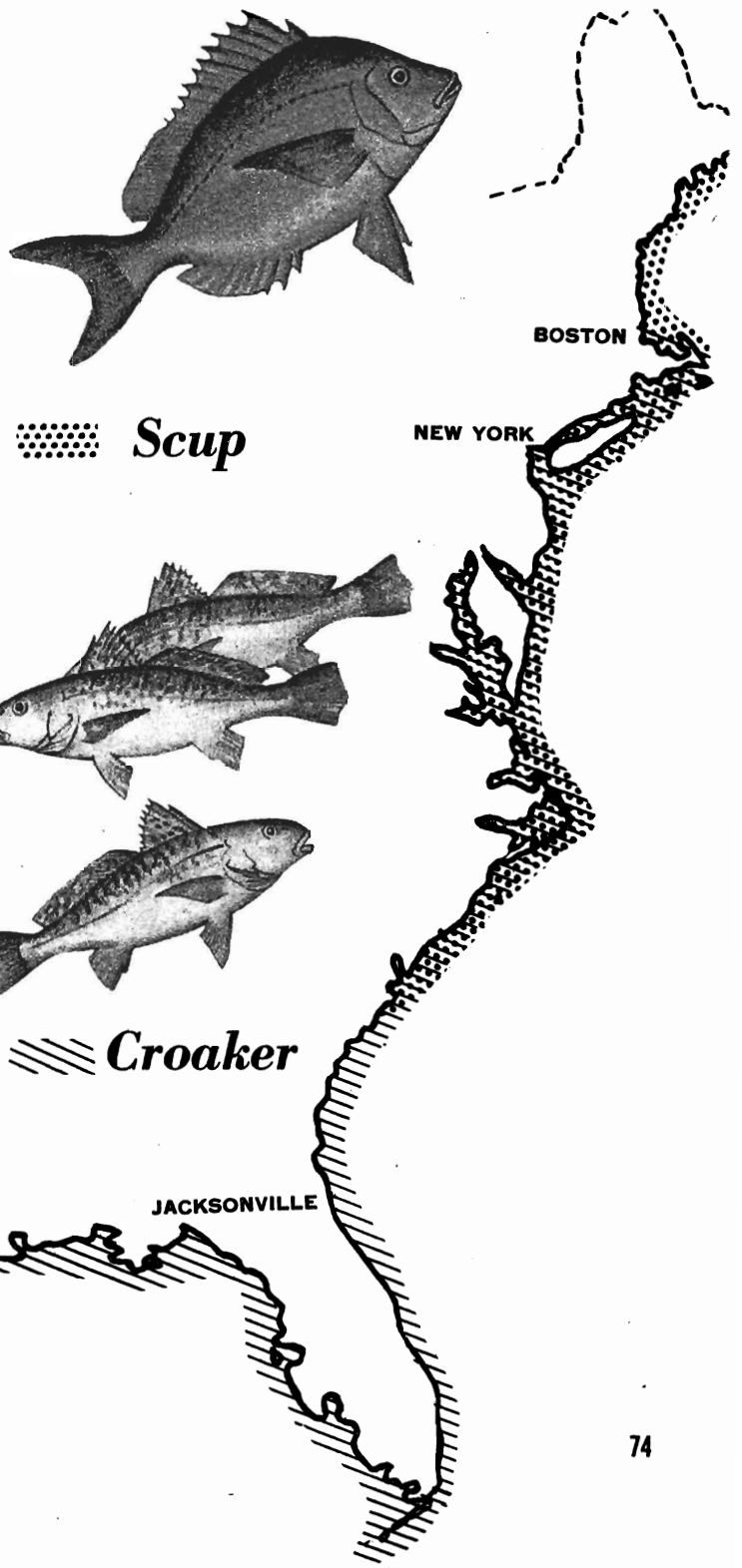
For adequate conservation of this species, it must yet be determined at what fishing intensity the resource will produce the highest sustained yield. Because the catch of scup is so unstable, it is highly desirable to improve methods of handling, freezing, and storing, so that in periods of glut surpluses can be properly cared for with a minimum of waste.

THE CROAKER OR HARDHEAD, close relative of the weakfish, is one of the principal food fishes of the Middle Atlantic States, supports an average total annual yield of about 52 million pounds. This catch is made with pound nets, otter trawls, and haul seines. The fish are sold in fresh-fish markets, often filleted. Large but unknown quantities are caught by anglers.

Little is known about the biology of the croaker. It is believed to spawn from August to November, and possibly later in southern waters. There is no information about the growth rate, age at spawning, or longevity. Market sizes range from a half to 1½ pounds.

In Chesapeake Bay croakers are caught in greatest numbers during a spring and fall migration to and from the bay. Winter fishing is done offshore.

The catch of croakers has increased tremendously in recent years owing to development of the winter trawl fishery off the Virginia and North Carolina Capes and to increased summer fishing. Nevertheless, there are no obvious signs that fishing intensity has exceeded the capacity of the resource. Old fish seem to be well represented in the catch even after 2 to 6 years of exposure to commercial and sport fishing activities. To insure preserving this resource at maximum productivity, however, a fund of knowledge about it should be developed and observations on the population in relation to the fishery should be continuously maintained.



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THE STRIPED BASS of the Atlantic coast is both a commercial and a recreational resource, yielding about 3 million pounds annually to market fishermen and an unknown but possibly equivalent amount to sport fishermen in the Chesapeake Bay and many other coastal points from New Jersey to Massachusetts.

Most of the commercial catch is taken in pound nets; smaller quantities are taken by haul seines, gill nets, handlines, purse seines, fyke nets, and otter trawls. The striped bass is sold only in the fresh-fish markets; none is frozen or otherwise processed.

The striped bass is a fish of the inshore waters and coastal rivers, seldom being found offshore more than a mile or two, and at times it ascends streams for several hundred miles. Its principal spawning and nursery areas along the Atlantic coast are in Chesapeake Bay, which is the source of most of the striped bass taken elsewhere along the coast. The fish spawns also in the upper part of Delaware Bay and in the lower Hudson River. The spawning season is in the spring or early summer, the exact time varying with latitude and temperature. Females usually spawn for the first time when 4 years old and about 20 inches long; males often mature at 2 years (approximately 12 inches).

Part of the stock spawned in Chesapeake Bay (probably no more than 10 percent of it) migrates to northern coastal regions. However, this migrating segment of the population represents 90 percent or more of the supply available to fishermen in northern coastal States. The other 10 percent probably originates from less productive spawning areas in northern States.

STRIPED BASS MIGRATE EXTENSIVELY in the spring and fall. In the spring they move from wintering areas in Chesapeake Bay, Delaware Bay, Hudson River, and other coastal rivers and small bays in New Jersey, Long Island, and even southern New England, to more northerly sections of the coast, especially to New England. In the fall, beginning about September, a return migration occurs, in the course of which "pods" of bass break off from the main run and winter at various spots along the coast from southern New England to New Jersey. The main part of the run appears to continue south to Chesapeake Bay.

Striped bass grow rather rapidly. They attain a length of 4 to 5 inches and a weight of about 1 ounce by the end of the first year. Thereafter they increase in weight rapidly: At 2 years the weight is one-half pound; at 4 years, 2¼ pounds; at 8 years, 12 pounds. Fish weighing 40 pounds or more are often caught by commercial fishermen and sometimes by sport fishermen.

The catch of striped bass fluctuates widely, owing to lack of an adequate reserve stock. These fluctuations reflect variations in the survival of the young. To stabilize the yield of this species at its highest sustained productivity, a minimum-size limit should be devised to protect the juvenile striped bass during their years of rapid growth, until they are old enough to have spawned. Because the striped bass migrates widely along the coast, such a measure cannot be fully effective unless it becomes adopted by all the States that share this resource. Several of the States have already adopted such a size limit.

WEAKFISH OR GRAY SEA TROUT is one of the chief market fishes of the Middle Atlantic region, yielding an annual catch of some 25 million pounds. It is also a popular sport fish from Long Island to Chesapeake Bay. Known as squeteague in southern New England, weakfish in New Jersey, and sea trout in Chesapeake Bay and farther south, this species is closely related to the spotted sea trout of the South.

Pound-net fisheries account for most of the catch in Chesapeake Bay, center of the commercial fishery; haul seines are used more extensively in North Carolina. Rod and reel fishermen usually chum the weakfish with bait shrimp.

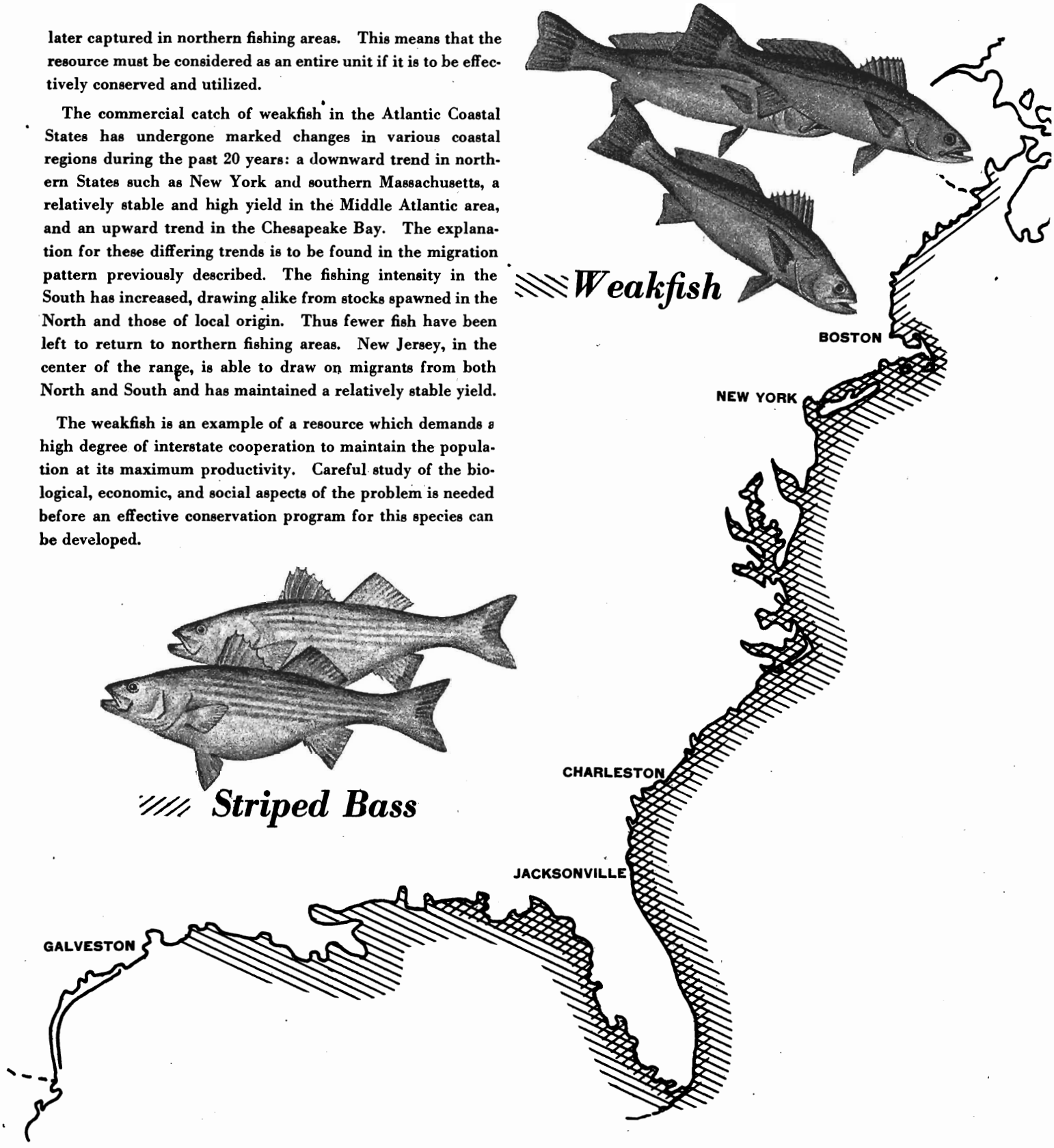
The weakfish is used almost entirely in the fresh-fish market and is sometimes prepared as fresh fillets. Small amounts are frozen, salted, or smoked, mostly for local use.

WEAKFISH ARE BELIEVED TO MATURE DURING THEIR THIRD SUMMER (when 2 years old) and spawn from mid-May to mid-June in bays from Hatteras to Cape Cod, but most intensively in the Chesapeake Bay. They migrate extensively each spring and fall, crossing State boundaries freely in the course of their travels. Many of the fish spawned in northern waters (New York) move at the end of their first summer to the region of Chesapeake Bay and tend to remain in southern areas for about 2 years. In their third summer they migrate northward and return to the South in the fall. Beginning in the fourth summer, and annually thereafter, they return to about the same northern area where they were spawned. These fish originating in the North are joined in their summer migration by fish originating in southern areas. The coastal runs of weakfish larger than 12 inches in length are therefore composed of a mixture of fish spawned in various parts of the coast. As a result of their migratory habits, weakfish spawned in the North are subject to an intensive fishery in southern areas during their second summer. On the other hand, some of the fish spawned in the South are

later captured in northern fishing areas. This means that the resource must be considered as an entire unit if it is to be effectively conserved and utilized.

The commercial catch of weakfish in the Atlantic Coastal States has undergone marked changes in various coastal regions during the past 20 years: a downward trend in northern States such as New York and southern Massachusetts, a relatively stable and high yield in the Middle Atlantic area, and an upward trend in the Chesapeake Bay. The explanation for these differing trends is to be found in the migration pattern previously described. The fishing intensity in the South has increased, drawing alike from stocks spawned in the North and those of local origin. Thus fewer fish have been left to return to northern fishing areas. New Jersey, in the center of the range, is able to draw on migrants from both North and South and has maintained a relatively stable yield.

The weakfish is an example of a resource which demands a high degree of interstate cooperation to maintain the population at its maximum productivity. Careful study of the biological, economic, and social aspects of the problem is needed before an effective conservation program for this species can be developed.



Atlantic Fishery Resources SHOREFISHES

THE SUMMER FLOUNDER OR FLUKE RESOURCE yields about 11 million pounds of commercially caught fish annually and, in addition, supports an extensive sport fishery in the bays and inshore waters of Long Island, along the New Jersey coast, and in the lower Delaware Bay and adjacent seacoasts. This is the only flounder taken in large quantities in the winter trawl fishery off the Virginia Capes and New Jersey. Summer fisheries for this species are carried on chiefly along the southern shore of Long Island and on the coasts of New Jersey and Delaware.

The populations of summer flounder available to the winter fishery in the offshore area from the vicinity of New York to Cape Hatteras are believed to be a mixture of fish that summer at various points along the coast. Some tagging has been done in an effort to trace the seasonal migrations of these fish. Most of the larger fish appear to spend the summer in northern regions—northern New Jersey, southern Long Island, and southern New England—while the smaller fish tend to distribute themselves from southern New Jersey to the Virginia Capes. Flounders that have reached a length of 12 inches or more appear to have a tendency to return year after year to the same summer areas where they were tagged and released.

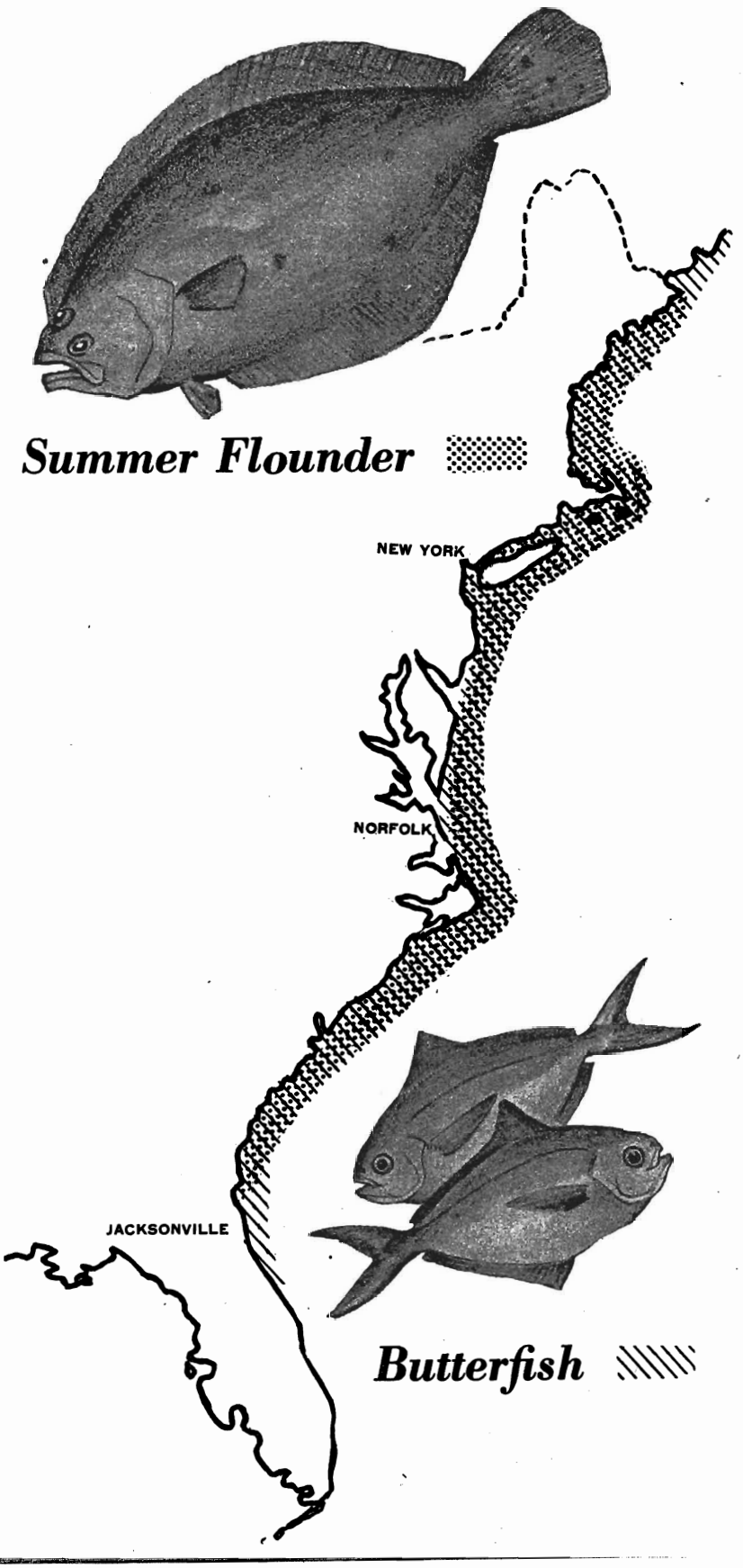
Information on the spawning of fluke is meager. It is believed that the fish spawn in the late fall or early winter, when they are moving offshore or have reached the offshore winter area. In the early spring and summer more young fish (less than 1 year old) are found in the inshore waters of Virginia, including the lower region of Chesapeake Bay, than in more northern coastal areas. From this it is assumed that the southern range of the species may be the most productive spawning and nursery region, from which migrations take place in later years to northern fishing grounds. Tagging experiments recently begun should be continued to test the accuracy of this assumption.

Because of its habits and the efficiency of the gear used in its capture, the summer flounder is in danger of being overfished. Continued observations of the resource are needed so that excessive withdrawals from the stock may be detected quickly and proper steps taken to avoid commercial depletion of the supply. Adoption by the various States of a minimum-size limit, drawn with a view to biological and market considerations, should afford a degree of protection and improve the utilization of the supply.

THE BUTTERFISH is exclusively a commercial species which supports an annual catch averaging about 12½ million pounds. Important markets are Boston, New York City, Philadelphia, Baltimore, and Norfolk.

Butterfish spawn in June and July in the bays, sounds, and other inshore waters from Chesapeake Bay to southern New England. By the end of the summer the young are about 4 inches long. Market sizes range from 8 to 11 inches and from a quarter of a pound to a pound. Like most other shorefishes, butterfish have fluctuated sharply in abundance during the past 15 years.

To sustain the productivity of this resource, and to reduce unnecessary waste, it is necessary to minimize the destruction of immature fish. An effective releasing device for returning captured small butterfish back into the sea has been developed for the pound net and floating-trap fisheries. This device is used in some localities, should be adopted universally among those fishing for this species.



Atlantic Fishery Resources SHOREFISHES

MULLETS, of which there are many species, are found throughout the world, mostly in tropical waters and in some regions are cultivated in seaside ponds. In the United States the striped mullet is the most important food fish of the southern seaboard. About 37 million pounds are caught annually, a quantity valued at something over a million dollars. It is a low-priced fish, usually sold fresh, and too often with a minimum of care in handling.

Close to two million pounds are cured annually. About three-fourth of it is dry-salted in Florida, the balance brine cured in North Carolina. Some mullet is now being filleted and packaged. A small amount of mullet roe is lightly salted and sun dried, producing a product comparable to caviar. Experiments indicate that a smoked fish of high quality may be prepared. No doubt further technological research would develop other food products from this abundant resource.

The mullet fishery is carried on chiefly in bays and inside waters, with gill nets, haul seines, and trammel nets. The center of the fishery is on the west coast of Florida, where more than three-fourths of the catch is made. North Carolina and Alabama also have important mullet fisheries.

In North Carolina these fish usually spend the summer in the bays and sounds, feeding on the vegetation of the bottom. In the fall, apparently when the spawn is maturing, the fish begin a mass exodus from these inside waters, passing out through the inlets and moving southward along the coast, presumably out to sea. At this time of year enormous catches—sometimes as much as 62,000 pounds in a single haul of the net—are made by the mullet fishermen.

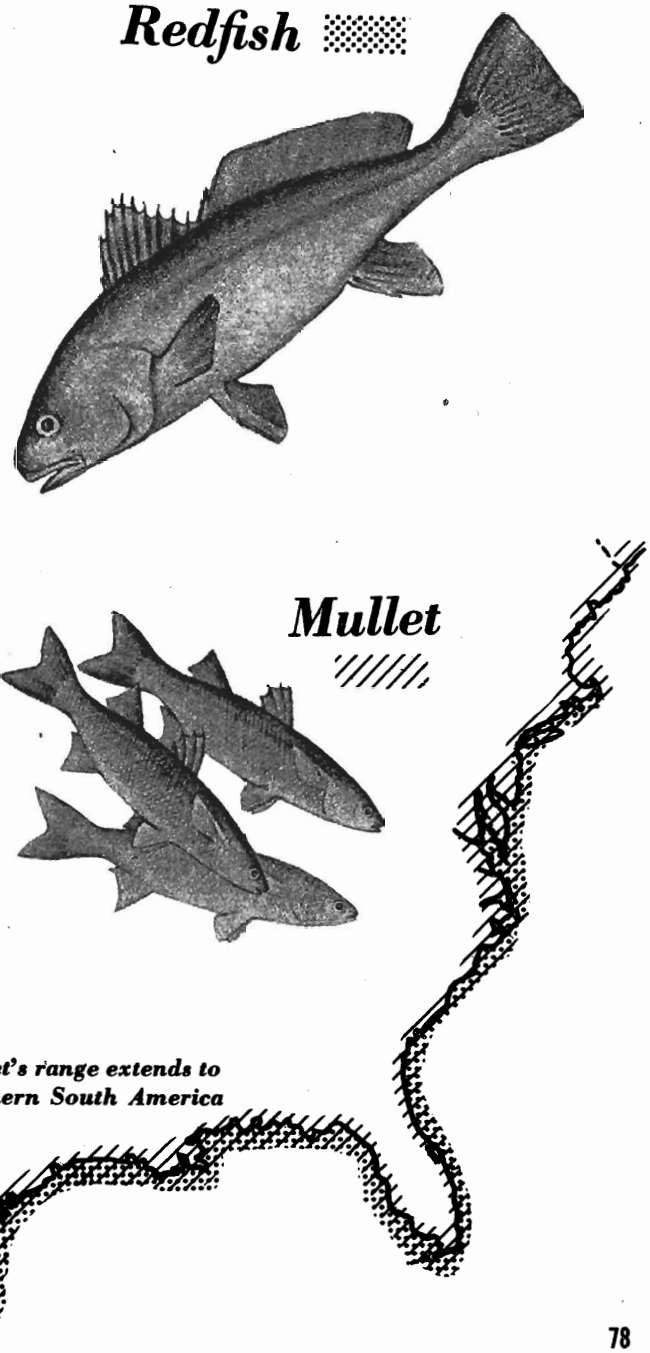
Little is known about the biology of this resource. In this country the limited investigations that have been made have centered in North Carolina. There the early fall runs, beginning in August, usually are composed of fish less than a year old. In September the runs are composed of 2-year-olds, and in October come the still older fish or roe mullet which then dominate the fishery. Virtually all the mullet leave the sounds by early November, and it is believed they spawn then in the mouths of estuaries and in the open sea. The schools are observed traveling southward and entering the inlets again following their seaward migration. The seaward and coastwise migrations, which probably do not involve great distances, seem to be characteristic of the mullet throughout its range. The production varies according to these runs or migrations. During certain months production is very heavy and marketing the catch then becomes difficult.

THE REDFISH OR RED DRUM is one of the more important food fishes of the Gulf and South Atlantic coasts. About a million and a half pounds are caught annually, mostly with haul seines, gill nets, trammel nets, and hook and line, and it is sold in the fresh-fish markets. A large import fishery for redfish operates from Brownsville, Tex., in the Laguna Madre area of Mexico. As a sport fish, known as channel bass, the redfish is one of the most important of the South. In some regions sportsmen may take as much as commercial fishermen.

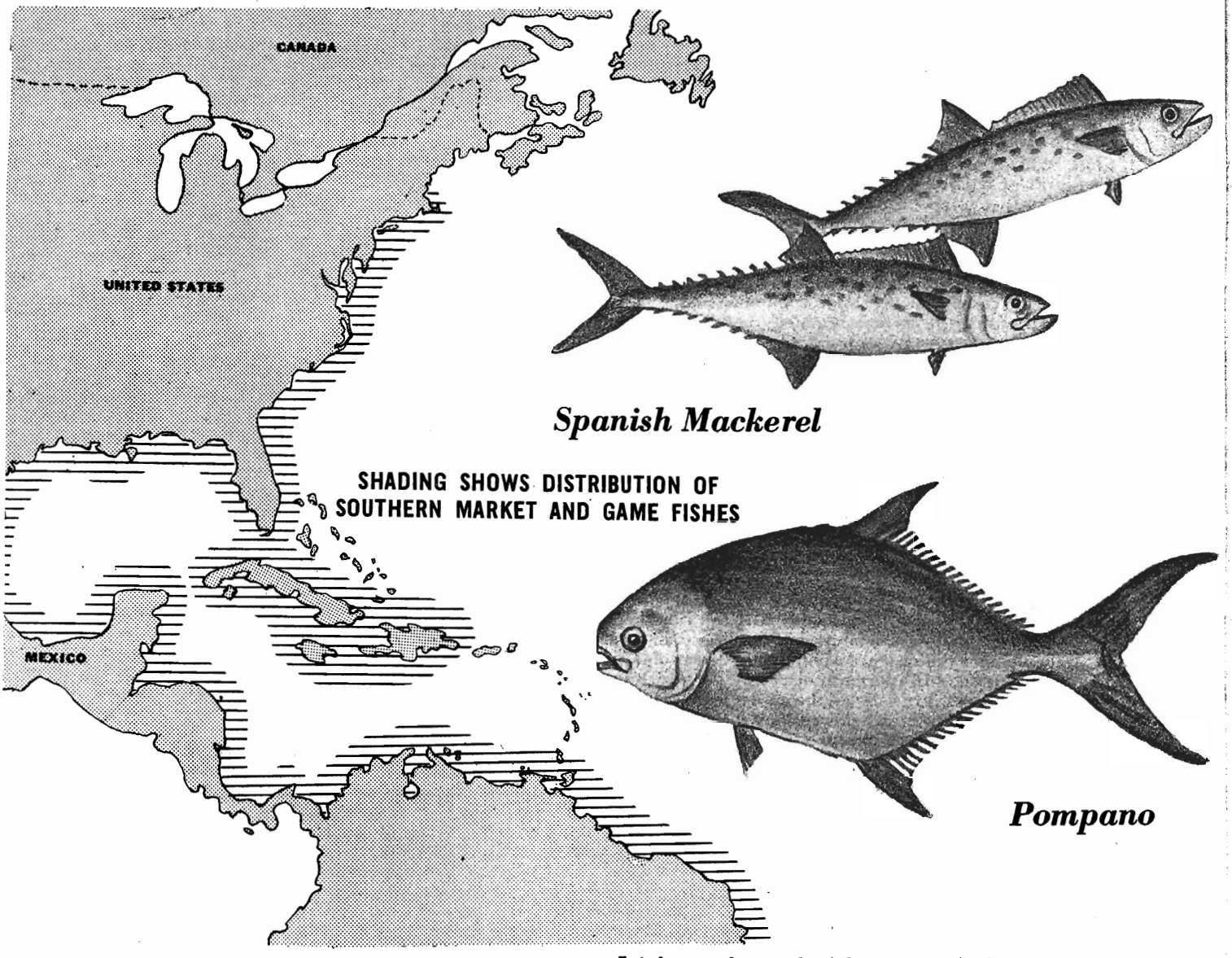
The Fish and Wildlife Service, studying redfish on the southern Texas coast, found that the fish spawn in that area mainly in the fall about the mouths of the coastal channels or passes. The newly hatched young then drift with the tides and currents into the bays and lagoons. In these protected waters they develop rapidly and soon reach a stage where they can swim under their own power. They scatter widely, usually seeking protection on quiet, grassy bottoms. Abnormally low tides may occasionally drain the water out of these shallow flats and leave the young fish stranded by the thousand.

With the coming of the cold weather of their first winter, the young redfish, now 2 to 6 inches long, find their way into the deeper bayous. There they remain until spring, when some of them leave the inland waters for the first time, going out through the passes to the open waters of the Gulf; others remain to wander through the inland bays and lagoons.

After their first year most redfish winter in the deeper bays or in the Gulf, returning to inside waters in the spring. The fall exodus is not especially noticeable, but the spring migration is undertaken by large bodies of fish moving together through the various passes, where many are taken by hook-and-line fishing. They feed mostly on shrimp and crabs, also on other invertebrates which they meet in their wanderings, and small fish. They grow rapidly, averaging about 13½ inches when a year old and 21 inches when two.



Atlantic Fishery Resources SOUTHERN MARKET FISHES



THE SPANISH MACKEREL resource yields an annual catch of 6½ to 8 million pounds. Almost the entire catch is handled in the fresh-fish markets, although small quantities are salted and smoked. Recent experiments indicate interesting canning possibilities. Additional technical studies may develop still other products. In Florida the Spanish mackerel fishery is carried on chiefly with gill nets, although small catches are made also with trammel nets, haul seines, and hand and troll lines. The Spanish mackerel is one of the most important sport fishes of the South, is taken mostly by trolling with artificial lures.

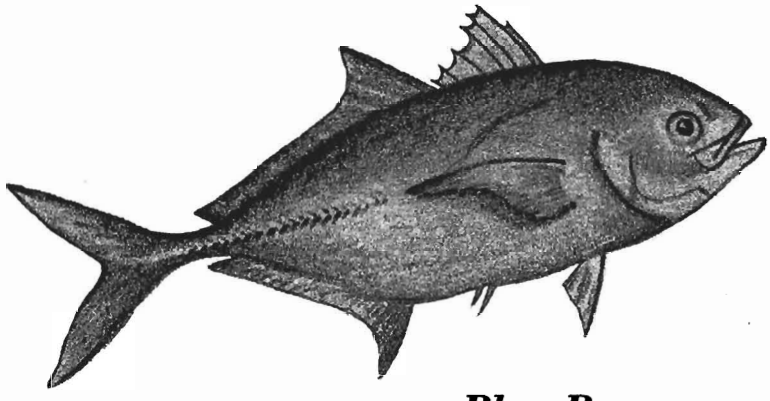
Since no studies have been made of this resource, little is known about it. Spanish mackerel are schooling in habit, and migratory. They seem to be concentrated along the east coast of Florida in the winter. Beginning in spring and continuing through the summer, the population expands its distribution, spreading northward and westward along the Atlantic and Gulf coasts. Beginning in early fall, they return to their wintering grounds.

It is known that on the Atlantic coast the Spanish mackerel spawns during its summer migrations. Eggs have been taken at various points from the Carolinas to Long Island, usually in the open ocean.

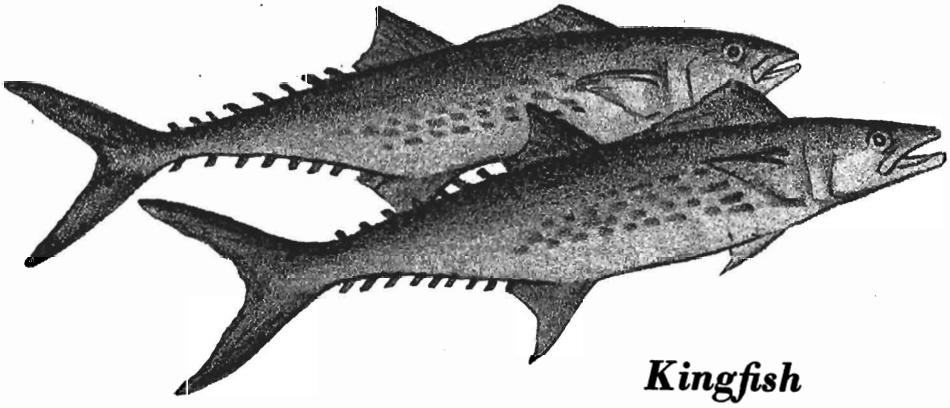
THE POMPANO is one of the choicest of saltwater fishes. Although less than a million pounds are caught annually, it is especially sought after, for fishermen receive several times as much for it, per pound, as they do for most other fishes. Pompano are taken with trammel nets, run-around gill nets, haul seines, and hook and line, mostly from January to April. The entire catch is marketed fresh, and large shipments are made to northern markets. A considerable quantity is caught by anglers, fishing from small rowboats and surf fishing with clams or sand fleas as bait.

Little is known about the life history of pompano. It seems to prefer sandy bottom near shore where it feeds. Schools of pompano are abundant about inlets, where they play in and out with the tides. In North Carolina small ones, from half an inch to 2 inches long, are often seen in the surf on

Atlantic Fishery Resources SOUTHERN MARKET FISHES



Blue Runner



Kingfish

the outer beaches, the waves repeatedly casting them out on the wet sand, from which they jump back into the next breaker. The young seem to migrate northward rather extensively; the adults are relatively nonmigratory. Pompano feed on mollusks and crustaceans. They grow to be 8 or 10 pounds, average around 2 to 3 pounds.

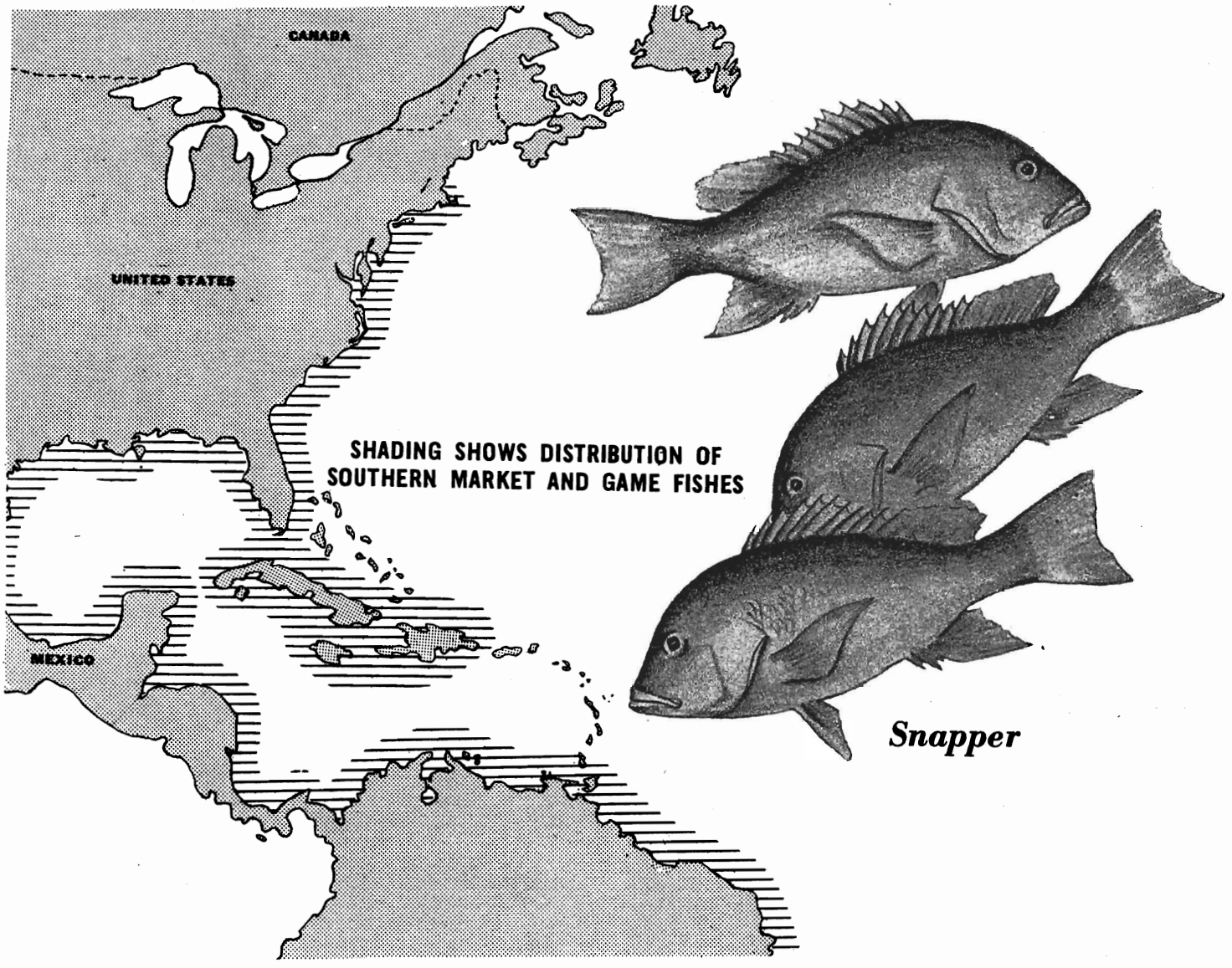
THE KINGFISH OR KING MACKEREL, a giant relative of the Spanish mackerel, supports a fishery producing around 4 million pounds a year. It is taken along both Atlantic and Gulf coasts by jigging with hand lines and with heavy gill nets, chiefly off Florida. Its size (average 9 to 12 pounds, but may reach 75 pounds), its strength, speed, and great fighting power make it one of the most important game fishes of the Southern States. It travels in large schools, ranging the waters of the open sea in search of menhaden and other small fishes. It is noted for its remarkable leaps, often clearing the water by 10 feet or more. Fishermen seeking Spanish mackerel often take the kingfish incidentally, because of the similar habits of the two species, but it is so strong and has such sharp teeth that it does considerable damage to the gear.

King mackerel have a pattern of migration similar to that of the Spanish mackerel. They, too, are concentrated on the east coast of Florida, and seem to expand their distribution northward and westward along the Atlantic and Gulf coasts in spring and summer.

Like the Spanish mackerel, the kingfish is fine flavored, with few bones. The larger fish are sold in steaks, the smaller ones whole. Most of the catch is marketed along the eastern seaboard, Richmond and New York being especially important markets for this species. Although most of the catch is sold fresh, the kingfish is excellent smoked and is sometimes canned tuna style.

THE BLUE RUNNER OR HARDTAIL, also called horse crevalle, jurel, skipjack, and jackfish, is commoner in Mexico and Central America than in the United States. Its local abundance is centered on the Gulf coast, where 700 to 800 thousand pounds are caught annually. The entire catch is utilized in fresh-fish markets. Nothing is known about the biology of this fish by which to judge its abundance or commercial potentialities. Migratory schools of the blue runner appear near Pensacola in April, are most numerous in May. Along the southern coast of Florida they are abundant in winter. They follow schools of small fish, sometimes leaping out of the water in pursuit of them. They, in their turn, are chased by sharks and porpoises, and are sometimes driven ashore in numbers. The blue runner attains a length of 20 inches and a weight of 4 pounds. Most of the catch is taken in haul seines, which are operated in shallow water along the shore. A few are taken by anglers trolling for mackerel and bluefish.

Atlantic Fishery Resources SOUTHERN MARKET FISHES



SNAPPERS ARE TROPICAL FISHES, found on both sides of middle America and in United States waters only along the south Atlantic and Gulf coasts, where they support an important special fishery. As fresh fish they have a particularly fine quality, are in great demand, and have a wide distribution among northern cities. Between 6 and 8 million pounds of snappers are caught annually. Several species are known in the Atlantic, of which one, *Lutianus blackfordii*, is the most important. During recent years, a considerable poundage of snappers has been imported from the West Indies and the west coast of Mexico. Large quantities are caught in the Southern States by anglers, mostly by still-fishing in inside waters.

The center of the red snapper fishery is now Pensacola. From there a round trip to the Campeche Bank takes about 23 days, of which 8 days are spent traveling to and from the grounds, 15 days fishing. Many of the snapper boats are small craft, but, owing to the skill and experience of their skippers and crews, they are able to weather the heavy blows and rough seas of the Gulf. Snappers are caught mainly with hook and line. A crew of nine men can haul in from 7 to 10 thousand pounds a day, depending on the depth of water and the wind and tide. The large schooners which fish on the Campeche Bank take most of their catch between October and April, while the smaller boats fishing along the United States coast, being more dependent on good weather, operate largely during the spring and summer.

SNAPPERS ARE FOUND ON BANKS. In the Gulf of Mexico the principal fishing ground is Campeche Bank, which lies off the coast of Yucatan. Smaller banks, known as *lumps*, off the United States coast in the Gulf, provide good fishing. Offshore, snappers live in deep holes and rocky gullies, where small fish, crabs, shrimps, and other marine animals which are their prey are abundant. They are usually found with groupers, which ordinarily outnumber them. They prefer warm water, and are likely to migrate away when the tempera-

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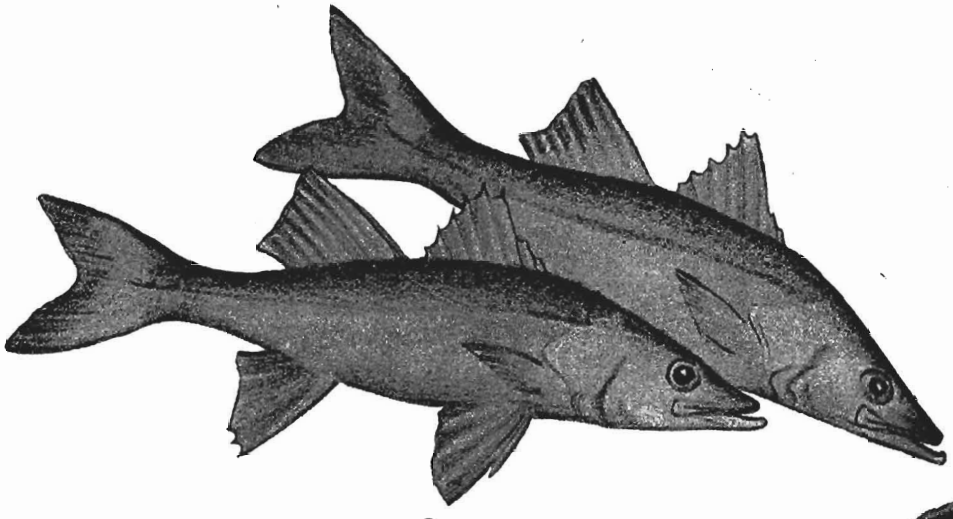
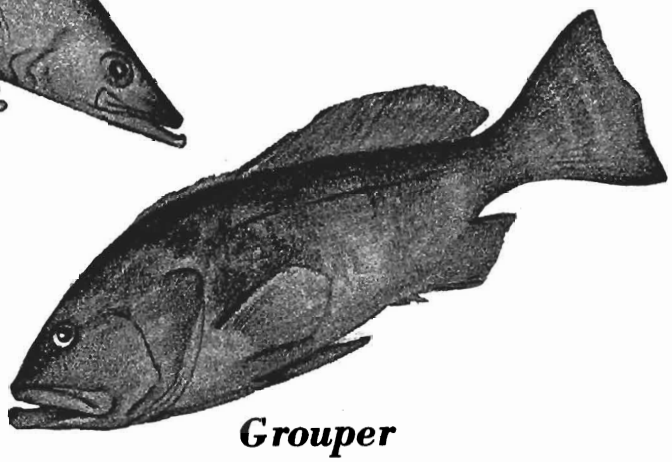


Snook



Grouper

ture falls below 50°. Little is known about snappers. Fishermen believe they move inshore in summer and offshore in autumn. They seem to move constantly from one spot to another, presumably according to food supply. They are believed to spawn in deep water during the late summer and fall.

THE GROUPERS are closely associated geographically with the snappers. They occupy the same banks as snappers, and are caught in the same fishery. Between 5 and 7 million pounds are taken annually, most of it on the Campeche Bank off the coast of Yucatan. Anglers take a considerable quantity.

Probably the most abundant of the several species of groupers, and so the most important commercially, is the red grouper found from Virginia to Rio de Janeiro, and sometimes straggling northward as far as Massachusetts. Also important are the Nassau grouper, the yellow-fin grouper, the black grouper, and the gag. All of these are most abundant in the Gulf of Mexico, and are variously distributed along the Atlantic coast.

Most of the groupers when fully grown weigh as much as 40 or 50 pounds, although those caught usually range from 5 to 15 pounds. They are sold whole, or are packaged as tenderloins, steaks, or fillets. Groupers are caught throughout the year. The chief market is in the southeastern States, which receive about three-fourths of the catch. Outside this area, St. Louis, Cincinnati, and Chicago are the principal markets.

Like the snappers, groupers are caught on hand lines. They are generally nonschooling in habit. Nothing is known of their life history, habits, or the extent of their abundance. They are believed to spawn in the spring, but even this is only conjecture.

THE SNOOK, also called robalo, is unimportant commercially in the United States, but is a very popular game fish. About half a million pounds are caught annually with various kinds of gear, mostly hand lines, and are sold in the fresh-fish markets. Some is smoked, making a product of excellent quality. Anglers take snook either by plug casting or by fishing with live bait.

The center of abundance for snook in United States waters is southern Florida, and it is only there that any considerable amount is taken. A few thousand pounds are taken along the south Texas coast. Snooks are probably more abundant in Mexico and Central America than in the United States; a small quantity is imported from Mexico.

Virtually nothing is known about the snook. It swims close inshore, where most of the fishing is done, and it ascends streams for short distances, though seldom above the limits of brackish water. They may grow to be as much as 30 pounds, but 3 pounds is closer to the average size.

KING WHITING, also called ground mullet, kingfish, sea mullet, and sea mink, is caught incidentally by fisheries using haul seines, gill nets, pound nets, and otter trawls. It is a low-priced fish, not generally appreciated, and large quantities caught by fishermen are thrown back to the sea. Thus this resource is wasted through failure to utilize it. Virtually nothing is known about the king whiting other than that it spawns for the first time when 3 years old, and that it spawns in spring and summer.

Atlantic Fishery Resources

THE BLACK DRUM resource yields 1 to 2 million pounds annually, 50 to 80 percent of it in Texas. The commercial catch is made with all kinds of gear—with pound nets, haul nets, gill nets, and hook-and-line. It is marketed entirely as fresh fish.

Black drum move out into the Gulf through the passes from late February to May to spawn near the entrances. During the late summer and early fall there is believed to be a secondary spawning period when the younger fish spawn. The baby drum enter inside waters soon after hatching, remaining there until they are at least 4 inches long. A year-old drum is about 10 inches long; a 5-year fish, 23 inches. The fish spawn when about 2 years old (14 inches long) and annually thereafter. A 4-foot drum produces about six million eggs.

Young drum look so different from their elders that they were formerly supposed to belong to a different species and were called the "banded drum" because of the broad brown and white bands on their sides. When fully grown the drum is silvery black with black fins. The largest specimen known weighed 146 pounds; average sizes are much smaller. Those taken in the open Gulf are often silvery, those in inshore waters black.

On the Texas coast the drum spend much of their time in the shallow inshore bays, both summer and winter. Sometimes the water in the passages to the deeper bays becomes so shallow that they have great difficulty navigating these channels and often are badly lacerated by passing over the oyster reefs. Young drum feed largely on worms and small fish while the older individuals prefer mollusks and small crabs.

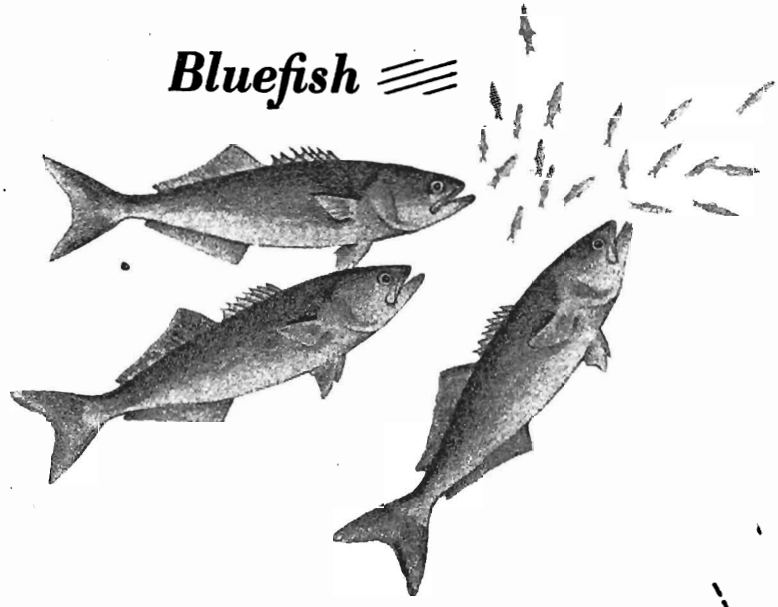
The black drum is a good sport fish. A rather large quantity of young ones are taken on light tackle. Fishing for the large roe drum—called "bulls"—when they enter the sounds or migrate along the beaches on the Atlantic coast is popular.

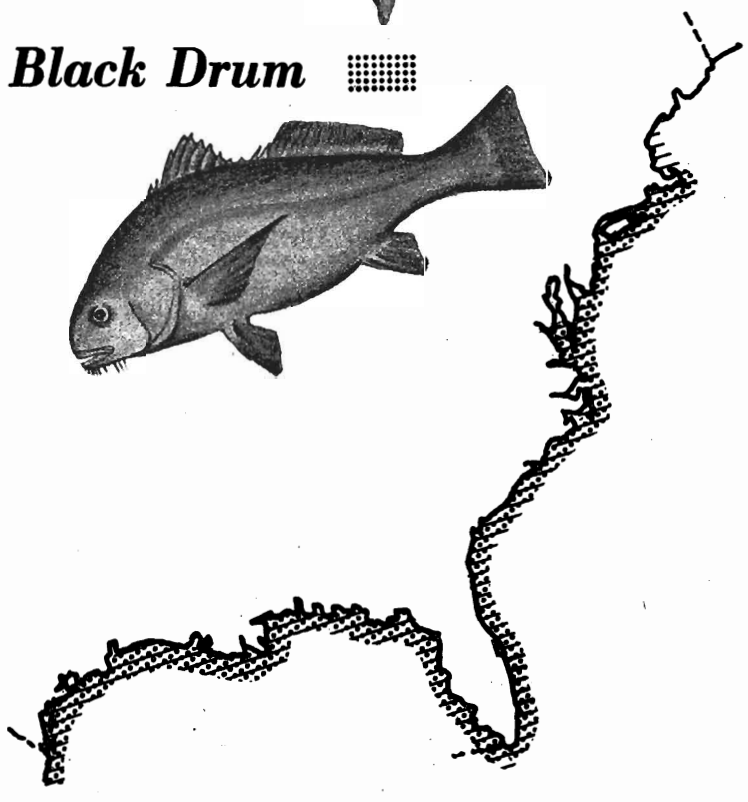
BLUEFISH is a pelagic species of widespread distribution in different parts of the world. It is excellent as food, and is a favorite game fish. The average United States catch for the 5 years ending 1940 was 6.8 million pounds, with a value to fishermen of around $400,000. Commercial fishermen catch bluefish chiefly with traps or pound nets, and with haul seines, gill nets, trammel nets, and with hand and troll lines. Sport fishermen take it chiefly by trolling with artificial lures, but also by still-fishing with a rod or hand line. The quantity taken by anglers has never been determined accurately but is estimated to equal or almost equal the commercial catch.

The biology and life habits of the bluefish have not been studied in detail in this country, and our knowledge is only that obtained by occasional and incidental observations. Bluefish travel in dense schools. They are extremely voracious, feeding on all kinds of small fishes. They are migratory but their movements are very erratic and are probably controlled by hydrographic conditions. In general, they move northward in spring and southward in autumn. They are taken in the winter in southern Florida, then off the Carolinas in March and April, off New Jersey in April and May, and off the south shore of Massachusetts in late May or early June. By November they are taken again in the Carolinas. About the end of November they appear on the east coast of Florida, and by December on the Gulf coast.

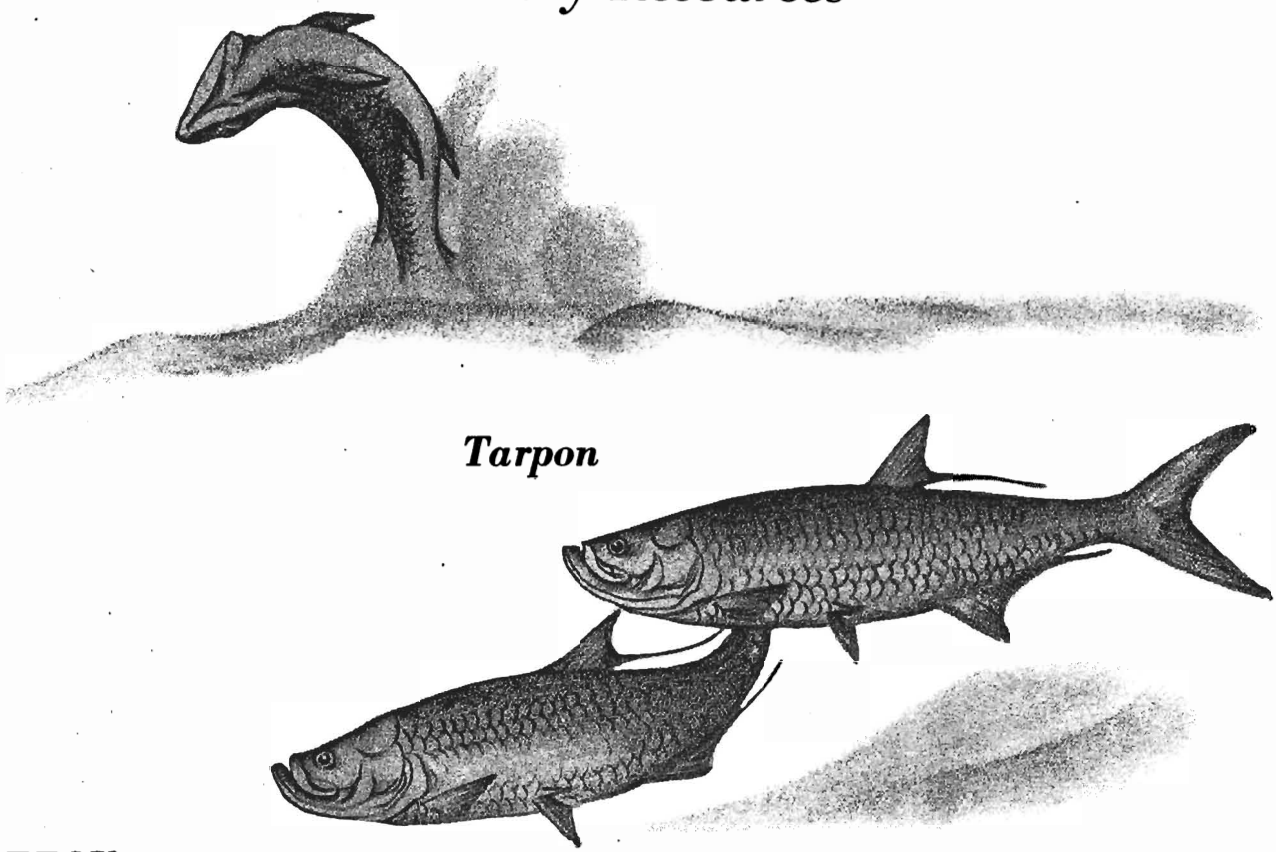
Bluefish are believed to spawn in May or June, probably offshore. Young bluefish of the year's spawning come inshore in late May or June. Growth during the first summer and autumn is rapid. The young fish tend to school according to size. There is no knowledge on which to base an opinion on the size of the population of bluefish, but this much is known: the available supply, and probably the actual abundance as well, fluctuate greatly.

Bluefish are usually sold fresh although a small amount is frozen. Some quantities of frozen bluefish have been imported from Argentina recently, and there are reports of bluefish off other parts of the South American coast, where plans are being made to freeze these fish for the United States market. Anglers in the United States frequently salt and smoke bluefish. It is believed that a commercial smoked fish of good quality could be developed with study. The principal markets are in the cities along the Atlantic seaboard, especially Baltimore, Philadelphia, New York, and Boston. The demand is greater than the catch and the price of bluefish is usually high.





Atlantic Fishery Resources



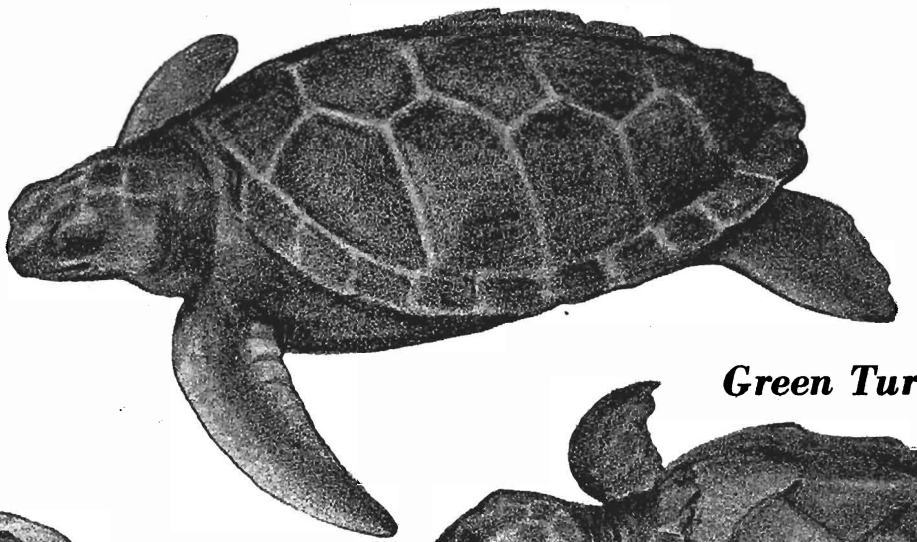
Tarpon

THE TARPON, a giant member of the herring family, is the most spectacular game fish of the South Atlantic and Gulf coasts. Although it is essentially a warm-water fish, it has been reported from every State of the Atlantic coast and as far north as Nova Scotia. It ranges southward to Brazil and is common in the West Indies. The tarpon is not appreciated as a food fish in the United States; in Latin America, on the other hand, considerable quantities are sold in fresh-fish markets. It is said to be excellent when smoked. In this country it is of prime importance as a game fish. Anglers take tarpon by trolling with artificial lures or with fillet of mullet or menhaden; also by still-fishing with live fish or crabs as bait. When hooked, the tarpon makes spectacular leaps, vertically 12 to 15 feet or more, horizontally as much as 30 feet.

Little is known about the tarpon. They spawn during spring and early summer, probably chiefly offshore in the blue gulf water. Presumably the eggs develop near or on the bottom and are believed to hatch into transparent, ribbonlike larvae, which subsequently metamorphose into the typical tarponlike body form. Eggs have not yet been identified with certainty as tarpon, and the larvae have not yet been collected. Young fish of 3 or more inches in length are found inshore. They frequently enter lagoons through temporary channels, later often become landlocked and perish wherever these seasonal pools of water evaporate. Thanks to accessory breathing apparatus, tarpon can survive in foul water polluted with decaying organic matter long after most fishes pass the point of tolerance. They run up rivers, sometimes as far as 100 miles or more. They are believed to grow rapidly and mature when around 4 feet long, during their seventh or eighth spring. They attain a maximum length of close to 8 feet and weight of 300 pounds. The average fish caught by anglers runs from 4 to 6 feet with weights of 75 to 150 pounds. Tagging experiments, conducted by the American Museum of Natural History, indicate tentatively that migration in the sea is not extensive, and that fishing mortality is moderate. They appear near the coast in spring, disappear in the late fall. Fishing is at its best in the early summer.

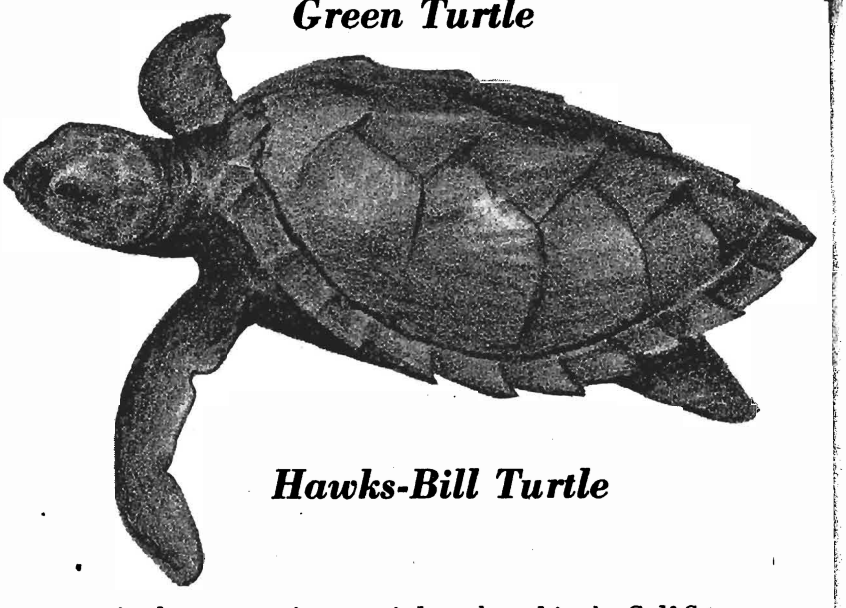
THE ATLANTIC COAST SHARK fishery, like that of the Pacific, is a new and rapidly growing industry, has taken between 7 and 10 million pounds of sharks annually in recent years. In general, with only occasional exceptions, the Atlantic sharks are less valuable than those of the Pacific, the vitamin A content of their liver oils being considerably lower. Most specimens test at less than 10,000 U. S. P. units of vitamin A per gram, although occasional oils of over 100,000 units per gram are obtained. The most important product is liver oil, which is used for medicinal purposes and in the manufacture of soap, tanning oils, and greases. Some of the flesh is sold in fresh-fish markets; some is manufactured into fish meal; and the hides are used for leather. The fins are sold to the oriental trade; the teeth are sold for novelties. Shark fishing in the Atlantic is done mainly with set lines and with anchored gill nets.

Little is known about the Atlantic sharks and no studies are being made of them. There are many species of varying value. The vitamin potency of the liver oil varies greatly with species, sex, size of fish, season of the year, and state of maturity.



Green Turtle

Diamond-Back Terrapin



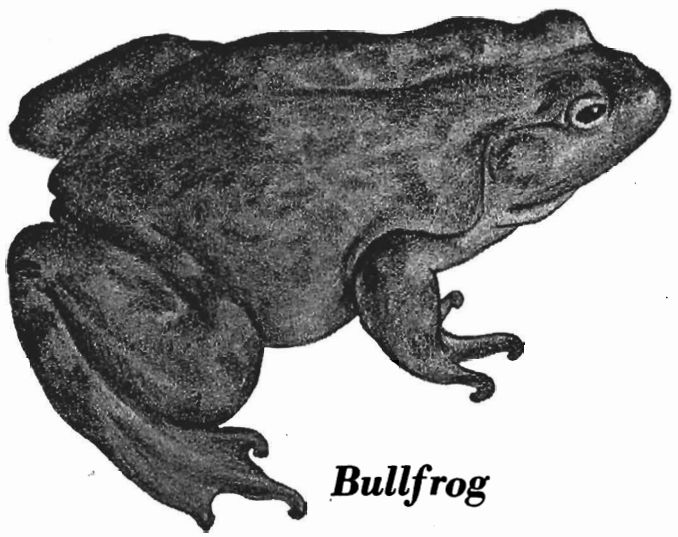
Hawks-Bill Turtle

DIAMOND-BACK TERRAPINS ARE TURTLES which inhabit shallow salt- and brackish-water bays, estuaries, and swamps along the Atlantic coast from Cape Cod to Yucatan. No fewer than five species are recognized in eastern United States. Scarcity, brought on by years of careless, unplanned fishing, has put the terrapin into the class of high-priced luxury foods. Around 50,000 pounds are captured annually, of which a small portion is canned, the rest sold fresh. The United States Fish and Wildlife Service has maintained a terrapin hatchery since 1909, at Beaufort, N. C. There young terrapin are reared through their first year, and thence distributed in favorable localities. The number of young handled in this way has been increasing, now numbers 10 to 15 thousand annually.

In nature, terrapins lay their eggs in sand somewhat above the average high-tide mark, during spring and early summer. At that time they are particularly susceptible to capture. Their growth rate varies widely. They reach marketable size when 5 to 10 years old.

SEA TURTLES ARE BUILT FOR LIFE IN THE OCEAN, have flippers like a seal's. They are tropical and semitropical animals, are sometimes carried northward in the Gulf Stream as far as Massachusetts. Best known and most highly valued for food is the GREEN TURTLE; the LOGGERHEAD, also used for food, is of lesser importance; the HAWKS-BILL is the source of commercial tortoise shell. A small United States sea turtle fishery is centered in southern Florida. Close to a million pounds of sea turtles are imported from Costa Rica, Nicaragua, Jamaica, Cuba, and Mexico. Almost the entire quantity is canned. Sea turtles are captured when they leave the water to lay eggs in the sand of beaches; they are also taken by trapping in entangling nets, and by spearing. There is virtually no knowledge by which to manage these valuable resources, and little is done to enlarge or sustain the yield.

SPINY LOBSTERS ARE TROPICAL CRUSTACEANS, taken in quantity on the Atlantic side only in Florida, and chiefly along the southern slopes of the reefs and keys. The United States commercial catch is about half a million pounds annually. Considerably more than this quantity is imported from the Bahamas and Cuba. In addition,



Bullfrog

another species of spiny lobster is imported from South Africa.

Spiny lobsters inhabit coral reefs, rocky bottoms, or other ground affording good cover. They hide by day under rocky ledges or among sponges, where they may be detected in clear water by their protruding antennae. At night they emerge to crawl about and feed. Then they are caught in pots by fishermen.

They congregate in large numbers along the shore during spring and summer to spawn. Some spawning continues into early winter. Virtually nothing is known about this resource by which to enlarge or sustain its abundance. State law prohibits lobster fishing during the spawning season.

FROGS ARE TAKEN FOR THE MOST PART from ponds and swampy areas not included in surveys of production of aquatic products; complete statistics on the commercial catch, therefore, are not available. The annual catch is estimated at more than 3 million pounds, valued at approximately one million dollars.

Edible frogs are taken in many of our States, chiefly Louisiana. About six species are considered edible in eastern United States, three in the western part of the country.

Frogs are captured on lines baited with red cloth, worms, or grasshoppers, by shooting, or by hand.

While many people have attempted to engage in intensive frog culture, few have found the venture especially profitable. Most so-called frog farms are simply natural marshy areas or ponds which provide suitable surroundings and adequate food. Larval frogs, or tadpoles, thrive on any soft vegetable or animal matter; adult frogs require live food or food in motion. The difficulty of supplying the proper food for the adults is one of the chief obstacles to success in intensive frog farming.

The principal markets for frogs are in the larger cities such as St. Louis, Chicago, New York, New Orleans, and Detroit.

Atlantic Fishery Resources LOBSTER

THE AMERICAN LOBSTER fishery takes 11 to 14 million pounds of lobsters a year, worth 2 to 3 million dollars to the fishermen. Thus it is the third most valuable marine resource in New England. The fishery provides full- or part-time employment to more fishermen than any other single New England fishery. It is carried on by numerous small, one- and two-man boats, operating along practically the entire north Atlantic coast and is virtually the sole financial support of many small coastal communities.

Statistics on the United States catch of lobster show a decline from 30 million pounds a year in 1800, to between 9 and 14 million pounds in recent years. The catch per trap in 1889, when the fishery was pursued with sail or hand-powered boats, was 173.5 pounds. In 1940, with all the advantages of gasoline powered boats, it was something less than 34 pounds.

LOBSTERS LIVE ON THE OCEAN BOTTOM from the shore line to the edge of the continental shelf, but usually are found in greatest numbers in depths of 1 to 30 fathoms. Along the New England coast lobsters mature and spawn when 10 to 12 inches long. They mate in the summer just after molting and the female retains the sperm until the following June to October. Then she produces the eggs and carries them attached under the tail until they hatch 10 to 11 months later. On hatching, the young lobsters drift freely in the open sea from 2 to 6 weeks, depending on water temperature. The babies are fragile, and shrimplike in form. They molt and grow a new shell three times before developing to the typical shape of the larger lobsters. Then they descend to bottom, where they spend the rest of their lives. Mature females spawn every 2 years.

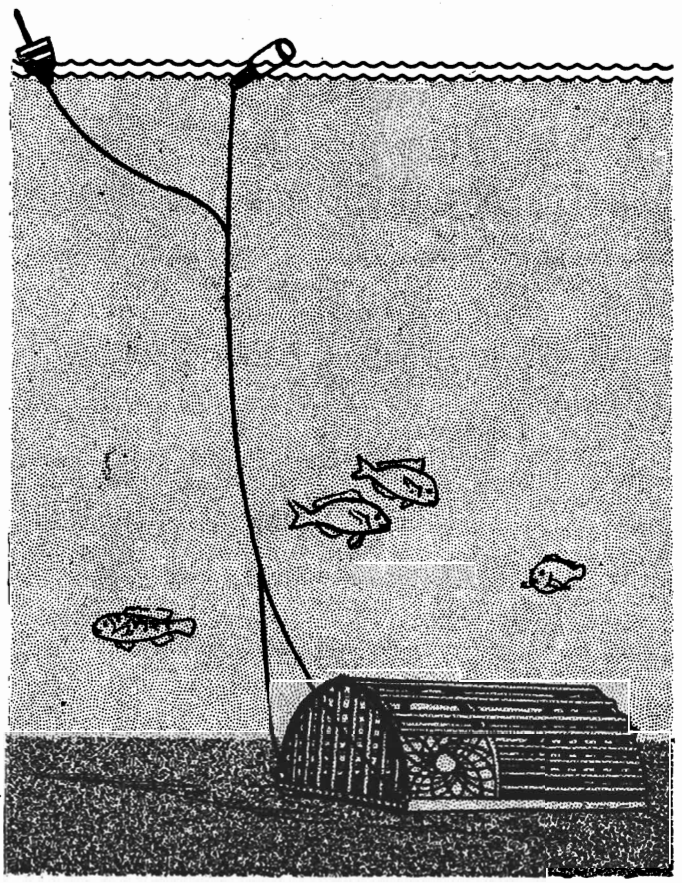
Lobster shells being rigid, cannot increase in size; therefore, they must be cast off (molted), at intervals to enable the animal to grow. During the first year, moltings are numerous, but thereafter decrease in frequency. The adult female usually molts once in 2 years. Small lobsters grow as much as 20 percent each molt; large ones average less than 9 percent.

The largest specimen on record weighed 45 pounds. According to tagging experiments, lobsters move offshore to deeper water in the fall and return in the spring. Their migrations are not extensive; larger individuals move about more than the smaller ones.

SIZE LIMITS, PROTECTION OF SPAWNING FEMALES, AND ARTIFICIAL PROPAGATION ARE THE CHIEF MEASURES used to protect the lobster resource. Lobster producing States have minimum size limits. In addition, Maine has a maximum size limit to protect the large spawners. The Fish and Wildlife Service operates a hatchery and rearing station at Boothbay Harbor in cooperation with the State of Maine and one at Gloucester, in cooperation with Massachusetts. Rhode Island operates a station at Wickford and Connecticut one at Noank. At these stations, egg-carrying female lobsters are kept in tanks while the eggs incubate. After hatching the young are reared in special tanks until after their third molt and they are ready to descend to the bottom. They are then liberated.

The Fish and Wildlife Service with the cooperation of the lobster-producing States is developing and carrying out experiments to determine the effect of present conservation measures. Results of these studies have led to increasing the size limit in some States, and to improving rearing methods. This improvement has increased the output of the Maine rearing station manyfold. Conclusions concerning the best size limits, the value of hatchery work and the best methods for improving production cannot be reached until more is known about the effect of the catch on the lobster populations, the size of the spawning stock needed for highest production, and other elements affecting the lobster's survival.

Lobsters must be stored and distributed alive and require extensive handling and storage equipment. Nevertheless they suffer considerable losses before reaching the consumer. Much of this loss could be eliminated by improving methods of handling. The resulting savings would benefit both producer and consumer.



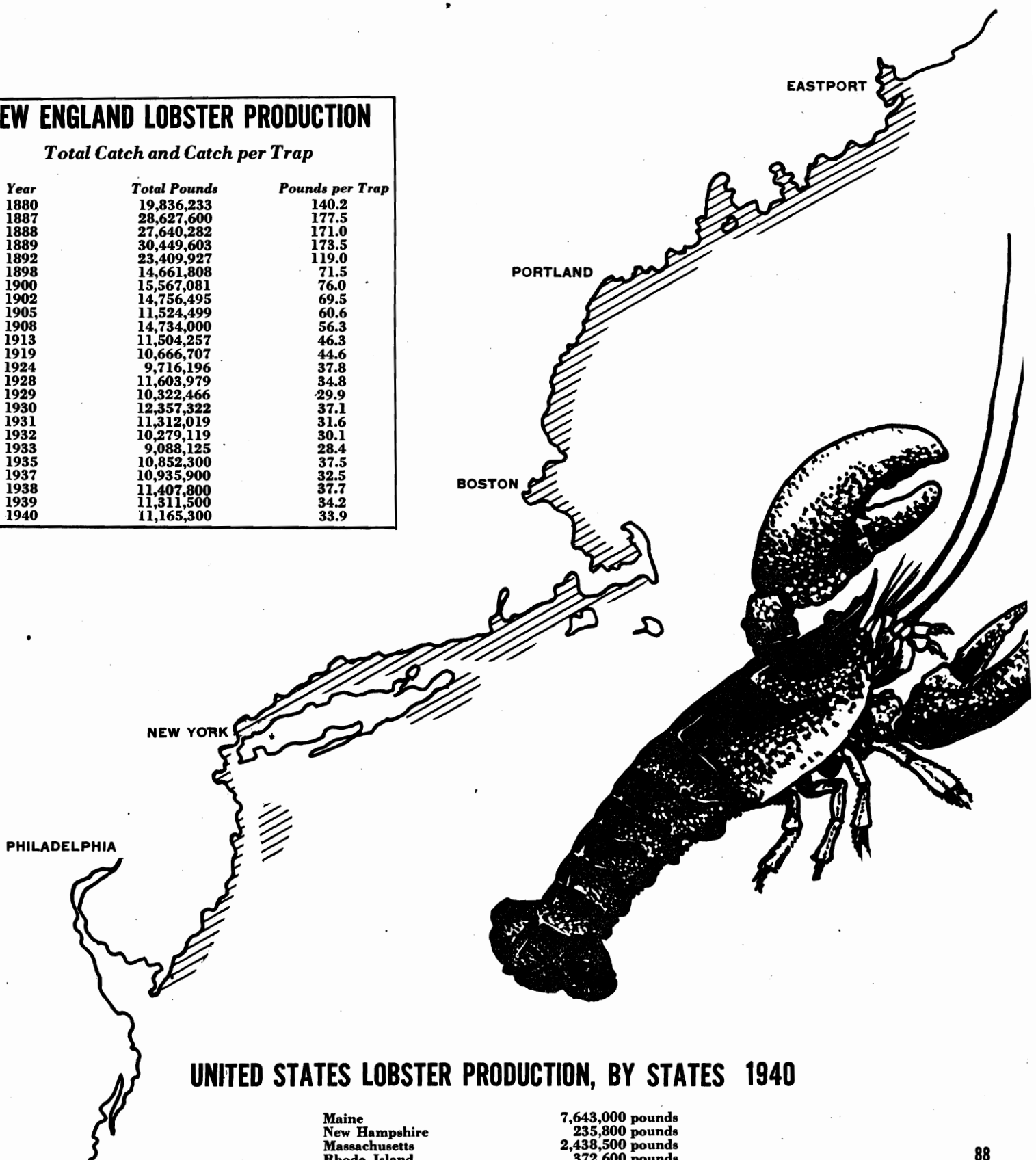
Lobsters are caught in small wooden traps or pots, which are baited with fish and lowered to the bottom at depths of 1 to 30 fathoms. Usually the traps are set singly, but in some localities, a trawl of as many as 12 traps may be fished. The traps are hauled daily or as often as conditions allow. A fisherman may operate 200 or more single traps but the average is less than 100.

Atlantic Fishery Resources LOBSTER

NEW ENGLAND LOBSTER PRODUCTION

Total Catch and Catch per Trap

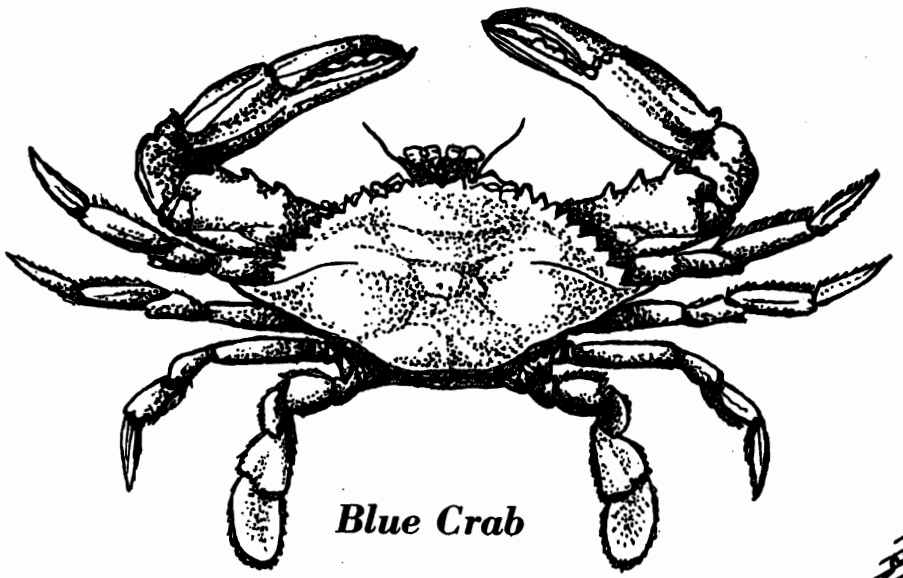
Year	*Total Pounds*	*Pounds per Trap*
1880	19,836,233	140.2
1887	28,627,600	177.5
1888	27,640,282	171.0
1889	30,449,603	173.5
1892	23,409,927	119.0
1898	14,661,808	71.5
1900	15,567,081	76.0
1902	14,756,495	69.5
1905	11,524,499	60.6
1908	14,734,000	56.3
1913	11,504,257	46.3
1919	10,666,707	44.6
1924	9,716,196	37.8
1928	11,603,979	34.8
1929	10,322,466	29.9
1930	12,357,322	37.1
1931	11,312,019	31.6
1932	10,279,119	30.1
1933	9,088,125	28.4
1935	10,852,300	37.5
1937	10,935,900	32.5
1938	11,407,800	37.7
1939	11,311,500	34.2
1940	11,165,300	33.9



UNITED STATES LOBSTER PRODUCTION, BY STATES 1940

Maine	7,643,000 pounds
New Hampshire	235,800 pounds
Massachusetts	2,438,500 pounds
Rhode Island	372,600 pounds
Connecticut	475,400 pounds
New York	191,100 pounds
New Jersey	401,900 pounds
Delaware	1,200 pounds
Virginia	2,200 pounds

Atlantic Fishery Resources CRABS



Blue Crab

THE BLUE CRAB resource of the Atlantic coast supports the largest crab fisheries of the United States. It produces annually around 80 million pounds of hard-shelled crabs and three million pounds of soft-shelled crabs, the total yielding close to 14 million pounds of edible crab meat worth between 3 and 5 million dollars. Chesapeake Bay on the Atlantic coast and Louisiana on the Gulf coast furnish 75 percent of the catch.

The blue crab is an animal of salt or brackish water, prefers shallow bays, sounds, and river channels, and is seldom found far out to sea. It may live for many hours out of water if kept moist and cool. It is very active during the warmer months of the year, and is extremely pugnacious. It seeks deeper and warmer water during the cold months and generally spends the winter in channels adjacent to its place of birth and growth. No extensive coastwise migrations have ever been demonstrated. Probably each section of the coast has its own local stock.

CRABS HAVE AN INTERESTING AND COMPLEX LIFE CYCLE IN WHICH THEIR MIGRATIONS PLAY AN IMPORTANT PART. Because the Chesapeake fishery for crabs has been longest established and also because the Bay apparently provides ideal surroundings for their propagation, the habits and life history of crabs are better known in the Chesapeake than anywhere else.

Each year between the first of June and the end of August, in Chesapeake Bay, a new generation of crabs is produced. At this season the female extrudes the eggs, each about one one-hundredth inch in diameter, and these together form a large yellowish mass known as the "sponge" and remain attached to the female crab. The eggs hatch in about 15 days. The young crabs are quite unlike their parents in appearance. As they grow they shed their shells repeatedly and in about a month assume a crablike form. Thereafter the crab molts about 15 times before reaching maturity, at first every 6 days and then after gradually lengthening periods up to about 25 days between final molts. Ordinarily the crab gains about one-third in size with every molt. Crabs reach their full growth and maturity, and cease to molt, during their second summer, when 12 to 14 months old.

Many people have the mistaken impression that the so-called "soft crab" is a distinct species. The term refers to any crab which has shed its old shell, before the new shell has hardened. As the soft-shelled crab is considered especially good eating, large numbers of young crabs are sought in the spring and early summer while they are still molting.

Usually the first spawning takes place when the female is about 2 years old. It is believed that some females live over another winter and deposit more eggs when 3 years old, but

Atlantic Fishery Resources CRABS

that few or none live longer than this. The life span of the male is probably about the same length.

In the Chesapeake most of the young crabs hatched in the lower part of the Bay soon begin a northward migration. Cold weather interrupts this journey, and they settle to the bottom and cease to feed and also to grow until conditions are more favorable. In the spring their migration is resumed, growth proceeds, and finally they reach Maryland waters as nearly mature crabs. The mating of the majority of the blue crabs of the Bay takes place in Maryland. After mating, the females return to the lower Bay, but most of the males remain behind, spending the winter in deep holes or creeks and rivers. Only about a fifth of the crabs taken in the lower part of the Bay during the winter are males. Nearly all the sponge-bearing crabs are found in Virginia waters.

TO DEVELOP AN EFFECTIVE PROGRAM OF BLUE CRAB CONSERVATION it is essential to know whether sharp natural fluctuations in the stock of crabs can be lessened or eliminated by practical conservation measures enacted in time by the respective States which control the crab fisheries. Can a maximum annual production of 68 million pounds of crabs be the legitimate goal of the crab industry in Chesapeake Bay or must a lower average annual production be predestined because of the varying degree of destruction of young crabs by adverse weather and other unalterable natural conditions? Will the maintenance of a large reserve brood stock of crabs automatically guarantee the survival of a large supply of young crabs which will serve to keep the fishery at a maximum peak?

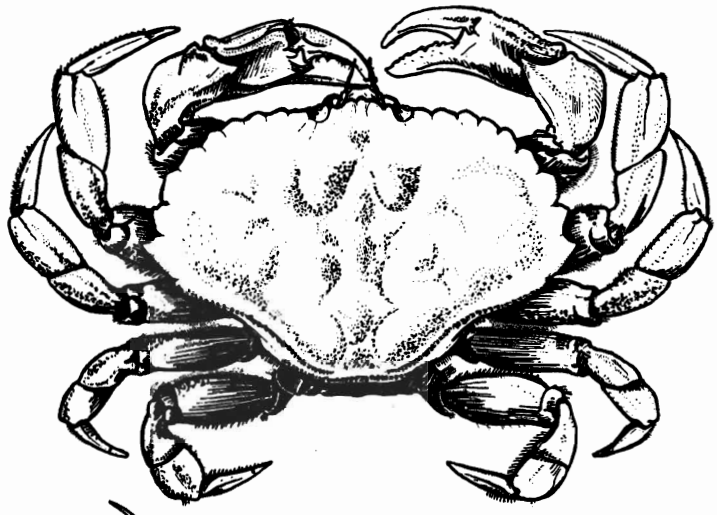
Such questions may be answered by studying the relation between the number of spawning crabs and the number of young surviving to commercial size.

HOW THE RESOURCE IS UTILIZED. Soft crabs are shipped alive to market while most hard crabs are steamed near the place of capture, the meat picked out of the shell, and shipped to markets in iced containers. Crab meat is also canned hermetically in some sections of the country, especially in South Carolina and Louisiana.

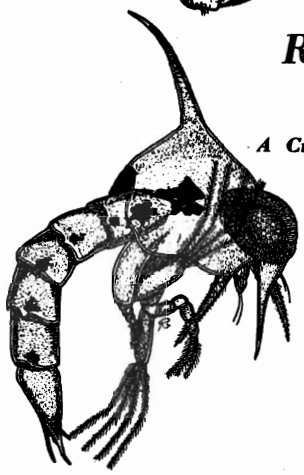
At the present time the most important markets for fresh crab are the cities of the Atlantic seaboard, which have long been familiar with this perishable product and know how to give it the special handling it requires. On the other hand, few midwestern cities know the blue crab as well, and as a result the interior markets to which the Gulf coast product could most profitably be shipped have not been fully developed. This lack of nearby markets for fresh crab has been an important factor in holding back the development of a large fishery in the Gulf of Mexico. Whether it could ever become as large as the Chesapeake fishery, however, is something that cannot be predicted until the crab populations of the region are studied.

IMPROVEMENTS ARE NEEDED IN OUR METHODS OF UTILIZING THIS RESOURCE. Fresh cooked crab meat is a delicate product. Careful sanitary control is required both in preparation and marketing. Only recently have methods been devised whereby blue crab meat might be canned successfully. The Fish and Wildlife Service has contributed to stabilizing the fresh crab meat industry by developing a method for the pasteurization of fresh crab meat. Studies are needed to find possible methods of utilizing the shell and waste, of which the quantity amounts to more than the meat.

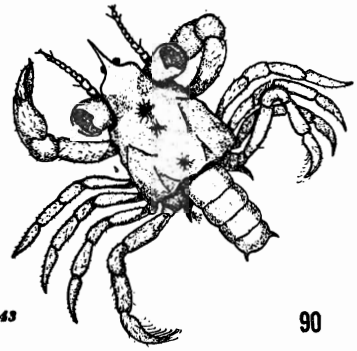
ROCK CRABS supply a small fishery in New England which before the war produced over 2 million pounds annually. Two species are utilized commercially. These are closely related to the Pacific Dungeness Crab but are smaller and apparently less abundant than that species. They are caught in ordinary or slightly modified lobster pots, mostly incidental to lobster fishing. In former years the crabs were sold almost entirely in local markets as fresh-cooked packaged meat. In 1941 a crab-canning industry started in Maine, stimulating a sharp increase in the catch. Owing to wartime exigencies, however, both the new industry and the catch have temporarily declined. Nothing is known about the biology of these crabs, hence there is no basis for conserving this resource. Few, if any, State regulations apply to this fishery. Since the fishery rejects the female crabs, which are too small to have commercial value, conservation measures may be unnecessary.



Rock Crab



A Crab larva, about three days after hatching



B Last larval stage

630701 O - 45 - 7

Atlantic Fishery Resources SHRIMP

Icing down the catch.

SHRIMP IS THE MOST VALUABLE FISHERY RESOURCE ON OUR SOUTH ATLANTIC AND GULF COASTS. It furnishes more food, engages more fishermen, and, in general, supports a larger industry than any other fishery of those regions.

SHRIMP LIVE ON THE SEA FLOOR, limited in their distribution to muddy or sandy bottom. Hence on the Atlantic coast, they are, for the most part, concentrated within 6 miles of shore; whereas in the Gulf of Mexico, they occur as far as the 30-fathom line, in places 45 miles from shore. Formerly the shrimp fishery was entirely an inshore one. On the Atlantic coast it has remained so; in the Gulf an offshore fishery has developed, concentrating its effort chiefly between the 5- and 15-fathom lines. Thus the fishery now tends to be divisible into two types: the inshore fishery, carried on by small boats in the inside waters and along the beaches; and the offshore fishery carried on by larger boats entirely in outside areas.

About 95 percent of the catch is composed of the common shrimp, *Penaeus setiferus;* and the remainder is divided between the grooved shrimps of the *Penaeus brasiliensis* group, and the sea-bob, *Xiphopenaeus kroyeri,* which is utilized in Louisiana only, and principally for drying.

The bulk of shrimp caught are in their first year of life. The oldest ones, taken offshore in deeper water, are something over a year old. Thus the fishery is supported for the most part by a single year class, which must, within its brief span, reproduce the population if the fishery is to be sustained.

The shrimp spawn from March into September, almost entirely in the outside waters. They do not carry their eggs as crabs or crayfish do, but deposit them directly into the water. The eggs and subsequently the newly hatched young drift passively with tide and currents, eventually reaching inside waters. There the infantile shrimp settle to bottom and find nursery grounds in the numerous small bays and creeks of the south Atlantic and Gulf coasts. They grow rapidly, and gradually work their way into the larger bays, and eventually move to the outside waters.

The product of the year's earliest spawning appears in the fishery from mid-June to mid-July, depending on climate and geography. From then on, increasing numbers of young recruits appear, until by July or August, they comprise practically the entire catch in the inside waters. By late summer or fall, the largest of these young shrimp begin to appear in the outside fishery. Meanwhile, winter approaches; the water cools.

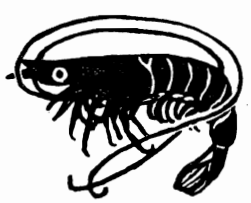
Then the largest shrimp migrate. On the south Atlantic coast, they move from the Carolinas, Georgia, and northern Florida into warmer waters between St. Augustine and Cape Canaveral, Fla. In the Gulf they move offshore into deeper and warmer water. Thus during the winter, only small shrimp are to be found in the bays, rivers, and bayous.

Growth is slight during the winter, resumes its rapid rate in the spring. Then the sex products mature, the females grow much larger than the males, and by March, the yearling shrimp move into deeper water to spawn. Apparently, from this point on they suffer a severe natural mortality rate, and only insignificant numbers seem to survive into the second year. While in deep water they are the object of the offshore fishery.

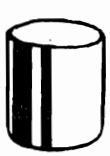
On the south Atlantic coast the winter fishery in Florida for shrimp that have migrated there from the northerly areas, is so intense that this migratory population is practically exterminated. Only those survive that had been too small to migrate and had wintered over on the inside waters and along the beaches from the Carolinas to northern Florida.

THE PROBABILITY OF DISCOVERING NEW IMPORTANT FISHING GROUNDS IN THE SOUTH ATLANTIC AND GULF OF MEXICO DOES NOT APPEAR PROMISING. Surveys in waters off our coast over these areas, made

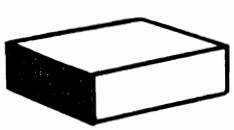
IN 1943 $15 MILLION WORTH OF SHRIMP WERE CAUGHT, WEIGHING 150 MILLION POUNDS. OF THIS AMOUNT,



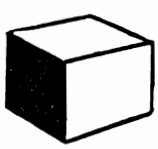
46% were sold fresh



25% canned



15% frozen



10% dried

4% cooked and peeled

+ a byproduct, shrimp bran

by the Fish and Wildlife Service and by the fishing industry, have shown that all the great shrimp-producing grounds are now being worked. The most recently developed new important fishing area, the Louisiana offshore grounds west of the Mississippi River, were discovered in 1937 and were studied by the United States Bureau of Fisheries (now Fish and Wildlife Service) with the research vessel *Pelican*. Those grounds have since become the center of a large fishery, carried on by some 200 large diesel-powered trawlers working out of Morgan City, producing over 20 million pounds of "jumbo" shrimp annually. A similar offshore fishery has developed in Texas, adding materially to the catch in that area.

WE ARE NOT NOW GETTING AS MUCH OUT OF THE SHRIMP RESOURCE AS WE SHOULD. This resource has been exploited without thought of sustaining the yield at its most profitable level. The cause of this prodigality is that fishermen have been working too hard catching baby shrimp in order to secure their desired tonnage. Under a proper management plan, these baby shrimp would be permitted to grow, and put on some weight before being caught. The result: More tons of shrimp with less effort, and lower handling costs. A suitable management plan, *based on our present knowledge*, is this:

1. Close the inside waters (that is, the nursery grounds) to shrimping during certain summer months when small shrimp comprise practically the entire population and are growing rapidly.

2. Close the inside and adjacent inshore waters during certain winter months when only small shrimp are present.

3. Leave open to fishing the year round the outside grounds and areas where only larger shrimp are present.

Some States have adopted regulations based on these principles, and others have done so only in part. In any event, the trend of legislative control seems to be in the right direction.

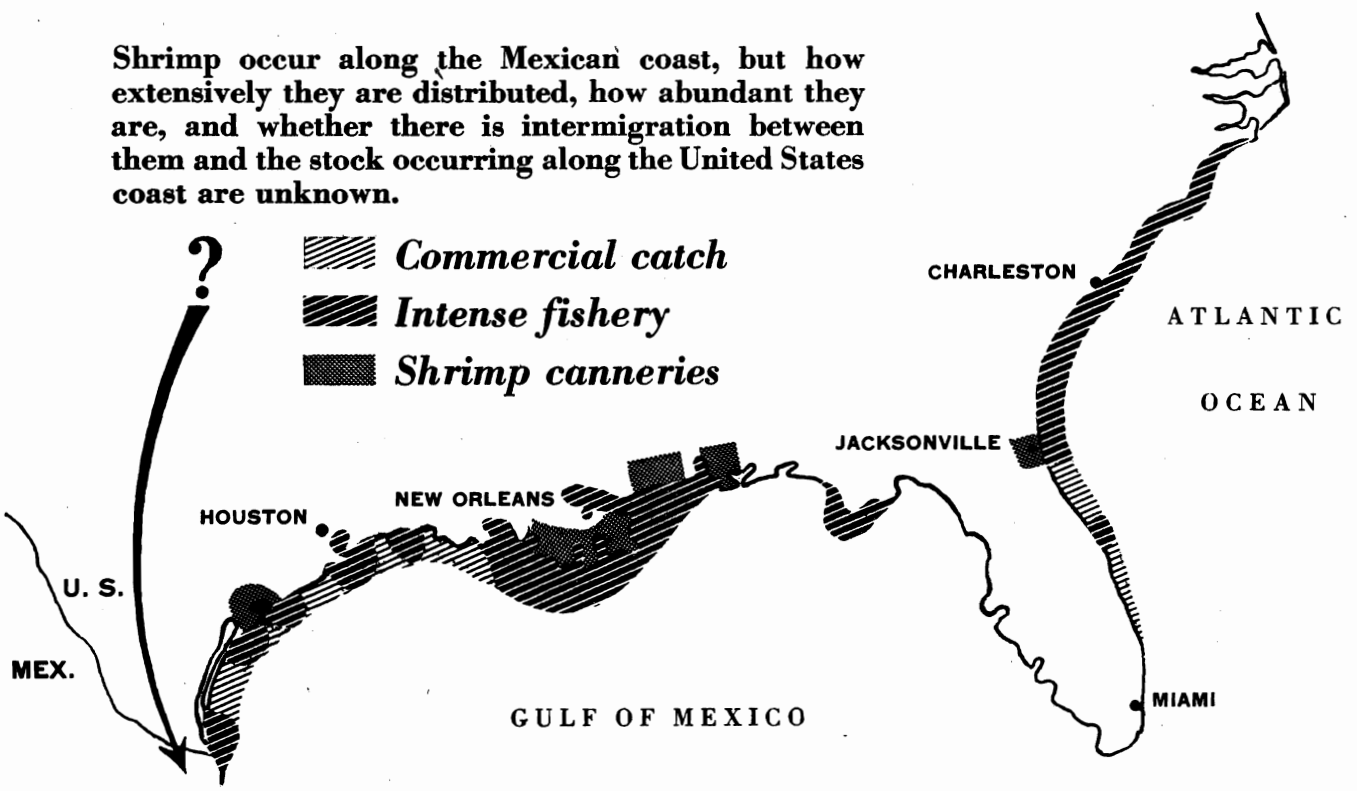
This plan should be progressively modified to keep pace with our advancing knowledge of the resource. Its effect should be continuously analyzed from complete and accurate statistics on the quantity and size of shrimp caught. Determination of the effect of different fishing intensities on the size of the shrimp population is the central goal of the United States Fish and Wildlife Service research on shrimp. The degree of accuracy of this estimate will depend on the extent to which we succeed in discovering and analyzing the effect on the size of the resource of the various intricately related and fluctuating natural conditions.

SHRIMP ARE CAUGHT BY OTTER TRAWLS, which are towed along the ocean bottom by power vessels. The trawls vary in width from 30 to 100 feet, depending on the vessel's power and size. The shrimp fishery employs about 3,000 shrimp trawlers, operated by 6,500 fishermen.

SHRIMP ARE MARKETED FRESH, frozen, canned, dried, and cooked and peeled. Shrimp bran, a byproduct, is manufactured from dried heads and hulls, sold for animal feeds. Recently, utilization of fresh and frozen shrimp has increased at the expense of canned production. It is expected that as freezing and marketing facilities become available, more of the catch will be marketed frozen. There are now about 50 canneries, located in Louisiana, Mississippi, Texas, Alabama, Florida, and Georgia. About half the total pack is put up in Louisiana, where the industry centers around New Orleans and Houma.

The shrimp canning industry has placed itself under a voluntary inspection system administered by the Seafood Inspection Service of the U. S. Food and Drug Administration. An individual packer desiring this service makes application for it, must show that his equipment meets specified standards, and that his plant operation conforms to regulations drawn up by the Administration. If passed, he may add to his can label the statement "Production supervised by U. S. Food and Drug Administration." No pack so labelled can be shipped until actually inspected and passed. About 90 percent of the pack is prepared under this inspection system, which has resulted in improved quality and better packing methods.

Shrimp occur along the Mexican coast, but how extensively they are distributed, how abundant they are, and whether there is intermigration between them and the stock occurring along the United States coast are unknown.



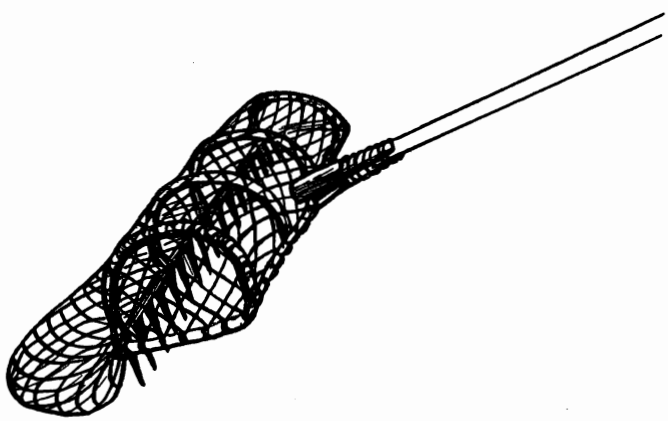
Atlantic Fishery Resources MOLLUSKS

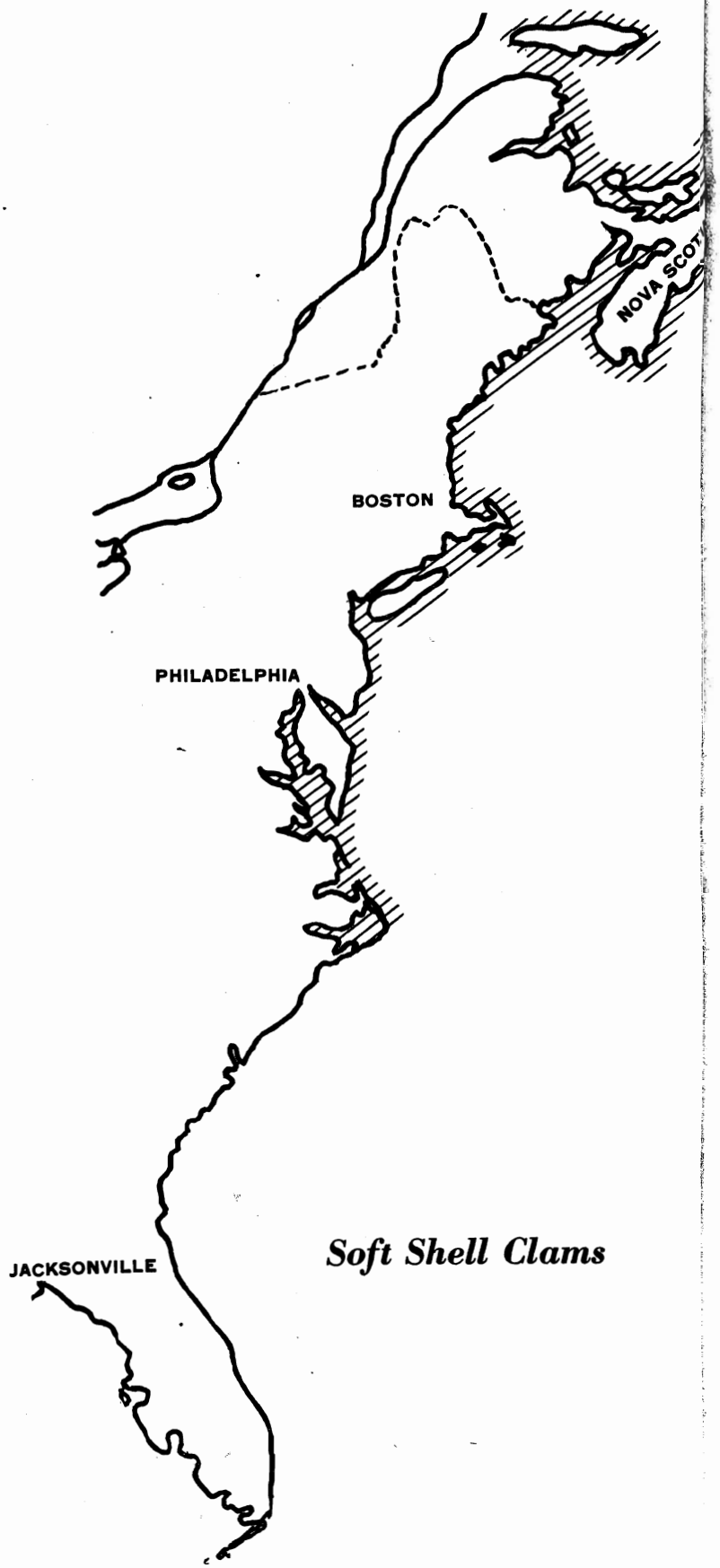
THE SOFT SHELL CLAM lives on tidal flats and beaches of harbors, inlets and bays, generally in the inter-tidal zone, though some deep water colonies are known to exist. The soft shell clam fishery yields about 16.5 million pounds of meat annually, worth about 1.2 million dollars. Almost the entire yield comes from public beds. Soft shell clams are dug with clam hoes, sometimes with spading forks. Usually the small clams, so-called "steamers," are sold in the shell, while the large-sized ones are shucked, and their meats iced.

The Atlantic clam resources have long been badly managed. For want of scientific cultivation and management of the fishery, many clam grounds are now barren or depleted beyond value. Furthermore, some large areas where clams are abundant are heavily polluted with domestic sewage and consequently closed to clammers.

IF THE ANNUAL YIELD OF SOFT SHELL CLAMS IS TO BE SUBSTANTIALLY INCREASED, most States must take better care of their resources either by scientific cultivation of public grounds, or by liberalizing the opportunities of private interests to lease grounds. Unfortunately, up to the present, municipalities and States rarely, if ever, have cultivated their clam resources; instead, they neglect them and allow this source of wealth to dissipate away.

CONTROL OF SHELLFISH IN NEW ENGLAND is divided between State and township. Usually the States set up over-all regulations and leave some of the details of seasons, licenses, and size limits to the townships. A 2-inch minimum size law is common throughout New England for soft clams and quahogs. Townships usually bar nonresident diggers and issue either family or commercial licenses to residents. Maine prohibits shellfish canning and interstate shipments of clams from five counties between May 15 and October 1. A few townships lease flats for private cultivation and provide protection for the lessee, but this practice is not widespread.





Soft Shell Clams

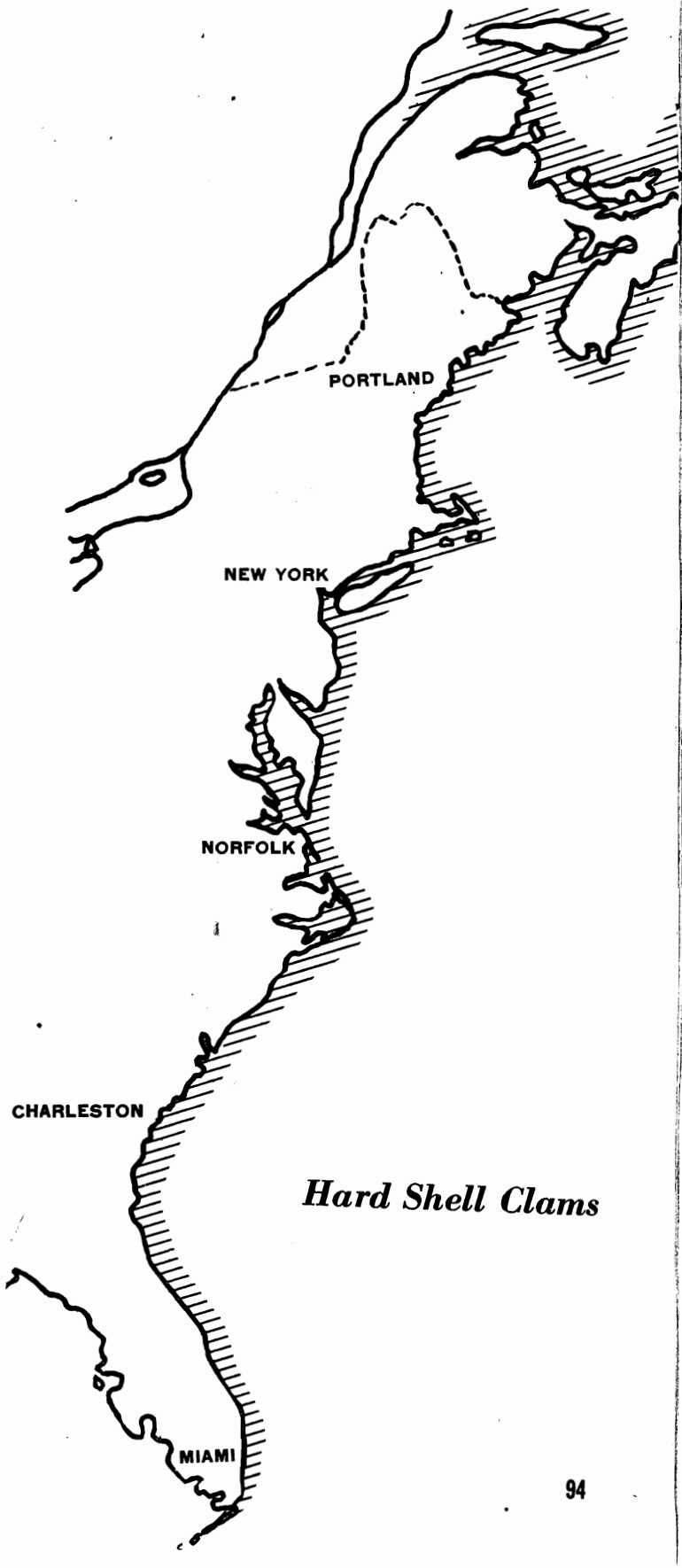
Atlantic Fishery Resources MOLLUSKS

THE HARD SHELL CLAM, also called quahog, hard clam, round clam, and little neck, lives from almost high-tide level to a depth of over 50 feet, usually on flats located several feet below the low-water line.

The hard-clam fishery yields annually about 13 million pounds of meat, worth about 2.2 million dollars. The bulk of the catch comes from uncultivated public grounds. The methods of harvesting hard clams vary considerably. The most primitive is treading, which means wading in the water, feeling for the clams with one's toes in the soft mud and then picking the clams up by hand. On tidal flats, during low-water stages, clams are dug out with clam hoes. Raking is common in Massachusetts. Tonging with oyster tongs is commonly employed in protected, calm water not deeper than about 12 feet. Dredging is the most efficient method of fishing for hard clams. However, it may be practiced only on privately leased lots or in areas where dredging is not prohibited by State or municipal laws.

The bulk of the clam catch is sold fresh; the rest is canned, either minced, as chowder, or as clam cocktail.

So long as the public fails to cultivate its clam grounds, discourages private cultivation, and pours its domestic sewage and industrial wastes over its good clam-growing area, it can get only a fraction of the potential yield out of this resource.



Hard Shell Clams

Atlantic Fishery Resources MOLLUSKS

SCALLOPS are mollusks with two shells (valves) which close tightly all around the rim except for two openings near the hinge. By continuously opening and closing their valves, scallops effect a natural form of jet propulsion which moves them rapidly but erratically for short distances. These openings also prevent them from being shipped in the shell, like clams and oysters. When removed from the sea, the shell loses its water and the scallop dies in a few hours. Hence the central muscle of the scallop, the only part which is eaten, must be cut out immediately after capture.

SEA SCALLOPS are found on sandy and rocky bottoms in depths of 2 to 150 fathoms. During the past 20 years the landings have risen from a few hundred thousand pounds to over 7 million pounds a year.

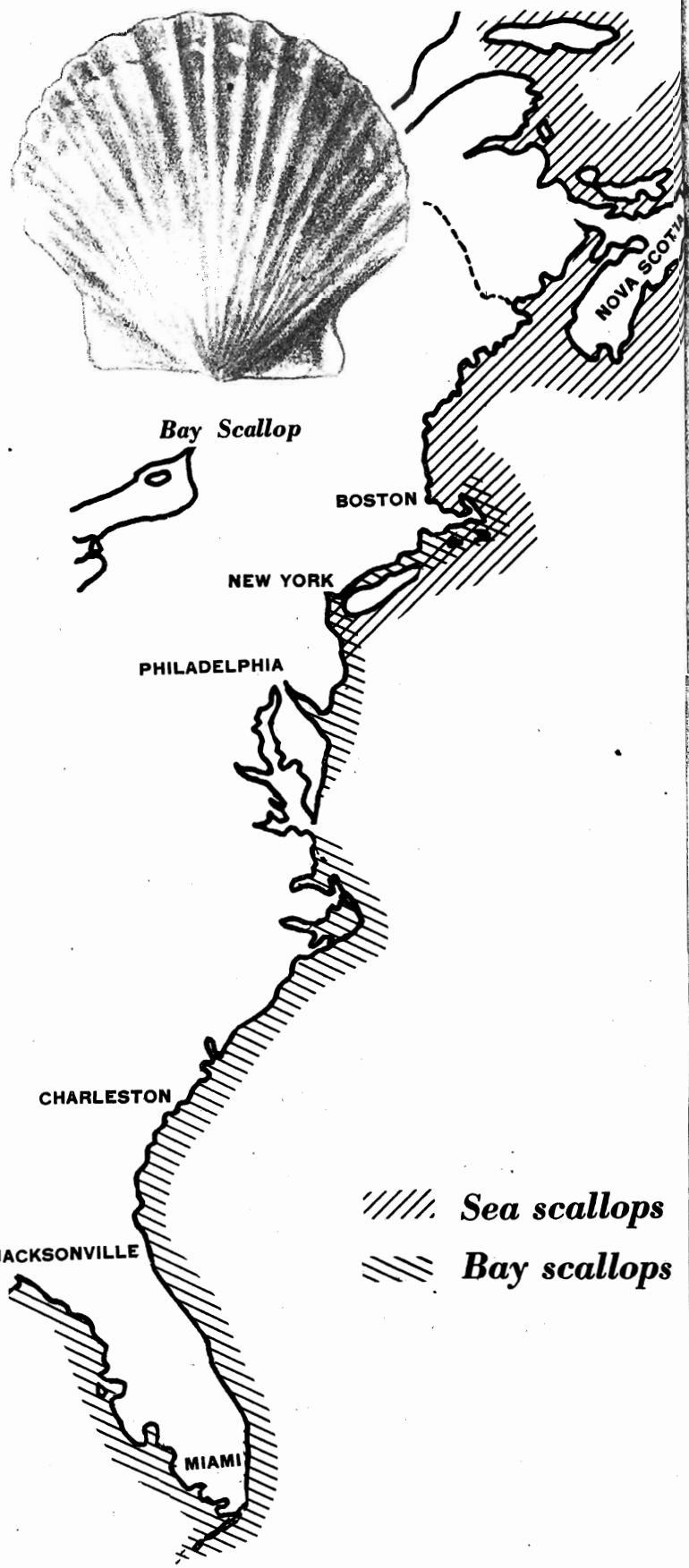
Scallop fishing is usually best on rocky bottom, and special iron dredges about 10 feet wide have been developed to fish this bottom. As the scallops are caught they are shucked and all but the central muscle thrown overboard. Despite the economic importance of the sea scallop, very little is known about its biology, about the possibilities of maintaining or increasing production, or about what measures would be of greatest benefit in helping the fishery.

BAY SCALLOPS are found in bays and estuaries from New England to the Gulf of Mexico. The most productive areas are sandy or muddy flats covered with eel grass. The scallops in the deeper waters of the bays are taken with small dredges operated by rowboats or catboats. Those in shallow tidal flats are taken with dip nets, rakes, or are picked by hand. Bay scallops are among the most costly and sought after of shellfishes. Biological studies have shown that bay scallops spawn during the summer when 1 year old and do not live to spawn a second time. New England State and township laws usually stipulate an open season during fall and winter and permit taking only adult scallops which exhibit a winter ring on the shell. Thus the commercial catch consists only of scallops which have completed their spawning and the quantities taken cannot influence the propagation of the species.

Bay scallops are subject to natural hazards of weather and current conditions which influence the setting or reproduction of the young. For protection from being washed away in storms, they depend on eel grass, in which they find shelter.

A disastrous plant disease killed off this grass during the 1930's, resulting in a severe decline in the bay-scallop fishery.

A program based on transplanting young or "seed" scallops to localities where natural reproduction is poor, but where growing conditions are favorable, offers considerable possibilities for increasing the catch.



Atlantic Fishery Resources MOLLUSKS

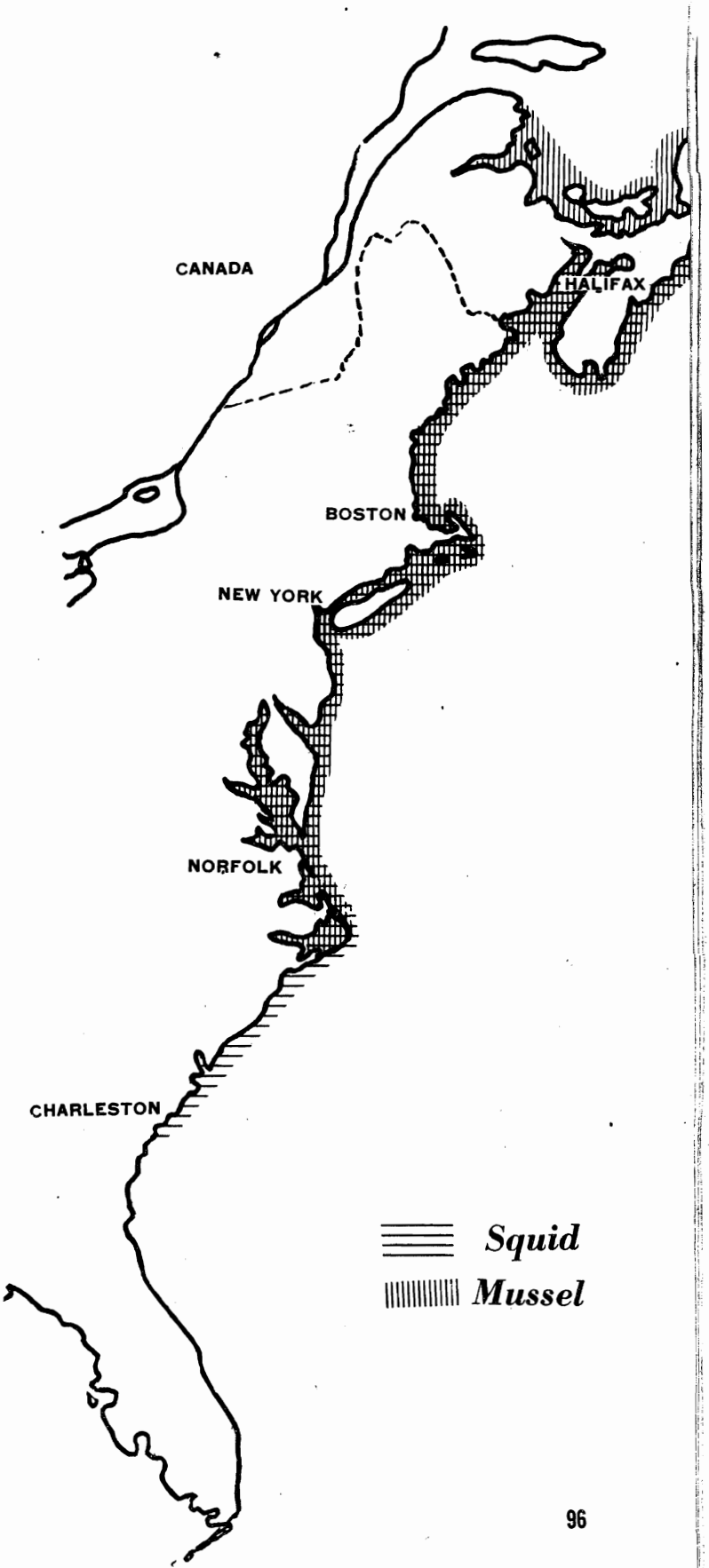
THE COMMON ATLANTIC SQUID is taken commercially along the entire coast as far north as Newfoundland, generally from June to August. Between 4 and 6 million pounds are caught annually, most of it used as bait in the groundfish fisheries. Considerable quantities are sold in the fresh-fish markets of cities with large foreign populations, such as Boston, New York, and Philadelphia. They are caught with pound nets, floating traps, otter trawls, and haul seines. Their availability and abundance fluctuate widely, and years of squid scarcity impose great hardship on line fishermen who depend upon them for bait. Squid are nutritious and flavorful; they could be more widely utilized by Americans for food.

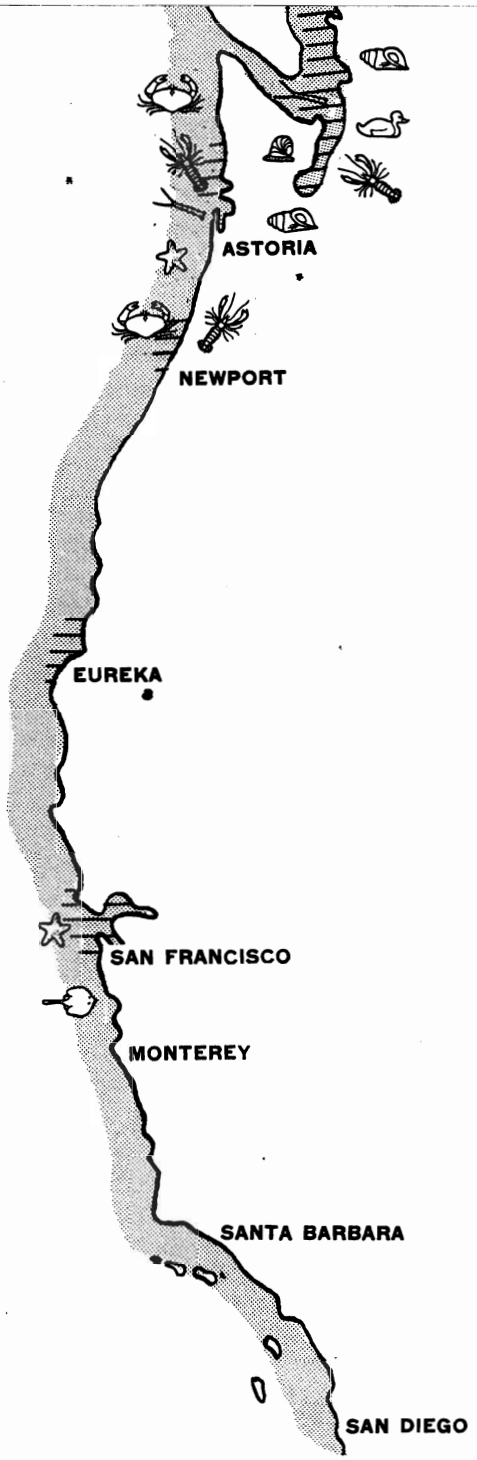
THE MUSSEL, long considered a delicacy in France and other parts of Europe, had never been utilized on a commercial scale in this country. In 1941 and 1942 the U. S. Fish and Wildlife Service, and the fishery departments of Maine and Massachusetts, conducted a survey of this resource. This showed that large populations of this shellfish existed between Cape Cod and central Maine and that this potential source of high-protein food was being entirely neglected. Wartime demand for full utilization of food resources encouraged development of this fishery, and it is quite probable that a demand for mussel products will persist after the war.

In 1942 about 1,500 bushels of Maine mussels were harvested, yielding about 15,000 pounds of food, which New England canners packed as an experiment. They experienced no great technical difficulties in preparing or marketing, and therefore increased the 1943 pack to nearly 1.5 million pounds of food.

In Maine, mussels exist along the shore and around islands on flats exposed at low tide. The usual practice in gathering the mussels is to take a dory or scow to the flats and fill it with mussels gathered with clam hoes, rakes, or pitchforks. Thus one man can gather from 15 to 30 bushels in a tide. The mussels are then taken ashore, washed, and the smaller ones culled out. In areas where the mussels are of uniformly large size, the factories prefer to buy the unculled and unwashed mussels, the washing being done by means of a fish scaler, a large rotary drum of wire mesh with jets of water washing out mud and debris.

In Cape Cod Bay, mussels of commercial size (2 inches or larger) are found only in deeper water. Here it is necessary to obtain them by means of dredges similar to those used for scallops. Some utilization of these mussels has been made, although greater labor costs in canning have not favored development of the fishery in this area.





OYSTER *Resources*

THE PACIFIC COAST contributes close to 10 million pounds of oyster meat, or about 11 percent of the Nation's total annual catch. Three species are utilized, of which the Pacific or Japanese oyster, introduced from Japan in 1902, is the most important. The small native Olympia oyster, which grows wild on rocks and bottoms from Vancouver Island to Mexico, is cultivated in Puget Sound near Olympia. It was once the object of a flourishing oyster-farming industry, which has declined and is now at low ebb of production. Cultivation of the eastern oyster, a species introduced from the Atlantic coast, has also run a course of success followed by decline and is now practiced on a limited scale in some places in California, where the 1940 production was near 113 thousand pounds.

Cultivation of the Pacific or Japanese oyster is the newest development of the Pacific coast oyster industry. From 1929 to 1941 the production of this oyster increased from 7,500 gallons of shucked meats to 478,000 gallons, plus 178,000 cases of canned oysters. At present about 7,500 acres of tideland in the State of Washington are used in cultivating this species, and the industry is gradually spreading to California. As a result of studies made jointly by the Department of Fisheries of the State of Washington and the United States Fish and Wildlife Service, special methods of catching spat have been devised and the industry is no longer dependent on imports of foreign seed.

Oyster farming in Washington is efficiently conducted, and various labor-saving devices are utilized. Harvesting is done by some companies with suction-type dredges, operated by only three men, and capable of taking 4,200 bushels of oysters within one high-tide period. Revolving cranes mounted on scows are used to pick up 25-bushel steel baskets full of oysters at the rate of one every 2 minutes. Devices for making spat collectors are used. Shucking houses and canneries employ the latest machinery, devices, and techniques developed through research and experiment.

The center of Olympia oyster culture in the State of Washington lies in the shallow bays of lower Puget Sound, where about 600 acres of tideland are under intensive cultivation by private growers. The State oyster reserves are not being maintained and are now in disrepair. Peculiar to the West Coast is the use of dikes in cultivating the native oyster. These are constructed either of cement or creosoted boards whose purpose is to retain a few inches of water over the oyster beds at low tide in order to prevent the heat of summer and the cold of winter from injuring the oysters. The cultivation of native oysters has proved to be profitable *when well managed.* However, in the past few years a number of difficulties have arisen which, for a time, threatened the entire native oyster industry with extinction. Adult oysters failed to fatten, and in many areas larvae failed to set on a commercial scale. Biological investigations of these problems, carried on cooperatively by the Fish and Wildlife Service and the Washington State Department of Fisheries, are in progress.

ON THE ATLANTIC COAST the eastern oyster grows naturally or is cultivated in the waters of every seaboard State. With the exceptions of Maine and New Hampshire, where natural beds were destroyed long ago and only a few living oysters can be found in isolated localities, every coastal State contributes its share to the annual production, which averages around 90 million pounds of oyster meat.

The eastern oyster is a typical inhabitant of shallow waters. It rarely occurs deeper than 40 feet, and prefers shallower grounds. In the South it is often found on tidal flats extending halfway between low- and high-water levels. Though it is frequently found on semisoft, muddy grounds, it thrives best on hard nonshifting bottom. Great variability in the size,

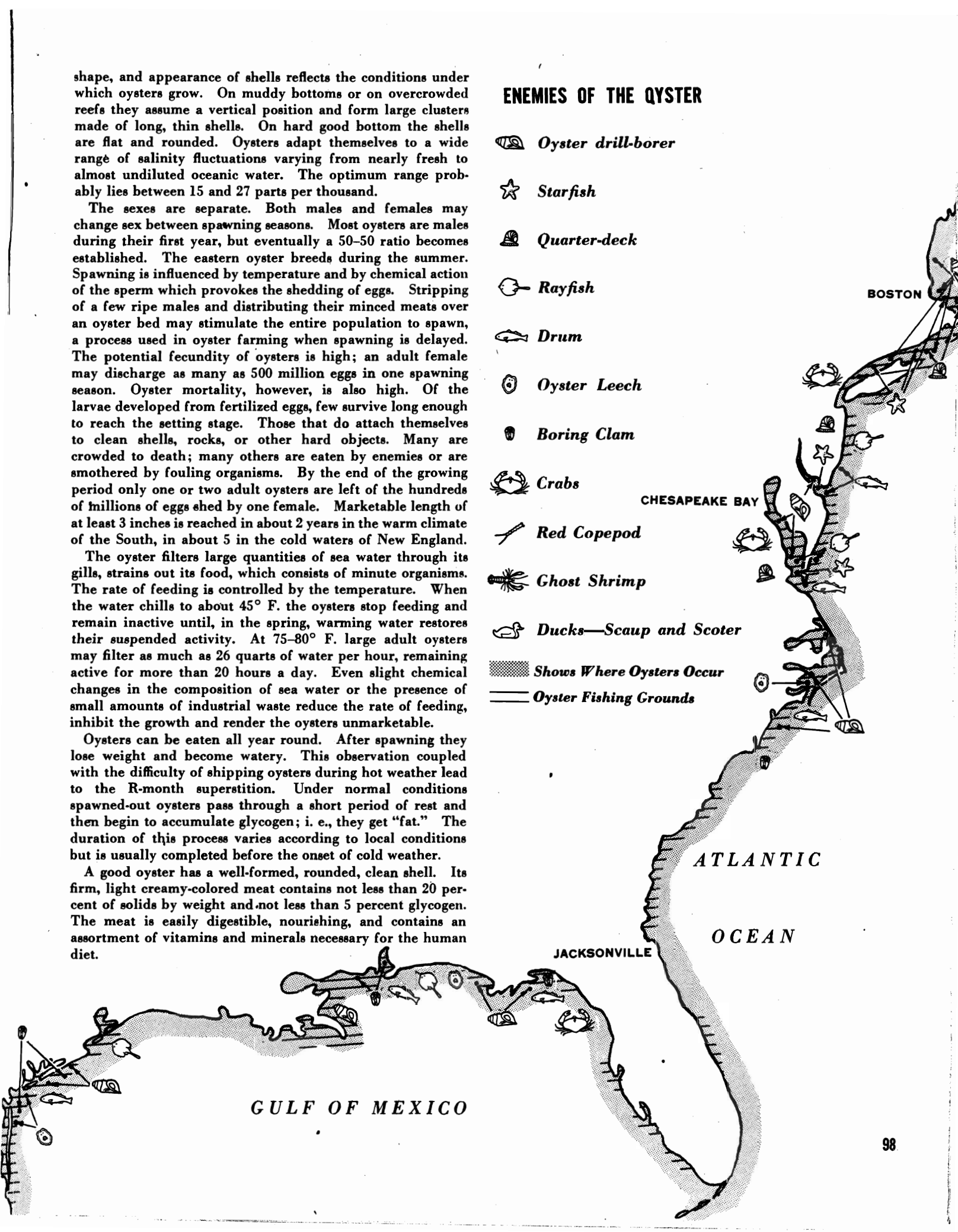
shape, and appearance of shells reflects the conditions under which oysters grow. On muddy bottoms or on overcrowded reefs they assume a vertical position and form large clusters made of long, thin shells. On hard good bottom the shells are flat and rounded. Oysters adapt themselves to a wide range of salinity fluctuations varying from nearly fresh to almost undiluted oceanic water. The optimum range probably lies between 15 and 27 parts per thousand.

The sexes are separate. Both males and females may change sex between spawning seasons. Most oysters are males during their first year, but eventually a 50–50 ratio becomes established. The eastern oyster breeds during the summer. Spawning is influenced by temperature and by chemical action of the sperm which provokes the shedding of eggs. Stripping of a few ripe males and distributing their minced meats over an oyster bed may stimulate the entire population to spawn, a process used in oyster farming when spawning is delayed. The potential fecundity of oysters is high; an adult female may discharge as many as 500 million eggs in one spawning season. Oyster mortality, however, is also high. Of the larvae developed from fertilized eggs, few survive long enough to reach the setting stage. Those that do attach themselves to clean shells, rocks, or other hard objects. Many are crowded to death; many others are eaten by enemies or are smothered by fouling organisms. By the end of the growing period only one or two adult oysters are left of the hundreds of millions of eggs shed by one female. Marketable length of at least 3 inches is reached in about 2 years in the warm climate of the South, in about 5 in the cold waters of New England.

The oyster filters large quantities of sea water through its gills, strains out its food, which consists of minute organisms. The rate of feeding is controlled by the temperature. When the water chills to about 45° F. the oysters stop feeding and remain inactive until, in the spring, warming water restores their suspended activity. At 75–80° F. large adult oysters may filter as much as 26 quarts of water per hour, remaining active for more than 20 hours a day. Even slight chemical changes in the composition of sea water or the presence of small amounts of industrial waste reduce the rate of feeding, inhibit the growth and render the oysters unmarketable.

Oysters can be eaten all year round. After spawning they lose weight and become watery. This observation coupled with the difficulty of shipping oysters during hot weather lead to the R-month superstition. Under normal conditions spawned-out oysters pass through a short period of rest and then begin to accumulate glycogen; i. e., they get "fat." The duration of this process varies according to local conditions but is usually completed before the onset of cold weather.

A good oyster has a well-formed, rounded, clean shell. Its firm, light creamy-colored meat contains not less than 20 percent of solids by weight and not less than 5 percent glycogen. The meat is easily digestible, nourishing, and contains an assortment of vitamins and minerals necessary for the human diet.



OYSTER *Resources*

OYSTER FARMING, highly developed in many States, provides about 58 percent of the total United States annual yield.

Several distinct operations are involved: First the bottom is cleaned and planted with shells, gravel, or other material to catch young oysters. After the set of oysters is obtained and allowed to grow for a few weeks or months, it is transplanted to growing grounds. As the young oysters grow and require more space they are transferred one or several times to larger areas. Before harvesting, the stock is transplanted again to fattening grounds, where the oysters accumulate large amounts of glycogen and acquire desired flavor. The last operation consists in harvesting, grading, and packing the oysters for shipment to market.

The net income of an oyster farmer depends on many variables, such as the quality of his grounds, distance from his shore base, acreage, success in controlling pests, cost of protection against trespassers, cost of labor, etc. In general, however, it far exceeds the income of the average agriculturalist. An annual productivity of 100 or even 150 bushels per acre is not an unusual return. Depending on the quality of the oysters, this crop may be the equivalent of 600 to 900 pounds of oyster meat and at prewar prices had a market value of $250 to $450.

From the viewpoint of conservation, oyster farming is the best means of sustaining this resource in the face of high fishing intensity. Furthermore, oyster farming makes it possible to transform and make profitable barren, unutilized areas of sea floor.

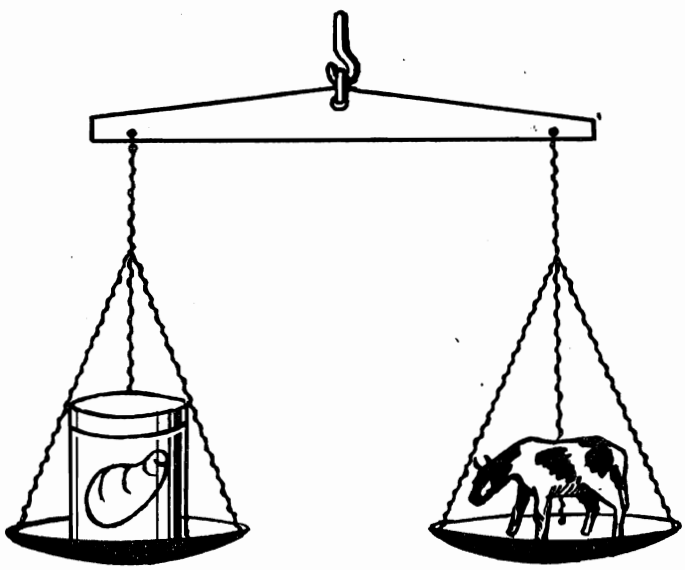
The simplified form of oyster farming practiced in the Delaware and Chesapeake Bays and in Louisiana waters consists of taking seed oysters from public reefs and planting them on privately leased bottoms. The oysters mature, are harvested, and sold in 1 or 2 years, depending on the size of the seed, which may vary from 1 to 2½ inches in length. The usual returns vary from 0.75 to 2.5 bushels of market oysters from a bushel of seed. Low returns of less than 1:1 are primarily due to the destruction of seed by drills, conchs, and other enemies.

The success of oyster farming depends on skill and on familiarity with modern methods of cultivation. With few exceptions, fishermen accustomed to gathering oysters from public reefs lack experience in oyster farming and have no understanding of the principles involved in breeding oysters. Establishment of experimental and demonstration farms is therefore imperative for the development of the oyster-farming industry in the South.

PUBLIC OYSTER GROUNDS.—More than a million acres of public reefs or rocks are open to free oyster fishing to those holding licenses sold by State departments of fisheries. Through bad management, most of this huge and potentially productive area has been badly depleted. In several States the destruction of oyster grounds has been completed and the oyster industry has almost ceased to exist. In others the productivity of bottoms has been reduced to a few bushels per acre.

Continuous decline in the productivity of public reefs proves that self-rehabilitation of grounds without active assistance from man is incompatible with intensive commercial exploitation. Efforts to combat depletion through the enactment of conservation laws, such as closed seasons, restrictions on gear, size limits, etc., have been fruitless, and the annual catch of oysters has declined to about half its former figure. Likewise, efforts of several States to rehabilitate public rocks by planting shells or seed have produced no appreciable results. In the absence of a carefully planned system of management, these costly undertakings are never successful. In a few instances where oyster populations had been restored through State plantings, the grounds have become depleted

AVERAGE ANNUAL PRODUCTION OF OYSTER MEAT (1938-1940)



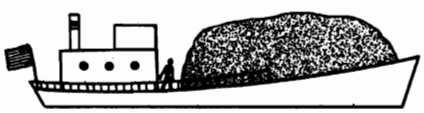
89.8 million pounds average annual production of oyster meat = *160,360 beef cattle in edible meat*

AVERAGE ANNUAL PRODUCTION OF OYSTERS IN U. S.

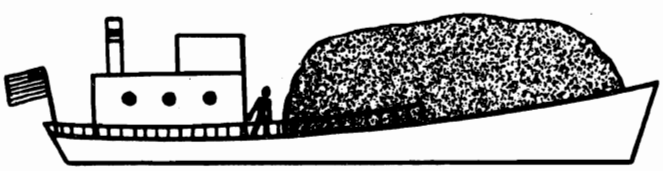
New England
7.5 Million pounds

Pacific Coast
9.7 Million pounds

Middle Atlantic
13.9 Million pounds



South Atlantic
& Gulf States
22.8 Million pounds



Chesapeake Bay
35.9 Million pounds

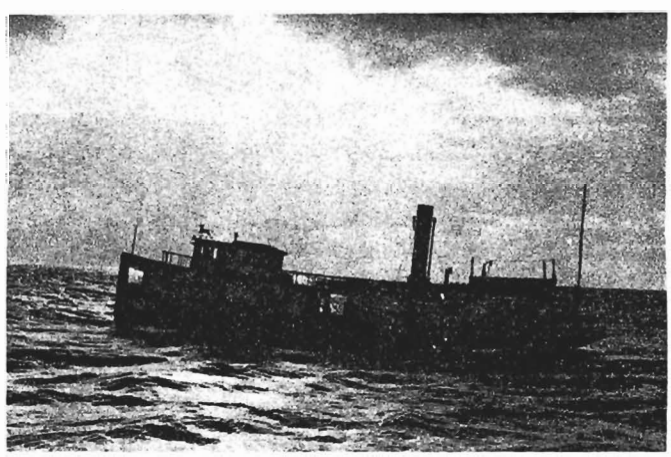
almost as soon as they were opened to fishing. These examples show that *control of the rate of harvesting* is necessary for maintaining the level of productivity on public grounds.

At present public funds spent on rehabilitating oyster grounds come from general taxation, and money used for planting operations is not recovered. If oyster fishermen were assessed according to their harvest from the public ground, the public's initial capital could be recovered and a revolving fund established for maintaining continuous management of the resource without further cost to the taxpayer.

This new approach to the century-old problem of public reef maintenance is now being tried in Maryland with the cooperation of the United States Fish and Wildlife Service. It requires careful planning of all operations, extensive experimentation in the field, accurate cost accounting and objective analysis of the results. It is hoped that work along these lines will be fruitful and instrumental in inducing other States to improve the management of their public oyster resource.

OYSTERS ARE HARVESTED with tongs and dredges and, in a few localities of the South, are picked by hand with grabs. Tonging is adapted to shoal and well-protected waters and is profitable only on grounds where oysters are plentiful. It is practiced only on public reefs where dredging is prohibited. A tonger averages 20 to 35 bushels a day.

Dredges are always operated from power boats or schooners. Some of the largest steamers used for oyster dredging in Long Island Sound are equipped with six dredges (three on each side) capable of harvesting at the rate of 1,400 bushels an hour on thickly planted grounds. Dredging requires great skill and long experience. Badly constructed gear or careless handling can cause great damage by breaking oyster shells or by forcing the oysters into the mud.



Dredge boat in Long Island Sound

OYSTER *Resources*

OYSTER ENEMIES.—The chief enemy of the oyster is the starfish, which infests the productive oyster beds in Buzzards Bay, Narragansett Bay, and Long Island Sound, and consumes hundreds of thousands of bushels of oysters annually. This pest can be reduced by mopping, dredging, or by spreading lime over oyster grounds.

The oyster drill, a marine snail widely distributed on the coast, and particularly abundant in the New England and Middle Atlantic States and in the lower part of the Chesapeake Bay, consumes a million dollars worth of oysters annually in Delaware Bay alone. It has been spread by careless oyster planting, not only along the Atlantic coast, but on the Pacific coast as well, and to Europe. Drills can be controlled by trapping and by the use of a special dredge; but coordinated and well planned State-wide or interstate campaigns are necessary to achieve success in destroying the centers of infestation.

Conch, drumfish, and various skates or rays frequently attack oyster beds in the Gulf of Mexico, devouring tremendous quantities. Oyster planters construct elaborate fences to keep the fish away and even resort to dynamiting to eliminate drums. Among the birds, the scaup duck is notorious for consuming large quantities of small oysters exposed at low tide.

Besides these enemies which actually devour oysters, are many parasites and commensals which invade the tissues and shells and impair the quality of oyster meat. Many other creatures compete with the oyster for space, and wreak damage by fouling the shells planted to catch set, or by smothering the young after they have attached themselves.

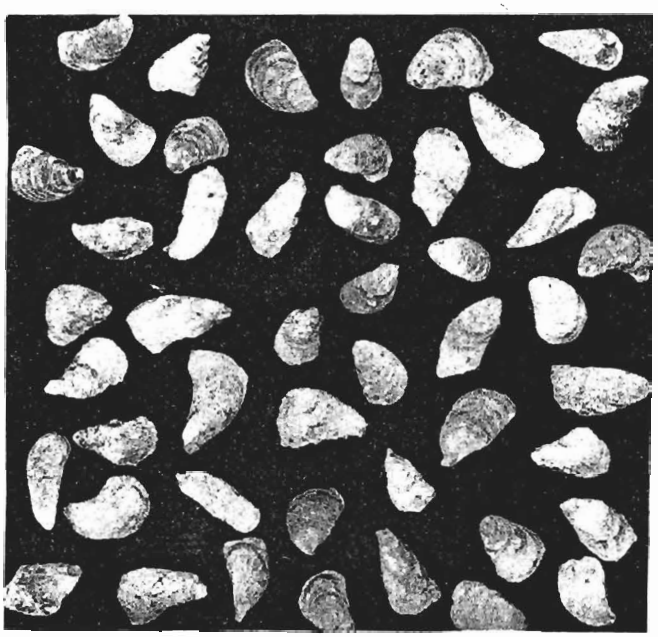
POLLUTION.—Domestic sewage and industrial wastes dumped into tidal waters ruin many valuable shellfish grounds. Some of the bays affected by domestic pollution may still be utilized as setting areas from which oysters can be later relayed to clean growing grounds; but many thousands of acres of formerly productive oyster beds have been so completely damaged by deposition of sludge and mud that all shellfish grown on them have perished, and these formerly valuable bottoms are beyond recovery.

Pollution puts a heavy burden of care and expense on the public and the oyster industry, necessitating constant vigilance by large staffs of State and Federal officers engaged in checking and certifying all shell-bearing grounds, and all shellfish shipped in interstate commerce. Under an elaborate system developed through cooperation of the United States Public Health Service, State and municipal departments of health, and the Federal Food and Drug Administration, the safety and interests of consumers are well protected.

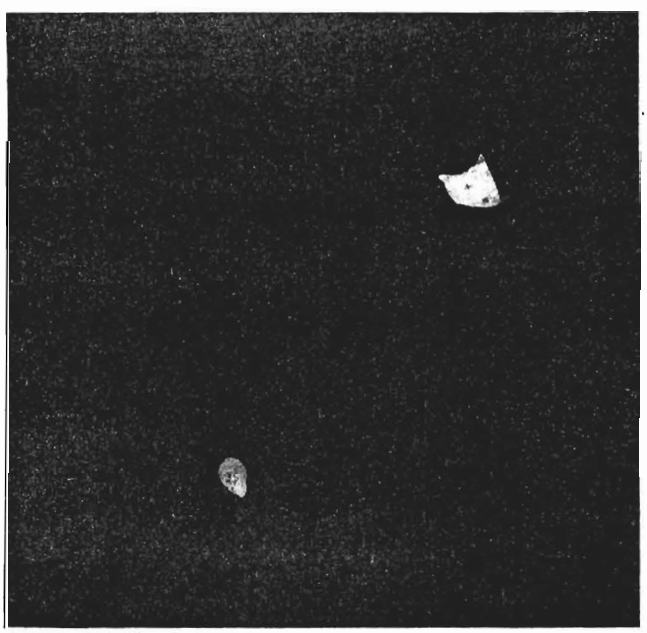
Poisonous industrial wastes, being usually highly diluted, do not kill shellfish as often as they interfere with their propagation, growth, fattening, and marketability. Many kinds of industrial wastes affect oyster grounds, among them, crude oil, pulp and paper-mill liquors, strong acids from pickling processes, bleaching, finishing, dyeing and laundry wastes, milk, milk products, molasses residues, and many others.

LEGISLATIVE REGULATIONS.—The oyster industry cannot complain for lack of legislative attention. Numerous State and Federal laws regulate every phase of the oyster fishery and vary not only from State to State but may differ

COMPARING PRODUCTIVITY OF CULTIVATED AND NATURAL OYSTER GROUNDS. EACH SQUARE REPRESENTS ONE SQUARE YARD.



Yield from one square yard of cultivated ground (1,000 bushels per acre).



Yield from one square yard of severely depleted uncultivated rock (11 bushels per acre).

in various counties and municipalities within the boundaries of the State.

Prejudices favoring free, unmanaged fishing, and failure to encourage or protect private planters impede full development and utilization of oyster resources. Every State permits leasing oyster bottoms for oyster farming. Yet the ambiguity of legal definitions of public rock or reef not subject to leasing makes it virtually impossible for private individuals in some of the States to acquire bottoms suitable for oyster farming. At the same time there is generally no provision authorizing State governments to manage the public oyster grounds. The consequence: General decline in the yield of oyster bottoms.

Surveys of oyster grounds made several decades ago listed as public reefs virtually all the grounds suitable for oyster farming. The revision of these surveys, necessary for the future development of the industry, is opposed by tongers and dredgers of certain States.

Legislation intending to liberalize the oyster farming laws of certain States has failed to protect the public against unscrupulous promoters and speculators. Restriction of leases to bona fide residents has been suggested as a remedy. Present Federal and State laws are inadequate to prevent the introduction of destructive aquatic pests. This condition should be corrected. Revision of oyster fishing seasons is desirable in certain localities.

OPPORTUNITIES FOR IMPROVING THE UTILIZATION OF OYSTERS.—Improved techniques in oyster farming, and efforts made by some of the State governments to increase the productivity of public grounds by planting shells and seed could result in over-production unless the quality of the oysters, which now varies widely, be improved.

The content of solids may vary from less than 10 percent to more than 24 percent of their weight. The nutritive and gustatory values follow accordingly. So far no attempts have been made to certify the quality of oyster meats on the basis of total amount of solids and of glycogen, the accumulation of which causes the "fattening" of oysters. With increased knowledge of feeding requirements and with better techniques of oyster culture, it will be possible to improve the product, and market oysters *of certified nutritive quality*. Experience shows that the demand for good oysters always exceeds the supply.

Yield from overcrowded uncultivated rock (3,000 bushels per acre). Size and quality vary, costing the oysterman much valuable time in culling.

Oyster tongers in Texas

The canning of oysters in the South Atlantic and Gulf States can be greatly improved by selecting better stock, and by modernizing canning equipment and methods of processing. At present the canneries use a large quantity of small, wild oysters from overcrowded natural reefs. Consequently the yield is low and the quality of the product cannot compete with that produced on the West Coast where modern methods of oyster culture and canning are practiced.

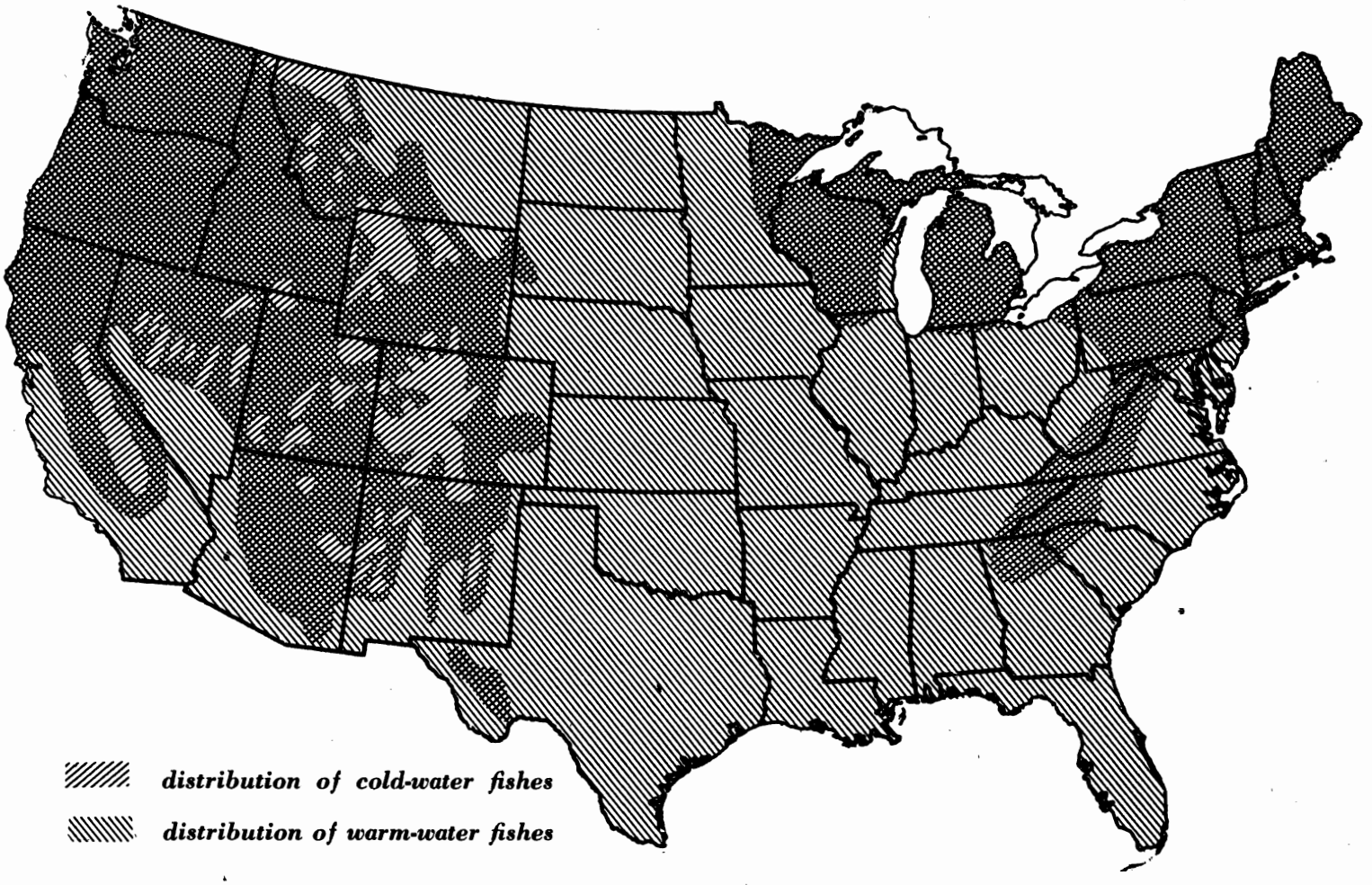
Prewar experience of some of the canneries in making smoked oyster, oyster spreads, and other varieties of specially processed oyster meats, points to the possibilities of further development in this direction. Quick freezing of oysters has been attempted on a commercial scale, but further experiment is necessary to adapt the freezing technique to shellfish meat.

FOR THE FUTURE.—If private industry is to be encouraged, adequate protection of property rights should be given to planters who should receive as much assistance from State and Federal governments as that rendered to agricultural farmers. This assistance may consist of any or all of the following: Experimental oyster farms to study local conditions and develop better techniques; maintenance of State-controlled seed oyster grounds to provide stock for planting; organization of State-wide combat of oyster pests; control, through legislative action and research, of pollution.

A program of State management of public oyster resources should provide for a competent staff of experienced oyster culturists, biologists, and economists. To avoid subsidies, harvesting on State-controlled bottoms should be adequately assessed to defray the cost of management. Sums collected in this way would form a revolving fund necessary for the maintenance of the plan.

Biological research needed for this program comprises studies of the feeding and fattening of oysters; field experimental investigations of the factors determining the productivity of oyster bottoms; predictions of the time of setting; control of enemies and fouling organisms; and finally, the study of selective breeding with the view to isolating from wild and mixed populations the most desirable varieties of oysters.

Fresh Water Fishery Resources



FRESH-WATER FISHERY RESOURCES. When the average man speaks of "fishing," he has in mind a fresh water stream or lake. These bodies of water individually contain rather small populations of fishes; but all the streams and creeks, lakes and ponds in the United States add up to a vast quantity of water, and the fish in them to a tremendous total in pounds of food.

Commercial fresh-water fisheries outside the Great Lakes (the Great Lakes are taken up in a separate section, *which see*) are carried on by a large number of individuals, most of them operating on a very small scale from day to day. The production per man by these fishermen is small, but according to the last statistical survey made (in 1931), the sum of all their efforts runs close to 85 million pounds of fish a year. They operate with all kinds of gear—with gill nets, fyke nets, traps, haul seines, hook and line, spears and many other, less conventional apparatus.

As impressive as these commercial fisheries may be, anglers fishing for recreation take a very much larger total from our fresh waters than do the commercial fishermen. For want of proper facilities to gather accurate statistics on anglers' catches we can make only a rough estimate of them. In some localities creel census studies have been made to determine quantities and kinds of fish taken from specific fishing areas. Judging from these isolated data, from estimates made by the State agencies and from various other sources, anglers catch not far from 260 million pounds of fish from United States fresh waters in a normal year.

It is estimated from the number of State licenses bought, and from various other sources that in the year ending June 30, 1943, at least 12 million people took advantage of our recreational fishing resources. Calculating from a grand total of 260 million pounds, the annual catch of the average angler comes to 22 pounds. While this weight may seem excessive to a trout fisherman whose season's catch may not total more than about 5 pounds, it barely exceeds a 1-day legal limit to those angling for coarser fishes.

IN MANY WAYS, FROM A CONSERVATION VIEWPOINT, FISHERY MANAGEMENT IN THE FRESH WATERS IS A MORE COMPLEX PROBLEM than it is in the ocean. To be sure, the fishery biologist studying the ocean environment faces a maze of problems in physical oceanography, climatology, and biology. But each lake, each pond, each stream and brook is, in effect, a little ocean, with its own individual set of involved conditions. The elements which

control the size of fish population, the biology of the fish and the productivity of the water in terms of fish per acre differ tremendously from lake to lake and stream to stream. For this reason, conservation of fresh water resources, and the research needed to devise rational regulatory measures, must be practiced on a highly localized basis. For this reason, too, it is impossible to make any statements on the condition of the fresh water fish resources as a whole.

LAWS AND REGULATIONS designed to conserve the fresh water fishes generally are promulgated and enforced by the State governments. The Federal government exercises jurisdiction over fresh water fishing only in Alaska, and in certain Federal reservations like national parks.

In general, State laws regulate the time, place, and manner of taking, the kind and amount of fish taken, and establish requirements for fishing licenses. They are intended to protect spawning fish and growing young, to maintain a spawning reserve, to distribute the supply among as many anglers as possible, and to secure financial support for the administrative program. Most regulations fall into one of the following categories: (1) Size limits; (2) closed seasons; (3) catch limits.

These laws are frequently based on the popular notion that overfishing is everywhere the only cause of declining abundance, and fail to recognize such destructive conditions as pollution or soil erosion. Frequently they are based entirely on opinion rather than knowledge. Sometimes they result in overproduction, with consequent stunting of the fish in the stocks. Too rarely is provision made for adequate study of the effectiveness of these laws, or for the development of the facts needed for designing good programs of fishery management.

HATCHERIES were developed when it became obvious that the most critical time in the lives of fishes is during infancy, when mortality is highest. By hatching eggs and rearing the young under protected conditions, it was believed that a stock of fish could be materially enlarged, sustained, and protected from depletion. It is still popularly believed that the work of hatcheries is everywhere superior to that of nature, and is quite enough to preserve our fishery resources against any danger, whether it be overfishing, pollution, predators, water utilization projects, or introduction of exotic species.

But experience has proved that in many situations, hatcheries alone cannot cope with these destructive forces, and frequently nature is more efficient than artificial propagation. Natural reproduction of the coarse fishes like sunfish, bass, yellow perch, bullheads, etc., has often been so completely sufficient for the capacity of a given place, that supplemental stocking has only resulted in overcrowding, with consequent stunting of the fish.

It has been lately recognized that hatcheries are most useful for stocking to meet specific deficiencies, for example, for replacing populations which have died out because of changed stream conditions, or for stocking farm ponds or other new impoundments; or to supplement other management practices in helping to rebuild stocks depleted by overfishing. There are many streams where year round conditions are unfavorable to self-sustaining trout populations, yet will support trout for the duration of a fishing season. In such places, hatcheries are contributing richly to public recreation by stocking with legal sized fish that have been reared under their protection.

While further improvements in the methods of propagating fishes under hatchery conditions are constantly being achieved, there is great need to know more about the requirements of the waters to be stocked, so as to promote better utilization of the hatchery production. Investigations have proved, for example, that more stocked trout survive in lakes than in streams, that in certain areas, stocking in the spring is more successful than stocking in the fall. In addition, there is clear need to improve and refine the hatchery techniques.

Today, Federal hatcheries produce over 100 million game fish annually, and State hatcheries many times that number. Probably in the future, fewer fish will be produced, but planting will be more scientific and more fruitful as knowledge of stocking requirements develops. Future hatchery establishments will rear the fish long past the hatching stage. This will require much more pond space, personnel, funds, and material than in the past but will better serve the growing demands of public angling.

MOST STATES DO NOT PROVIDE FOR CONTINUOUS SCIENTIFIC STUDIES OF THEIR FRESH WATER FISH POPULATIONS. For the most part the United States Fish and Wildlife Service is staffed only for studying a few certain special localized problems. Hence, too little is known about the biology of our fresh water fishes and about their habitats to prescribe proper management practices in all situations.

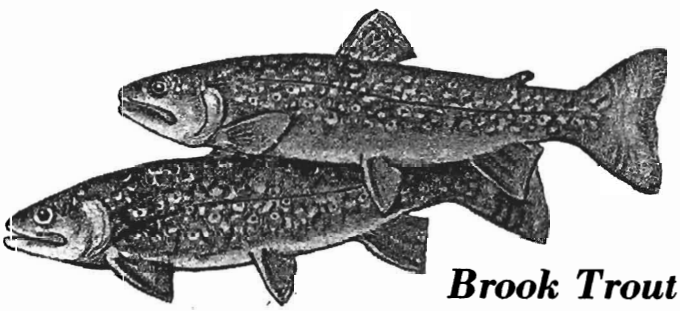
Means of improving the fish stocks are continually being tried by various agencies in various places, all too frequently without adequate coordination. For example, much has been done in the past decade to attempt improving streams by building current deflectors, by constructing small reservoirs, and small dams to retard run-off and maintain stream flow; by planting trees and shrubs to check erosion and regulate stream flow, by making brush shelters and gravel bars at appropriate places for spawning beds, by planting aquatic vegetation, and by destroying objectionable submerged weeds. These efforts have been successful in places where physical conditions keep production from attaining its full capacity. In some areas, on the other hand, where "stream improvements" have been attempted by untrained people, or are otherwise not based on knowledge, they have done more damage than good, or have produced no effect whatever.

Farm-pond experiments are revealing some fundamental principles concerning the production of fish. They are showing what kinds of fish will produce the most returns when stocked together, what number and size of fish should be stocked per unit acre, what kind of vegetation and what kind and quantity of fertilizer are best for maximum production.

Fresh Water Fishery Resources

THE COLD WATER FISHES ARE PRIMARILY A RECREATIONAL RESOURCE AND ARE THE MOST VALUABLE OF THE INLAND FISHERIES. They afford sport to millions of anglers, who spend many millions of dollars annually in their pursuit. Most important and widely distributed of the cold water fishes are the trouts, of which, two, the lake trout and the steelhead, support commercial as well as recreational fisheries. The closely related grayling is a cold water game fish of restricted distribution in the United States. The smelt is another cold water fish, which is taken for food in New England streams, affords sport in some of the northern lakes, and supports a commercial fishery of some magnitude in the Great Lakes (*which see*).

Throughout large areas of the United States, the cold water fishes have become greatly reduced in numbers, largely through destructive changes in their habitat by deforestation, erosion, or pollution. Proper husbandry of the resource involves restoration of acceptable habitats, control of angling, and, in some cases, carefully directed stocking.



Brook Trout

BROOK TROUT, native to eastern North America, originally ranged from Labrador to Georgia and westward through the Great Lakes region; they have now been introduced on the Pacific coast and in mountain streams of other areas where the waters are cold enough to support them. A sea-run brook trout inhabits the Atlantic coast from Massachusetts northward, running up coastal streams to spawn in the fall, returning later to the ocean. This is apparently a distinct stock, whose individuals do not mate with stream forms of the same species.

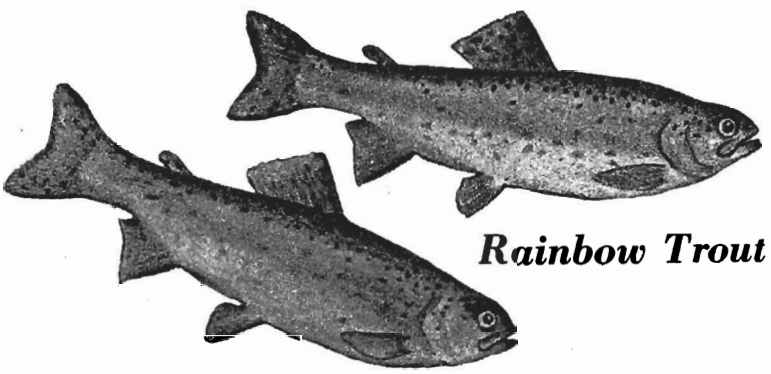
Brook trout vary greatly in color, size, and shape, according to the waters from which they are taken, are at their best in cold, headwater streams, but are everywhere rated high for their gamy qualities. They do not tolerate water temperatures in excess of 75° F., therefore seldom live in the lower reaches of streams. They do well in ponds and lakes if the bottom waters are cold and rich in oxygen, and where predacious warm water species such as bass, pike, or perch are excluded.

Brook trout up to 17 pounds have been recorded; in recent times, however, individuals weighing more than 3 pounds are scarce, the average being much smaller.

In the fall, brook trout move into small, spring-fed tributaries if they are accessible, building nests and spawning on gravelly bottom. Females may spawn for the first time at the end of their first year, produce 100 to 300 eggs. Older trout produce 2,000 eggs. By selective breeding in hatcheries, egg production has been increased to as many as 1,100 at the first spawning. The eggs develop in 1 to 3 months, depending on temperature. After leaving the gravel nests, the young feed on minute aquatic life, grow rapidly, and are 2 to 4 inches long in the fall.

There is evidence that adult brook trout migrate downstream in the fall, after spawning, to winter in deep pools. They return upstream in the spring, but move about little during the summer.

THE RAINBOW TROUT is a fish of the western mountains, at home in swift, turbulent streams. Of all the trouts it is most adaptable, tolerating summer temperatures up to 83° F. It is more easily handled in hatcheries and more resistant to disease than the brook trout. By artificial propagation, its range has been extended to overlap that of the brook trout. It is able to maintain itself well, even under heavy fishing.



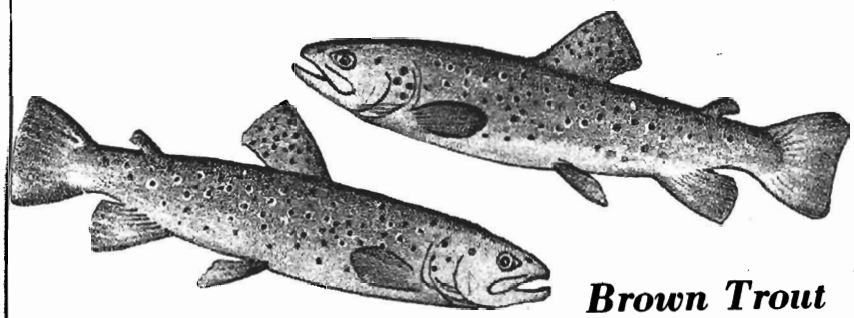
Rainbow Trout

There are two types of rainbow trout: A resident form which makes only limited migrations, and a migratory, sea-run form known as the STEELHEAD TROUT. The habits of the steelhead closely parallel those of Atlantic salmon, the fish leaving the streams and entering the ocean, where they remain for 2 or 3 years before returning to spawn. Like the Atlantic salmon but unlike the Pacific ones, they do not, as a rule, die after spawning but return to spawn again in later years. In the ocean they grow to a large size, average 10 pounds in weight. Because of their strong migratory instincts, steelheads should be planted in streams that have free access to the ocean or to large lakes. They are spring spawners, can utilize tributaries that later become very low or dry up for short periods.

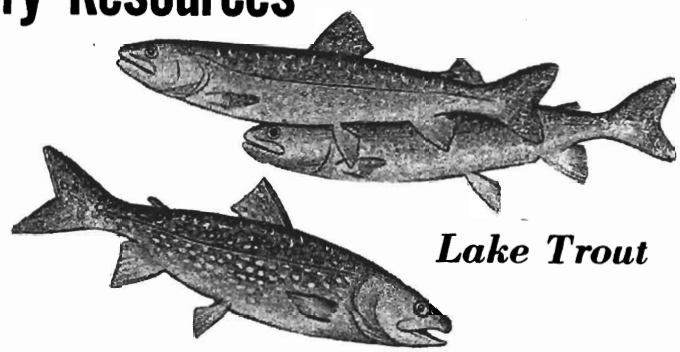
Steelheads are fished commercially throughout their range, i. e., from California to Alaska. About 3 million pounds are caught annually. The largest quantities are taken from the Columbia River system. They are also a favorite game fish.

THE BROWN TROUT was introduced from Germany in 1883, has now become one of the mainstays of trout fishing in this country because it is generally hardier and better adapted to withstand difficult stream conditions than most of the native species. Whereas the brook trout

Fresh Water Fishery Resources



Brown Trout



Lake Trout

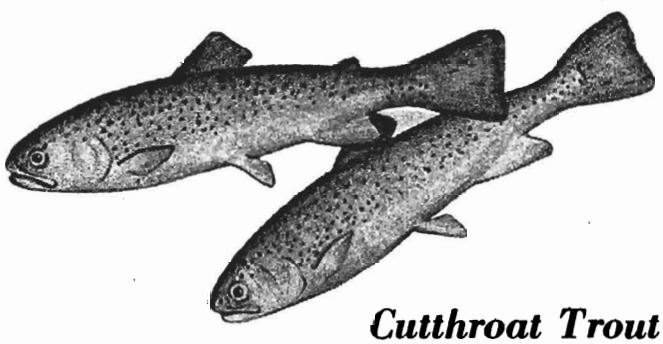
does best in turbulent upstream waters, the brown is better suited to the lower reaches of streams, with their quieter waters. They survive temperatures up to 81° F., actually thrive better in somewhat warm water than in very cold.

Like brook trout, they spawn in the fall, usually moving into small tributaries. The female trout deposits from a few hundred to several thousand eggs, depending on her size; incubation requires about a month, takes longer at low temperatures.

Brown trout caught by present day anglers weigh from ¼ to 4 pounds, very rarely up to 12. Maximum recorded weight is 40 pounds.

The so-called Loch Leven trout is simply a form of brown trout indigenous to Great Britain. It was brought to this country in the last century and is now merged with the European strain through interbreeding.

THE CUTTHROAT or BLACK-SPOTTED TROUT is the native trout of the Great Basin region where streams flow eastward from the slopes of the Rocky Mountains. Its temperature requirements are more like those of the brook trout; it is, therefore, found in the cooler headwaters. Its range has been extended to Pacific coast streams, but not eastward to any extent. In



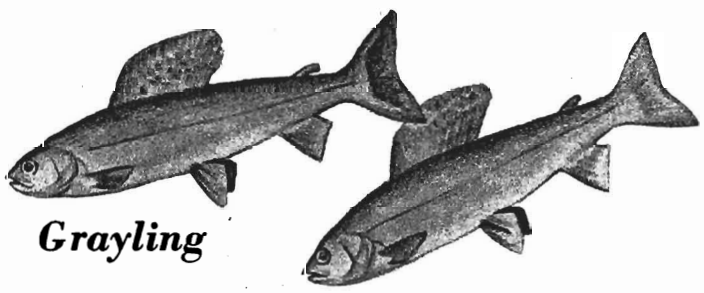
Cutthroat Trout

many streams it is found in association with the rainbow. It is a spring spawner and may hybridize with the rainbow, producing undesirable progeny.

The Pacific coast cutthroat is a sea-run form, occurs from northern California to Alaska, and ascends streams only a short distance to spawn. Cutthroats that inhabit lakes ascend tributary streams to spawn.

Other local strains of black-spotted trout have a distinctive appearance and may be designated by a descriptive name, such as the golden trout of California.

THE LAKE TROUT thrives in the cold lakes of the northern tier of States from New England, where it is known as togue, to Montana, also in the lakes of the Yukon basin in Alaska. This is a large fish, sometimes weighing more than 100 pounds. It requires deep, cold lakes, preferably with rocky bottoms and shore, rarely enters streams. In the Great Lakes the lake trout is both a commercial and sport fish; in the smaller inland lakes it is exclusively a sport fish. It moves from the deeper, cooler waters of its normal habitat to rocky shoals at the onset of cold weather to spawn.



Grayling

THE GRAYLING is a cold water game species of limited distribution, found in the headwaters of the Missouri River, formerly in Michigan (this strain is now extinct), and in Arctic regions. It is closely related to the salmon family, also to the smelts and whitefishes. Grayling spawn in the spring, are successfully handled in hatcheries. Average sizes are 9 to 12 inches. They take the fly readily and are favorites of anglers. Knowledge of their biology is fragmentary.

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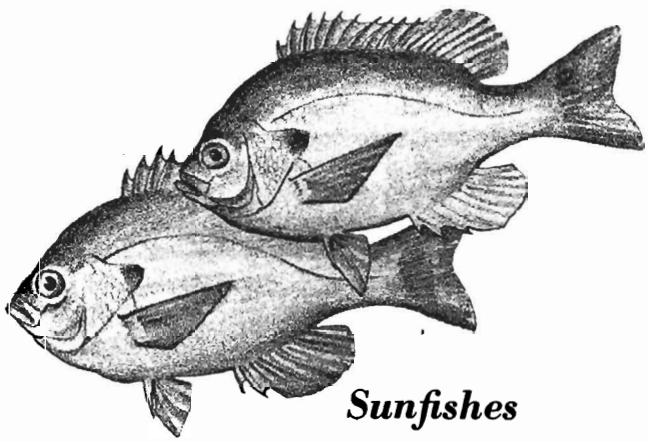
Fresh Water Fishery Resources

THE WARM WATER FISHES ARE A DIVERSE AND WIDELY DISTRIBUTED GROUP, finding suitable habitats over much of the United States. They include such species as the black basses, the sunfishes, walleyed pike, yellow perch, the white and yellow basses, catfishes, buffalo fishes, carp. They are important as a recreational resource; also as a source of easily obtained food for many persons who take them on hook and line from nearby waters. Most of them are caught commercially in the larger lakes and rivers. Exceptions are the black basses, which in almost all States are reserved by law as game fish. Many States also prohibit commercial fishing for the sunfishes and crappies. A few of the warm water fishes, notably carp and buffalo fish, are of slight if any interest to the anglers.

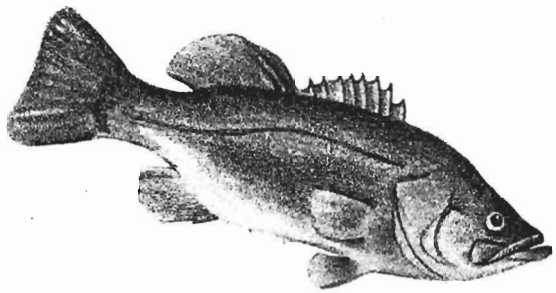


Sunfishes

THE SUNFISHES afford sport for both the novice and the expert, and are among the most universally popular of inland fishes. Of the several species native to the United States, the bluegill sunfish is perhaps best known, is considered most satisfactory for private cultivation in ponds. Through introduction, its distribution has become almost Nation-wide. It is extensively reared for use in stocking in combination with largemouth black bass, a combination found satisfactory because predation by the bass prevents the sunfish population from outstripping its food supply, allows the surviving bluegills to grow to a size desirable for sport or food. A considerable body of knowledge concerning the relations of sunfishes to the natural food supply and to other species has recently been developed; it is now possible to control stocking of these fish to produce good results.

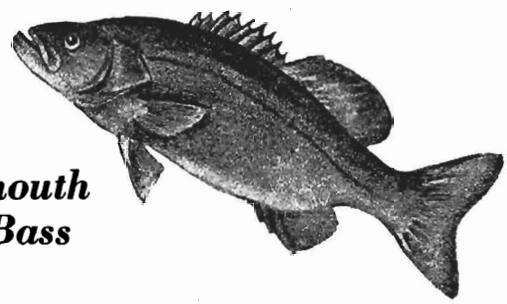
Sunfishes are nest builders, spawning in the spring and summer and caring for the eggs until hatching. Bluegills usually begin to spawn at the age of one year, raise several broods during a season.

The sunfishes are reserved by most States as game fishes. In some instances such restrictions may defeat their purpose, for, if the fish are not removed rapidly enough, ponds or small lakes quickly become crowded with stunted fish. In such cases a regulated commercial fishery would actually provide better angling.



Largemouth Black Bass

THE LARGEMOUTH BLACK BASS is one of the most important inland game fishes of America. Its native distribution extends throughout the Great Lakes region and Mississippi Valley to northeastern Mexico and into Florida, and northward along the Atlantic Coastal Plain. It is typical of weedy, mud-bottomed lakes and sluggish streams. It is largest in the warm lakes and rivers of the Southern States, growing to 15 or 20 pounds. Elsewhere the average weight is probably less than 3 pounds. It has been widely propagated and distributed from artificial ponds. Every properly stocked farm pond includes this bass; it prevents overpopulation by its predacious and cannibalistic feeding habits. Bass are nest builders, the male building the nest in gravel or on the roots of aquatic plants, guarding the eggs and later the fry, sometimes until they are more than an inch in length.

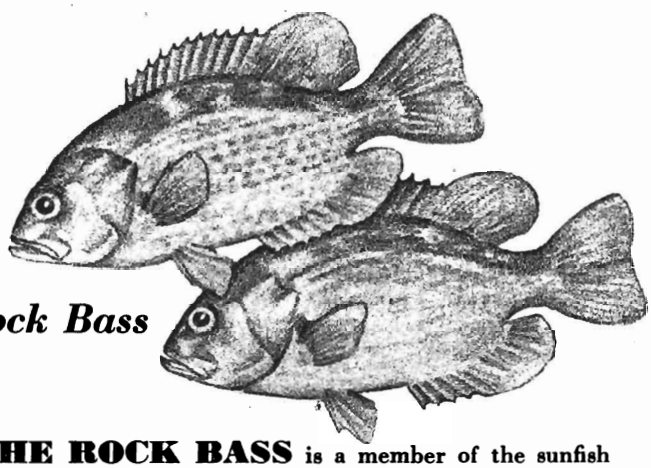


Smallmouth Black Bass

THE SMALLMOUTH BLACK BASS originally ranged from the Great Lakes, the upper Mississippi, Ohio, and St. Lawrence River systems to eastern Oklahoma and the Tennessee River drainage. It has now been stocked extensively from the Atlantic to the Pacific coasts. It seldom exceeds 5 pounds in weight; average weight probably is less than 2 pounds. It is a game fish of clear, cool rivers and lakes, offers sport to the fly- and light-tackle fisherman. It requires gravel for its nesting. The fry are cared for during a brief period only. In the Appalachian Mountain region are many famous bass streams where pollution is limiting angling for this species.

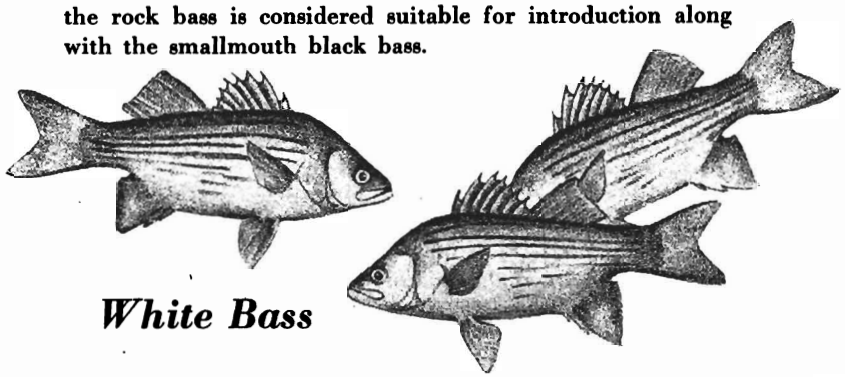
Several other minor species have recently been identified. They have a localized range, closely resemble the smallmouth in their habits and characteristics, and may possibly be intermediate between the true largemouth and smallmouth.

Fresh Water Fishery Resources



Rock Bass

THE ROCK BASS is a member of the sunfish family. It is a fish of rocky streams and lakes, widely distributed throughout the northern part of the Mississippi drainage, less abundantly in the south. On the Atlantic coast it occurs as far south as North Carolina; it has been artificially introduced in suitable areas bordering the Pacific. Small commercial fisheries for it exist in the Great Lakes, but it is considered chiefly a sport fish. It spawns in the late spring or early summer, requiring gravel for the construction of its nest. Rock bass appear to vary considerably in size in the different parts of their range, in some places rarely reaching a pound in weight, in others commonly exceeding 2 pounds. The conditions which control these variations are not well understood, and should be investigated. In spring-fed ponds, the rock bass is considered suitable for introduction along with the smallmouth black bass.



White Bass

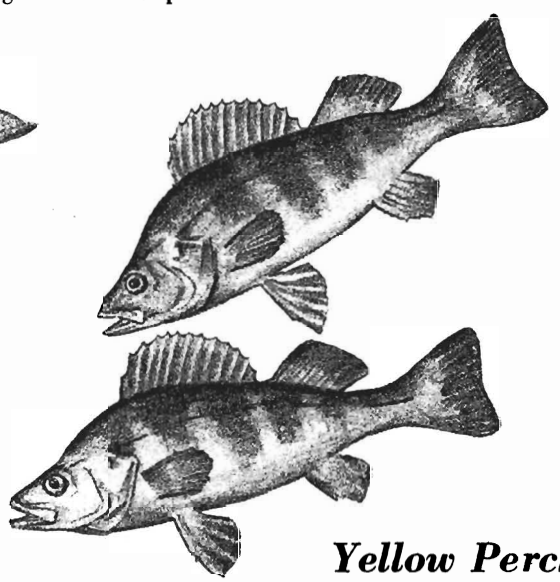
WHITE BASS is the fresh-water counterpart of the striped bass of the seacoasts, to which it is related. Like the striped bass, it is both a recreational and a food resource. It is chiefly a fish of lakes and large rivers. Its center of abundance is in the Great Lakes region, where it is the object of a commercial fishery; it is also widely distributed throughout the basins of the upper Mississippi and Ohio Rivers. In some areas it has been planted in reservoirs and in impounded areas in the larger rivers to provide sport fishing.

The white bass spawns in the spring, migrating into smaller tributary streams to deposit its eggs in shallow water. It is not a nest builder, does not care for its eggs or young. Limited tagging of this species suggests that its migrations may be fairly extensive. Adult white bass reach a foot or more in length, weigh 1 to 3 pounds. Knowledge of the biology of this fish—its abundance, relations to other species, and reaction to withdrawals from the population by fishing—is limited; available information suggests that these facts may vary widely from lake to lake.

THE YELLOW PERCH is a fish of small ponds and lakes, found also in streams in many parts of its habitat. It occurs from Nova Scotia to North Carolina in coastwise waters and throughout the Great Lakes and upper Mississippi Valley. The range, however, has been greatly extended by artificial propagation.

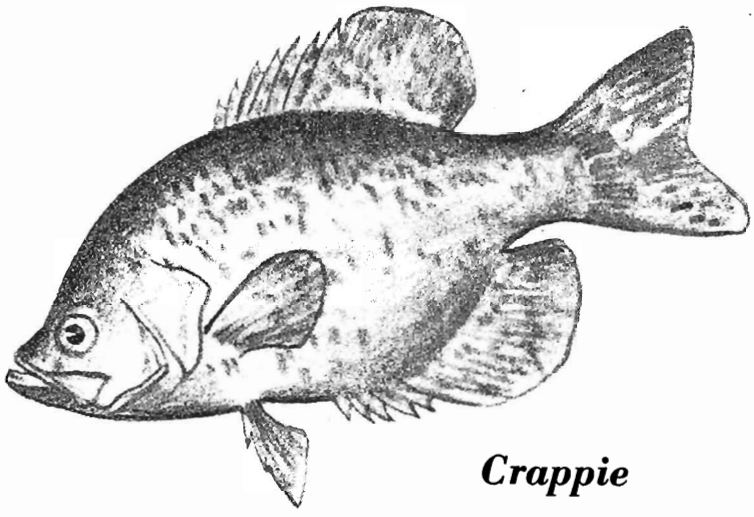
The yellow perch is one of the most important commercial species in the Great Lakes (*which see for further discussion*) and elsewhere is taken commercially in small quantities. Throughout most of its range it is chiefly important as a sport fish which requires no great skill for its capture; therefore it is available to the most inexperienced angler.

The yellow perch spawns in spring, depositing its eggs in ribbonlike bands over brush and vegetation along the shore. The young appear to have a high rate of survival. Small bodies of water tend to become overpopulated, and populations of stunted individuals result. In the smaller lakes there are indications that the perch, by competing for food and space, may affect the welfare of other species. These complex interrelationships should be carefully investigated for each locality. Present knowledge is inadequate for proper management of the species.



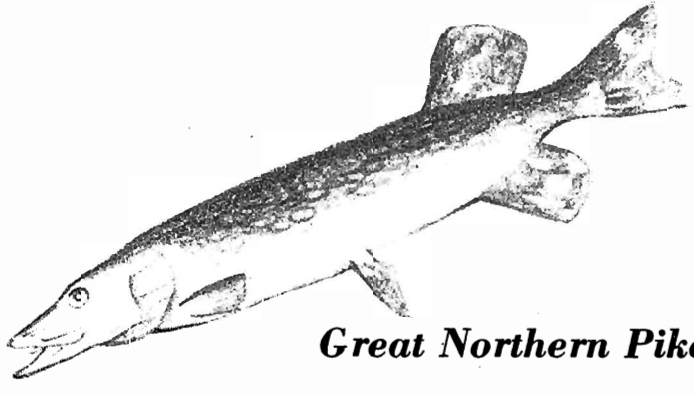
Yellow Perch

Fresh Water Fishery Resources



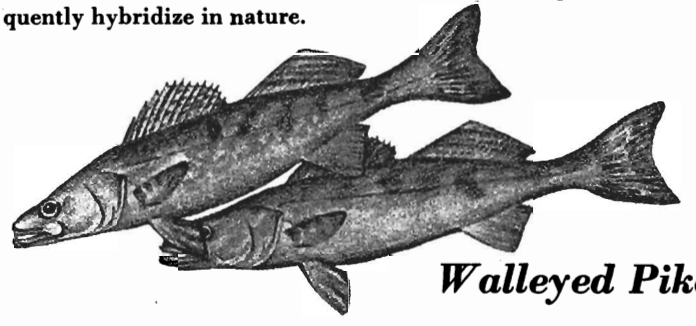
Crappie

BLACK AND WHITE CRAPPIES are a food and recreational resource, especially suitable for pond culture. They are native to the Great Lakes and Mississippi Valley, have been widely distributed throughout the United States by propagation, and can endure a great variety of conditions. In most States, commercial fishing for crappies is prohibited by law. Such restrictions sometimes defeat their purpose of providing good sport fishing, for crappies are extremely prolific, reproduce at such a rate that small lakes quickly become crowded with stunted fish that offer little sport. Removal of the annual crop of fish not needed to maintain the stock, whether by angling or by regulated commercial fishing, improves sport fishing by eliminating overcrowding and allowing the fish to grow to good size.



Great Northern Pike

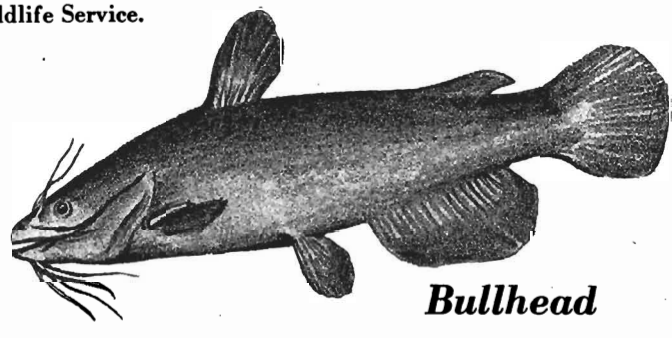
GREAT NORTHERN PIKE and MUSKELLUNGE are confined chiefly to the larger, cooler lakes in the Northern States from Minnesota to Maine. Because of their fighting qualities and large size they rank high as game fish, are propagated in hatcheries. Northern pike may weigh 25 to 30 pounds (occasional very large ones over 50), grow rapidly, and are as much as 12 inches long at the end of their first summer. Some 36-inch pike have been found to be about 9 years old. This species feeds largely on other fishes, of which it consumes enormous quantities. It spawns in the spring, may deposit over 100,000 eggs, which hatch in about 2 weeks. It is well adapted to artificial propagation. The muskellunge is very similar to the northern pike in its rapid growth, feeding habits, and adaptability to cultivation, but ordinarily spawns somewhat later, choosing shallow streams rather than the weed beds preferred by pike. There is some evidence, however, that the two species frequently hybridize in nature.



Walleyed Pike

THE WALLEYED PIKE, called yellow pike by commercial fishermen, is a wide-ranging fish of extensive distribution throughout the Great Lakes and Ohio basins, southward as far as Georgia and Alabama. Although hardy and prolific, it requires clean lakes or rivers and in some areas has been adversely affected by pollution. It is an important game fish throughout its range, but almost the entire commercial catch is made in the Great Lakes. It may be taken by still fishing, trolling, or casting, and since it remains active throughout the winter it is sometimes taken through holes in the ice.

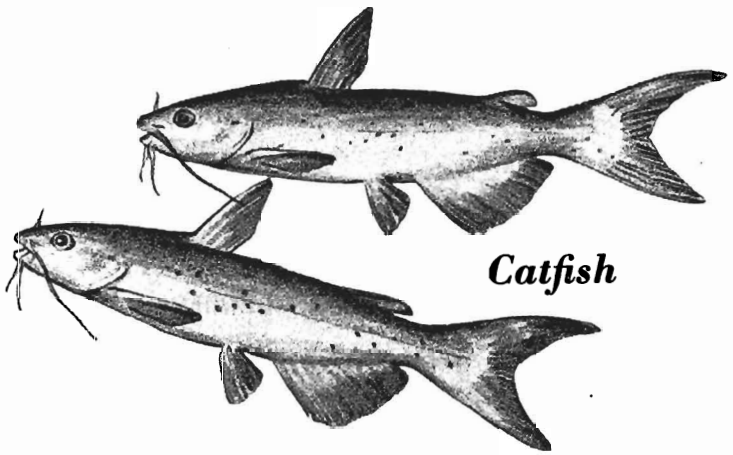
Information about the biology of the walleyed pike is fragmentary. It spawns early in the spring, running up small streams to deposit its eggs and sometimes remaining in the headwaters for several weeks. Where artificial propagation of this species is attempted, fish culturists trap it during its ascent of the streams and take the eggs for hatching. Several millions of fry are planted annually by States bordering the Great Lakes; and also, on a limited scale, by the U. S. Fish and Wildlife Service.



Bullhead

CATFISH AND BULLHEADS are widely distributed throughout the world, are represented by a number of species in North America. They are hardy fishes, much sought by anglers, supporting the most valuable commercial fishery of the Mississippi and important fisheries in the Atchafalaya, the St. Johns, and other rivers.

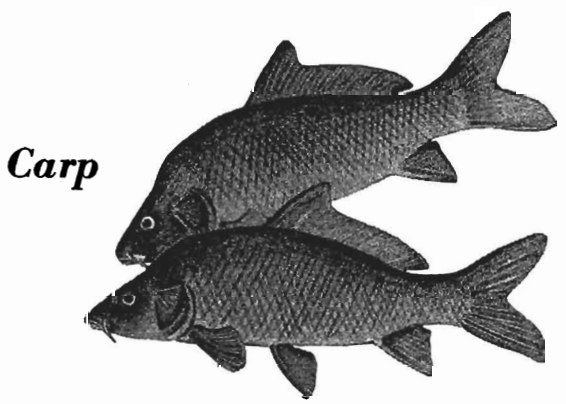
Fresh Water Fishery Resources



Catfish

In general, the larger catfish inhabit rivers and swiftly flowing water; bullheads are more likely to be found in ponds or sluggish streams. The various species are widely distributed, being found throughout the Mississippi Valley, the Great Lakes basin, somewhat less abundantly on the Atlantic coast, and by introduction in waters of the Pacific slope. They spawn in rocky crevies, in holes in the banks, or under accumulations of brush or vegetation, and guard the eggs and young. Practical methods of artificially propagating the horned pout and the channel catfish have been developed and these species are reared for stocking. Less success has been attained in propagating other species of catfishes. Little is known about the size of catfish populations and the conditions that control their abundance.

CARP are taken in the Mississippi River and its tributaries in quantities of 10 or 12 million pounds a year. They are a staple item in the fisheries of the river, are caught in many States and shipped chiefly to the larger cities like Chicago and New York. They are abundant but underutilized in the artificial lakes of the Tennessee Valley.



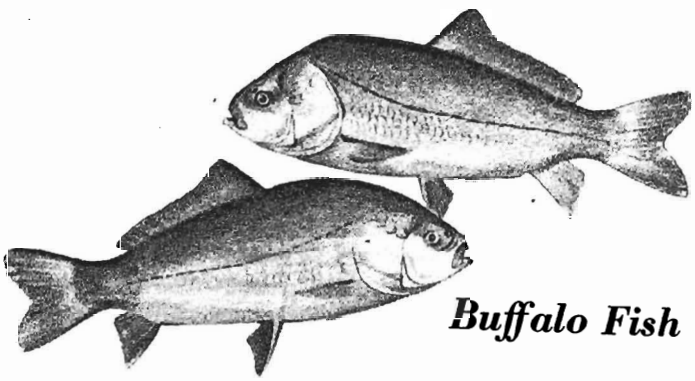
Carp

In small, otherwise clear lakes and ponds, carp tend to make the water turbid and indirectly interfere with the feeding of other species. Their control in such bodies of water, if sport fishing is the primary interest, thus becomes important. However, comparatively little is known about the effect of carp on other species under a variety of conditions.

Carp are also the object of commercial fishing in the Great Lakes (*which see for further discussion*).

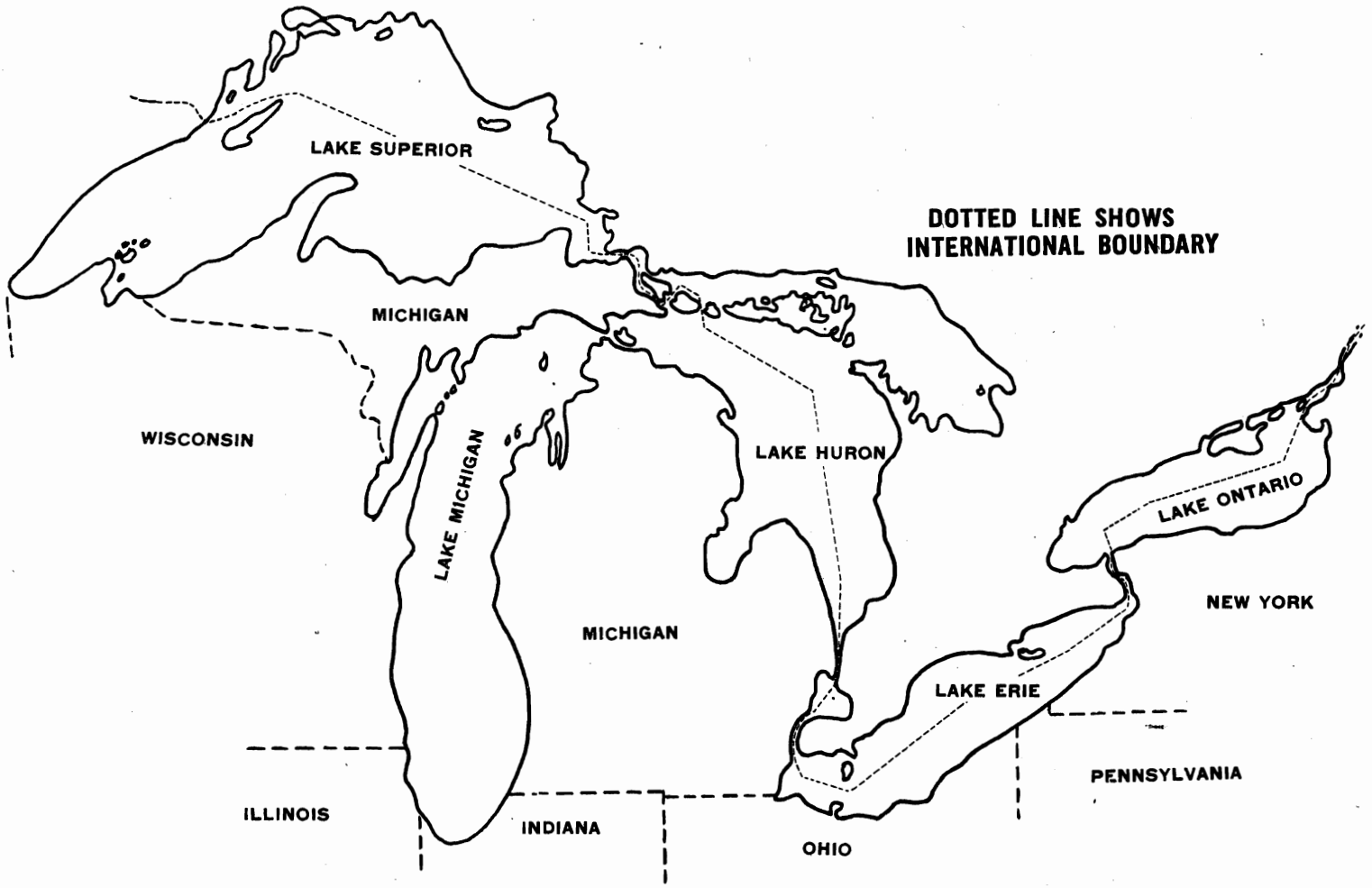
BUFFALO FISH are widely distributed throughout the Mississippi Valley, where they are caught in greater quantity than any other fish. They are exclusively commercial fishes, of no interest to anglers. Like the carp, buffalo fish eat quantities of vegetation and minute aquatic animals, so are able to live in bodies of water unsuitable for such predacious fish as bass. They are abundant in many of the larger impoundments like the artificial lakes of the Tennessee Valley; here they represent an important food resource of which only a fractional part is harvested.

Little is known about the actual abundance of buffalo fish, the effect of fishing upon their populations, and the interrelations between these and other species of fish. Some of the present State regulations have the effect of holding commercial fishing to a minimum in certain waters. Studies should be made to learn whether properly regulated commercial fishing might bring about a more desirable balance of species.



Buffalo Fish

Fresh Water Fishery Resources GREAT LAKES



THE GREAT LAKES AND THEIR CONNECTING WATERS form the largest single fresh-water area in the world. They have a surface area of about 60.9 million acres, a total shore line of more than 8,300 miles, and a combined maximum length of more than 1,600 miles. All of the Great Lakes except Erie have depths of more than 700 feet.

These inland waters are important to our Nation as a natural transportation highway and as our richest source of fresh-water fishes for commerce and recreation. The total United States and Canadian commercial production of fish from the Great Lakes is around 100 million pounds per year. More than 5,000 United States fishermen and 2,000 boats are normally engaged in the fishing industry.

The Great Lakes provide a great diversity of habitat, and different areas vary widely as to kinds and abundance of their fish populations. In general, the shallower waters contain the largest variety of species and yield the largest catches. Thus Lake Erie, the shallowest of the lakes, is the most productive. In the deeper lakes the inshore waters and the bays yield the bulk of the total catch. But even though deeper waters are less productive in species and tonnage, they are the home of the lake trout and chubs, which are high-priced and important fishes. The deepest places of the Great Lakes are unproductive; only in certain regions of Lake Superior are nets set farther down than 100 fathoms.

All Great Lakes fishes may migrate extensively in response to seasonal temperature changes or for spawning. Most shallow-water species avoid the warmest water, move offshore in the summer. Then commercial operations are abandoned or limited in bays and shoal areas.

Commercial fishing on the Great Lakes is carried on with small boats, most of them 25 to 60 feet long. These craft, which have a limited cruising range, return to port daily, distributing their landings among many small ports scattered throughout the area. About 49 percent of the catch is taken with gill nets, the balance with trap nets, pound nets, seines, fyke nets, and set lines. Gill nets and set lines may be fished in deep or shallow water, but the other gears are restricted to the shallower areas.

Time has brought many changes in the Great Lakes fisheries. Whereas formerly the fisherman made large catches fishing from his sailboat with the crudest of gear, now he is hard put to show a profit in spite of the advantages of powerboat and modern fishing equipment. This dismal situation comes from bad management of our Great Lakes resources. Certain fishes

that once were abundant are now commercially insignificant (sturgeon, Lake Erie cisco, blackfin of Lakes Huron and Michigan, bluefin of Lake Superior) or extinct (Lake Ontario bloater). Others (as lake trout, whitefish, the pikeperches, and the yellow perch) have been so reduced that in many areas production has declined in spite of greatly increased fishing intensity. Fishes formerly considered "trash" (suckers, carp, sheepshead, burbot) are replacing the more valuable species in the catch, and even these cheap fishes show signs of declining abundance in some areas.

YET THE GREAT LAKES FISHERIES CAN BE RESTORED TO A SUSTAINED HIGH LEVEL OF PRODUCTION by remedying the known causes of depletion. At present, fishing is too intense and wasteful. There is too much gear, and too many small, immature fish are destroyed. Protection of the Great Lakes resources is inadequate because control is divided. Each State and Province exercises complete jurisdiction over the fisheries within its boundaries. Consequently there is a wide diversity of fishing codes, even among States and Provinces bordering the same lake. This situation is absurd since the populations of fish move about freely in a lake without regard to interstate and international boundaries. Under divided control the State with the poorest laws sets the standard for an entire lake. Legislatures and conservation departments are reluctant to enact fishery regulations undeniably essential to sound conservation when they know that those regulations will place their fishermen at a competitive disadvantage with operators from neighboring States who exploit the same stocks of fish. Furthermore, fishermen properly bring strong political pressure to bear for the elimination of differences in laws that expose them to unfair competition.

From cause to effect, therefore, the sequence is: divided control—inadequate protection—depletion.

Adequate regulations are the first essential for restoring the Great Lakes fisheries. As far as practical, these must be uniform throughout all the lakes and enforced by uniform methods. Although adequate and uniform regulations are sorely needed, it is difficult to attain them. This problem was a major point of consideration in the Report of the International Board of Inquiry for the Great Lakes Fisheries, issued in 1943. The report of the full board (both United States and Canadian members) advocated merely a "common control" of the fisheries. In a supplementary report, however, the United States members examined the various procedures by which the common control might be established and concluded that an effective agency can be created only by international treaty between the United States and Canada.

The setting up of machinery for the international control of the Great Lakes fisheries will not be sufficient in itself. If the regulations promulgated by the proposed international agency are to be effective for the rehabilitation of the fisheries, they must be founded on sound and comprehensive scientific data. The considerable amount of research already carried out by the Fish and Wildlife Service will provide a starting point for the scientific management of the fisheries. But to get the most that these resources can yield without impairing their sustained productivity, we have yet to unravel the complex inter-relations among the following: size of the various stocks, size of the broods, aquatic climate, fishing intensity. To reach this goal, it is essential to prosecute continuous observations on the several fisheries; and, in order to make the knowledge effective, it must be published. Only thus can the regulations be objectively devised, tested, understood by the public, and adjusted to meet the changes in the fisheries that inevitably will occur.

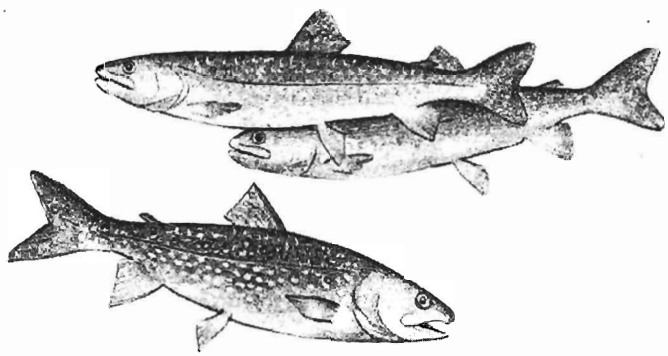
THE LAKE TROUT is the most valuable Great Lakes fishery resource, yielding around 10 million pounds annually, worth over three million dollars at current prices. It is a popular game fish, and "deep-sea" sport trolling for it has expanded greatly in the last decade.

The lake trout has long been subjected to a heavy fishing pressure with consequent serious reduction in abundance. In Lakes Michigan, Superior, and Huron the annual catch is now considerably less than it was in former years, in spite of the great increase in fishing effort and the greatly improved efficiency of fishing gear during later years.

In spite of the great size that lake trout may reach—an 88-pound fish is on record—it grows slowly in early life and does not spawn until 7 or more years old. At that age a lake trout averages 21.5 inches in length and 2.8 pounds in weight. Tagging experiments conducted in Lake Michigan show that small fish usually travel only short distances, but large ones migrate widely and, of course, with complete disregard to interstate boundaries.

The trout receives protection through size limits, closed seasons, and regulations on gear. The laws vary from State to State and within individual lakes. It is generally true that the lake trout needs better protection than it now receives; size limits are especially inadequate for the protection of immature fish.

The development of an effective program for the rehabilitation and conservation of the lake trout will require extensive investigations of its biology, and of the effect on the population of various fishing intensities and methods of fishing. It is essential also to determine the effectiveness of artificial propagation in restoring and maintaining this resource.



Lake Trout

Fresh Water Fishery Resources GREAT LAKES

HOW LAKE HERRING AND CHUBS ARE DISTRIBUTED IN U. S. WATERS OF THE LAKES

LAKE HERRING AND **CHUBS** are closely related fishes, all in the same family as the whitefish.

THE LAKE HERRING is the most important of this group, about 22 million pounds being caught annually from the Great Lakes. It is sold fresh, salted, and smoked. Increasing quantities are filleted.

In the Great Lakes the lake herring is essentially a shallow-water fish, although it moves offshore to cooler water in midsummer. It is rarely taken in water deeper than 20 fathoms, never in water deeper than 35 fathoms. Little is known about the early life history. Growth is extremely variable. In Saginaw Bay, lake herring average around 8½ inches at 2 years of age, 10 inches at 3 years, and 11 inches at 4 years. Some herring mature in the second year; almost all by the third. The lake herring feeds on plankton and on mollusks, crayfish, insect larvae, and fish eggs. Nothing definite is known about the size of the population of this species but the fact that the average age of fish in the commercial catch is younger than formerly and that only one year class, the fourth, now dominates the catch each year indicates intensive fishing.

The lake herring is protected by regulations on gear and in some States by closed seasons. None of the States have a size limit on herring.

THE LAKE ERIE HERRING OR CISCO is a fast-growing and valuable species of lake herring, which was destroyed as a profitable resource by wasteful fishing practices. This is a classic example of a valuable fishery resource that clearly became depleted through bad management. Up to 1924 this resource had supported a United States fishery producing 8 to 39 million pounds a year. Beginning about 1925 the total annual catch declined rapidly until in 1928 it was only 600,000 pounds; it has remained below a million pounds ever since. In 1938, when the catch went up to 810,000 pounds, it looked as though the cisco population might be recovering. But in the absence of any adequate effort to nurture this recovery the fishery quickly reduced the stock. Fishermen took 717,000 pounds in 1939, only 25,200 pounds in 1942.

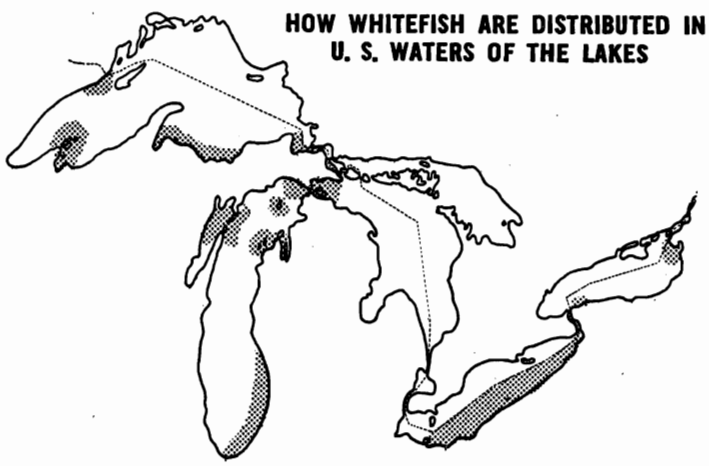
Aside from size limits in Ohio and Pennsylvania, the cisco is protected only by regulations governing the general fishing.

THE CHUB populations have all suffered the consequence of man's fishing well but not wisely. Seven species of chubs are found in the Great Lakes; all seven are seriously reduced in numbers; some of them have become extinct as commercial fish—bluefin of Lake Superior, the blackfin of Lakes Michigan and Huron, and the bloater in Lake Ontario. Present annual catch of chubs is a little over 2 million pounds. The entire catch is used for smoking. As recently as 1934 the catch had been 7 million pounds. There is no reason why these fisheries could not be restored to national importance by good management.

Knowledge of the biology of the seven species of chubs is fragmentary. Growth, age, spawning habits, migrations, and size of stock are all incompletely known, all vary widely from one species to another and within each species, and from one region to another.

The principal chub-producing States provide varying degrees of protection for chubs in the form of closed seasons and regulations on gear. However, more effective protection is needed.

HOW WHITEFISH ARE DISTRIBUTED IN U. S. WATERS OF THE LAKES



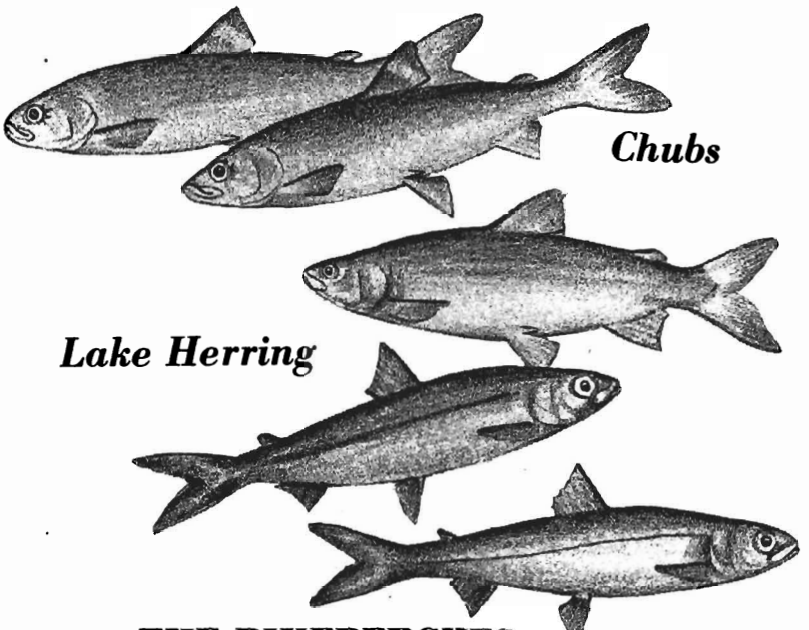
WHITEFISH, OFTEN CALLED THE KING OF FRESH-WATER FISHES, HAS BECOME SEVERELY DEPLETED THROUGH WASTEFUL FISHING METHODS AND INADEQUATE PROTECTION. The process of depletion has been gradual in most areas, but the stock in Lake Huron became virtually exterminated in the 1930's by overfishing with a new and ruinously efficient gear, the deep-trap net. This gear took whitefish in prodigious quantities from the offshore waters where they concentrate in summer. Unfortunately, its use was not prohibited until after the fishery of Lake Huron had reached a state of collapse.

Present United States landings average about 4½ million pounds a year. Most of the catch is marketed fresh. Considerable quantities are smoked. Whitefish roe, a byproduct of the fishery, is used as a substitute for sturgeon roe in the manufacture of caviar.

Whitefish live in the moderately deep water of the lakes, feeding on shellfish and insects, and come into the shallows

only for a brief period in the late spring and early summer, and for spawning in the fall. They spawn on rocky reefs and shoals in depths of 4 to 20 feet. A female deposits 10,000 to 75,000 eggs, depending on her size. The eggs hatch in about 5 months. Growth is extremely variable from region to region and from year to year. In Lake Huron the fish grow to be about 5 inches long in the first year, 9 inches in the second year, and about 12 inches in the third, 16 in the fourth, and 19 in the fifth. The oldest specimen on record was 26 years of age.

Because of the great demand for the whitefish and the resulting heavy fishing pressure, the restoration of the stock and its maintenance at a high level of abundance offer difficult problems. Obviously, present regulations fail to accomplish their purpose. This is not to be wondered at, for some of them fail to utilize available knowledge about the whitefish. For example: The minimum size limit varies from State to State, but nowhere is it higher than 2 pounds. Unfortunately, on the average, 2-pound whitefish are not old enough to have spawned even once. The average male spawns for the first time at 2.4 pounds in Lake Huron, the average female not until about 3.8 pounds. Obviously, minimum size limits are grossly inadequate. In spite of this gloomy situation, the whitefish resource can be restored if enough knowledge about it is accumulated *and intelligently applied.*



Chubs

Lake Herring

THE PIKEPERCHES are members of the perch family, quite unrelated to the pikes in spite of their common name; indeed, they are the largest members of the perch family in American waters. They are of considerable importance to Great Lakes fisheries, producing an annual catch, in recent years, fluctuating between 9 and 13 million pounds. In addition, the United States imports almost twice this quantity from Canada. Pikeperches are caught mostly with trap nets and gill nets, and are sold entirely in the fresh-fish markets, considerable quantities being filleted.

THE BLUE PIKE, which occurs only in Lakes Erie and Ontario, is the most important of these fishes to United States fishermen. In Lake Erie, where this species has been studied, most fish mature when about 13½ inches long. They grow to be about 3 inches long in their first year of life, 7 inches in their second, 9½ in their third, 11½ in their fourth. The annual catch fluctuates rather widely, in recent years between 3 and 6 million pounds.

Of the three States that produce blue pike, Ohio and Pennsylvania have size limits, New York has none. Additional protection is afforded by closed seasons and gear regulations that apply to the fishing as a whole.

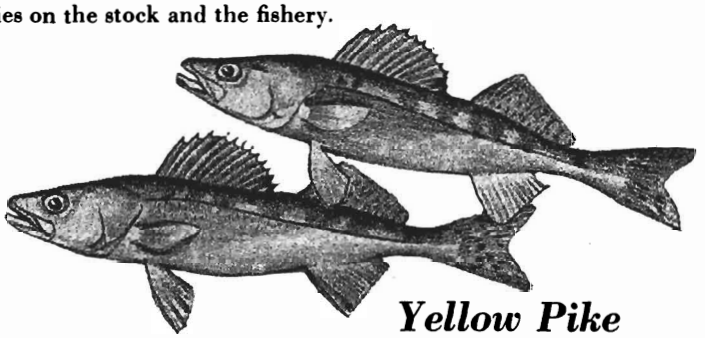
YELLOW PIKE, called "wall-eyed pike" by anglers, the largest and most widely distributed of the perches, occurs close to shore in rather shallow water in spring and autumn, moves offshore to deeper water in summer. It spawns in April. Yellow pike in Lake Erie grow to be about 4 inches long, on the average, in their first year, 8½ inches in their second, 11½ inches in their third, 15 inches in their fourth year. Specimens as long as 3 feet have been reported. They mature when around 12 or 13 inches long. The commercial catch in the Great Lakes has been 5 to 6 million pounds annually since 1940. In addition, around 8 million pounds have been imported from Canada.

Regulations for the protection of yellow pike vary widely from State to State. The present high abundance of the species in the principal centers of production, western Lake Erie and Saginaw Bay, suggests that for the present no changes are needed in those areas.

THE SAUGER is of habits similar to those of the yellow pike. It is a smaller fish, rarely exceeding a foot or 18 inches in length. From its first to its fourth year of life in Lake Erie it averages about 4, 8, 11, and 12½ inches, respectively. Most specimens are mature at a length of 13 inches. The United States catch from the Great Lakes has been around a million pounds a year in recent years. Around 13 million pounds are imported from Canada.

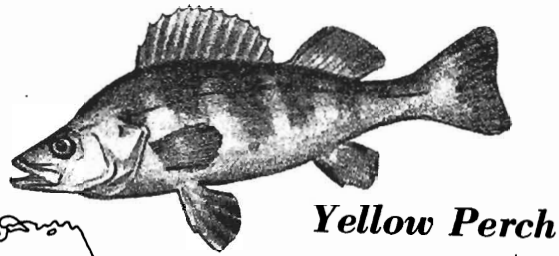
Saugers are protected by size limits in two States but are not covered by closed seasons or gear regulations other than those applying to commercial fishing in general.

Although yellow pike are now plentiful, the stocks of blue pike and sauger are at a relatively low level. They could be restored, however, by adequate conservation measures. Present knowledge can be the basis of a starting point for the maintenance of the yellow pike and the restoration of the other two pikeperches; but, if management of this resource is to result in the highest possible returns that these resources can yield, it must go hand in hand with continuous scientific studies on the stock and the fishery.

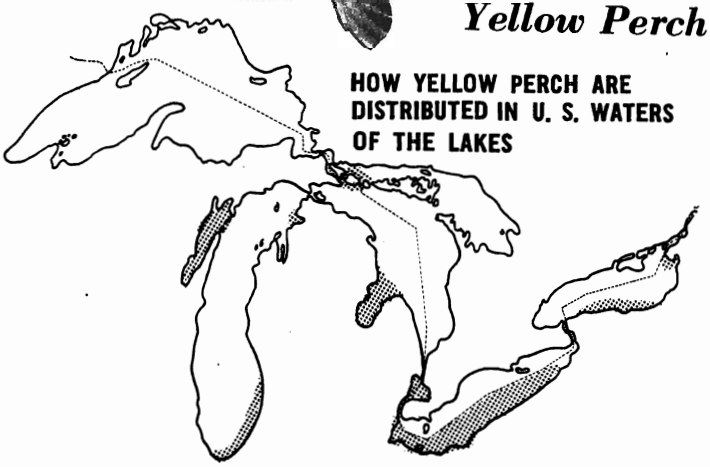


Yellow Pike

Fresh Water Fishery Resources GREAT LAKES



Yellow Perch



HOW YELLOW PERCH ARE DISTRIBUTED IN U. S. WATERS OF THE LAKES

THE YELLOW PERCH population in the Great Lakes has in recent years yielded 5 to 7 million pounds annually to commercial fishermen. In many regions the catch is but a small fraction of what it was formerly, indicating a severe but unnecessary and reparable reduction in abundance. Yellow perch are caught with trap nets, fyke nets, gill nets, pound nets, and haul seines and are sold in fresh-fish markets, a considerable quantity as fillets. In addition to the amount taken commercially, large and unrecorded quantities are caught by anglers, for it is a favorite sport fish on the Lakes.

As with other fresh-water fishes, the biology of yellow perch varies widely from place to place. Although primarily a lake fish, it avoids the greater depths and seldom lives deeper than 100 feet. It travels in schools, often congregating in thickets of weeds. Perch feed mostly on insects and crustaceans. They spawn from April to June, producing masses of eggs which form ribbons often several feet long and stick to weeds and other objects in the water. The eggs hatch in 3 to 4 weeks; the young live near to shore in their first year, later move to deeper parts of the lakes. Growth varies in the different lakes. The length of 8½ inches (the legal length in most Great Lakes waters) is attained by Lake Erie yellow perch in about 3 years, by Saginaw Bay fish during the fourth year, and by perch of Green Bay and northern Lake Michigan in approximately 5 years.

The decline in the catch of yellow perch is evidence enough that the resource is not being successfully managed. To point out one deficiency, even the best of the present size limits permit capture of yellow perch before they have completed the period of their most rapid growth. This is like cashing in bonds just before a dividend is to be declared. Some States have no size limit on yellow perch, and others permit their capture on the spawning grounds.

SUCKERS, of which there are several species, are an under-exploited resource. Although the catch averages 4 to 4½ million pounds a year, this is probably but a fraction of the potential yield. Almost no use is made of some species, which are consequently left free to multiply and occupy the space left by those more valuable fishes that have been thinned out by overfishing. Thus for want of sufficient use by man, this resource is as badly wasted as the more valuable ones. Fishermen often complain that suckers feed on the spawn of other fishes. If this belief is confirmed by scientific studies, the numerous bays in which suckers are the dominant fishes, that have been closed by State legislatures to commercial fishing for the alleged protection of sport fishing, obviously should be reopened.

Although quantities of suckers are caught throughout the year, distinct peaks of production occur in the spring and fall. Suckers of all species spawn in the spring, running up into small streams to deposit their eggs. They begin this journey as soon as the ice is out of the streams, often fighting their way through swift currents and rough waters. Virtually nothing is known about the biology of suckers.

In some States suckers are protected by closed seasons and size limits.

THE BURBOT is one of the few under-utilized and unappreciated resources of the Great Lakes. Large quantities that are caught are discarded as unmarketable, and fishermen will avoid places where burbot are known to be plentiful. Total United States catch in recent years has averaged about half a million pounds annually. Presumably this species is not favored for sale in the round because of its odd appearance. The fact is that the burbot is a nutritious fish, closely related to the cod of New England and comparable in quality to that famous fish. Its flesh is excellent, and its liver is a rich source of vitamins. In recent years numerous producers have increased their sales of burbot by marketing them as dressed fish or as fillets. Large quantities are sold for the manufacture of pet food.

The burbot is found in the Great Lakes and in smaller lakes and some rivers all the way from the latitude of Maine and New York and the upper Missouri and Columbia Rivers to the Arctic Circle. Like the codfish of the sea, the burbot prefers cold water. Usually it remains in the deeper parts of the ponds and lakes it inhabits and has been taken at depths as great as 700 feet. It is generally a nocturnal feeder and in some places comes into the shallows at night.

Studies made by this Service on the food of the burbot in Lake Michigan revealed it to be a competitor of the lake trout and to prey on commercially valuable members of the whitefish family.

THE SMELT, a native of New England rivers and lakes, was introduced into Crystal Lake, Michigan, in 1906 to provide food for salmon, which was also being introduced. The salmon failed to survive; not so the smelt, which multiplied beyond all expectation, escaped into Lake Michigan and since has spread throughout the Great Lakes.

Though at first considered a nuisance and a threat to the stock of native fishes, smelt increased in abundance to such a degree as to become an economic asset to many Great Lakes communities. First came the smelt-dipping jamborees which attracted an important tourist trade. Later, after the commercial fishermen of Green Bay developed apparatus for its capture under the ice, the smelt became extremely valuable commercially. In addition, tremendous quantities were dipped by amateurs from streams during the spawning run. It is estimated that in 1940 dip-netters alone took 12 million pounds. The total United States commercial catch in 1940 was 4.2 million pounds. In 1942 it was 3.3 million pounds.

The smelt had hardly established itself as an important commercial species when it was all but wiped out during the winter of 1942–43 by an unexplained but none the less devastating epidemic. Although almost no spawning occurred in 1943, reports of scattered runs in 1944 give reason to hope that the species may become reestablished within the next few years.

Mature smelt, i. e., those 2 years old and older, are ready to spawn as soon as the ice breaks up in the spring. Then they leave the large lakes and, traveling by night, run up the tributary streams, orienting themselves against the outgoing currents. They pause in their journey during the day and spawn, all the while holding their position in the stream under overhanging banks or logs, or even permitting themselves to drift downstream toward the lakes. The eggs are sticky and attach themselves to whatever objects they meet in the water, such as piers of bridges, piling, or stones of the river bed. They hatch in 20 to 30 days, depending on temperature. The delicate and transparent larvae are soon carried downstream to the lakes. Growth of smelt varies widely from one region to another. In Green Bay, Lake Michigan, where biological studies have been made on this species, they reach an average length of 7 inches in 2 years, 10 inches in 3 years, 12 inches in 4 years, and 14 inches in 5 years. Green Bay smelts have been found to feed largely on crustaceans; the small percentage taking fish had eaten mostly other smelt.

If smelt should again become abundant, investigations should immediately be started to determine the relation between fishing intensity and the productivity of this resource, and also the relation of this species to other species as a competitor, as a predator, and as a source of food.

CARP WERE INTRODUCED INTO THE UNITED STATES IN 1876, thus completing the round-the-world spread of this species through the agency of man. It is native of China, was brought to the European continent in the thirteenth century, to England in the sixteenth, and finally to America. Quickly establishing itself, the carp multiplied rapidly and is now abundant and widely distributed. Commercial fishermen took carp from the Great Lakes for the first time in the 1880's and now catch over 5 million pounds a year from those waters. Even with this rather large production, the population of carp could probably support a larger fishery were it not for a limited demand. Carp, like suckers, have been needlessly protected by conservation measures which close certain waters to commercial fishing.

Carp feed on plants and small animals such as shellfish, insect larvae and crustaceans. They are extremely hardy and can stand a wide range of temperatures. They spawn in May and June. Growth of carp varies widely, but is fairly rapid. They average about a pound when a year old.

CATFISH AND **BULLHEADS** contribute about 1½ million pounds of fish to the Great Lakes fisheries. They are caught mostly with trap nets, also with fyke nets and haul seines; and they are sold entirely in the fresh-fish markets. Catfish make up between 80 and 90 percent of the catch.

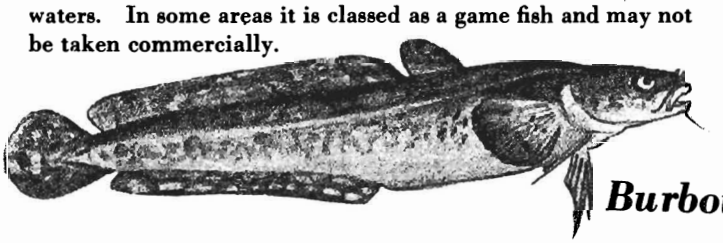
Little is known about the catfish and bullhead populations of the Great Lakes. Information is needed on the growth, spawning, and migrations of these fishes, and on the elements controlling their abundance. The ways in which abundance is affected by fluctuations in the water level and the resulting variations in the extent of accessible marshy areas need to be investigated.

Both catfish and bullheads receive protection in the form of size limits in the principal centers of production. The ultimate results of a recent downward revision of these limits in Michigan waters to conform with lower limits in effect in Ohio remain to be determined.

SHEEPSHEAD is a fish of coarse flesh which is in less demand than most other Great Lakes species. Even during the period of wartime scarcity buyers and operators have found it necessary to impose daily boat limits to avoid gluts and complete collapse of prices. The development of methods of processing and the sale of greater quantities as dressed and smoked fish should improve the demand for this abundant but under-utilized fish. Sheepshead grow slowly, take 6 to 7 years in Lake Erie to reach a weight of around 2 pounds. This fish is protected by size limits in Illinois and Ohio. Present United States total annual landings vary from three to five million pounds a year.

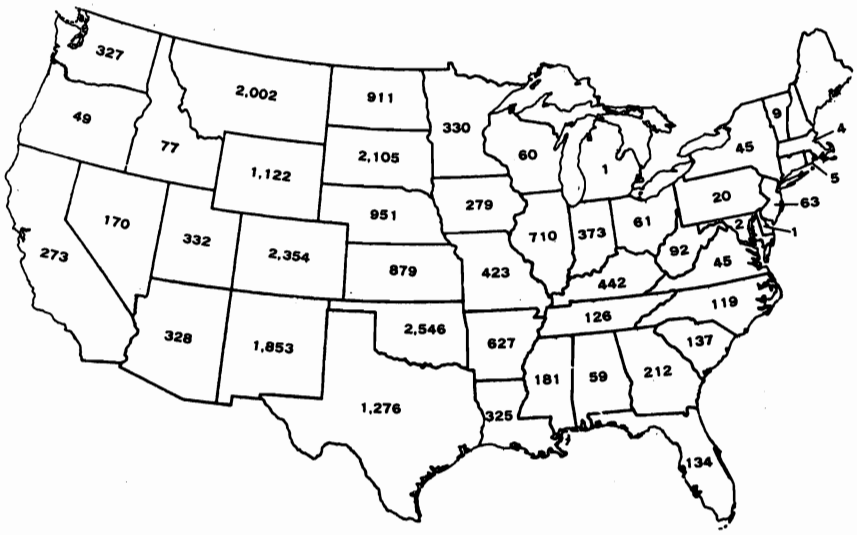
WHITE BASS: The demand for this fish is also limited and therefore the production is limited, too, particularly during late spring and early summer when the yield is high and other fresh-water species are plentiful on the market. The United States catch of white bass varies widely, averages around 500,000 pounds a year. This variation may be caused by the fact that the fishery depends largely on fish of two ages (2- and 3-year-olds) and hence is affected by fluctuations in the size of individual year broods. The causes of these fluctuations are unknown. Growth of white bass has been studied in Lake Erie. There they reach about 8½ inches in 2 years, 10½ inches in 3 years.

The white bass is protected by size limits in its principal center of production (western Lake Erie) and in certain other waters. In some areas it is classed as a game fish and may not be taken commercially.



Burbot

Fresh Water Fishery Resources POND FISH CULTURE



Farm and ranch ponds established on private lands by Soil Conservation Service to January 1, 1944

ARTIFICIAL PONDS ON FARMS CAN BE CONSTRUCTED AND MAINTAINED TO SUPPLY FOOD AND SPORT FISHING TO FARM OWNERS. There are already about 360,000 acres of farm and ranch ponds in the United States, with a potential yield of 18 million pounds of edible fish a year. There is room for much more.

In spite of equipment shortages due to the war, the number of ponds has been increasing steadily during recent years. The Soil Conservation Service has helped build about 22,000 ponds, and the Agricultural Adjustment Administration over 325,113 ponds during the past 6 years. In Texas alone, there are now about 100,000 ponds of various sizes, of which probably 70 percent are suitable for fish. After the war, construction of farm ponds can be aided greatly by the transfer of trail-builders, bulldozers, tractors, carry-alls, scarifiers, and other equipment from the War and Navy Departments to the Government agencies which are now building these ponds.

SUCCESSFUL FARM POND MANAGEMENT DEPENDS UPON THE APPLICATION OF CERTAIN PRINCIPLES OF STOCKING AND MAINTAINING THE POND. Personnel trained in this work should be available to supervise the stocking of ponds and aid the farmer in correcting past mistakes. At present, only 4,722 ponds are actually under management supervision by trained personnel in the Soil Conservation Service. Success in the operation of a farm fish pond depends largely on the selection of suitable species, stocking in the proper proportions, fertilizing the pond, and harvesting the crop regularly.

Bluegill sunfish and largemouth black bass are most suitable for stocking farm ponds. Bluegill sunfish, when stocked at the proper rate, 1,000 to 1,500 per acre in fertilized ponds, will weigh 4 ounces 1 year after stocking. Its young provides food for the largemouth bass which is stocked with it. Both species are usually introduced into ponds at the same time, and care must be taken that they are the same size when stocked.

Largemouth bass may weigh 1 pound within a year after stocking in a fertilized pond. This fish is cannibalistic as well as carnivorous and is the means by which the pond is kept from getting overpopulated with sunfish as well as with its own kind. It is stocked at the rate of 100 per acre in fertilized ponds and 30–50 per acre in unfertilized ponds.

Crappies and bullheads or catfish may also be stocked in farm ponds along with bass and bluegill sunfish, but they do not survive along with those species. If crappies are desired in a pond, one-fourth of the above number of bass are replaced with an equal number of crappies. If catfish are wanted, one-fourth of the above number of bluegills are replaced by catfish (or bullheads) at the rate of 25 bullheads for each 100 bluegills replaced.

PROPER FERTILIZATION OF FARM PONDS IS IMPORTANT. Unfertilized ponds will produce from 40 to about 150 pounds of fish per acre, annually, whereas fertilized ponds will produce from 200–400 pounds.

After several applications of fertilizer soft waters usually become green and turbid with microscopic plants. This turbidity prevents the establishment of larger plants in the pond. The microscopic plants showered on the bottom, dead and alive, provide the food for enormous numbers of midgefly larvae and other aquatic insects which are the principal food of the bluegill sunfish. When the turbidity called "water bloom" decreases to the point where the bottom can be seen at depths greater than 18 inches, more fertilizer is added, usually at about monthly intervals until cool weather begins. Then fertilization is discontinued. The cost of fertilization varies between about $11 and $20 per acre per season.

IN A PROPERLY MANAGED POND, VEGETATION IS CONTROLLED. Weedy ponds provide such good shelter for small fish that a pond can soon become overpopulated. The best means of controlling weeds is by heavy fertilization. In ponds where vegetation has already gotten beyond control, fertilization should begin in winter or as soon as possible after the ice melts. This stimulates the growth of filamentous algae (submerged green scums) which drape over the plants and eventually smother them. When warm weather arrives, decay of the smothered plants stimulates development of the microscopic plants which cloud the water and make further growth of the large plants impossible.

HOW STOCKING RATE AFFECTS SIZE OF POND FISH

When 1,500 bluegills are planted, per acre, they average after 1 year 4.0 ounces. When 180,000 bluegills are planted per acre, they average after 1 year .02 ounce.

In hard waters, weed control is more difficult and chemicals such as sodium arsenite and copper sulphate must be used. This requires technical supervision to prevent killing the stock of fish.

HARVESTING THE FISH CROP. Properly stocked and managed farm ponds are capable of producing at least 200 pounds of edible fish per acre annually. Ordinarily, the farm-pond owner will probably not have time to remove that weight of fish each season by angling alone, though he should strive to do so, for otherwise his pond will become overcrowded and the fish stunted. The removal of fish from farm ponds would be facilitated by the use of large seines, but most State laws prohibit their use.

IN GENERAL, EXISTING LEGISLATION IS NOT HELPFUL TO THE FARM-POND PROGRAM. Farm-pond culture in many States is subject to legislative restrictions of various kinds. Many States impose closed fishing seasons, size limits, and other restrictions applying to public fishing waters. Recent experiments in farm-pond culture have shown very clearly, however, that the common game and fresh water species will grow rapidly with an adequate food supply, and that unless the yearly crop is removed by fishing, stunted populations will result and fishing will deteriorate.

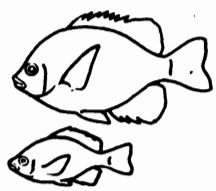
More fish could be made available as food to inland sections by encouraging pond-raising of largemouth bass and sunfish commercially for sale in public markets. In some areas, considerable revenue might be obtained by pond owners through sale of the sport as well as the fish. Regulations permitting sale from private ponds should, of course, be drawn up to protect fishing resources in public waters.

Many States have laws making it impossible to obtain stock for private ponds from State hatcheries. This leaves the U. S. Fish and Wildlife Service with a large task in fish production to meet the rapidly growing demand for fish to stock private and public waters.

ADDITIONAL FACILITIES ARE NEEDED TO MAINTAIN THE FARM-POND PROGRAM AND ENCOURAGE ITS GROWTH. The Soil Conservation Service has estimated recently that 649,000 additional farm and ranch ponds are needed in the United States to meet soil conservation needs. Nearly one billion fish would be required to stock that number of ponds. These would have to be produced largely in the warm water ponds of the U. S. Fish and Wildlife Service. However, to produce this quantity of fish, 18,000 acres of hatchery ponds would be required; and the Fish and Wildlife Service has only 3,000 acres of ponds available for such use at the present time.

HOW FERTILIZATION AFFECTS SIZE OF POND FISH

With fertilization, after 1 year, fish average 4.0 ounces. Without fertilization, after 1 year, fish average 1.1 ounce. 1,500 fish planted per acre in both cases.

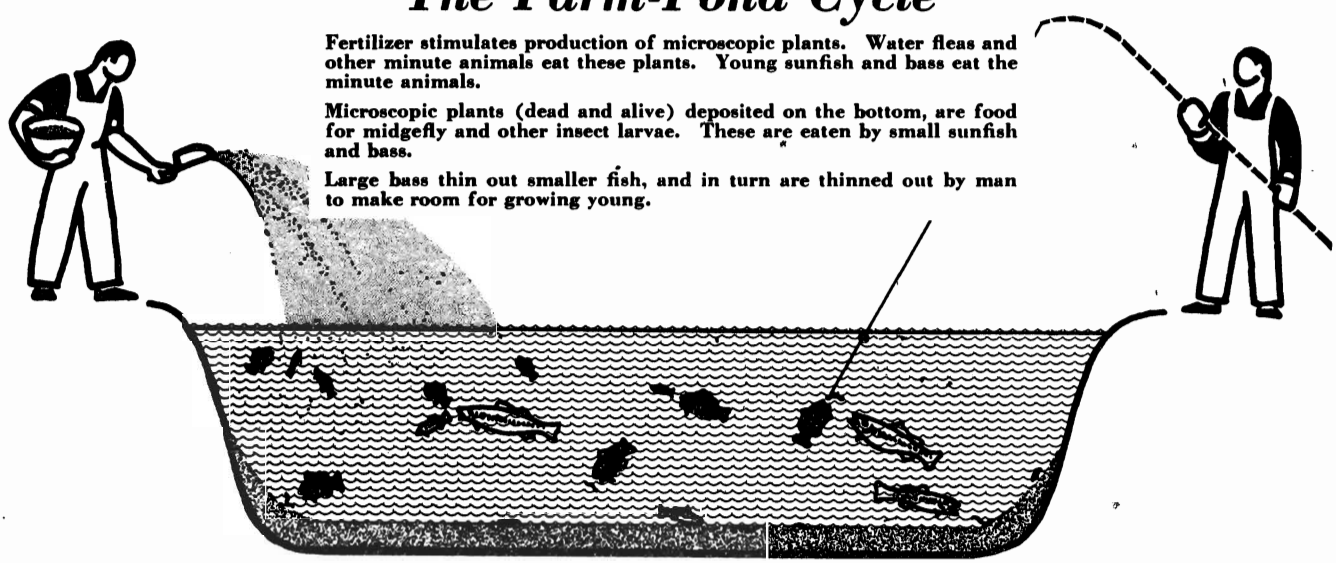


The Farm-Pond Cycle

Fertilizer stimulates production of microscopic plants. Water fleas and other minute animals eat these plants. Young sunfish and bass eat the minute animals.

Microscopic plants (dead and alive) deposited on the bottom, are food for midgefly and other insect larvae. These are eaten by small sunfish and bass.

Large bass thin out smaller fish, and in turn are thinned out by man to make room for growing young.



Atlantic Fishery Resources SPONGES

THE SPONGE FISHERY OF THE UNITED STATES IS PROSECUTED IN ONLY A LIMITED AREA IN FLORIDA, but yields a product worth, in 1943, more than two million dollars. Before the war, United States production of sponges exceeded 600,000 pounds, but wartime exigencies reduced the yield to 174,000 pounds in 1943.

Apart from their familiar household uses, sponges are required in the manufacture of special hygienic and surgical preparations, in leather dressing and glazing, in washing railroad cars and locomotives. They are used by tile and bricklayers, painters, decorators, lithographers, jewelers, and silversmiths.

A sponge of good commercial quality must answer many specifications. It must be spheroidal or cake-shaped in form, soft and fine in texture, and tough, durable, resilient, and absorptive. These characteristics are determined largely by the size and arrangement of the fibers. The Florida sheepswool is of higher quality than sponges of the same species produced in Cuba and the Bahamas. Three other varieties—wire, grass, and yellow—are inferior in quality and therefore of less importance to the industry.

THE SPONGE IS ONE OF THE SIMPLEST FORMS OF ANIMAL LIFE. It lives on the bottom of the sea attached to rocks, coral, and other hard objects. The skeleton, a mesh of elastic fibres, comprises the greater part of its body and actually is the sponge of commerce, for the soft parts are removed in processing. The delicate living tissues form a highly complex system of canals and chambers through which a continuous flow of water is maintained. Sponges live on minute micro-organisms suspended in the water which is filtered through sponge canals.

During the warmer part of the year sponges produce eggs, which are fertilized and developed within the body, then emerge as minute, oval-shaped larvae. After a short period of free-living in the sea the larva settles on the bottom, attaches itself, and begins to grow. Since no studies have been made on the biology of American sponges the exact time of spawning and the duration of the larval period are not known. Sponges are believed to grow rather slowly.

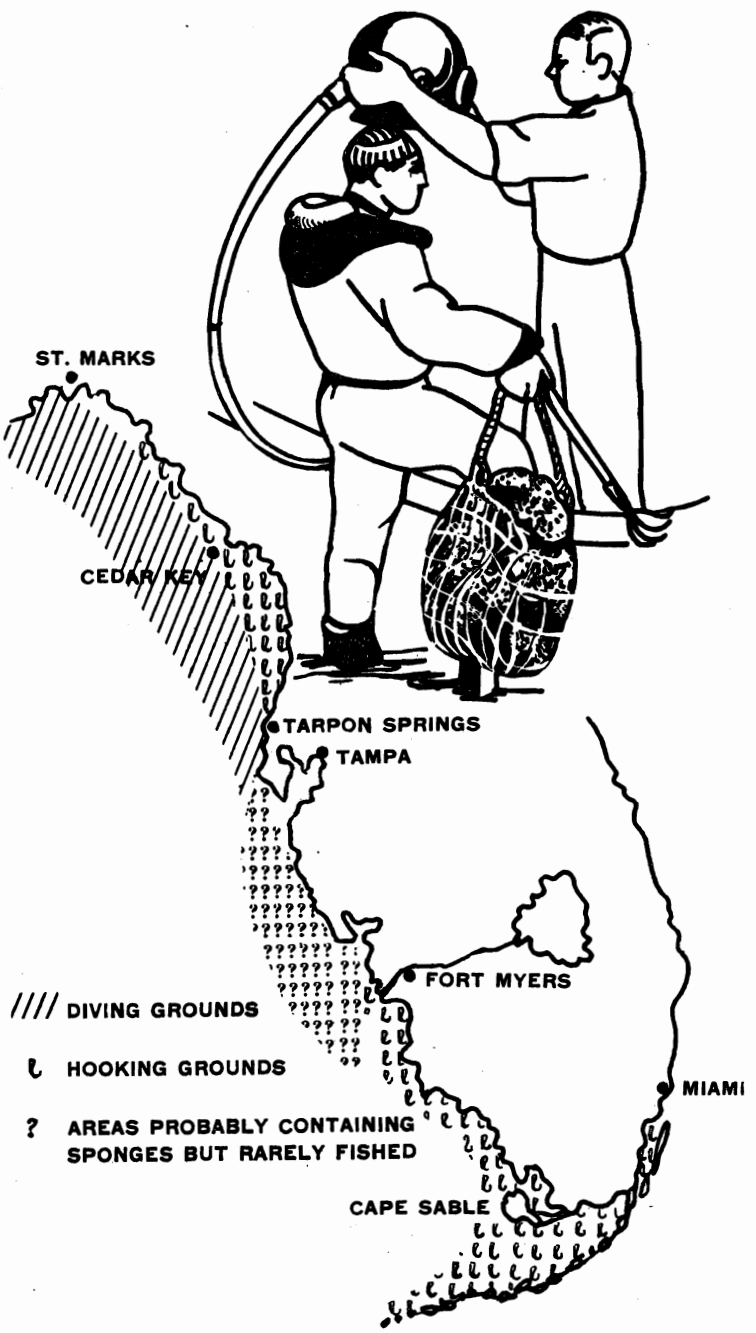
A sheepswool sponge of marketable size, i. e., not less than 5 inches in diameter, is probably at least 4 or 5 years old.

THE EXTENT AND DENSITY OF THE SPONGE POPULATION SUPPORTING THE UNITED STATES INDUSTRY ARE NOT KNOWN. Lacking this fundamental knowledge, we do not know whether the present intensity of fishing exceeds the rate of natural replenishment and the fishery is being gradually depleted or whether some fishing grounds are under-exploited. There is some indication that the yield per unit of effort, which is considered a measure of abundance, has somewhat declined during the past decade. In 1939 the Key grounds were swept by a sponge disease which killed 30 to 60 percent of the stock. The Bay grounds were affected to a much lesser extent. From this and other causes, the Key grounds reserved for hooking have so declined in productivity that they furnish less than 10 percent of the total catch.

Maintenance of the sponge industry in the United States is primarily dependent on careful management of the offshore grounds. The enforcement of a minimum-size law is the principal conservation measure now in force, but its effectiveness has not been determined. For effective conservation, reliable information is needed regarding (1) exact location and extent of the grounds, (2) density of sponge populations by species and age groups, (3) rate of reproduction and growth of sponges on various grounds, (4) effect of diving on sponge populations (destruction of small, unmarketable sponges), (5) ecological factors affecting sponge populations, (6) sponge diseases and their prevention.

SPONGE FARMING has been found practicable in large-scale experiments conducted by the British Government in the Bahamas and British Honduras and may be the means of restoring the Key West industry. However, because of certain limitations, farming can be developed in the United States in only a few selected localities.

Propagation or farming of sponges is based on the remarkable ability of the sponge to regenerate the entire organism from a small cutting. Rectangular slices about two by four by one-half inches, cut with a very sharp knife from a healthy sponge, are tied to a piece of rock or specially made cement disc and immediately placed in water. From 16 to 32 pieces can be cut from one adult wool sponge. Regeneration and growth begin immediately, and eventually the sponge attains marketable size and a rounded shape. In the Bahamas, sponges grown from cuttings reach marketable size in about 3 or 4 years. During this time they require no special attention except protection against storms and thievery.



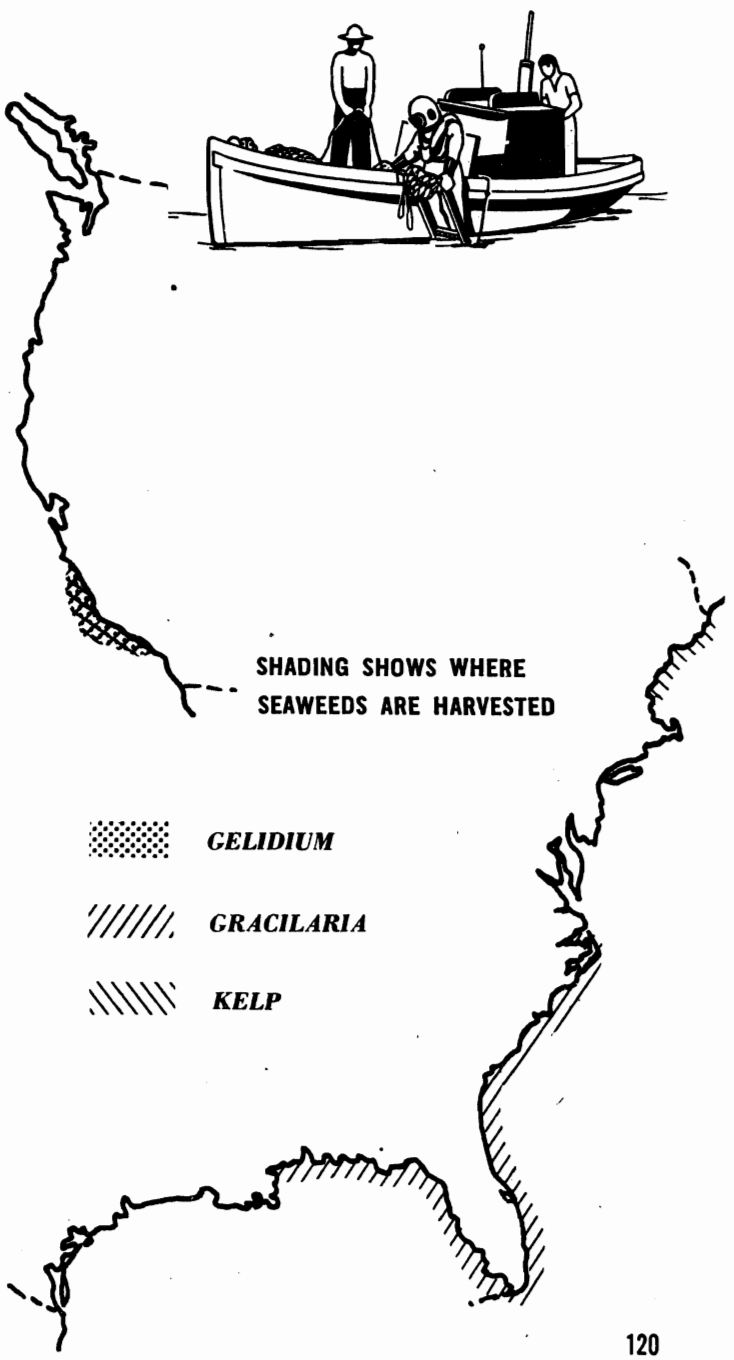
U. S. Fishery Resources SEAWEED

SEAWEEDS, which before World War II were very under-exploited, constitute one of our most valuable marine resources, reproducing themselves without artificial cultivation or fertilization, and supplying materials available from no other source.

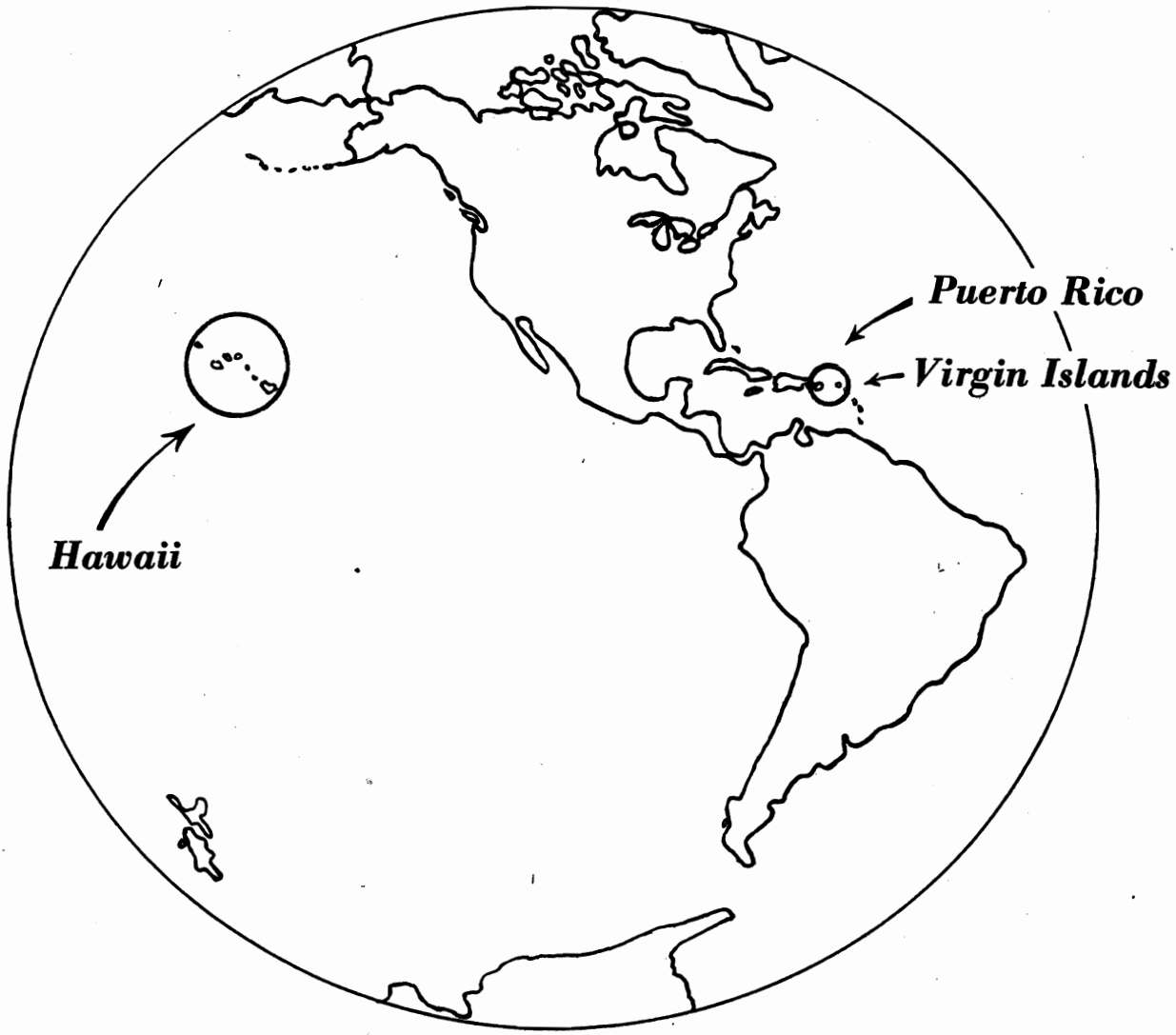
IRISH MOSS (*Chondrus crispus*) has been used as a food and in medicinal products for centuries. The early settlers imported small quantities for these purposes up to the year 1835, at which time extensive growths were discovered along the New England coast. This gave rise to a new industry for the population of that section, and, while its growth has not been large, it gives seasonal employment to several hundred people. Irish moss had been used chiefly as a component of puddings and as a demulcent in cough remedies; also, to some extent, in the manufacture of stabilizers for ice cream, chocolate milk, cheese, bakery products, confections, and dental impression compounds. The production of Irish moss in 1940 amounted to approximately 600,000 pounds, valued at $59,000.

KELP: The commercial utilization of the vast kelp (*Macrocystis pyrifera*) beds on the Pacific coast, and of *Laminaria digitata* on the Atlantic coast, was begun in a small way in 1912. This seaweed was at that time used in the production of potash for fertilizer and explosives. Bromine and iodine were recovered as byproducts. During the war in 1917–18 considerable money was spent in research to develop more economical methods for obtaining these products, since the shortage was acute. At the close of the war considerable progress had been made, but since imports of cheaper material could be obtained, most of the kelp plants closed. One or two remained in operation preparing fertilizer and dairy cattle food from the dried seaweed. It has since been found that the kelp contained alginic acid, which can be used in the manufacture of a material known as algin. This has a wide variety of uses, the most important of which is a stabilizer for ice cream and other dairy products. It is also valuable in the preparation of rubber articles, finishing of leather, waterproofing cement, fireproofing wood and other inflammable materials, treatment of boiler water, can-sealing compounds, water-base paints, dental-impression materials, and gaskets for aeroplane engines. This has grown into an industry of considerable importance, particularly during the present war, since many of the materials used by the armed forces contain algin.

AGAR AGAR is the name given to a gum extracted from several of the red seaweeds, which has a variety of essential uses in the manufacture of several products. The principal species used in its manufacture is *Gelidium corneum*. Most of the agar used in the United States had been imported from the Orient before World War II, the domestic production being less than 1 percent of our requirements. The war forced the United States to explore for new sources of agar-producing weed, for one of the most extensive uses of the gum is in making bacteriological media and it is essential in hospitals. Early in 1942 surveys of the coast lines were begun to learn whether or not supplies of *Gelidium* were available to satisfy our national requirements. Other species of weeds were investigated to determine whether or not a suitable substitute gum could be manufactured from them. One species, *Gracilaria*, at first gave evidence of containing gums which could be substituted for those formerly prepared from *Gelidium*. Upon a more detailed investigation it was found that, while this gum could be substituted for agar in some industries (i. e., manufacture of electric-lamp and radio-tube filaments and storage batteries), its physical and chemical properties made it rather unsuitable for bacteriological purposes. Meanwhile several firms had begun harvesting the small beds of *Gelidium* found on the California coast, and as these operations were extended new beds were located. At the present time there appears to be an ample supply of raw material, and, while the manufacturing process is expensive, it is possible to supply sufficient quantities to satisfy our bacteriological and medical needs.



Fishery Resources, HAWAII AND PUERTO RICO



IN PUERTO RICO AND THE VIRGIN ISLANDS, the per-capita consumption of fish is the highest of all the peoples living under the flag of the United States. The population of 2 million consumes about 150 million pounds of fish a year. Yet so limited is the supply of the island fishery resources that 80 percent of this amount must be imported[1]; and only 3 to 4 million pounds are caught locally.

Caribbean fishermen work the waters within rowing or sailing distance of their homes. Seasonally they catch migrating fish by trolling, and all year 'round take bottom species with fishpots and hand lines. Their gear is crude but moderately effective among the coral reefs.

The water bathing Puerto Rico and the Virgin Islands is transported in the Atlantic North Equatorial Current from the coast of Africa. During its transoceanic passage the greater part of its nutrient salts become extracted by living plants and animals, or are precipitated to the ocean floor, and it is thus made barren by the time it reaches the West Indies. Only immediately around the islands, where accretions from the land provide additional nutrients, can the water support any significant amount of resident aquatic life. Here the coral reefs and their attendant vegetation provide a favorite habitat for many fishes. On the narrow shelves surrounding the islands live snappers and groupers, also crabs, shrimp, spiny lobsters, and other shellfishes of lesser importance. Moderate quantities of mullet, tarpon, and snook frequent the river mouths, and irregular and unpredictable runs of migrating mackerels, tunas, and jacks use the passages between the islands. The streams and lakes support only meager populations of fresh-water fishes.

[1] The bulk of imported fish is salted; the consumption statistics are stated on the basis of fresh round weight.

Numerous efforts have been made to enlarge fishing enterprise in the West Indies. Many ambitious commercial fishing ventures have been proposed. Some minor projects have met with a measure of success, but most ventures have been abandoned after trial operations or have not progressed beyond promoters' dreams. In truth, modern mass-production fishing holds little promise in the waters around these islands. The bottom species near the large communities are now severely taxed by overfishing. Those on more remote areas might be fished somewhat more heavily with profit, and some additional quantity of the migratory species might be taken by increasing the fishing effort; but the increase in catch resulting from such intensification would probably at best be slight and transitory. The only way productiveness of present fishing could be increased and sustained is by rebuilding the stocks through such good-management practices as restriction of fishing in some areas, adoption of size limits, clearance of channels leading into river mouths, and abatement of pollution. This kind of program, however, requires, for the most part, knowledge about the biology of the fishes, which we do not possess and which would have to be developed through scientific study. Meanwhile the lot of the fisherman can be improved by teaching him better methods of preservation and by making him familiar with uses for his unexploited marine resources. For this purpose the U. S. Fish and Wildlife Service has established a technological laboratory at Puerto Rico.

THE TERRITORY OF HAWAII has an extraordinary variety of fishery resources, the most valuable of which has been exploited almost entirely by Japanese nationals before the war. In spite of the rich diversity of species, not one of them is vastly abundant as are such northern fishes as herring and cod. Nevertheless, Hawaii is peculiarly well situated for development of great ocean fisheries, for around the islands of the western Pacific are large quantities of tuna, which before the war had supplied Japanese canning industries. Hawaii is no farther from these profitable grounds than Los Angeles is from the southernmost latitude visited by the California tuna fleets. Up to the present, however, Hawaiian fisheries have not extended more than 100 miles from home waters. They have been of two types:

1. THE INSHORE FISHERIES are carried on in the shallow waters inside the reefs surrounding the islands or in the bays and offshore areas which can be fished from shore-beached boats. The total production entering the market from these areas is about 14 percent of the total island catch. Hawaiians, Filipinos, and Chinese have always dominated these fisheries. They use canoes and skiffs, fish with hand lines, gill nets, haul seines, and traps. Among the most valuable species taken by this fishery are the various kinds of jacks, including the fish called horse mackerel on the United States west coast, and groupers, snappers, and parrot fishes. Among crustaceans are spiny lobsters, crabs, and mantis shrimp. A fresh- or brackish-water species of shrimp is taken in the mouths of rivers and bays. Native oysters occur in sheltered localities but are not generally used for food. Pearl oysters are found on the western reefs. Before the war, oysters and clams were imported from Japan and bedded for later use. Octopus is very abundant, and also squids, which are not taken commercially. Seaweeds of various kinds are gathered locally. Sea cucumbers, which are used to produce the article known as trepang or bêche-de-mer in the Orient, are present but apparently not utilized.

2. THE OFFSHORE FISHERIES provide, in normal times, about 86 percent of the total landings in the islands. They are pursued in deep water as far as 100 miles offshore, with Diesel-powered vessels of 20 to 90 feet in length. The principal species taken are tunas, most of them skipjack and yellowfin (*which see*), mackerel scads, and swordfish. Skipjack (called aku) are taken by pole-and-line fishing with live bait as chum. Yellowfin (ahi) are caught with buoyed long lines, mackerel scads (akule) with nets. Before the war these fisheries were dominated by Japanese. Many, if not most, of these people were aliens and were characteristically secretive about fishing grounds and methods. There is consequently no accumulation of technical information about the fishery or the fishes. Exigencies of the war have reduced the offshore fleet to a fraction of the pre-war size. The catch declined accordingly, but in 1943 showed signs of recovery as a result of efforts by Hawaiians and Filipinos.

ANNUAL YIELD OF FISH IN POUNDS

	Average 1933–40	*1942*	*1943 (Estimate based on first 8 months' production)*
Deep-sea fisheries...	*12,662,000*	*155,000*	*475,000*
Inshore fisheries...	*1,997,000*	*418,000*	*1,460,000*

POND FISH CULTURE of mullet, milkfish, ten-pounder and barracuda is practiced in impoundments constructed of lava rock along the marshy shores and in sheltered arms of bays and estuaries on most of the islands. This was once a flourishing industry, but for various reasons, probably mostly economic, it has declined severely.

The ponds are stocked with young fish which have been seined along the shore and in the open sea and which are allowed to grow to market size. Neither artificial propagation nor feeding of the impounded fish is practiced.

Pond fish culture is frequently criticized by Hawaiians as being unscientific. Operators are said to overstock their ponds, thus get less return for their effort than would be provided under good management.

THE INSHORE FISHES HAVE DECLINED IN ABUNDANCE IN THE LAST 25 YEARS, according to widespread belief. Various practices might contribute to such depletion; among them, the destruction of large quantities of immature fish is perhaps the most serious. Local citizens condemn the use of small-meshed nets, spears, haul seines, and buoyed long lines (flag-lines). However, there is at present no knowledge about Hawaiian fishes on which to base regulations for restoration. The U. S. Bureau of Fisheries (succeeded by the Fish and Wildlife Service) recommended in 1938 that the Federal government undertake biological and technological investigations in cooperation with the Territorial government. In recognition of these recommendations, the legislature of the Territory of Hawaii has authorized an appropriation of $10,000 annually since 1941. Use of this money for its purpose awaits appropriate action by the Federal government.

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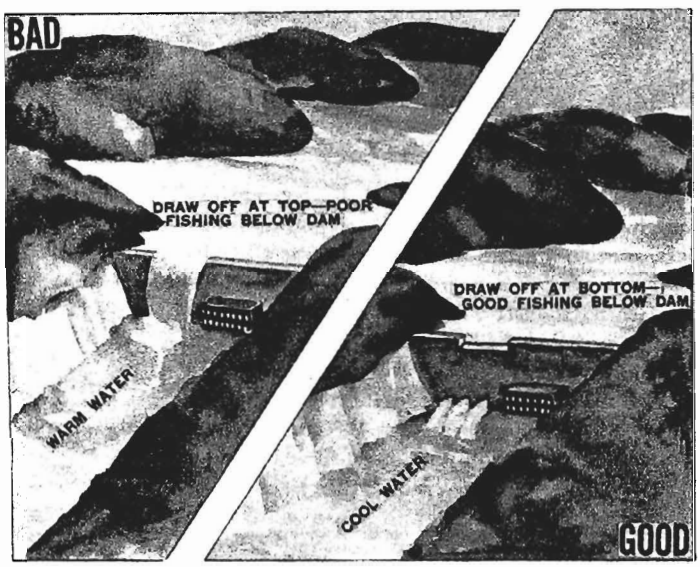
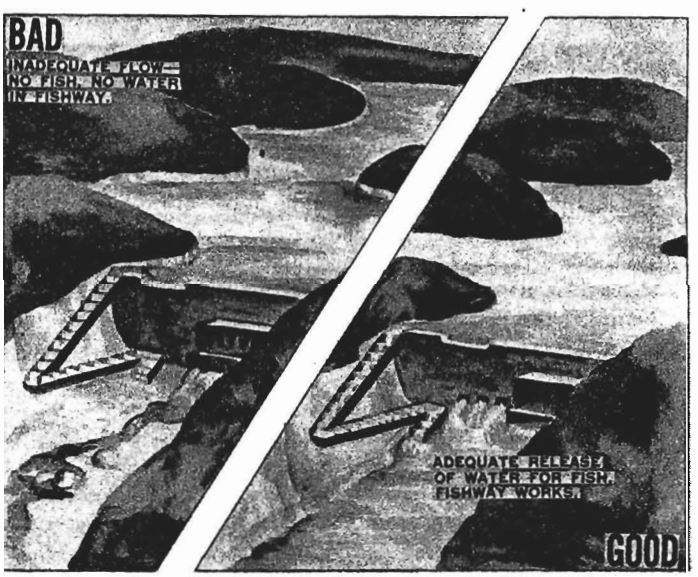
Water Utilization Projects and Fishery Resources

WATER-UTILIZATION PROJECTS OFTEN CONFLICT WITH THE MAINTENANCE OF FISHERY RESOURCES. The larger and more complicated the engineering devices are for utilizing natural water supplies, whether they be for domestic use, industrial processes, irrigation, flood control, navigation, waste disposal, or simple drainage, the greater the likelihood of serious interference with the fish supply. Fish are delicately adjusted to their environment and an entire population of them can be destroyed by small changes in the water involving any of the following: chemical composition, gas content, temperature, volume, rate of flow. Any of these changes may result from deforestation, from improper cultivation of the land, from irrigation, from mining, from drainage of swamps, from "improvement" of waterways, from a host of manufacturing processes, from simple impoundment for controlling floods or for generating electricity. Thus land utilization and water utilization are closely related. The maintenance of one of the important water resources, i. e., the aquatic life it contains, is frequently overlooked when water-use projects are planned.



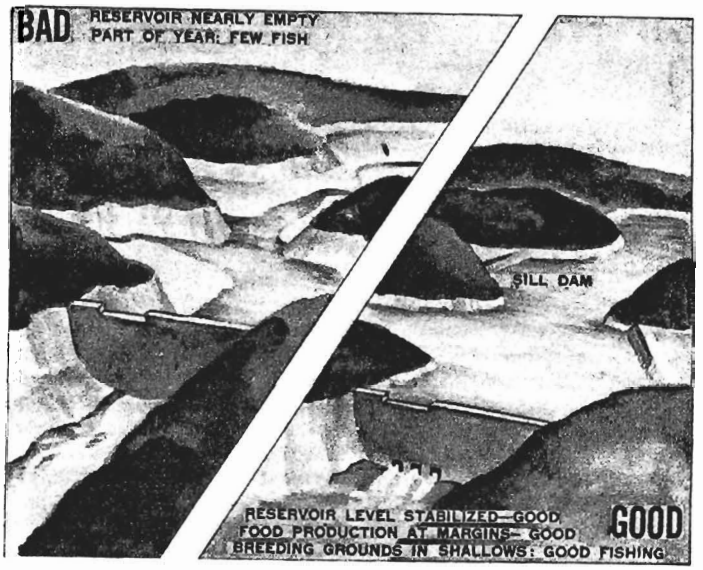
DAMS CONSTRUCTED FOR HYDROELECTRIC POWER should be designed to draw water from the lower, cooler levels of the reservoir if cold-water fish, like salmon and trout, are important in the lower drainage. In the warm, muddy Colorado River, water drawn from 300 feet below the surface of Lake Mead furnishes rainbow trout fishing for miles below Boulder Dam. In general, surface overflows at such dams should be avoided.

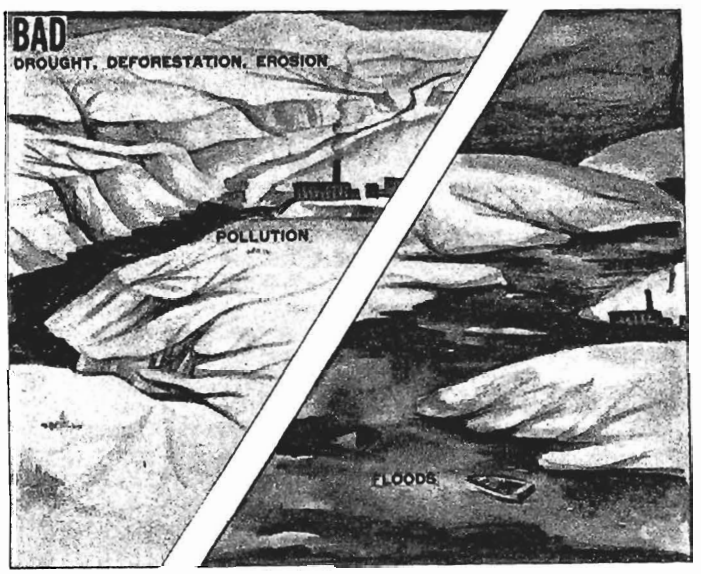
WHERE DAMS OBSTRUCT THE MIGRATION OF SALMON, steelhead trout, shad, alewives, and other fishes that come from the sea to spawn in fresh water, fishways should be provided to permit ascent of the adults over the dam on their spawning migration without delay, and the passage of the young downstream over the dam on their seaward migration without injury.



WHERE DAMS OBSTRUCT THE FLOW OF A RIVER, the downstream fish population may be destroyed. To overcome this evil, storage dams should continuously release enough water, adjusting the flow according to seasonal needs, to maintain good fishing. The recreational and food values of these resources may justify the expense of providing additional storage, and where they do, this expense will be amply repaid by lasting benefits.

DAMS BUILT FOR POWER, or for improving navigation, can be operated to *improve* fish production. Fish and fish-food organisms require stabilized water levels. Rapid or extreme variations in water level in the reservoir renders the most productive shallow margins of the lakes useless. Where variation of water level is unavoidable, nursery and feeding areas can be maintained by constructing small inexpensive secondary dams across the mouths of creek-fed bays and indentations of the lake where water levels and biological conditions can become and remain stabilized. The outflow from these nursery areas will tend to stock the lake with fish.

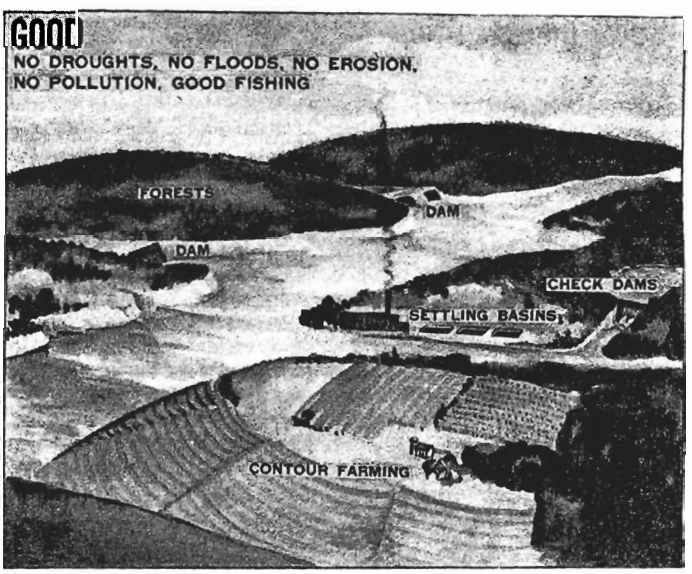




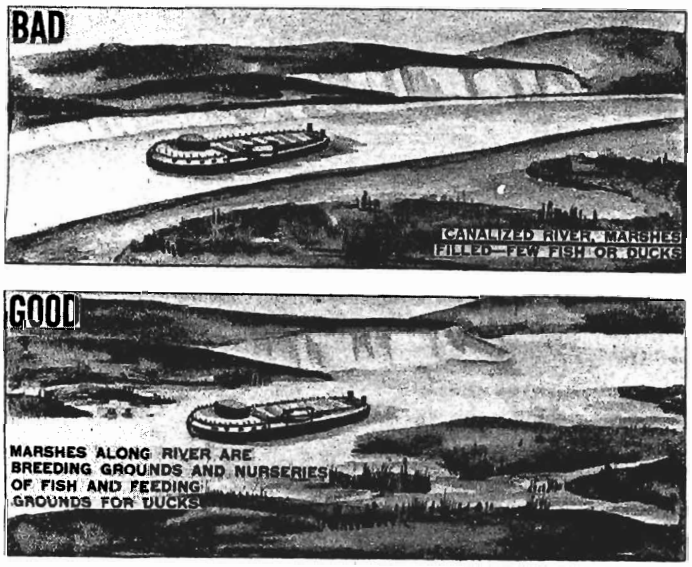
RIVERS HAVE LONG BEEN CONSIDERED THE PROPER PLACE TO DUMP WASTES OF FACTORIES, mines, oil wells, and domestic sewage. The belief that running water purifies itself in 30 (or 300 or 3,000) feet is a fallacy. Factory, mine, or petroleum wastes may destroy scores of miles of valuable fishing grounds. Raw sewage is dangerous from the health standpoint and depletes the oxygen supply so necessary for aquatic life. Properly treated and in moderate quantities, however, it fertilizes the waters and increases fish food and fish production, just as fertilization increases production from the soil. Where streams are impounded, or where summer droughts reduce stream flow, pollution of the waters may be doubly disastrous to aquatic life.

IMPROPER LAND USE MAY DESTROY IMPORTANT FISHERY RESOURCES. Deforestation increases run-off that scours stream beds, destroying fish food, burying fish nests and driving or carrying the fish away. Improper cultivation increases soil erosion. Muddy waters are intolerable to many kinds of fishes; they prevent penetration of light and thereby suppress aquatic plant life.

DROUGHTS, caused mainly by the same conditions that produce floods, may be as destructive as floods. The constant flow of clear cool water is necessary for the welfare of our northern fishes. Reforestation, contour farming, the checking of floods in the upper tributaries, and the prevention of pollution, are some of the means of insuring better fishing.

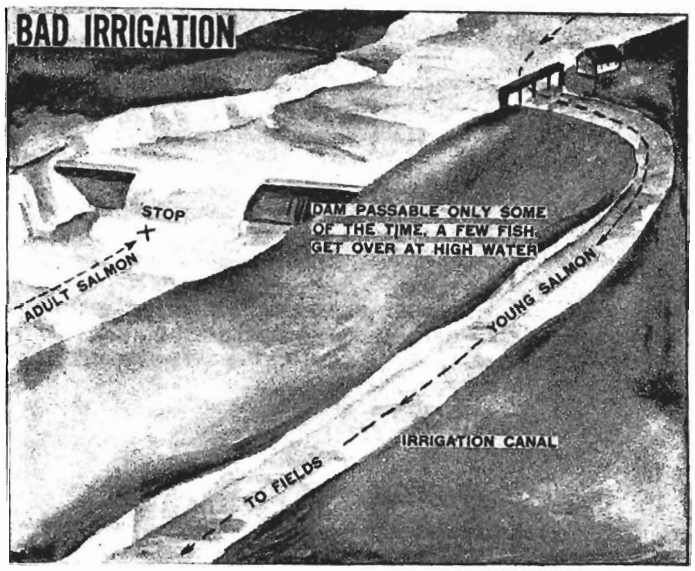


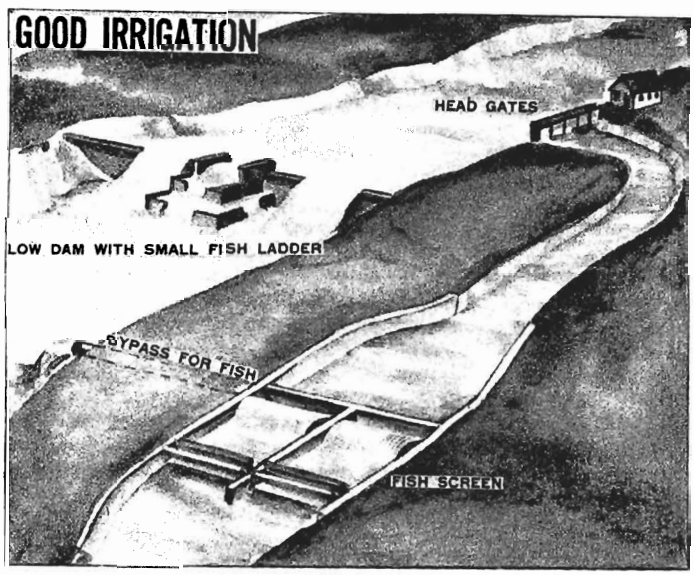
Water Utilization Projects and Fishery Resources



SHIP CANALS ARE POOR PLACES FOR FISH to breed and grow in. A canal carries the water away too rapidly. When bordering marshes are filled, breeding and feeding places are destroyed. Natural river areas, well supplied with backwater marshes where water levels can be stabilized by occasional dams, provide *both* for navigation *and* an abundant fish supply.

IRRIGATION IN ARID SECTIONS OF THE WEST is a dangerous threat to the fish supply in Pacific coast streams. Young salmon migrating to the ocean follow the main current of the stream. When large quantities of water are diverted by dams and canals for irrigation, the young salmon pass out into the laterals and on to the fields by the millions. These canals should be screened, and bypasses carrying the fish back to the river should be provided. Upstream migration for adult salmon for spawning should be assured by the construction of fish ladders.



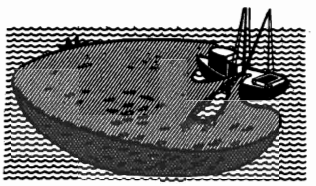


THE CONFLICT BETWEEN WATER-UTILIZATION PROJECTS AND THE FISHERIES CAN BE SOLVED BY ADVANCE PLANNING. In the past, the advantages of power for industries, inland navigation for commerce, irrigation and flood control for agriculture, and the engineering feasibility of dam construction have been the sole criteria in planning water-use projects. The economic, recreational and aesthetic values of our food and game fish resources have been overlooked. The protection of these is usually forgotten until after projects have already been authorized by Congress, engineering designs have been completed, or construction actually begun. Protective devices, therefore, have been unnecessarily expensive, and often ineffective.

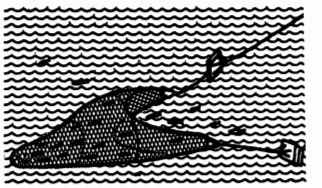
To eliminate this hazard to our aquatic wealth, national planning agencies, now staffed chiefly by engineers and economists, should include fish and wildlife administrators and biological technicians. A start has been made to secure informal cooperation to this purpose by the several Federal construction agencies. The principle of closer cooperation should be confirmed and implemented by Federal legislation.

ECONOMICS OF THE UNITED STATES FISHERIES

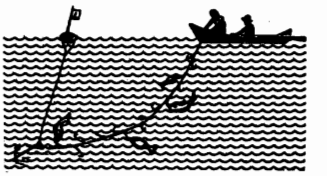
IN AN AVERAGE PRE-WAR YEAR—



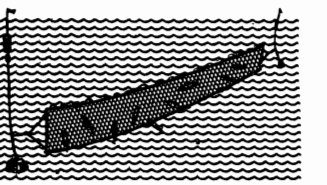
WITH PURSE SEINES,
13,000 FISHERMEN CAUGHT
2,100 MILLION POUNDS



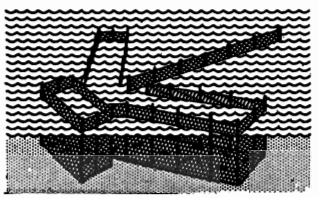
WITH OTTER TRAWLS,
11,000 FISHERMEN CAUGHT
700 MILLION POUNDS



WITH LINES
24,000 FISHERMEN CAUGHT
500 MILLION POUNDS



WITH GILL NETS,
19,000 FISHERMEN CAUGHT
200 MILLION POUNDS

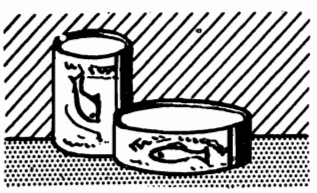


WITH POUND NETS
6,000 FISHERMEN CAUGHT
400 MILLION POUNDS

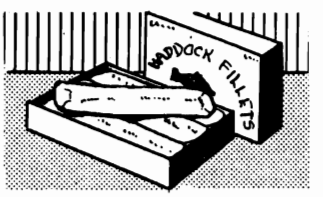
WITH ALL OTHER
TYPES OF GEAR,
19,000 FISHERMEN CAUGHT
500 MILLION POUNDS

TOTAL PRODUCTION,
4,400 MILLION POUNDS OF FISH

THESE FISH WERE PROCESSED THUS:

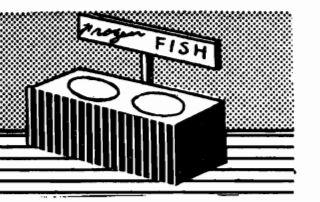


1,500 MILLION POUNDS
WERE CANNED

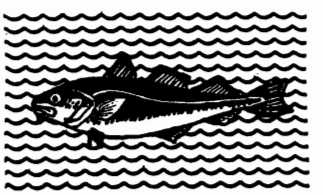


340 MILLION POUNDS
WERE FILLET-PACKAGED

150 MILLION POUNDS
WERE CURED



130 MILLION POUNDS
WERE FROZEN WHOLE



680 MILLION POUNDS
WERE SOLD FRESH

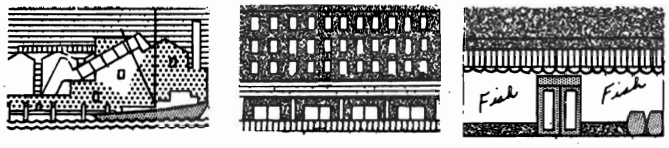
1,600 MILLION POUNDS WERE
MADE INTO FISH MEAL AND OIL
AND OTHER BY-PRODUCTS

STATISTICS ON FISHERMEN

31,900 FISHERMEN WORKED REGULARLY ON VESSELS OF OVER 5 TONS NET
33,400 FISHERMEN WORKED REGULARLY ON SMALLER BOATS OR FROM SHORE
59,500 FISHERMEN WORKED CASUALLY ON SMALLER BOATS OR FROM SHORE

ECONOMICS OF THE UNITED STATES FISHERIES

The 1943 Value of Fish and Fishery Products



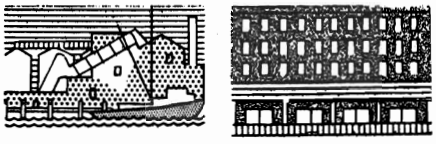
THE INITIAL VALUE OF THE FRESH FISH TO BE CANNED WAS
$60,800,000

CANNING ADDED
$96,200,000

WHOLESALING ADDED
$15,700,000

RETAILING ADDED
$57,500,000

For canned fish the United States public paid
$230,200,000

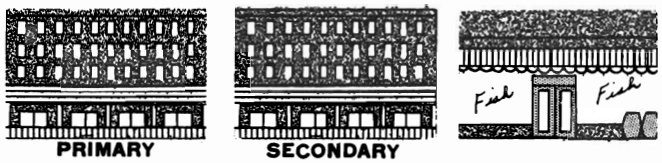


THE INITIAL VALUE OF THE FRESH FISH TO BE MADE INTO OIL, MEAL, AND BY-PRODUCTS WAS
$12,000,000

MANUFACTURING ADDED
$42,900,000

DISTRIBUTING ADDED
$5,500,000

For oil, meal, and by-products the United States public paid
$60,400,000



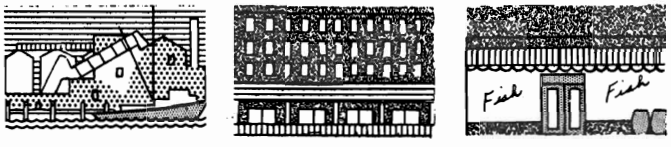
THE INITIAL VALUE OF THE FISH TO BE SOLD AS FRESH FISH WAS
$60,400,000

PRIMARY WHOLESALING ADDED
$22,100,000

SECONDARY WHOLESALING ADDED
$20,700,000

RETAILING ADDED
$34,400,000

For fresh fish the United States public paid
$137,600,000



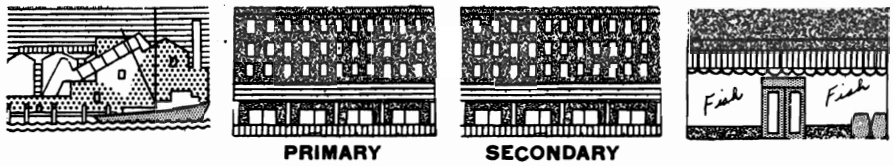
THE INITIAL VALUE OF FISH TO BE FILLETED AND PACKAGED WAS
$23,600,000

PROCESSING ADDED
$40,400,000

WHOLESALING ADDED
$16,000,000

RETAILING ADDED
$26,700,000

For packaged fillets the United States public paid
$106,700,000



THE INITIAL VALUE OF FISH TO BE FROZEN (OTHER THAN FILLETED) WAS
$6,700,000

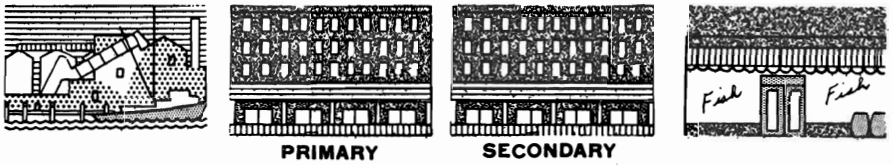
PROCESSING ADDED
$2,300,000

PRIMARY WHOLESALING ADDED
$3,200,000

SECONDARY WHOLESALING ADDED
$3,000,000

RETAILING ADDED
$5,100,000

For frozen fish (other than filleted) the United States public paid
$20,300,000



THE INITIAL VALUE OF FISH TO BE CURED, SMOKED, AND PICKLED WAS
$10,800,000

PROCESSING ADDED
$7,200,000

PRIMARY WHOLESALING ADDED
$6,500,000

SECONDARY WHOLESALING ADDED
$6,200,000

RETAILING ADDED
$10,200,000

For cured, smoked, and pickled fish the United States public paid
$40,900,000

ECONOMICS OF THE UNITED STATES FISHERIES

WHO GETS THE VESSEL OWNER'S AVERAGE DOLLAR

BOAT SUPPLIES, REPAIRS, DEPRECIATION,	16%
FISHERMEN'S SHARE AND LABOR,	53%
PROFIT,	9%
MISCELLANEOUS,	7%
FISHING GEAR,	5%
ICE,	2%
FUEL AND OIL,	5%
FOOD,	3%

WHO GETS THE WHOLESALER'S AVERAGE DOLLAR

VESSEL OWNER FOR FISH,	70%
PROFIT,	5%
WAGES AND SALARIES,	12%
RENT,	1%
MISCELLANEOUS,	7%
PACKAGING SUPPLIES, ETC.,	2%
DELIVERY EXPENSES,	3%

WHO GETS THE RETAILER'S AVERAGE DOLLAR

WHOLESALER FOR FISH,	65%
SALARIES AND WAGES,	18%
RENT,	4%
ICE AND STORAGE,	1%
WRAPPING SUPPLIES,	3%
DELIVERY EXPENSES,	1%
MISCELLANEOUS,	5%
PROFIT,	3%

THE ANNUAL PROFIT (INCLUDING MANAGERIAL SALARIES) OF

FISHERMEN AND BOAT OWNERS IS
$133,720,000

MANUFACTURERS AND PROCESSORS IS
$29,400,000

WHOLESALERS IS
$16,920,000

RETAILERS IS
$54,160,000

TOTAL $234,200,000

TO OBTAIN THIS SUM BY INVESTING MONEY AT 4 PERCENT PER ANNUM WOULD REQUIRE, FOR

FISHERMEN AND BOAT OWNERS, A CAPITAL OF
$3,343,000,000

MANUFACTURERS AND PROCESSORS, A CAPITAL OF
$735,000,000

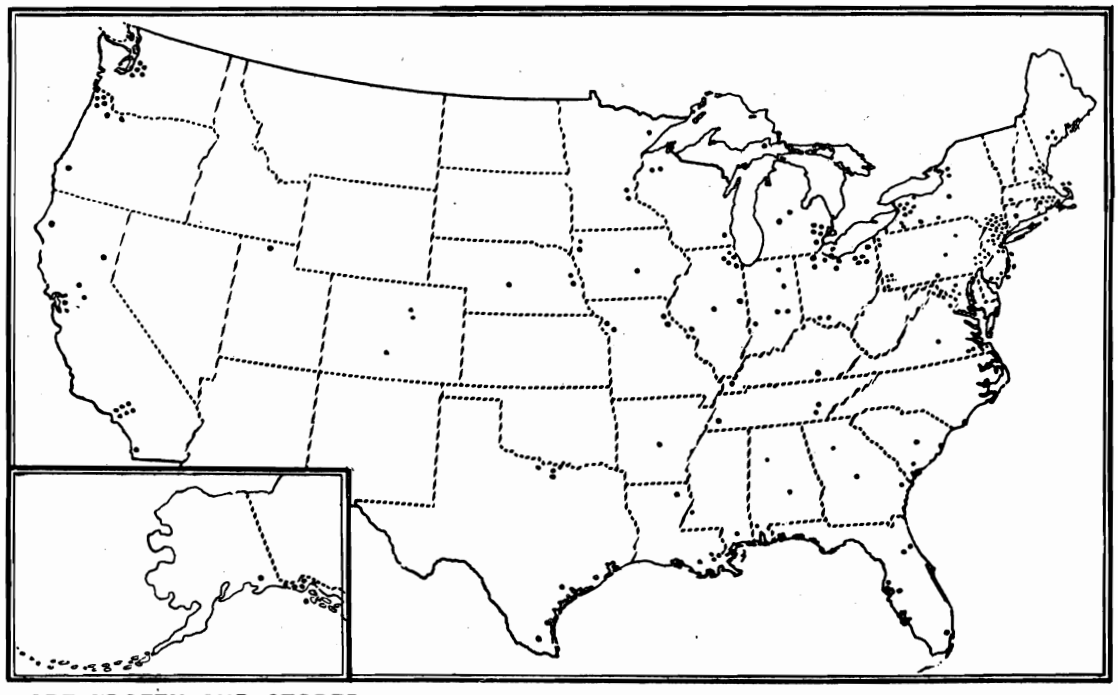
WHOLESALERS, A CAPITAL OF
$423,000,000

RETAILERS, A CAPITAL OF
$1,354,000,000

THIS IS THE TOTAL CAPITALIZED VALUE OF UNITED STATES FISHERY RESOURCES:

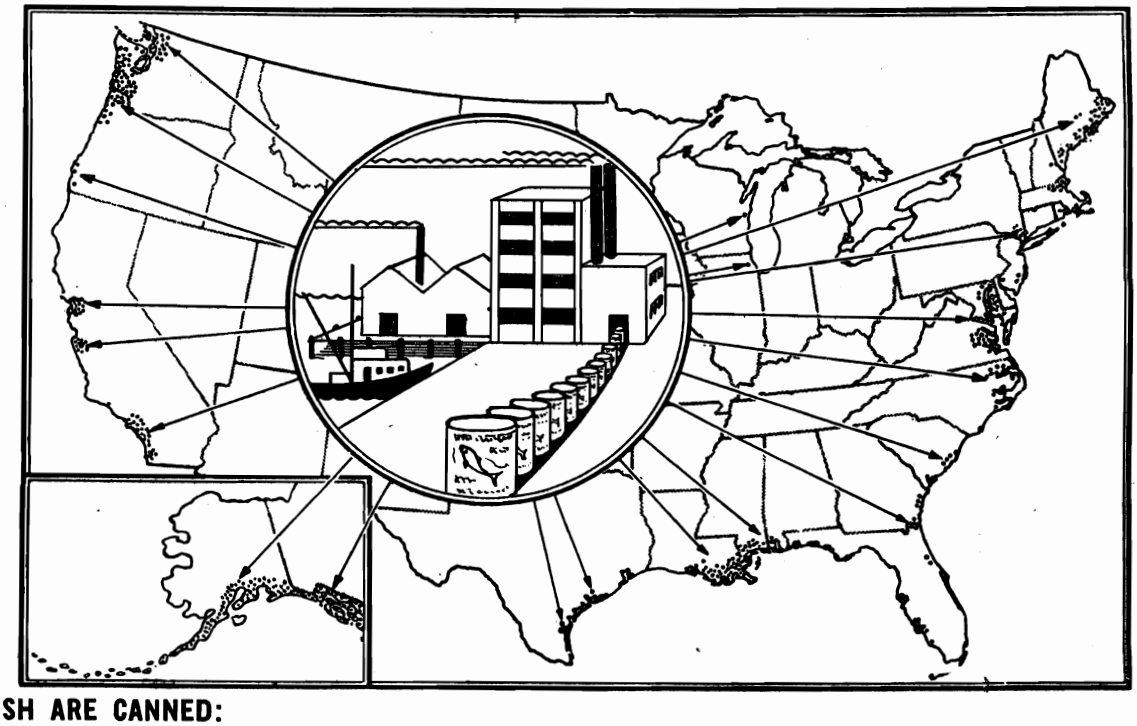
$5,855,000,000

ECONOMICS OF THE UNITED STATES FISHERIES



WHERE FISH ARE FROZEN AND STORED:

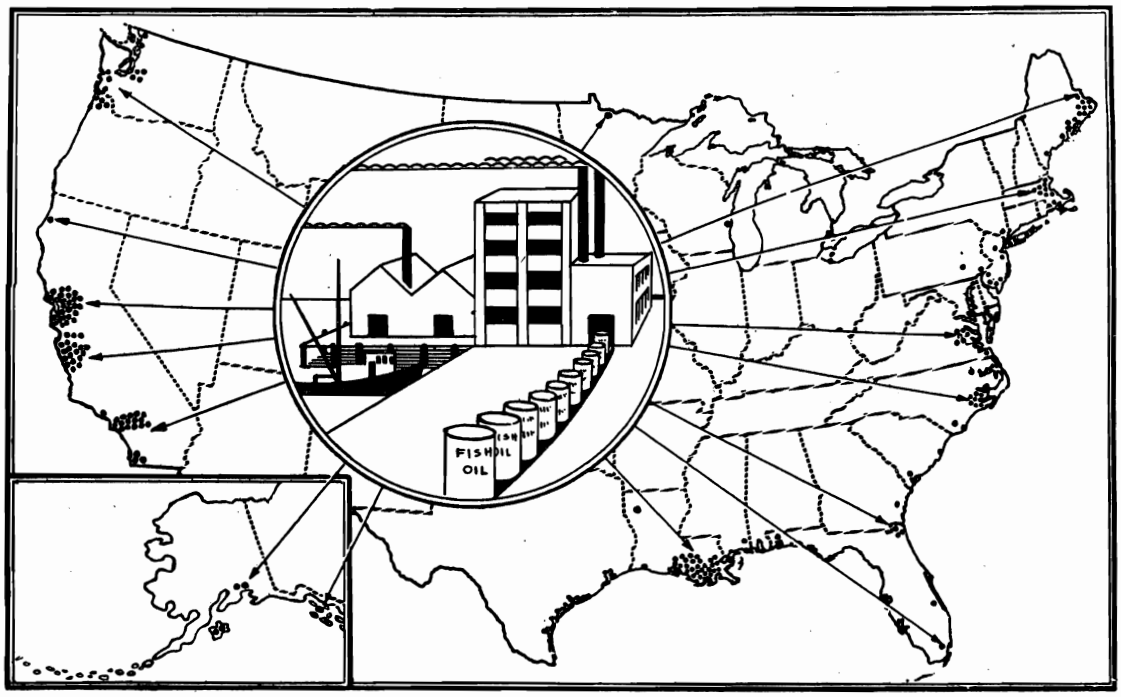
ABOUT 250 MILLION POUNDS OF FISHERY PRODUCTS ARE FROZEN AND STORED IN OVER 200 COLD-STORAGE PLANTS IN THE UNITED STATES AND ALASKA.



WHERE FISH ARE CANNED:

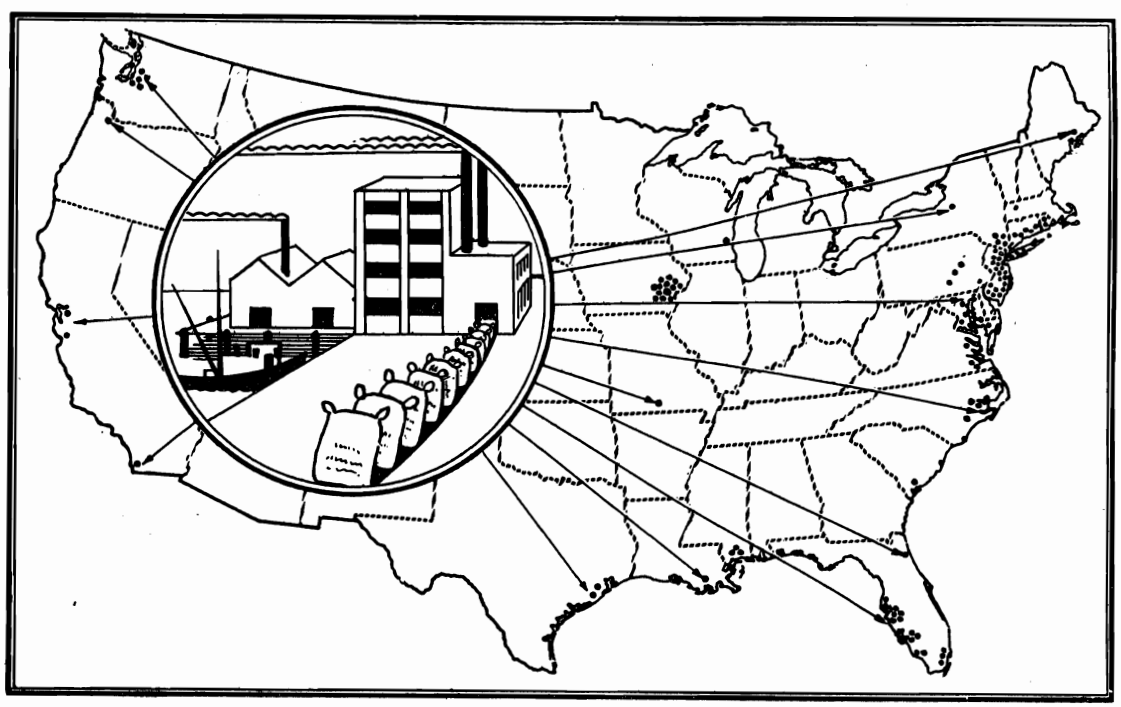
IN 1941, 400 CANNERIES PRODUCED OVER 900 MILLION POUNDS OF CANNED FISH AND SHELLFISH. THE PACIFIC COAST STATES AND ALASKA PRODUCED 82% OF THE PACK, THE ATLANTIC COAST AND LAKE STATES 16% AND THE GULF STATES 2%.

ECONOMICS OF THE UNITED STATES FISHERIES



WHERE FISH OILS, FISH MEAL AND SCRAP ARE MADE:

THE MOST VALUABLE FISHERY BY-PRODUCTS ARE FISH AND FISH LIVER OILS, USED FOR MEDICINAL PURPOSES, FOR FORTIFYING ANIMAL FEEDS, AND IN A VARIETY OF INDUSTRIAL PROCESSES. FISH MEAL AND SCRAP ARE IN GREAT DEMAND AS CONSTITUENTS OF ANIMAL FEEDS.



WHERE SHELL PRODUCTS ARE MADE:

SHELLS OF OYSTERS, MUSSELS, AND OTHER SHELLFISHES ARE USED IN POULTRY FEED, AND FOR THE MANUFACTURE OF LIME, STUCCO, BUTTONS AND NOVELTIES

CONCLUSIONS AND RECOMMENDATIONS

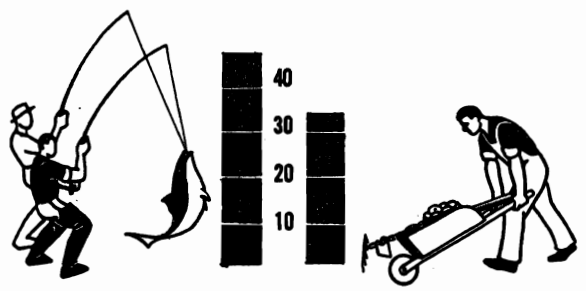
THESE ARE THE CONCLUSIONS TO BE DRAWN FROM THE FACTS GIVEN IN THIS BOOK:

1. The United States fishery resources (as defined in the preface) are a very important part of the national wealth. Their money and employment value, their unique food properties, and their universal recreational appeal make them worth whatever effort is necessary to maintain them at high productive level. Like any other form of wealth, this inheritance of ours can be abused, misspent, and ruined from want of care. It can be wasted as much by a miserly failure to use it fully. This book has given us examples of fishery resources that were once great and valuable, but which now are reduced to insignificance through bad management (Great Lakes ciscoes, and whitefish of Lake Huron; Atlantic salmon, among others); and it has given us other examples of fishery resources that are still hardly touched (Pacific coast anchovies, cod, pollock).

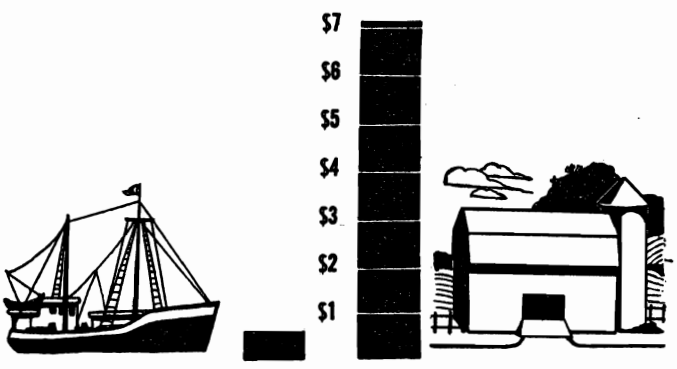
2. From a conservation viewpoint, the fisheries are perhaps the most poorly managed of all our national resources. Legislative regulations governing them, where they exist at all, are piecemeal, localized and often based on lay opinion, superstition or snap judgment, rarely on knowledge. Yet there is a science of fishery conservation, which is highly specialized and exact. That it has not been more fruitful in this country is no reflection on the science or the scientists but rather on the public's failure to back them up. True, fishery science is costly. It has to be costly if it is to be properly done; but it more than pays for itself in increased value and security of wealth which it strives to protect. Nevertheless, Federal and State conservation agencies have everywhere been required to do their fishery conservation work on a financial shoestring. Small wonder that they have obtained shoestring results. There is only one example of a fishery resource that has been successfully studied and conserved over most of its range; that is the Pacific halibut, administered by the International Fisheries Commission since 1930. This is the only fishery conservation agency that has come even close to being adequately supported in money and personnel.

3. However much the American public might treasure its fish for the food and recreational value they afford, it shows little respect for the water they must inhabit. It defiles its streams and lakes with sewage and industrial wastes; it draws from them for irrigation, and for domestic and manufacturing purposes; it uses them for transportation, and it blocks them off with high dams. These uses all involve modifications in the water courses of one sort or another, which are too often antagonistic to fish life. In addition, all sorts of other human activities serve to destroy fish habitats. Yet there is no reason why man's uses of water need be inimical to maintaining fishery resources.[1] That they have been so is largely the consequence of the lack of coordination among the many agencies—Federal, State, municipal, private—which are separately concerned with the various uses of water, and the lack of representation by conservation agencies in the designing and operation of water use plans.

4. The commercial fisheries, taken as a whole, are among the least progressive industries in the United States. They are generally slow to improve their products, to develop new ones, to exploit virgin resources, to correct wasteful fishing methods or to utilize the whole of their raw material. This backwardness is not the fault of the industry, but rather the consequence of its widespread, diffuse character. The fishing industries are composed of small, independent enterprises, widely scattered throughout the country and along extended coast lines; they are concerned with a great diversity of local fisheries and they are beset by a notoriously unstable supply. Most fishery companies must be conservative to survive, are too small to carry on technological research for developing new fields, except at best on a very limited scale. In most States, public agencies have not been equipped or staffed to help them. And the Federal Government gives them only a fraction of the aid it accords other food industries.



AVERAGE ANNUAL CONTRIBUTION OF EACH FISHERMAN AND FARMER TO TOTAL PRODUCTION



ANNUAL FEDERAL EXPENDITURES FOR EACH TON OF FOOD PRODUCED

[1] Read the section on water utilization.

CONCLUSIONS AND RECOMMENDATIONS

STATE AND FEDERAL FUNCTIONS: THERE IS DUAL RESPONSIBILITY IN MAINTAINING OUR FISHERY RESOURCES. The legislative regulation of the fisheries in continental United States is exercised by the States.[1]

From this viewpoint, the fish delivered into a State are considered that State's resource. Thus, for example, the State of Massachusetts has a primary interest in the haddock landed at Boston, New Bedford, and Gloucester, for the haddock fishery is one of that State's most important maritime industries. But haddock is sold all over the country in such great quantities as to weigh heavily in the Nation's food economy; hence the Federal interest in conserving this resource, in enlarging knowledge about it, in maintaining high standards of quality in the processed fish and in supporting haddock industries.

State fishery conservation laws are often nullified by the fact that the fish migrate independently of State boundaries. This fact frequently discourages States from even attempting to regulate for the protection of species that seasonally visit their shores. It also brings about such situations as we find in the Great Lakes, where the State making the most half-hearted, ineffectual regulations, sets the standard for all the others (*read the section on The Great Lakes*). Here then is indicated another Federal function in fishery matters: To promote unity among the several States in achieving the highest known standards of excellency in conservation regulations. This it does, not to be benevolent to the States, but to protect the national interest in preserving public wealth.

Many of our fishes, particularly the marine ones, are not only interstate but international in their distribution, and are exploited by other countries as well as by the United States. The groundfishes, tunas, swordfish, spearfishes, and Great Lakes fishes are a few examples in point. These can be effectively conserved only by international action, and this can be arranged only by the Federal Government.

TO SUMMARIZE THE FEDERAL FUNCTIONS: *In the territories*, the Federal Government exercises regulatory jurisdiction over the fishery resources and responsibility for their conservation and full utilization.[1] *In the States*, it acts, for the national interest, as a research, advisory, and coordinating agency wherever several States are concerned with a common conservation problem. It engages in fishery restoration and management activities, including propagation, independently in waters under Federal jurisdiction, and in collaboration with the States in other waters where national interest is involved. It develops and disseminates knowledge about whole fishery resources (i. e., as opposed to local segments of them). It collaborates in the conservation of species shared between the United States and other nations. It promotes the fullest and most widespread utilization of the commercial fish catch, and the achievement of the highest standard of quality of the fishery products.

The foregoing is a statement of an ideal. The Federal Government has never done justice to these functions because its fishery conservation agency (formerly Bureau of Fisheries, now Fish and Wildlife Service) has never been given broad enough direction by the Congress to permit it to carry out a unified program to suit the needs of the country as a whole. Without a fundamental plan, the Service has evolved by a process of tacking on projects one by one, which have generally been thrust upon it to meet particular crises, often as the result of pressure by special groups. The appropriations to the Service are based principally on the support of these projects. Thus the Federal Service is helpless to execute a dynamic program based on national needs; instead, it can only carry on with its agglomerate of activities inherited from the past, and wait for further crises which its timely services would otherwise have averted. Furthermore, it has been unable to inform the public of many of its findings, because it is limited in what it may spend on publication to a mere fraction of its requirements.

FROM THESE CONCLUSIONS, IT IS RECOMMENDED THAT—

1. The Federal expenditures, (a) for the benefit of United States fisheries be raised to a level comparable with those made for other food industries; (b) for the conservation and development of its fishery resources be made sufficient to accomplish their purpose.

2. The Congress authorize the Fish and Wildlife Service to organize a dynamic program that anticipates the needs of the Nation's fishery resources as a whole.

3. The Congress authorize the Fish and Wildlife Service to cooperate actively in its scientific research with all the countries that share with the United States common fishery resources.[1]

4. Federal legislation be enacted to provide for: (a) Federal control of water pollution; (b) coordination at the national level in planning, construction and operation of all projects which involve the use of water, with full representation by the United States Fish and Wildlife Service.

[1] The Federal Government has exclusive authority to regulate the fisheries in the territories. Only in Alaska does it exercise this function.

[1] Such authorization has been made for cooperation with the American Republics in the Act of Aug. 9, 1939 (53 Stat. 1290; 22 U. S. C. 501).

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