JOHN T. GHARRETT, Editor

PACIFIC MARINE FISHERIES COMMISSION
340 State Office Building
1400 S.W. Fifth Avenue
Portland 1, Oregon

PRINTED IN U.S.A.
ABBOTT, KERNS & BELL CO.
PORTLAND, ORE.

PACIFIC MARINE FISHERIES COMMISSION

Bulletin 3

THE SABLEFISH FISHERY OF CALIFORNIA

THE WASHINGTON AND OREGON SABLEFISH FISHERY

THE SABLEFISH FISHERY OF BRITISH COLUMBIA

PRELIMINARY REPORT ON THE ALASKA SABLEFISH FISHERY

A RACIAL STUDY OF PACIFIC COAST SABLEFISH, *ANOPLOPOMA FIMBRIA*, BASED ON MERISTIC COUNTS

RESULTS OF SABLEFISH TAGGING EXPERIMENTS IN WASHINGTON, OREGON, AND CALIFORNIA

AGE AND GROWTH OF THE OREGON SABLEFISH, *ANOPLOPOMA FIMBRIA*

Portland, Oregon

1954

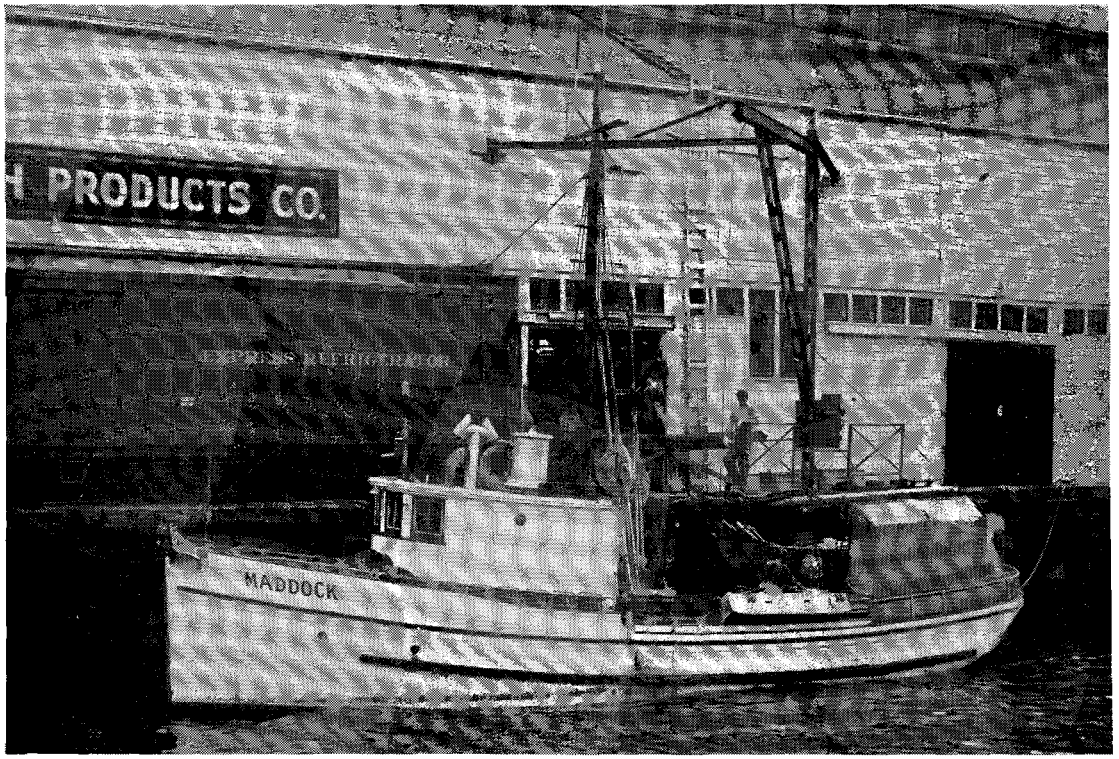

Photo by International Pacific Halibut Commission

Unloading the Catch of a Typical Sablefish Setline Vessel.

FOREWORD

The Pacific Marine Fisheries Commission was created in 1947 when the States of California, Oregon, and Washington entered into a compact with the consent of the 80th Congress of the United States for the purpose of coordinating the research and management of the marine fisheries of mutual concern to the three states.

The Commission has no regulatory powers but is essentially an investigating and research body with authority to submit specific recommendations for fisheries management to its member states. Its research staff consists of the respective fisheries research divisions of the three states acting in collaboration. In addition, the cooperation of other interested agencies extends the coastwise scope of the investigations.

The sablefish or blackcod fishery of the Pacific Coast operates from California to Alaska and is one of the oldest fisheries of the region. It was started on a limited basis during the last decade of the 19th century off Washington and British Columbia. From there, it expanded to California, Oregon, and Alaska, but prior to 1913, the fishery was of very moderate significance on the Pacific Coast. The development of the fishery was greatly stimulated by the demand for fisheries products created by World War I, when about 13 million pounds were landed on the Pacific Coast in 1917. In 1946, the annual coastal landings reached about 15 million pounds under the stimulus of World War II and a strong demand for the natural vitamin A yield of the sablefish livers and viscera. Since then, the readjustment of the market and competition from other sources of vitamin A have resulted in average annual landings of about 9 million pounds.

The fishery originated as a setline (longline) fishery, which gear still accounts for practically all of the sablefish landed in British Columbia and Alaska. In Washington, Oregon, and California the otter trawl fishery has become increasingly interested in the capture of sablefish and is, at present, contributing appreciably to the landings of this species in the three states.

While this is not a major fishery such as those for salmon and tuna, it is, nevertheless, of considerable importance to the fishing industry of the Pacific Coast. Its importance stems primarily from its supplementary nature. As a result of the present short legal halibut season, many of the halibut fishing vessels rely on the sablefish fishery to extend their seasons' earnings. Also, the contribution of the sablefish to the otter trawl landings supplements significantly the earnings of that fleet. Coastwise, the number of fishing craft operating on sablefish is relatively few; but in certain areas, such operations are of decided local importance.

An apparent decline in the sablefish populations on some fishing banks, as reflected in fishing operations and as indicated by preliminary research, prompted the Commission in 1950 to direct its staff to intensify sablefish investigations. Canada and Alaska also participated in the research on this species. The following reports describe the findings of the sablefish research conducted by the Commission's staff. Also included are reports by the Fisheries Research Board of Canada and the Alaska Department of Fisheries. The International Pacific Halibut Commission, charged with the management of the halibut fisheries of the northern Pacific Ocean, has in the course of its duties incidentally accumulated considerable data concerning the sablefish fishery off Oregon, Washington, British Columbia, and Alaska. These data have been made available to each of the respective research organizations.

The Pacific Marine Fisheries Commission has assembled this Bulletin in order that the information may serve as a basis in consideration of the management and future research of the sablefish fishery.

PACIFIC MARINE FISHERIES COMMISSION

EUGENE D. BENNETT
RICHARD S. CROKER
DON C. ELLIS
ROBERT L. JONES
ROBERT J. SCHOETTLER
VINCENT THOMAS
JOHN C. VEATCH

CONTENTS

THE SABLEFISH FISHERY OF CALIFORNIA

I. History and Research
J. B. PHILLIPS

II. Catch Analysis
J. B. PHILLIPS
and
SEIGI IMAMURA

Marine Fisheries Branch
California Department of Fish and Game

BULLETIN 3
PACIFIC MARINE FISHERIES COMMISSION
Portland, Oregon, 1954

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

THE SABLEFISH FISHERY OF CALIFORNIA

I. History and Research

INTRODUCTION

Sablefish were being utilized as food by the native Indians along the Pacific Coast long before the white man appeared on the scene. Although salmon was the most desired fish, the coastal Indians also utilized halibut, sablefish, rockfish, smelt, and other fishes and marine animals, as needed.

Commercial exploitation on the Pacific Coast by the white man began about the middle of the 19th century. In his commercial operations, the white man followed the Indian and exploited the most desired and most available fish first—namely, salmon. The early salmon operations were confined to the Columbia and Sacramento Rivers. It was not long before the white man turned to the sea for the harvesting of other species of fish that were there in abundance. Some of the species of fish that are now in great demand were formerly discarded as scrap fish in the earlier days of our commercial fisheries. Sablefish, ling cod, and rock fish are good examples.

Until 1905, Washington was the only Pacific Coast state that recorded any commercial landings of sablefish. These fish represented fish that were bought at a low price, as an accommodation to halibut fishermen who caught them incidental to their main operations. Because of the price, dealers could afford to experiment with means of handling this rich, white-meated product. As a result, there is now a fairly stable demand for several million pounds of this fish a year, primarily in the frozen and smoked state.

Whereas in earlier years the problem was one of attempting to develop a favorable market for a good fish which was being discarded at sea, the artificial over-development that was inspired by World War II demands has created a reverse problem. This is the problem of determining proper regulation to maintain at least the current yield in the future. Complications arise from the fact that the fishery is being exploited by both longline and otter trawl fishermen.

DISTRIBUTION OF THE SPECIES

Sablefish,[1] *Anoplopoma fimbria*, are found along the Pacific Coast from Alaska to Southern California, but with a greater concentration in the northern part of the range. In general, adult fish are found in deep water, sometimes down to 400 fathoms (2,400 feet) in the winter and early spring months when spawning is in progress. Although some small, immature fish may be found scattered into deeper water, usually the smaller fish are found in shallower water than the adults. Very young sablefish may be found near the surface at times. During the summer there appears to be a shifting of the larger fish to somewhat shallower water. This situation is partially reflected in the longline operations in California, wherein the best fishing for large fish is encountered in 200 to 250 fathoms during the winter months, and 90 to 165 fathoms during the summer months.

Sablefish are found in greater concentrations over a blue-clay or mud bottom. They are less abundant over sand, rock, or other types of bottom. Sablefish are fairly well dispersed along the coast, but with concentrations here and there. In California the areas of concentration appear to be within or near the numerous submarine canyons that occur along the coast, or in large depressions.

In California, the abundance of sablefish, as reflected in the annual landings, decreases from north to south. For the 10-year period, 1943–1952, the Northern California ports of Eureka and Fort Bragg accounted for 58 percent of the state total; the Central California ports of San Francisco, Santa Cruz, and Monterey accounted for 39 percent; the Southern California ports of Santa Barbara, San Pedro, and Newport Beach accounted for 3 percent of the state total.

[1]Black cod is an alternate name. Candlefish and coalfish are names occasionally used in California.

MARKETS

Sablefish are the basis of a minor fishery in California, but the importance of this fishery has been increasing gradually, primarily because of a wider acceptance of the smoked product. For all of California, during the 10-year period, 1943–1952, the average annual landings amounted to 2,700,000 pounds, while in the previous 10-year period, 1933–1942, the average annual landings amounted to 1,200,000 pounds, compared to an average annual catch of 835,000 pounds for the 10 year period, 1923–1932.

Only a limited amount of sablefish is accepted by the fresh fish trade because of the oily nature of the flesh. Smaller sablefish are usually filleted and sold fresh, while the larger sizes are dressed and frozen.

The salting of fish was a well established practice long before sablefish became of commercial importance. In the earlier years of the fishery, relatively more of the catch was salted. There has been a lessening of activity along this line since 1935. The 1942–1945 World War II period saw a temporary increase in salting for export. However, the salt fish trade has not kept pace with the increased activity in freezing and kippering of this product. One factor which contributed to the decrease in the use of salt fish was that the European immigrants were accustomed to such products, but their children have developed other food habits. The popularity of salt sablefish in the past was closely related to that of salmon. When salt salmon was in short supply, salt sablefish would sometimes be accepted as a substitute because of its fatness and low price.

Although refrigeration of fish and other foods dates back to the early days when natural ice was used, the freezing of fish by artificial means did not become important until 1900. The large frozen pack of sablefish is used to substitute for shortages in competing lines in eastern markets, and it is used in the preparation of the smoked or barbecued product. Fish curers have found that the quality of barbecued sablefish is improved when the fish are first frozen.

Sun-drying and smoking of fish was practiced by Indians along the Pacific Coast before the white man came. Smoked fishery products are a natural development of primitive drying, when fish were hung in huts and a smoky fire started to hasten the drying. Commercial smoking of fish includes the salting of fish for varying periods of time. The process of hard or dry salting, prevalent in early days, has given way to a lighter salting, such as mild curing. The smoking or kippering of sablefish follows closely the procedure used on salmon. The popularity of sablefish in the smoked form started about 1910 when leading hotels and restaurants in the Puget Sound region commenced featuring "Barbecued Alaska Black Cod".

Smoking of sablefish in California started about 1915. Virtually the entire state production was centered at San Francisco until 1945. At this time the Los Angeles area broke into prominence, and since 1948 nearly as much of the smoked product has been produced in that area as at San Francisco. A lesser amount is produced in the Eureka area. The amount of sablefish smoked annually in California has increased from about 200,000 pounds in 1925 to about 500,000 pounds in 1952. Additional sablefish is shipped frozen to eastern states where it is smoked.

FISHING GEAR

Longlines or set lines (multiple-hook lines) and otter trawls (drag nets) are the two main types of fishing gear that take nearly all the sablefish landed in California.

Drag Nets

Trawling, or drag net fishing, started along the Pacific Coast at San Francisco in 1876, following the successful introduction of "paranzella" gear. This type of drag net was towed by two boats, one attached to each wing. In 1918, the otter trawl was introduced into California. This net is operated from a single boat. As familiarity with this gear increased and improvements were made, the otter trawl gradually replaced the paranzella. By 1938, the otter trawl had superseded the paranzella. At present, there are several modifications of the otter trawl in use, including the "balloon net", introduced into California from Oregon in November 1943.

Until 1929, nearly all dragging operations in California had been conducted south of Pt. Arena. In 1929, the San Francisco fleet of about 20 boats commenced working the relatively unexploited

grounds northward of Pt. Arena to Eureka. These operations were seasonal, the fleet returning to San Francisco during the winter months. In 1938, the center of production of the drag net fishery shifted from San Francisco to Eureka, where a resident fleet of draggers rapidly increased in numbers, totaling 60 boats in 1946. Many of these operators are from Oregon and Washington.

Depths Fished

Starting in 1876, dragging was conducted in the shallow waters of San Francisco Bay. As these waters became over-fished, the draggers moved outside into the ocean. In 1906, the State Legislature prohibited drag net fishing in San Francisco Bay. In the open ocean waters, fishing was confined to depths less than 50 fathoms for a number of years. Gradually the extent of the grounds fished increased and by 1934, depths down to 100 fathoms were being fished. In 1948, two draggers working out of Eureka tried fishing in a depth of 200 fathoms and made good catches of dover sole and sablefish. A scarcity of dover sole in depths that were normally fished led to this exploration in deeper water. Other draggers followed suit in fishing the deeper waters and by 1952, some of the Eureka boats were trawling in water as deep as 330 fathoms. However, a number of boats are still fishing the shallower waters from about 30 to 100 fathoms.

Mesh Sizes

Prior to 1934, the mesh size in the bags, or cod-ends, of the drag nets used in California did not measure more than 3½ inches, stretched measure. Starting about July 1934, San Francisco drag boat operators voluntarily replaced their 2½- to 3½-inch mesh bags with 5-inch mesh bags (middle of knot to middle of knot) as recommended by the State. However, this voluntary arrangement lasted only a few years, and the operators reverted to the smaller mesh. From 1943 until 1949, a few of the otter trawls in use in the Eureka region had mesh of up to 5 inches, in the bag, but most drag nets were still equipped with finer webbing. On January 1, 1948, all portions of drag nets used in California were required by law to have at least 5-inch stretched mesh, clear opening between the knots. This corresponds to a commercial measure of about 5½ inches, from middle of knot to middle of knot, for medium weight twine. It soon developed that at that time webbing of that mesh was hard to obtain, and on July 1, 1949, the requirements were changed to permit the use of webbing of 4½-inch mesh, or larger, between the knots. This requirement is still in effect.

Closed Areas

California's laws dealing with drag net fishing areas are complex and have been frequently changed. They have been well summarized by W. L. Scofield in the California Division of Fish and Game Fish Bulletin No. 72. The only such code sections which could have had any great over-all effect on the sablefish fishery are those which have prohibited dragging within three miles of the mainland shore from the Oregon line south to Pigeon Point (40 miles south of San Francisco). This law has been in effect since 1933.

In 1953 the area closed to trawling within three miles of shore was extended south to the Ventura County line. South of the Ventura County line the operation or possession of a trawl has been prohibited since 1915.

Longlines

The history of the longline gear in the sablefish fishery in California revolves around an eventual compromise between a light type of gear, coiled in flat baskets, that originated in Central California and a heavy type of skate gear that was used in the halibut fishery in the Pacific Northwest and introduced into Northern California. Halibut skate gear has never been of much importance in the sablefish fishery off Central California because very few Pacific halibut are found south of Point Arena. In the Central California region, basket longline gear composed of finer lines and closer-spaced, smaller hooks was in use by Italian and Portuguese fishermen at San Francisco and Monterey before 1880. Until about 1924, when the commercial sablefish fishery developed in Northern California, practically all of the state landings of this species were made in the Central California region by basket longline gear and by drag nets. The use of basket gear spread northward to Fort Bragg and later to Eureka. The Southern California region has been of little importance in this fishery because of a natural scarcity of sablefish in the southern portion of its range.

The Northern and Central California longline vessels that at times fish for sablefish range from 28 to 64 feet in length. A typical boat is about 45 feet long. Two to three men is the usual crew. One to five men are the extremes noted by us. The number of baskets of gear fished by a two-man crew in Central California is generally 10 to 15 a day. In Northern California, 15 to 20 tubs or baskets are fished in a day by a two-man crew. The number of units of gear fished on different days by the same boat crew may vary depending on weather, availability of bait, amount of time left for fishing after reaching the fishing grounds, and the number of units that have been prepared for fishing. The lines are allowed to "soak" for one and one-half to three hours, and hauled the same day, if possible.

Longlines in Northern California

Between 1920 and 1930, several Seattle halibut vessels cruised as far south as the Eureka and Fort Bragg areas, fishing for halibut and, incidentally, for sablefish. As a result, a number of Northern California fishermen commenced using halibut skate gear for halibut and sablefish. Fishing for sablefish on a commercial scale started about 1924 in the Eureka area and about 1926 in the Fort Bragg area. About 1928, Eureka fishermen started a trend toward lighter lines and more closely-spaced hooks, specifically for fishing sablefish. Also, instead of coiling the lines on a piece of canvas, with hooks on the inside of the coil, the lines were coiled in tubs with hooks placed around the upper rim of the tubs.

By 1935 the tub gear used in fishing sablefish had become well established. A representative tub of gear in use since that time has a mainline of 3/16-inch diameter manila or cotton rope. The gangings are 36- to 48-thread cotton twine, about one and one-half feet long and spaced three to four feet apart bearing 7/0 or 8/0 hooks. There are 150 to 220 hooks per tub. The tubs are about 20 inches in diameter and 10 inches high, with a cork strip tacked to the outside of the top rim for the lodgment of hooks. The up-and-down line from flag to anchor may be as heavy as ⅜-inch diameter manila rope.

About 1944, basket longline gear was introduced at Eureka by Fort Bragg fishermen, who, in turn, had learned about this gear from Central California fishermen. Although some of the Fort Bragg fishermen used main lines as fine as 120-thread cotton, and 24- to 36-thread gangings when fishing for rockfish, heavier gear was preferred when the fishermen were specifically after large rockfish or sablefish. This heavier basket gear is quite similar to the tub gear described in the preceding paragraph. Fort Bragg fishermen prefer 6/0 to 7/0 hooks for sablefish.

The circular wicker baskets that give the gear its name are about two feet in diameter, about six inches deep, and are shaped like a large saucer. A strip of matting is bound to the rim of the basket for lodgment of hooks when the line is coiled. In baiting, the hooks are disengaged and the baited hooks allowed to dangle over the edge of the basket. The small base of the basket permits ready turning so that the kinks in the line can be straightened, or the hooks baited, in a limited space. Less stacking space is required for baskets than for tubs. The main advantage of tub gear is that the line can be coiled more easily in the tub and the hooks stuck in sequence in the outside rim while the line is being brought aboard on the fishing grounds. With baskets, most fishermen coil the line and hooks together irregularly and put them in order after fishing has been completed. In 1950–1951, two boat crews at Fort Bragg made a practice of coiling line and sticking hooks in order while recovering their basket gear, but this was unusual. During World War II, because of the intensive fishery for sablefish, some Fort Bragg fishermen paid one dollar a basket to retired fishermen and women ashore to have their basket gear coiled in order and baited after a day's fishing.

Basket gear has not replaced the tub gear at Eureka. During the past few years, perhaps one-half of the sablefish fishermen are using baskets and the rest tubs. Occasionally a fisherman will use both types. In the Fort Bragg area, basket gear entirely replaced tub gear in the sablefish fishery during the period 1935–1940. However, tub gear is still used by Fort Bragg fishermen for soupfin shark and ling cod. The tub gear in the Fort Bragg areas evolved by modification of the halibut skate gear, as occurred at Eureka.

In 1928–1929, power gurdies for pulling lines were first used in Northern California. The idea was obtained from Seattle boats that fished in this region. The first gurdies were ordered from

Seattle supply houses, but later these were constructed locally. Previously, the lines were pulled by hand, which limited the amount of gear that could be set.

Longlines in Central California

The earliest commercial landings of sablefish in California were made at San Francisco, Monterey, and Santa Cruz. As early as 1880, there were 6 to 8 small jig boats at San Francisco, each with 30 to 35 baskets of longline gear that were fished for rockfish, sablefish being caught incidentally. Similarly, there were several small boats at Monterey and Santa Cruz that were fished with basket gear. There were only a few baskets of longline gear among Southern California fishermen at this time. The San Francisco region has not kept pace with the development of the fishery in the Monterey region because of the inaccessibility of deep water zones, near which concentrations of larger fish are usually found.

Basket gear is used universally in the Central California region. Because of the diversity of species that are fished, the weight of lines, size of hooks, and spacing between hooks varies. Mainlines vary from 90- to 234-thread cotton, and hook sizes from 3/0 to 11/0 depending on the species sought. Gear that is fished specifically for sablefish usually has a mainline of 216- to 234-thread, hard-laid cotton. The mainline is heavy because of the rocky nature of the coast and bottom along which a great deal of fishing is done. The gangings, usually 2 to 3 feet long, are of 36- or 42-thread, hard-laid cotton and spaced 2 to 3½ feet apart. There are 200 to 300 hooks to a basket. Hooks are usually 6/0, although 7/0 may be used occasionally.

In Monterey Bay, small sablefish are often taken on the lighter basket gear that has been set for other species of fish. This is particularly true in the summer months when there is a greater concentration of sablefish in somewhat shallower water.

Power gurdies for pulling longlines did not come into use in Central California until about 1938. Previously, the lines were pulled by hand.

Longlines in Southern California

There is limited fishing for sablefish in the Southern California region because of a natural scarcity of this species. Catches of sablefish landed at Santa Barbara and San Pedro are usually incidental to fishing operations conducted on rockfish. Most of these fishermen use drop lines, instead of longlines.

The few dory fishermen that fish off Newport Beach, just south of San Pedro, use longlines in their rockfish and sablefish operations. Because the species fished for are rather small, including sablefish, the fishing gear used by these fishermen is light. Mainlines are 60- to 72-thread cotton, with 21-thread gangings about 9 inches long and spaced 2 feet apart. There are 400 to 500, size 4/0 or 5/0, hooks to a line. The lines, pulled by hand, are coiled in tubs that are about 14 inches in diameter and 14 inches high. The baited hooks are coiled inside the tub along with the mainline. The lines are set overnight and before they are pulled on the following day, another string of baited line is set. The dories, usually operated by one man, are 14 to 16 feet long with 10-horsepower, gasoline outboard motors. Fishing for sablefish is conducted in 100 to 300 fathoms.

Closed Areas

Longlining or setlining (trawl lines) have been permitted in the open ocean waters along the California coast since the earliest days of the commercial fisheries. For the past 25 years, the waters of Humboldt Bay, San Francisco Bay, San Diego Bay, and those surrounding Santa Catalina Island have been closed to longlines. Also, a limited portion in the northern and southern ends of Monterey Bay and in the northern end of Santa Monica Bay have been closed. But, these inshore closures have not restricted the longline fishery for sablefish. There have been no legal restrictions on the size or weight of fish landed. Dealers have imposed certain limits from time to time.

FISHING AREAS

Drag Nets

A summary of the areas and depths fished by the drag net fleet has already been presented under the section, Fishing Gear. Drag boat operators are not primarily concerned with the capture

of sablefish but may encounter them in numbers while fishing for other species. On occasions, drags may be made in an area where a concentration of large sablefish is expected, in order to fill out a load.

Longlines

The areas fished by longline boats along the California coast have not changed, to any great extent, during the past 20 years. Most of the areas that are fished currently were already discovered by 1930. Although depths down to 350 fathoms were tried in earlier years, it was found that a greater concentration of large fish was to be found at a depth of 200 to 250 fathoms in the winter months and about 90 to 165 fathoms in the summer months.

Longline boats from the port of Eureka have fished northward to the Oregon border and southward to Shelter Cove, at times. The most intensively fished area is off the Eel River to about Redding Rock. This includes the famous "Rockpile" of Eureka. Longlining for sablefish in this area usually starts in April and may extend into November.

The areas fished by longline boats working out of Fort Bragg extend from Shelter Cove, about 40 miles to the northward, to Point Arena, 25 miles to the southward. Most of the fishing is conducted in the zone from southwest to northwest of Fort Bragg. The well known "Ten-mile Hole" is in the latter direction. The greatest fishing effort comes during the winter and spring months, when there is the least activity in the Eureka area.

Longlining for sablefish out of the port of San Francisco has always been uncertain because of the distance that has to be traveled before deep water is reached. Practically all of the landings at San Francisco and Bodega Bay are now by drag boats.

The areas fished by longliners working out of Monterey and Santa Cruz extend from off Pigeon Point, about 20 miles northward of Monterey Bay, to Point Lobos, a few miles southward of Monterey Bay. One of the best producing areas is about south-southwest of Santa Cruz, at the edge of the Monterey submarine canyon. The landings in the Monterey area are spread throughout the year.

PRICES

As early as 1899 and until about 1920, fishermen received from one to three cents a pound for sablefish. Subsequently, the price paid fishermen has increased gradually. Since 1946, fishermen have received from ten to eighteen cents a pound for dressed fish. The usual price during this latter period, for large fish, has been twelve cents a pound. The price offered fishermen is dependent, to some extent, upon the amount of fish that is held in cold storage.

Since about 1929, Northern California dealers have considered a weight of seven pounds round, or five pounds dressed, head-off, as the lower limit for large sablefish, for which a premium price is paid. The demand for large fish originates with fish curers. They desire the large sizes so that after the fins, belly strip, etc., have been trimmed, there will be several fleshy cuts available. Starting in 1933, some fish from four to seven pounds, round, have been accepted at a reduced price, usually about one-half that paid for large fish. During World War II, minimum weights were abandoned and fishermen were encouraged to bring in small as well as large fish because of the demand for fillets for salt fish export. Following this period, the weight classifications were resumed.

Because large sablefish are not abundant in Central California waters, dealers in this region will accept smaller-sized fish than will the dealers in Northern California. Fish of about five pounds round, and over are dressed out, while fish from about three to five pounds round, are filleted for a limited demand for the fresh product.

In general, wholesale fish dealers do not set daily limits on the amount of large fish landed by longliners. Sometimes fishing is curtailed by a reduced price offering due to excessive cold-storage holdings. Otter trawlers are sometimes limited in the amount of large fish they may land, and when the market is weak a dealer may discourage any landings of sablefish from this source.

At the port of Eureka, fishermen formed the habit of dressing and beheading sablefish in the early years of the fishery. Otter trawl fishermen almost always dress the sablefish they deliver at the markets, and most longline fishermen dress their catch, even on one-day trips. It has been estimated by various Eureka dealers that 85 to 90 percent of the total sablefish landings at that port are in a dressed form. The exception to this was the period 1943–1946, when Federal Office of Price Administration regulations made it profitable for both longliners and otter trawlers to land

their fish in the round at all ports. Small fish were accepted in considerable numbers at this time. At the port of Fort Bragg, it is estimated that about 90 percent of the sablefish landings by both longline and otter trawl gear are in a round condition. Most trips are for one day only. When an occasional two or three-day trip is made, the first day's catch may be dressed out. At the Central California ports of San Francisco, Santa Cruz, and Monterey the catches of sablefish are invariably landed in a round condition. Most of the trips are for one day only.

In dressing and beheading sablefish, approximately 32 percent of the round weight is lost. The loss is slightly greater with large fish than with small fish. Also, the loss varies somewhat depending upon the amount of food in the stomach and the state of gonad development.

FISH LIVERS

At one time, the sale of fish livers from certain species of marine fish was a lucrative by-product of these fisheries. Cod-liver oil has been used as a prophylactic preparation for more than a hundred years, but it was not until the more recent discovery of vitamins that the therapeutic value of the oil was associated with the high concentration of vitamin A in these livers. The livers of certain other fishes have been found to have high concentrations of vitamin A, and also of vitamin D.

During the period, 1930–1936, the demand for fish livers for vitamin oil manufacture was such that livers from halibut, sablefish, ling cod, salmon, tuna, swordfish, mackerel, rockfish, and a number of other fishes were saved. (It was soon found that the oil from salmon livers was difficult to extract and of rather low potency.)

The growth of the fish liver market and the eventual slump following the introduction of the synthetic vitamin A product is reflected in the prices paid to fishermen over the period of years. During the period 1931–1936, halibut, sablefish, and ling cod livers were classed together and prices per pound of the liver from these species increased from 12 cents in 1931 to 45 cents in 1936. In 1937, separate prices were offered for each species. During the period 1937–1940, producers were paid 35 cents for sablefish livers, 40 cents for ling cod livers, and 50 cents a pound for halibut livers. In 1941, pharmaceutical houses offered producers 25 cents, 50 cents, and 30 cents a pound, respectively, for the livers of the above species. This bid was rejected by a large group of fishermen in the Pacific Northwest, who in turn formed their own association for processing fish livers. However, other fishermen, including these in California, continued to deal through their regular establishments.

In 1942–1943, the market for liver oils became confused because of OPA regulations. Also, the War Production Board issued a limitation, Order L-40, which sharply restricted the use of vitamin A in animal feeds, pills, capsules, etc. In 1944, the OPA abandoned all regulations of the fish liver market. However, one feature of OPA regulations was retained by the industry, and this was the basing of price paid fishermen on the actual oil content and vitamin potency of the livers rather than on a straight price per pound. During the period 1943–1946, the prices paid for livers, on an actual potency basis, averaged about $1.35 for sablefish and halibut, and nearly $2.00 a pound for ling cod livers. Individual lots varied considerably in potency due to size of fish, season of capture and other factors.

In 1947, the market for domestic fish livers suffered deterioration because of two major announcements. That summer, the Supreme Commander for Allied Powers in Tokyo announced that there was available, and permission would be granted, to export a large tonnage of vitamin A oils from Japan. Later, in the fall of that year, scientists of Distillation Products announced that vitamin A has been successfully synthesized on a basis which promised to be commercial. In 1948, there was a virtual collapse of the domestic fish liver market. This was due to the predicted importations from Japan, followed shortly by the production and sale of synthetic vitamin A at less than the prices for the natural product. Although the livers from certain fishes are still being saved, this is no longer a lucrative item. During the period 1948–1952, fish livers from acceptable species of fish (including sablefish) were bringing producers 15 cents to 35 cents a pound.

RESEARCH

The following summaries of studies on the sablefish are presented as material that may be of value in considering management of the fishery. The studies are based on fish taken in the Northern and Central California regions.

Fork Length – Total Length Conversion

Fork length is often the most accurate length that can be readily and rapidly taken by anyone who is measuring a large number of fish for scientific purposes. This is the straight line distance from the most anterior portion of the head, with jaws closed, to the ends of the shortest middle rays of the caudal (tail) fin, when the fish is held flat against a measuring board. Fork length is taken in preference to total length because the ends of the tail fin may sometimes be frayed or broken. Total length is the longest measurement of the fish from the anterior to the posterior extremities of the body. The upper and lower lobes of the tail are bent toward the longitudinal axis of the body so as to yield the greatest length.

Fork length and total length measurements were obtained for 1,340 sablefish landed at Eureka, Fort Bragg and Monterey. These fish ranged in total length from nine to 41 inches. The data for the two sexes were combined because there was no consistent differences when the two sexes were plotted separately. The straight line shown in Figure 1 is fitted to the points that represent the average total length for each one-half centimeter of fork length. A dot represents an average that includes five to 30 fish, where as "x" represents an average based on less than five fish. The line that best fits all the points is one wherein the fork length is 93.8% of the total length. That is, total length is obtained by dividing fork length by .938 and fork length is obtained by multiplying total length by .938.

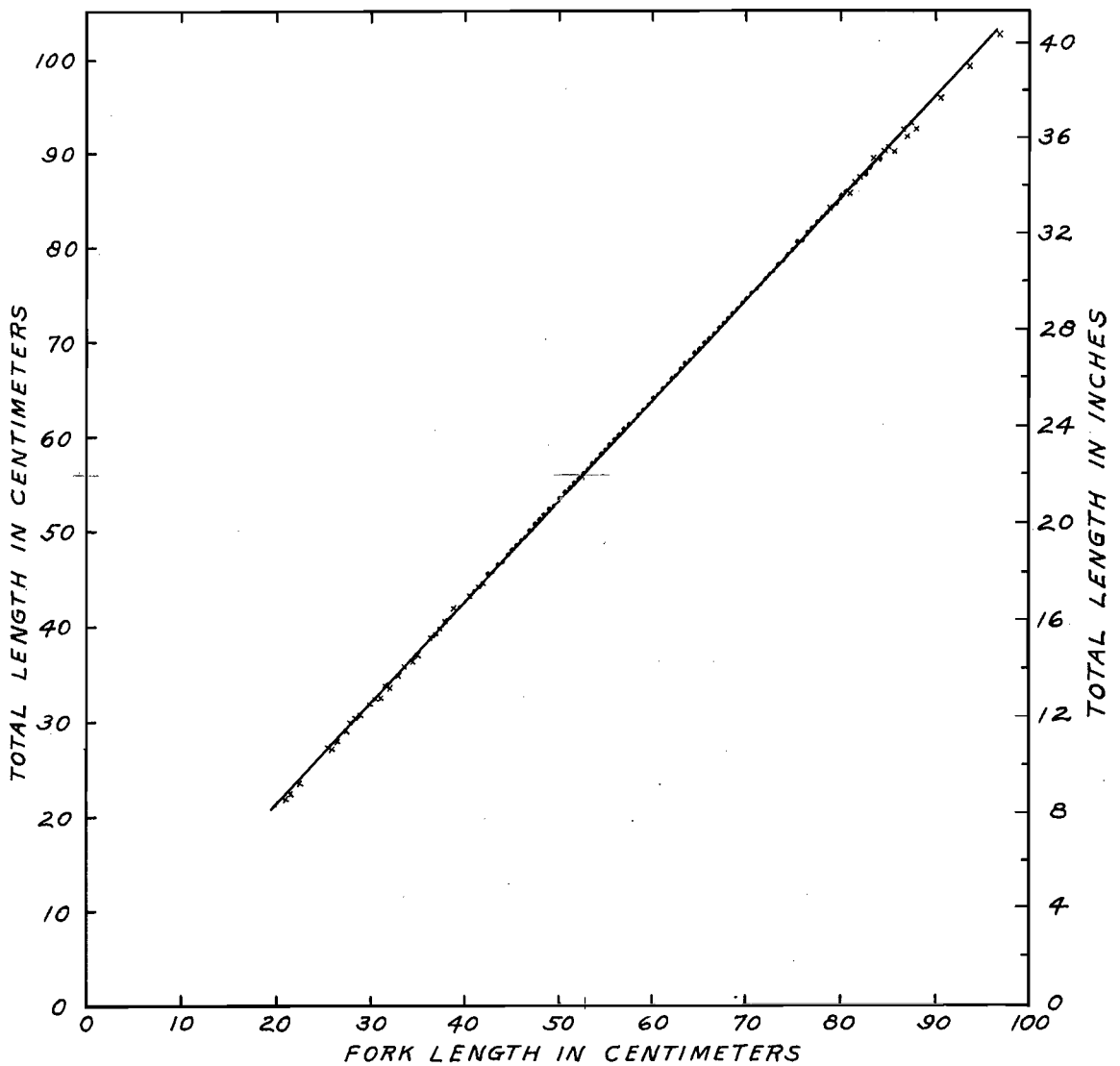

FIGURE 1. Fork length—total length conversion for sablefish taken in California.

Conversion of Head-off to corresponding Head-on length

In the Eureka region large sablefish are usually landed in a dressed, head-off condition. In order to determine how long such fish were before the head was cut off, the following data were gathered: 1,400 round fish were measured from snout to fork of tail (A–D in the sketch in Fig. 2) and from the origin of the first dorsal fin to fork of tail. The origin of the first dorsal fin was taken perpendicular to the snout to fork of tail measurement (C–D in Fig. 2, not B–D). In Figure 2, the average measurement from the origin of the first dorsal fin to the fork of the tail is plotted for each one-half centimeter of measurement from snout to fork of tail. A dot represents an average that includes five to 35 fish while an "x" represents less than five fish.

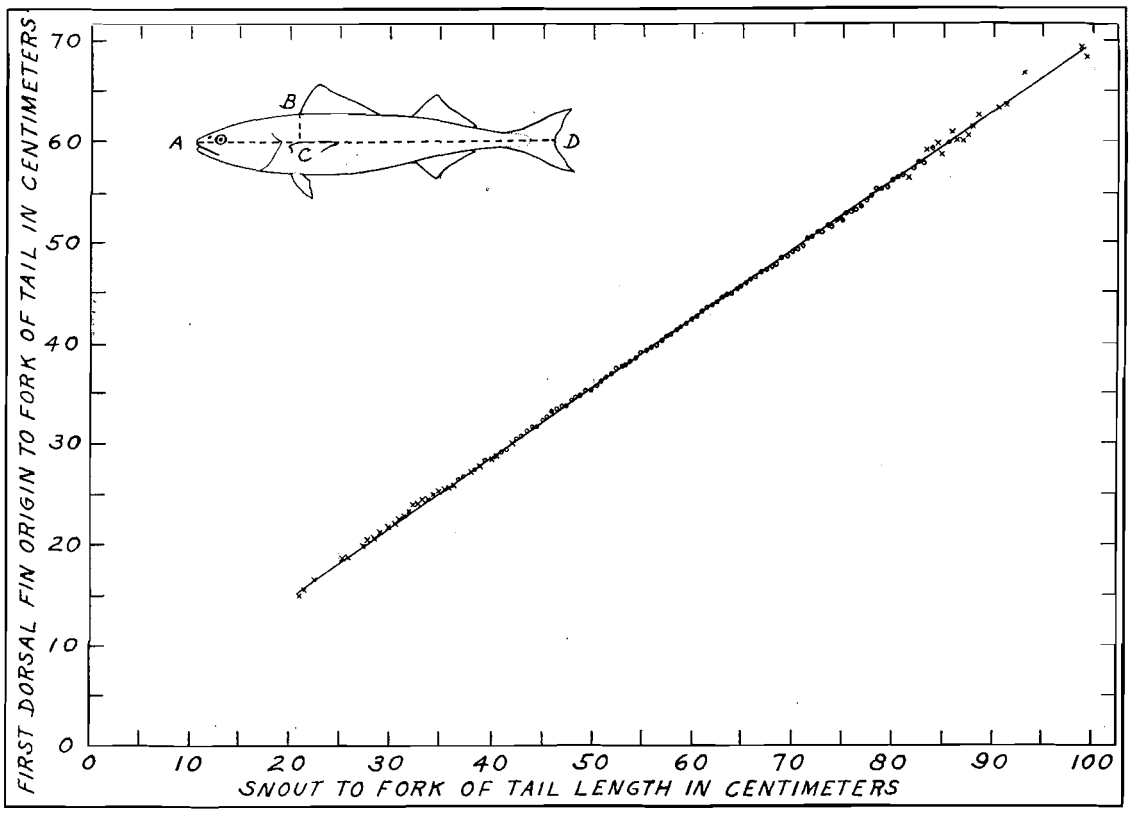

FIGURE 2. Conversion of head-off to corresponding head-on lengths for sablefish taken in California.

Although a straight line fits the points fairly well, the slope of the line indicates a slight decrease in the length of the body from the origin of the dorsal fin to the fork of the tail, as the fish becomes longer.

LENGTH-WEIGHT RELATIONSHIP

Round Fish

Lengths and weights, in the round, were obtained for 1,475 sablefish landed at the ports of Eureka, Fort Bragg and Monterey, at different times during the year. The bulk of these fish were from commercial longline catches; the remaining portion were from otter trawl catches made in the Eureka region. Slight differences are indicated between the length-weight relationships of the males and females. However, these differences are not large enough to warrant separate consideration of the sexes.

The average weights shown in Figure 3 were obtained by totaling the weights that occurred at each one-half centimeter of length and dividing by the number of fish. In Figure 3, a small circle represents an average that includes five to 38 fish, whereas an "x" represents on average based on less than five fish. No allowance was made for the weight of stomach contents or for the weight of developing gonads. The line indicates the most probable fit for the points that represent the average

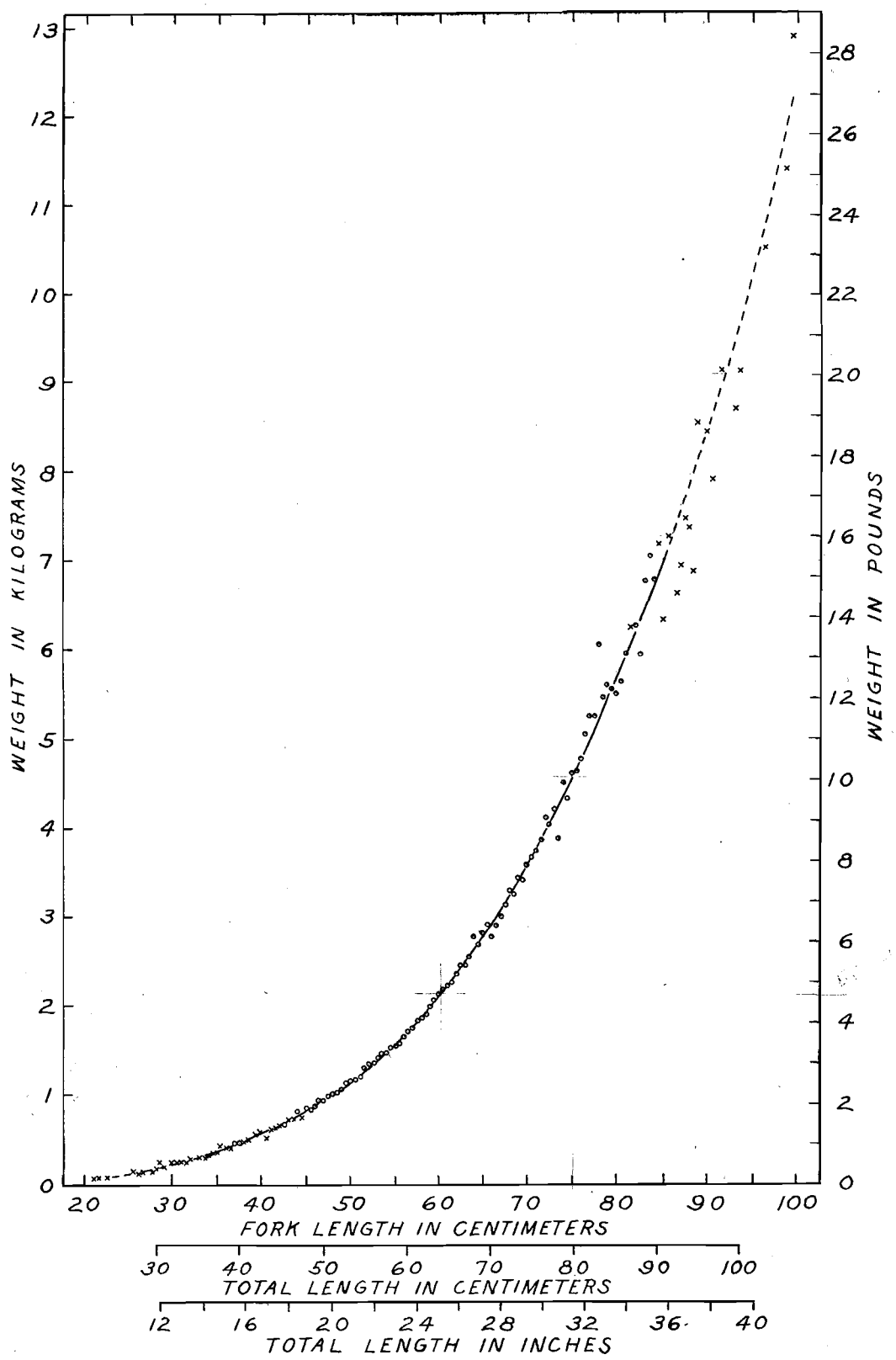

FIGURE 3. Length-weight relationship for sablefish taken in Central and Northern California. Round fish.

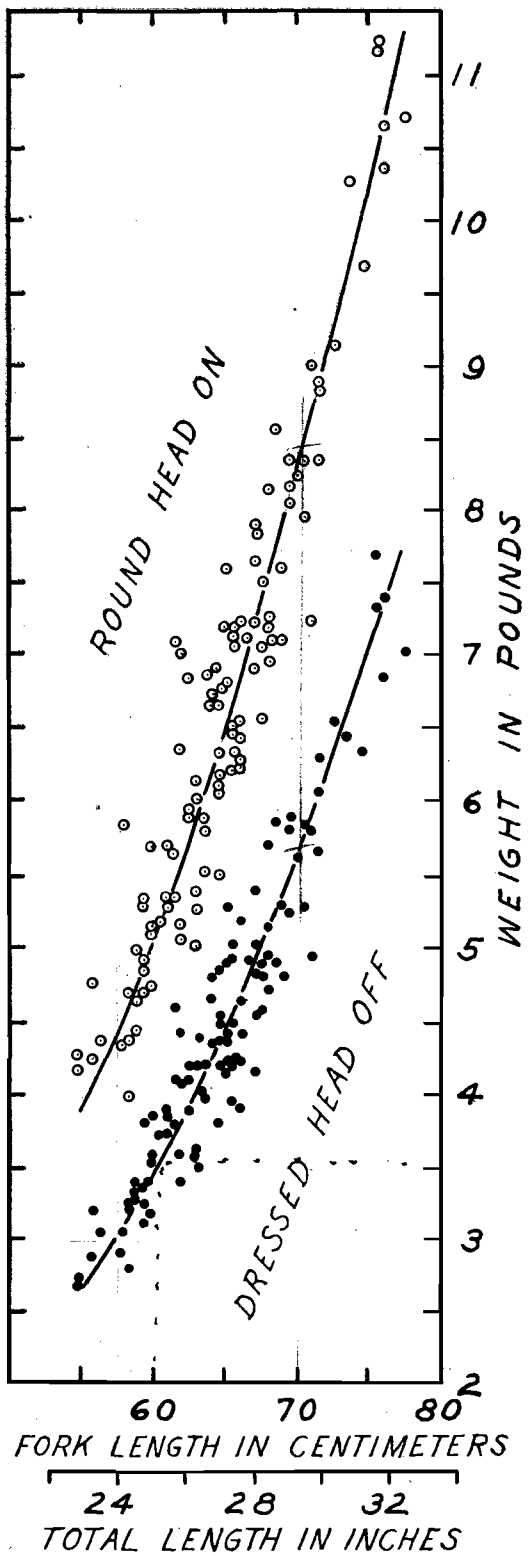

FIGURE 4. Round and dressed weight conversion for sablefish weighing four to eleven pounds, round, taken at Fort Bragg, California, October 28 and 29, 1953.

weights for the different lengths. This line was fitted from a plot of the logarithms of the lengths against the logarithms of the respective average weights. At about 24 inches total length, a slight change in slope was apparent from such plotting. This slight change in slope could be due to the onset of maturity (see Figure 5).

Round and Dressed Weight Conversion

Round, head-on weights and the corresponding dressed, head-off weights were taken on 106 sablefish, 23 to 33 inches, total length, landed by longline and otter-trawl fishermen at Fort Bragg, October 28–29, 1953. The dressing and cutting was done by regular fish butchers at the Fort Bragg wholesale fish markets.

It will be noted from Figure 4 that the round weights for fish of the same length may vary as much as two pounds, while the corresponding dressed, head-off weights may vary one and one-half pounds. The average loss in dressing and heading fish of four to two pounds weight was approximately 32%. (The round, head-on weights total 1,432.6 pounds, while the dressed, head-off weights totaled 974.5 pounds). However, in this connection it might be pointed out that the loss with mature fish is apt to be greater at this time of year because of the developing gonads. No data are available, at this time, for the loss in weight at other seasons of the year.

Spawning Season and Size at Maturity

Observations on the gonads of sablefish at the ports of Eureka, Fort Bragg and Monterey indicate that the main spawning period for sablefish in California is December through April, with the peak occurring in January and February. The period in which spawning occurs was judged from the appearance of recently spent ovaries that contained some remaining clear, glassy eggs. Although ripe, running tests were encountered during the period of spawning, ovaries in a ripe, running conditions were rarely encountered in the commercial catches. Measurements of egg diameters in a number of ripening ovaries show that here is just one group of maturing eggs for a season. A female 40 inches long will produce close to one million eggs in a season. Smaller sized fish will have correspondingly fewer maturing eggs. A female 21 inches long will produce about 100,000 maturing eggs in a season.

Observations on 6,000 fish taken in different regions in California during the spawning months

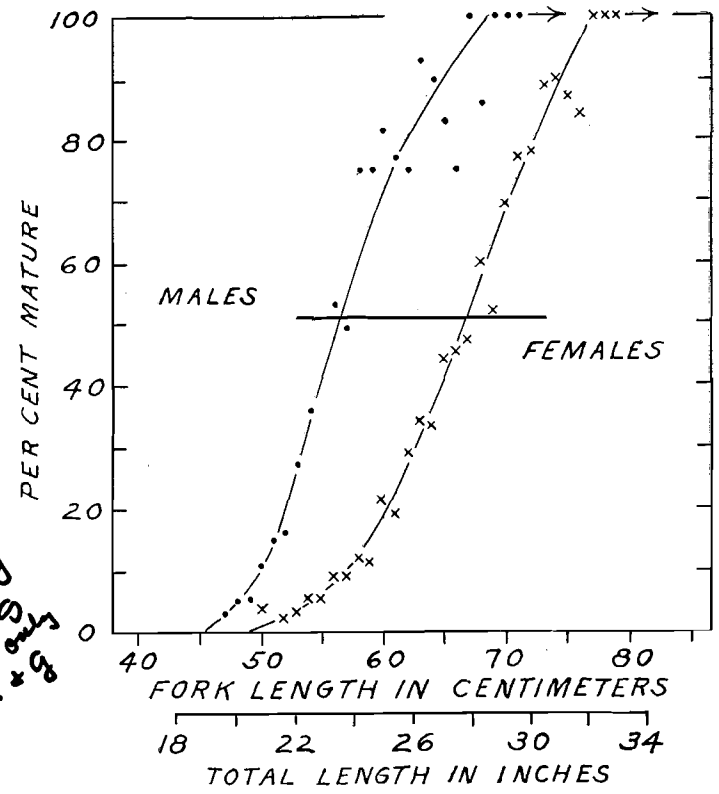

FIGURE 5. Maturity sizes for sablefish in California.

indicate that fifty percent of the males and of the females mature at total lengths of approximately 23.5 and 28 inches, respectively. One hundred percent maturity occurs at total lengths of about 28.5 inches for males and 32 inches for females. (See Figure 5).

RELATIONSHIP OF SIZE OF SABLEFISH TO DEPTH OF WATER

A system of sampling the unsorted catches of certain otter trawl boats working out of the port of Eureka has been in operation since 1950. On the fishing grounds, a portion of a haul that is being dumped from the net falls into a fish box, with a locking lid that has been provided by our laboratory. Payment is made for each box of material, plus a poundage payment for commercially valuable species that are encountered in the boxes. The species found in the sample boxes are tabulated by size, weight and other biological information. The greatest proportion of the commercial species are flatfish but sablefish are encountered, sometimes.

During the period 1950–1953, about 800 sablefish were tabulated from the sample boxes. These were taken in drags made between Crescent City and Eureka and in depths ranging from 35 to 330 fathoms. To determine if there were any relationship between the size of fish and the depth at which the drags were made, the length frequency data for sablefish were classified by three zones of depth, as shown in Figure 6: 35–67 fathoms, 70–147 fathoms and 185–330 fathoms. These three zones were determined by natural breaks in the data. Because of the limited number of fish the sexes were combined.

Sufficient data were available only for the summer and fall season, June-November, for a comparison of the size of fish taken in the different zones of depth. It will be noted that the greatest concentration of small fish, 13 to 18 inches length, occurred in the shallowest water zone. The greatest concentration of larger fish occurred in the deepest water zone. Both small and larger sizes of fish were present in waters of intermediate depth.

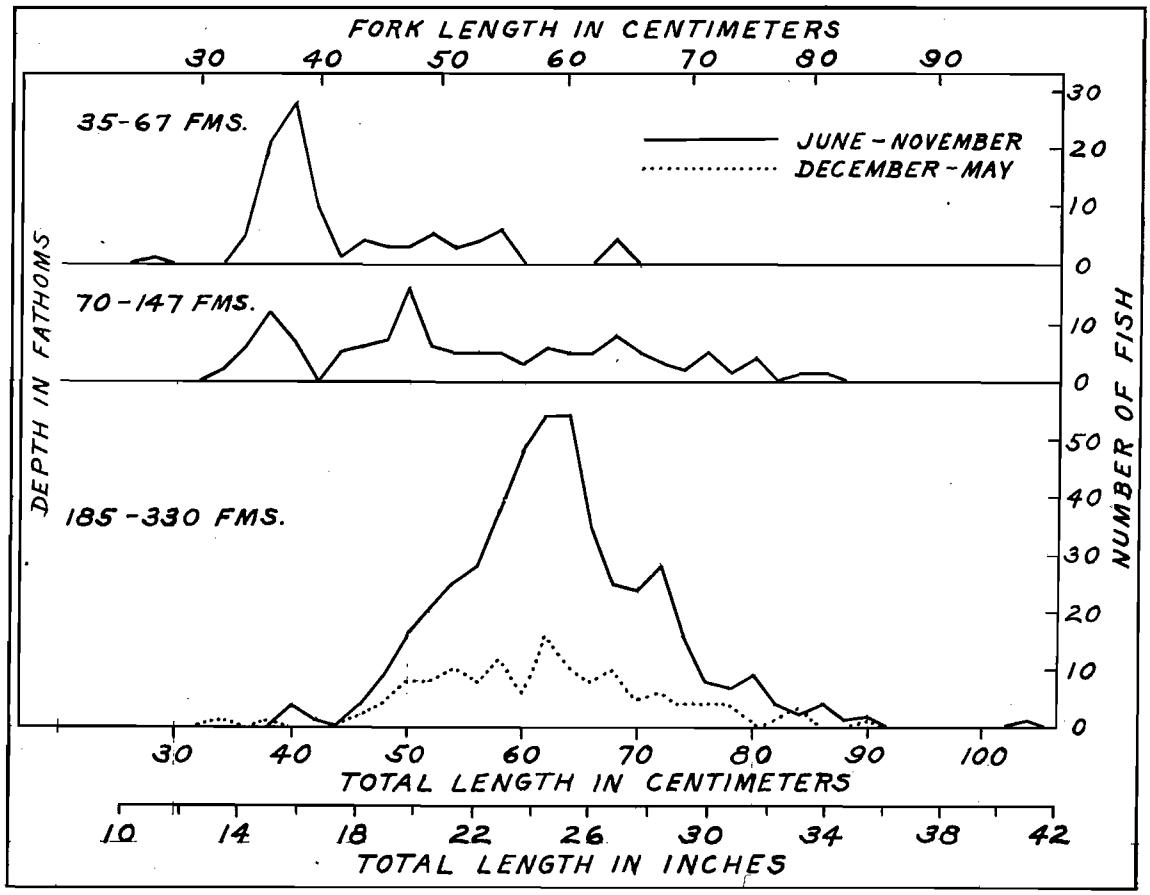

FIGURE 6. Relationship of size of sablefish to depth of water based on random catches of otter trawlers operating in the Eureka region. Sexes combined.

LENGTH FREQUENCIES OF CALIFORNIA SABLEFISH CATCHES

Longline Catches at Eureka, Fort Bragg and Monterey

During the period March, 1950 to March, 1953, measurements were taken on nearly 7,000 sablefish caught by longline boats at the ports of Eureka, Fort Bragg and Monterey. The length frequency distribution for the entire period of sampling, for both sexes combined is shown in Figure 7. The largest male encountered in the sampling program was 35 inches while the largest female was 41.5 inches, total length. Because the females attain a length that is appreciably greater than that of the males the sex ratio may vary depending on the size range of the fish caught.

Southward of Eureka, there is a decrease in the proportion of the fish that are over six pounds, round weight, or more than 27 inches, total length. The greatest discrepancy occurs in the Monterey region. Although all dealers along the coast prefer the larger sizes, it is apparent that not many large fish are available to the fishermen in the latter region. Since sablefish are not abundant enough to be of much importance in the commercial catch to the southward of Monterey Bay, environmental conditions for this species may be less favorable in the Monterey region than are the conditions farther north.

Some of the measurements on sablefish in the Eureka and Fort Bragg areas were made on the fishing grounds during the course of tagging operations. Because of this, a large proportion of the sizes less than four pounds, round or 24 inches, total length would not be included if the sampling were all done on shore. Some of the smaller sizes are discarded at sea or cut up as bait, or brought ashore when there is a demand for crab bait. In the Monterey region, the length frequency distribution represents, quite closely both the actual catch of the longliners and the market landings because of dealer acceptance.

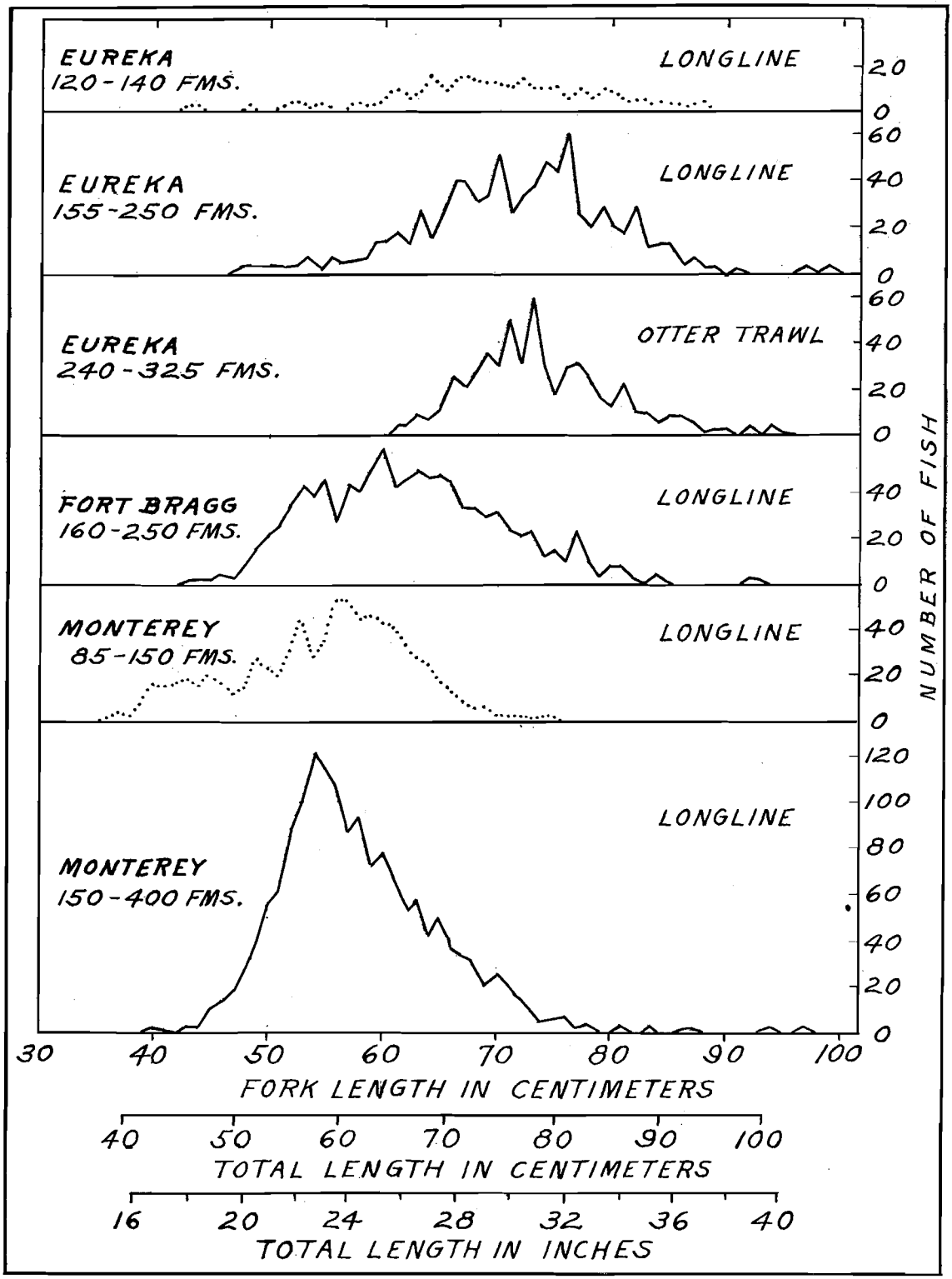

FIGURE 7. Length frequencies of sablefish catches made at Northern and Central California ports.

Otter Trawl Landings at Eureka

During the period December, 1951, to August, 1952, measurements were made on 585 sablefish in a dressed, head-off condition that were landed by Eureka otter trawl fishermen. The fish were caught in drags made in water of 240 to 325 fathoms depth from Cape Mendocino to Cape Sebastian. The fish were measured from the origin of the first dorsal fin to the fork of the tail. The figures were then converted to lengths of fish with heads on, by means of Figure 2. The result of these conversions to the probable head-on lengths are shown in Figure 7.

Even though the bulk of the otter trawl catches were made at a greater depth (240 to 325 fathoms) than were the deepest longline catches (155 to 250 fathoms), in general there is a great deal of similarity between the two size distributions for the Eureka area, considering fish of five pounds, round, and over. The average size of each of the distributions, for fish of five pounds, round and over is approximately 31 inches, total length, or 9.5 pounds, round weight.

SUMMARY

Sablefish are found along the Pacific Coast from Southern California into Alaska. This fishery is unimportant in Southern California. The current California landings are nearly two million pounds a year, or approximately one-fifth of the entire coastal landings. The highest landings in California occurred in 1945, during World War II, when a little over six million pounds were landed.

Adult sablefish are taken in deeper water than are the juveniles. In the winter months, large fish may be taken from as deep as 400 fathoms. The best fishing for large fish is encountered in 200 to 250 fathoms in the winter months and in 90 to 165 fathoms in the summer months.

The sablefish is considered as one of the best of the smoked fishes but is not sold fresh to any great extent because of the high oil content. Small quantities are drysalted. A premium price is paid for large fish that are about seven pounds and over, in the round. This demand originates with fish curers, who also desire that the fish be frozen.

At one time livers from certain species of marine fish, including sablefish, were a lucrative by-product of these fisheries. However, large-scale production of synthetic vitamin A in recent years has greatly depreciated the value of fish livers.

II. Catch Analysis

INTRODUCTION

The analysis of the California catch of sablefish is based upon catch statistics and is designed to determine the current condition of the stocks of fish supporting the California fishery. The total annual California catch of sablefish in pounds for the years 1916 through 1952 is shown in Figure 8. Although the annual landings reached their highest peak of a little over six million pounds in 1945, during World War II, the current average annual landings are close to two million pounds, based on the seven post-war years, 1946–1952. The rise in catch culminating in 1935 was reportedly due to a transient demand for fish livers. Since 1941 was the last year that this fishery was at the previous relatively normal level before the recent growth, this analysis will cover the 12-year period, 1941–1952.

We are indebted to Mr. H. C. Godsil of the California Department of Fish and Game for organizing the material upon which this study is based.

Landings

The California catch of sablefish is made predominantly from Monterey, north. The areas of landing, by principal ports, are shown in Table 1 and Figure 9. During the 12-year period, 1941–1952, the Eureka, Fort Bragg, and Monterey areas (the Monterey area includes the port of Santa Cruz as well as the port of Monterey, both on Monterey Bay), composing statistical regions 2 and 5, accounted for nearly 95 percent of the total state catch. Accordingly this analysis will be based primarily upon the catch in the foregoing regions.

Table 1. Total Annual Pounds of Sablefish Landed in Each Region in California During the Period 1941–1952*

Year	Eureka	Fort Bragg	San Francisco	Monterey	Santa Barbara	Los Angeles	San Diego	State Total
1941	175,021	185,679	70,889	53,971	5,185	45,795	.....	536,540
1942	513,245	1,119,384	29,764	290,874	2,382	16,809	64	1,972,522
1943	474,763	1,432,901	36,901	1,221,784	3,409	34,147	1,469	3,205,374
1944	919,084	1,040,384	47,332	2,102,627	.....	7,024	.....	4,116,451
1945	3,029,636	628,193	165,361	2,427,934	1,467	6,496	.....	6,259,087
1946	1,857,479	151,181	99,637	533,382	24	15,170	.....	2,656,873
1947	512,487	167,277	21,610	162,902	.....	37,834	.....	902,110
1948	1,076,651	676,451	23,827	244,630	.....	45,862	1,012	2,068,433
1949	742,302	537,487	50,841	329,230	4,497	75,533	135	1,740,025
1950	445,304	179,960	65,854	845,504	5,860	41,499	.....	1,583,981
1951	741,557	478,761	265,858	1,038,200	1,141	59,419	137	2,585,073
1952	379,541	277,960	246,257	433,081	830	6,198	.....	1,343,867
Ave. Pounds	905,589	572,968	93,678	807,010	2,066	32,649	235	2,414,195
Ave. Percent	37.6	23.7	2.9	33.4	0.9	1.4	0.1	100.0%

*Weight of fish landed. Includes both round and dressed fish.
Statistical Region 2—Eureka (Oregon border, Lat. 42°00′ to Cape Mendocino, Lat. 40°27′).
Fort Bragg (Cape Mendocino to Point Arena, Lat. 38°57′).
Statistical Region 4—San Francisco (Point Arena to Pigeon Point, Lat. 37°10′).
Statistical Region 5—Monterey (Pigeon Point to Piedras Blancas, Lat. 35°40′).
Statistical Region 6—Santa Barbara (Piedras Blancas to Point Dume, Lat. 34°00′).
Statistical Region 7—Los Angeles (Point Dume to San Mateo Point, Lat. 33°23′).
Statistical Region 8—San Diego (San Mateo Point to Mexico Border, Lat. 32°32′).

Two types of fishing gear, longlines (multiple-hook lines) and otter trawls (drag nets), account for nearly all of the sablefish landings in California. Table 2 and Figure 10 show the total annual pounds of sablefish landed by longline fishermen and by otter trawl fishermen in the Eureka, Fort Bragg, and Monterey areas for the years 1941 through 1952. Seventy-eight percent of the landings for this period in these three areas were made by longliners. It can be noted that until 1944 otter trawl gear was not an important consideration in the California sablefish fishery. Since 1944, otter trawl landings have become more important in the Eureka and Fort Bragg areas. During the seven year post-war period, 1946–1952, the otter trawl landings were 37 percent of the combined longlines and trawler landings for the Eureka and Fort Bragg area, together. In just the Eureka area, the otter trawl landings have been a little greater than the longline landings for the past three years, 1950–1952.

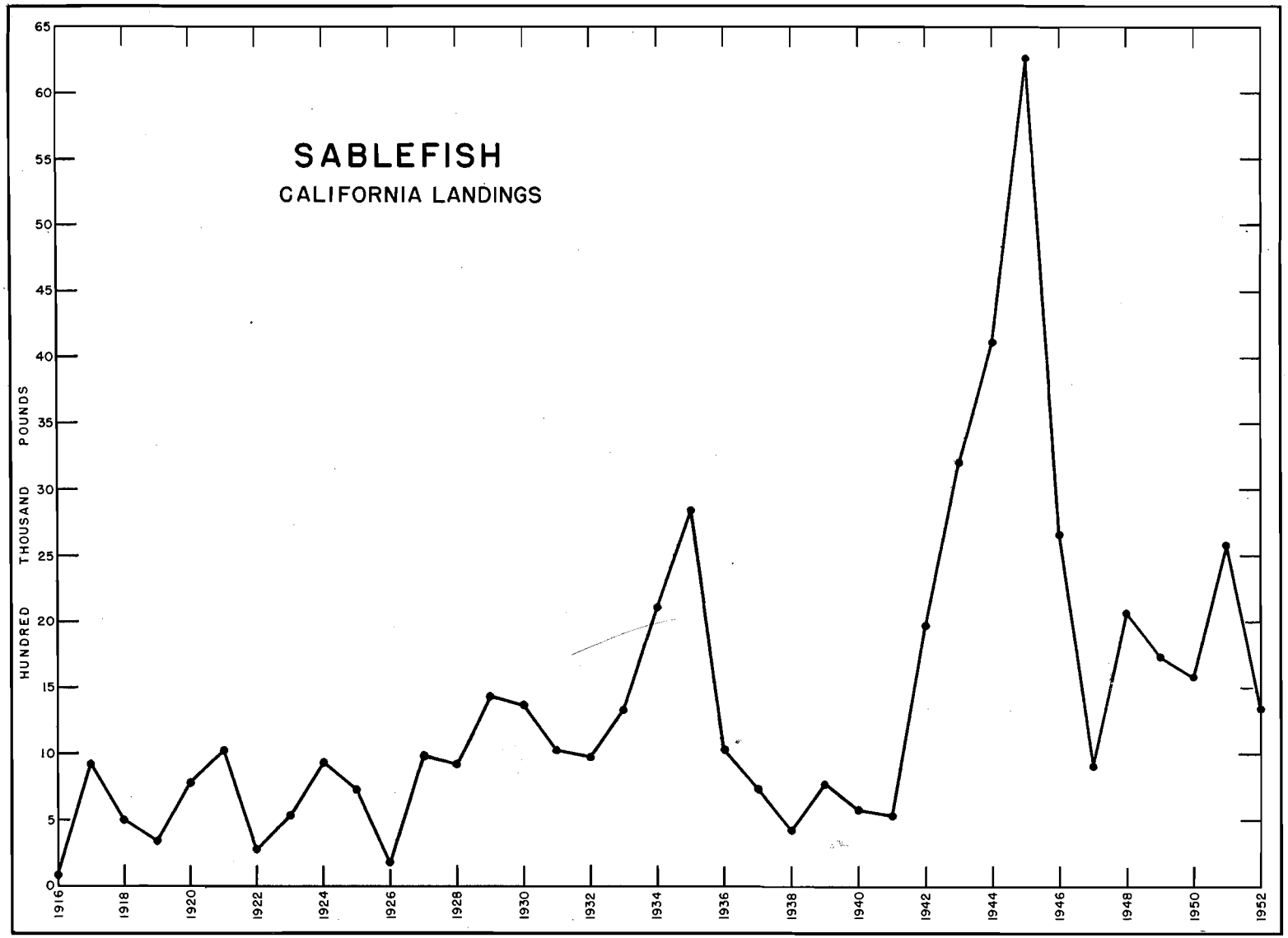

FIGURE 8. Pounds of sablefish landed in California each year from 1916 to 1952, inclusive.

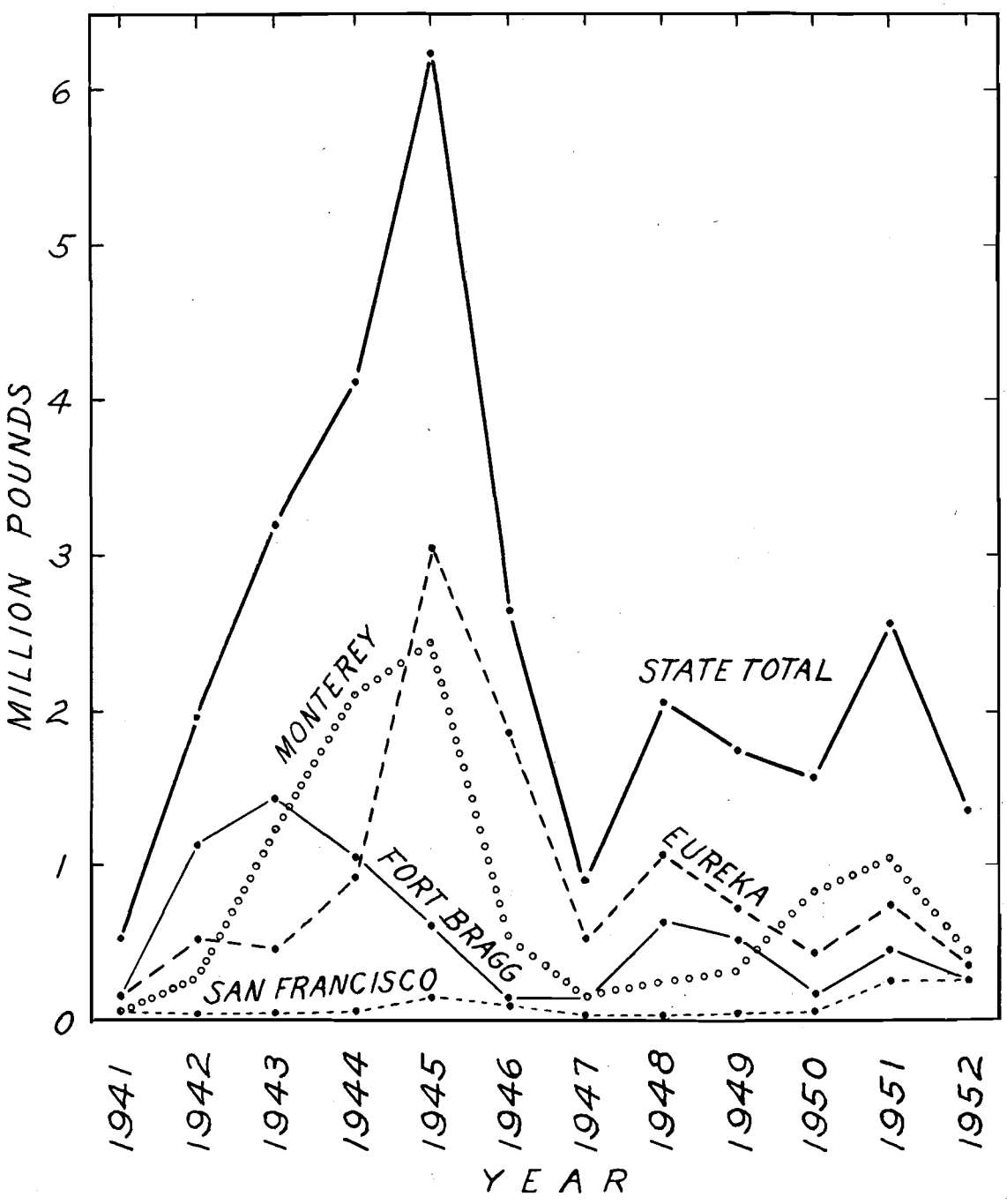

FIGURE 9. Total statewide and regional landings of sablefish in California for the years 1941-1952. The landings for the Santa Barbara, Los Angeles and San Diego regions are not shown because the combined landings for these Southern California regions are generally less than those shown for the San Francisco region.

TABLE 2. TOTAL ANNUAL POUNDS OF SABLEFISH LANDED BY OTTER TRAWL IN THE EUREKA, FORT BRAGG AND MONTEREY REGIONS OF CALIFORNIA

Year	Eureka			Fort Bragg			Monterey		
	Longline	Otter Trawl	Misc.	Longline	Otter Trawl	Misc.	Longline	Otter Trawl	Misc.
1941	167,514	3,865	3,642	141,157	44,400	122	52,243	1,441	287
1942	495,205	16,585	1,455	1,117,263	.....	2,121	290,619	255	.....
1943	404,554	70,209	.....	1,415,715	550	16,636	1,219,710	1,885	189
1944	547,932	371,135	17	1,033,403	1,373	5,608	2,101,591	1,036	.....
1945	1,080,235	1,949,325	76	380,471	247,722	.....	2,407,972	19,962	.....
1946	1,518,624	338,824	31	116,724	34,457	.....	533,382	.....	.....
1947	425,088	87,237	162	131,172	34,292	1,813	153,772	9,115	15
1948	651,926	423,960	765	444,208	232,243	.....	224,753	19,705	172
1949	363,454	378,487	361	404,053	133,434	.....	314,948	14,227	55
1950	93,062	352,242	.....	109,578	70,382	.....	821,536	22,992	976
1951	280,236	461,321	.....	334,663	144,098	.....	1,018,356	19,813	31
1952	142,090	237,451	.....	196,601	81,359	.....	337,524	95,557	.....
Ave. Pounds	514,160	390,887	542	485,417	85,359	2,192	789,700	17,166	144

During the period 1941–1951, the landings of sablefish in the Monterey region were made almost exclusively by longline operators; 1952 is the only year in which the otter trawl landings were of any considerable importance. Of the total annual catch in this region, the percentage taken on longline gear during these years was:

Year	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952
Percent	97	100	100	100	99	100	94	92	96	97	98	78

The marked increase in the poundage delivered by otter trawlers in 1952 was the result of an increased number of deliveries from a larger number of boats. Although this could indicate the beginning of a new epoch in this region, it does not materially affect the present analysis.

The percent of the total annual landings of sablefish that occurred each month during the period 1941–1952 are shown in Table 3 for the Eureka plus Fort Bragg area (Statistical Region 2) and for the Monterey area (Statistical Region 5). The average percent for each month was obtained by total the percents for the 12 years and dividing by 12.

TABLE 3. PERCENT OF LANDINGS OF SABLEFISH THAT OCCURRED EACH MONTH DURING THE PERIOD 1941–1952 IN STATISTICAL REGIONS 2 AND 5

Month	Region 2		Region 5	
	Average Percent	Range of Percents	Average Percent	Range of Percents
January	1.6	0.0– 4.9	6.8	0.0–27.5
February	2.0	0.2– 6.7	7.7	0.0–21.6
March	4.2	0.8–15.1	6.2	0.3–14.0
April	8.4	2.6–18.3	9.8	0.8–20.8
May	11.3	4.9–21.6	8.4	1.2–17.7
June	12.1	4.3–18.8	8.4	0.1–15.4
July	12.5	6.9–18.4	7.3	0.0–12.7
August	14.3	6.3–23.9	8.3	0.1–14.6
September	13.5	6.8–20.1	8.4	0.2–21.7
October	10.2	3.2–17.4	10.8	0.0–27.9
November	5.9	0.6–10.7	9.4	0.8–34.5
December	4.0	0.0–21.4	8.4	1.8–41.0
	100.0		99.9	

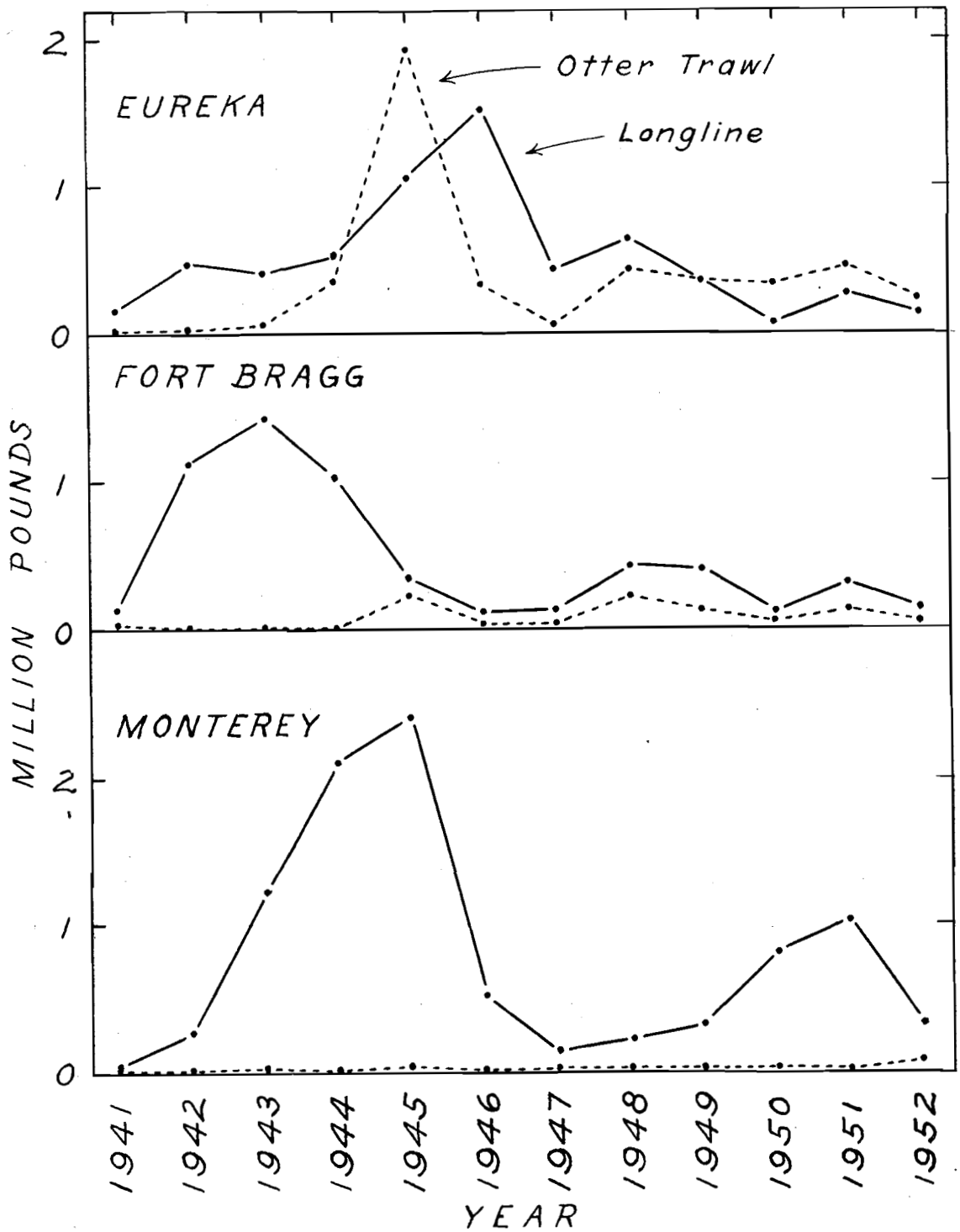

FIGURE 10. Total annual pounds of sablefish landed by longline fishermen and by otter trawl fishermen in the Eureka, Fort Bragg and Monterey regions of California, during the years 1941-1952.

Effort

In the present study, the unit of effort is based upon the pounds per delivery of sablefish made by longline gear fishermen. The longliners ordinarily make daily trips to fish specifically for sablefish, and any other species of fish that may be encountered are incidental to this purpose. Occasionally, when the demand is exceptionally good, a vessel will make a two- or three-day trip to a more distant and productive ground. Landings of sablefish by otter trawlers during the same period can, for the most part, be considered as incidental to fishing activities conducted primarily for various species of flatfish and rockfish. In recent years, there has been some tendency for otter trawlers to make an occasional drag specifically for sablefish in an attempt to fill out a load before returning to port. However, the longliners have been able to maintain a favorable position in the California fishery because they can still produce good catches of prime, large fish by working areas and depths that are still somewhat inaccessible to most otter trawl gear.

A desirable unit of effort should take into consideration the actual amount of gear used and the length of the time fished. Such precise information is practically unavailable from all of the longline operators. In general, the two- or three-man crews on the relatively small longline boats have not made a practice of keeping logs of their fishing operations. However, since there has been no appreciable change in longline fishing methods or in the grounds commonly fished over the period of this analysis, the relative catch per delivery should yield a comparable measure of the abundance of the stock of sablefish, provided that the effects of economic factors are considered.

Table 4. The Annual Number of Boats, Number of Deliveries and Average Pounds per Delivery of Sablefish Landed in the Eureka, Fort Bragg and Monterey Regions During the Years 1941 Through 1952.

(The Total Annual Pounds Landed Are Shown by Type of Gear in Table 2)

LONGLINE FLEET

Year	Eureka			Fort Bragg			Monterey		
	Number of Boats	Number of Deliveries	Ave. Lbs. per Delivery	Number of Boats	Number of Deliveries	Ave. Lbs. per Delivery	Number of Boats	Number of Deliveries	Ave. Lbs. per Delivery
1941	47	422	397	51	445	317	94	505	104
1942	49	680	728	52	1,032	1,083	56	579	502
1943	49	504	803	59	994	1,424	71	1,571	776
1944	41	476	1,151	47	889	1,162	91	2,878	730
1945	41	590	1,831	37	312	1,220	92	2,831	851
1946	55	834	1,821	25	136	858	59	816	654
1947	43	400	1,063	12	80	1,640	32	207	743
1948	30	432	1,509	27	287	1,548	39	560	401
1949	28	251	1,448	23	271	1,491	49	697	452
1950	14	131	710	7	85	1,289	66	1,116	736
1951	12	130	2,156	7	271	1,235	53	982	1,037
1952	9	147	967	9	104	1,890	34	444	760

OTTER TRAWL FLEET

1941	3	7	552	4	27	1,644	3	14	103
1942	7	35	474	0	0	0	1	3	85
1943	8	98	716	2	2	275	3	7	269
1944	27	339	1,095	2	3	458	2	6	173
1945	58	938	2,078	17	187	1,325	4	31	644
1946	59	533	636	14	126	274	0	0	0
1947	39	228	383	12	70	490	6	21	434
1948	49	640	662	13	241	964	4	21	938
1949	40	587	645	10	139	960	8	49	290
1950	34	561	628	7	141	499	9	41	561
1951	30	561	822	9	293	492	4	65	305
1952	44	568	418	9	177	460	14	168	569

The annual number of boats, number of deliveries, and the average pounds per delivery for the longline fleets and for the otter trawl fleets fishing in the Eureka, Fort Bragg, and Monterey areas are shown in Table 4 and in Figures 11 and 12. All deliveries of known longline and otter trawl

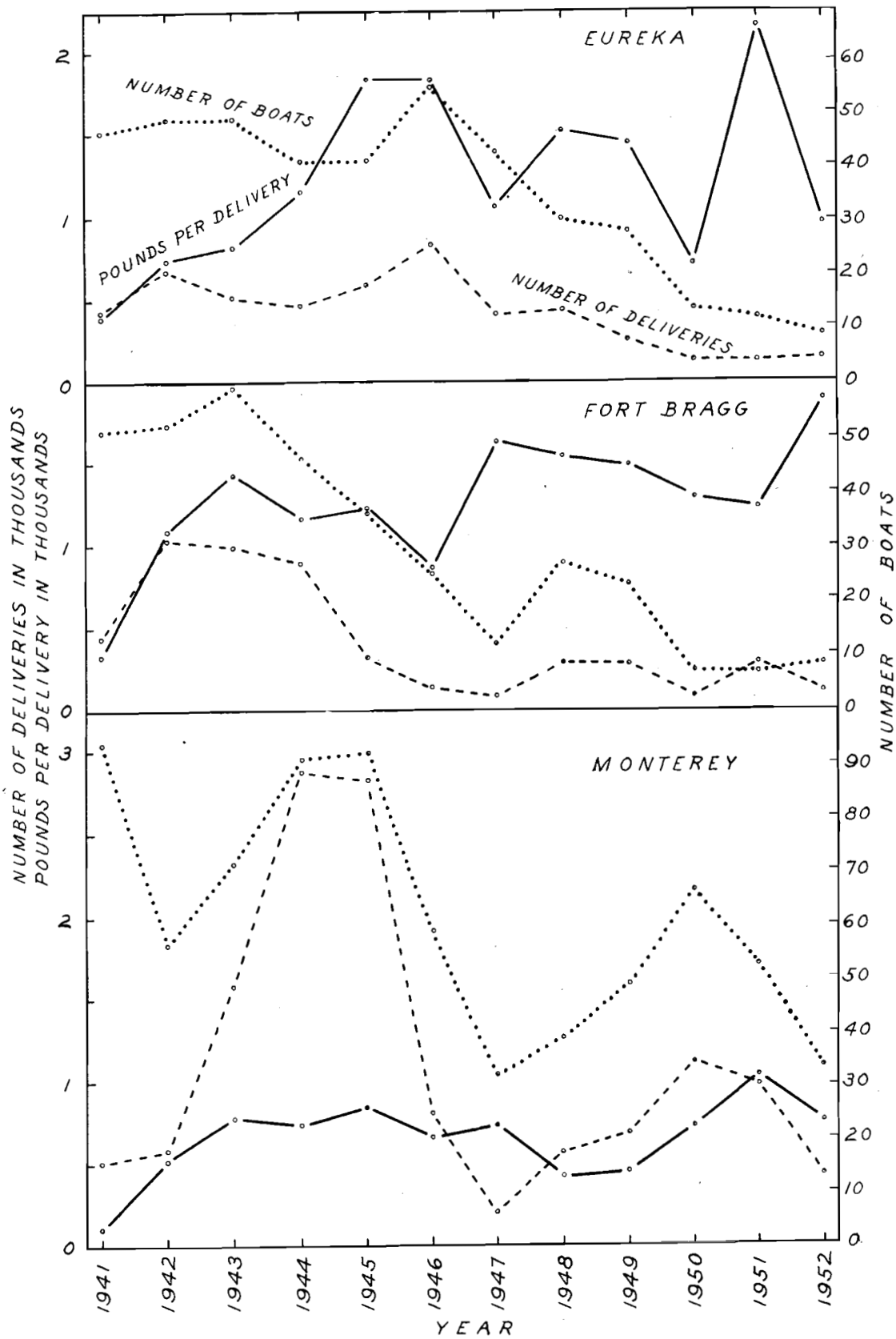

FIGURE 11. The annual number of boats, number of deliveries and pounds per delivery for LONGLINE boats that fished sablefish in the Eureka, Fort Bragg and Monterey regions during the years 1941 through 1952.

vessels have been included. The only omissions are catches from a few boats that delivered sablefish in negligible quantities and could not be identified as either longline or otter trawl users, and small quantities of sablefish which were landed by vessels using other gear. Such deliveries have been included in the "Miscellaneous" category. The total poundage in this category, for the three areas for the period 1941–1952, amounts to one-tenth of one percent of the total state landings for the same period.

It can be noted in Figure 11 that in spite of the decline in the number of boats and the accompanying decline in the number of deliveries for the longline fleets in the three areas during the period of the analysis, the average pounds per delivery increased rapidly during the first few years and fluctuated around a nearly horizontal, or even slightly upward, trend line in the later years. The fluctuations around the trend line in the Eureka area are greater than the fluctuations shown for either Fort Bragg or Monterey. A possible explanation for this condition is that although the Eureka dealers encourage the landing of large fish to a greater extent than do the Fort Bragg or Monterey dealers, on occasions when cold storage holdings are low, they may accept certain amounts of medium sizes that ordinarily would be discarded on the fishing grounds. In this analogy, note the close apparent inverse correlation of the annual average pounds per delivery for the Eureka area during the post-war years (Figure 11) with the corresponding cold storage holdings at the start of these years (Figure 14). Medium sizes are accepted with greater regularity at Fort Bragg and at Monterey. Also, at Monterey a certain proportion of small sizes are regularly accepted, provided there are some large fish in the catch.

If we consider the last seven-year period, 1946–1952, as representing the normal post-war demand, we find that for this period the longline fleets made an annual average delivery of 1,382 pounds in the Eureka area; 1,422 pounds in the Fort Bragg area; and 683 pounds in the Monterey area. The significantly lower average pounds per delivery for the Monterey region is most likely associated with the fact that in this region a two-man boat crew will normally set 10 to 15 baskets of gear in a day, whereas in the Eureka plus Fort Bragg region, a two-man crew will normally set 15 to 20 baskets or tubs of gear in a day. Also, significantly smaller fish are landed in the Monterey region, which would tend to depress the total poundage taken. In this connection, it might be pointed out that the Monterey region is near the southern distribution of abundance for this species. In the remaining regions to the southward of the Monterey region, the total pounds landed during the 1941–1952 period amounted to only 2.4 percent of the entire state total poundage for the same period.

The landings of sablefish by otter trawlers are not as representative of the abundance of the stocks of fish as are the landings by longliners, because in the former case this fishery has been incidental to other fishing, while in the latter case it has been the primary fishery. However, Figure 12 is presented to show for the otter trawl fleets the same information as shown for the longline fleets in Figure 11. The rapid increase in the number of boats in the otter trawl fleet in Northern California between 1943 and 1945 can be noted. Except for the peak war year of 1945, the average pounds per delivery has fluctuated around a much lower trend line than that represented for the longline deliveries. The annual average landing of sablefish by otter trawl boats during the seven-year post-war period, 1946–1952, was 599 pounds for Eureka; 591 pounds for Fort Bragg; and 442 pounds for Monterey. The high landings in 1945, particularly in the Eureka area, are associated with a high war demand for fresh and salted fish. Ninety percent of the Eureka otter trawl landings in this year were delivered at "small fish" prices.

Figure 13 is presented to show the relative constancy of the annual return per unit of effort, particularly in the post-war years, for the longline fleets fishing sablefish in the Eureka, Fort Bragg, and Monterey areas. For this presentation the annual average pounds per delivery, shown in Table 4 have been accumulated starting with 1941 and ending with 1952. Such an accumulation in successive years has the same effect as plotting a succeeding year's average, using the previous year's average as an origin. In all three cases, a straight line would be the best fit for the plotted data, except for the first few years in the Eureka and Fort Bragg areas. If the decrease in pounds per delivery shown for the Monterey area in 1948 and 1949 had been maintained in the succeeding years, this would have indicated a definite change in trend that would bear investigation to determine the cause.

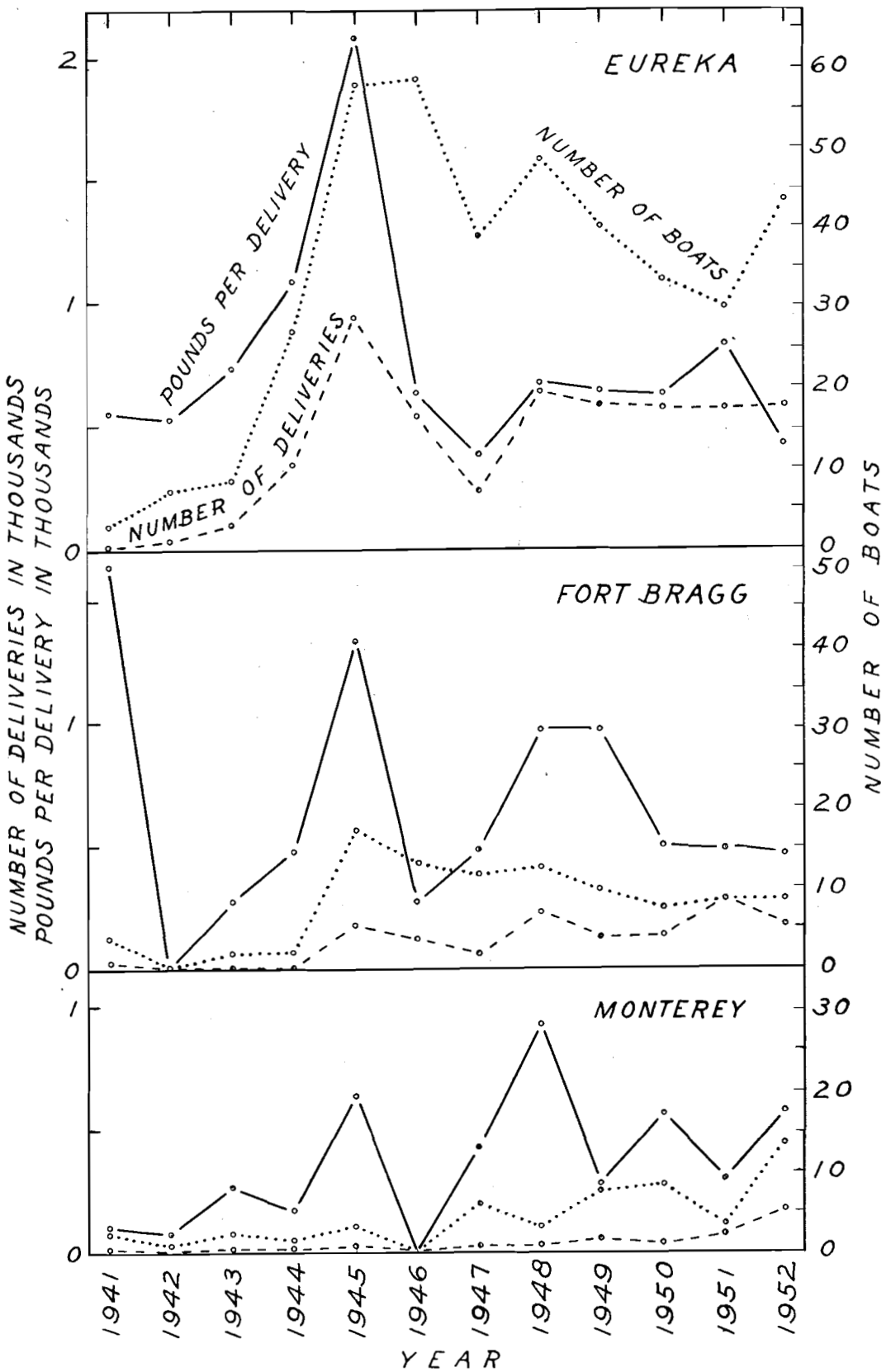

FIGURE 12. The annual number of boats, number of deliveries and pounds per delivery for OTTER TRAWL boats that fished sablefish in the Eureka, Fort Bragg and Monterey regions during the years 1941 through 1952.

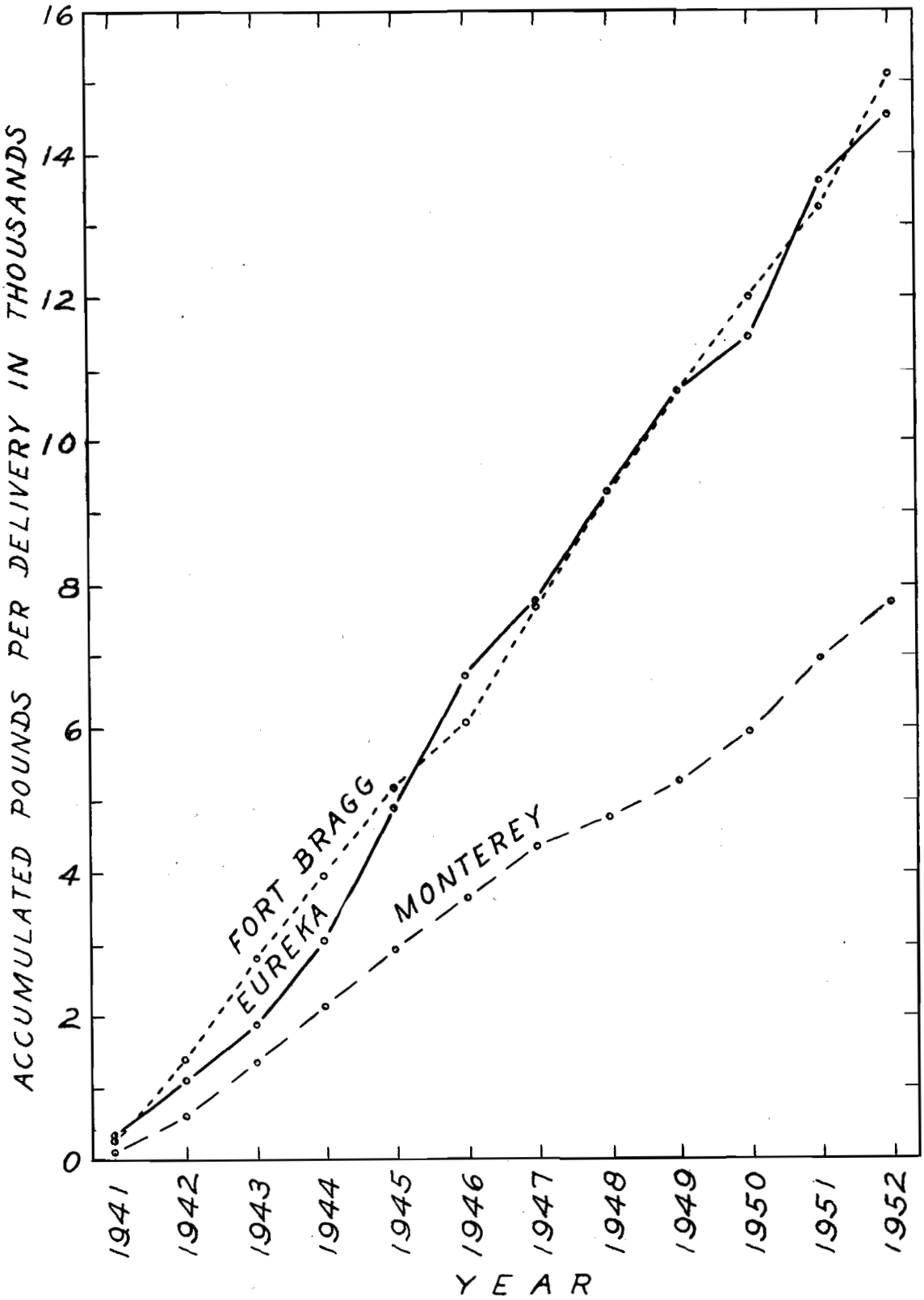

FIGURE 13. Successive accumulation of the annual, average pounds per delivery of sablefish by longline boats operating in the Eureka, Fort Bragg and Monterey regions, starting in 1941 and ending in 1952.

It is apparent that the significant decrease in the number of longline boats and the resultant decrease in the number of deliveries between 1941 and 1952 in all areas cannot be attributed to poorer fishing because the annual average pounds per delivery has been maintained in the more recent years.

One of the main reasons for the decrease in the numbers of longline boats in the sablefish fishery was the rapid increase in the numbers of otter trawl boats that occurred between the years 1943 and 1945 in Northern California. The much expanded trawler fleet did not compete directly with the boats in the longline fleet that fished primarily for sablefish. Because of the effectiveness of the "Balloon" trawl in the capture of rockfish, many of the longliners who depended primarily on trips for rockfish and incidentally on trips for sablefish for a livelihood were forced to use otter trawl gear, or engage in other activities.

The effect of the expansion of the trawler fleet in Northern California has had an indirect effect in causing a reduction in the size of the longline fleet in the areas to the southward. This is because the otter trawlers can deliver larger quantities of rockfish at a cheaper price than can the longliners. From this standpoint, the significant increase in the otter trawl fleet in the Monterey region in 1952 is not unexpected and can be expected to develop further, to the disadvantage of the longline fleet.

The importance of rockfish in the economy of the longline fleet can be noted in the following listing of the annual average pounds landed in California during the period 1941–1952 of the most important species that have been the object of longline fishermen—rockfish, seven and one-half million pounds; sablefish, two and one-half million pounds; ling cod, one and one-quarter million pounds; Pacific (Northern) halibut, one-quarter million pounds. Up to the year 1943, sharks were also an important adjunct to longline fishing. For the years 1941 through 1943, an average of nearly five million pounds a year were landed. However, during the peak years of fishing for soupfin shark, it was found that gill nets were much more effective in the capture of this shark than were longlines. As a consequence, from 1943 on, the use of gill nets in the shark fishery likewise had an effect on reducing the number of longliners that operated in the later years of this analysis.

The longliners that are now largely confining their efforts to sablefish can hope to maintain their favorable position in this fishery as long as they can continue to produce large fish that command a premium price.

Since the annual average pounds per delivery by the longliners has been maintained at a reasonable constant trend, whereas the annual average number of deliveries have not, it would appear that certain economic factors have an effect on controlling the catch, rather than the total catch being controlled by changes in the abundance of the stocks of fish in California. In the following section, the relationships of certain economic factors on the total catch are analyzed.

Factors Affecting the Catch

There is sufficient evidence in the foregoing catch analysis of the sablefish fishery in California to indicate that the fishery, during the period 1941 to 1952, has been controlled primarily by what the market will absorb. In the post-war years, 1946–1952, it appears probable that the catch of sablefish has been limited by quotas and that the fishermen have thus restricted their catches.

Dealers do not ordinarily limit a delivery of large fish—that is, fish weighing six to seven pounds and over, in the round. However, control over the total catch is usually exercised by limiting the number of deliveries that are made, or by reducing the price paid fishermen until a point is reached where the fishermen estimate that they cannot get a fair return for their effort, and stop fishing. The only direct limitation on a daily catch that a dealer is apt to apply is in the amount of medium or small fish that he will accept, and the demand for such sizes is not as stable as is the demand for large sizes.

The main support of the sablefish fishery is the smoked product, and processors of this product prefer large fish in order to obtain ample, fleshy cuts. The catch is generally placed in cold storage and withdrawn as needed for smoking. Hence, the cold storage holdings offer a possible index of demand.

TABLE 5. TOTAL POUNDS OF FROZEN SABLEFISH HELD IN COLD STORAGE IN THE UNITED STATES AT THE START OF A YEAR, AND THE TOTAL CATCH OF FRESH FISH THAT WAS MADE DURING THAT YEAR

Year	Total Pounds in Cold Storage in United States at the Start of the Year	Total Pounds of Fresh Fish that were Landed During the Year*	
		California	Pacific Coast†
1941	2,440,853	536,540	5,781,545
1942	1,697,655	1,972,522	8,967,138
1943	3,021,132	3,205,374	10,725,798
1944	2,336,535	4,116,451	13,376,131
1945	3,525,770	6,259,087	14,786,176
1946	4,122,592	2,656,873	13,849,446
1947	6,711,808	902,110	4,222,428
1948	2,667,021	2,068,433	9,601,974
1949	4,674,840	1,740,025	9,238,637
1950	5,015,637	1,583,981	5,154,951
1951	2,470,200	2,585,073	12,612,023
1952	3,711,680	1,343,867	5,726,143
Average	3,532,977	2,414,195	9,503,532

*Weight of fish as landed. Includes both round and dressed fish.
†Exclusive of British Columbia.

In Table 5 and in Figure 14 are shown the total pounds of frozen sablefish held in cold storage in the United States at the start of each year, and the total pounds that were caught in California during that year for the period 1941–1952. It will be noted from this comparison that during the last seven-year period, 1946–1952, there is a fairly strong inverse correlation with the size of the cold storage holdings at the start of a year and the eventual total catch for that year. The coefficient of correlation is minus .73. That is, low cold storage holdings at the start of a year are followed by a higher catch during that year, while high cold storage holdings are followed by a proportionately lower catch for that year. If the year 1946 is dropped from this correlation, assuming this as an adjustment year between the war years and the remaining post-war years, an even stronger inverse correlation is obtained (Minus .86).

The five-year period, 1941–1945, cannot be considered as normal because of the effect that World War II had on fishing for nearly all of this period. The greatly increased demand for fresh and salted fish brought on by the war resulted in unduly large landings of small fish that normally would not have been harvested. Cold storage holdings suffered partially because of this, but largely because of inequitable OPA maximum price ceilings that were in effect during the war.

However, in spite of the undue exploitation of the stock on the fishing grounds during the peak war years, the return per unit of effort by the primary fishery (longlines) has been maintained in the post-war period. This, combined with the high inverse correlation between catch and cold storage holdings during the same period, lends support to the conclusion that the size of the seasonal sablefish catch has been governed primarily by economic demand, rather than by the abundance of the stocks on the fishing grounds.

Prevailing prices to fishermen likewise affect the catch. When the catch in the Monterey region is correlated with the price paid fishermen during the period 1941–1952, omitting the years 1942–1945, which were dominated by war demand and price controls, the correlation is fairly strong and direct (Plus .72). That is, in general, a high catch is associated with a high price and a low catch with a low price.

Another economic factor that may materially influence the catch is the volume of annual shipments into California. Unfortunately, this cannot be appraised fully because up to 1949, little effort was exerted by our agency to secure records of such shipments. In 1949 a start was made and for succeeding years the record is more complete. The recorded shipments for these years are as follows:

Year	Total Pounds
1949	31,198
1950	335,990
1951	302,415
1952	545,772

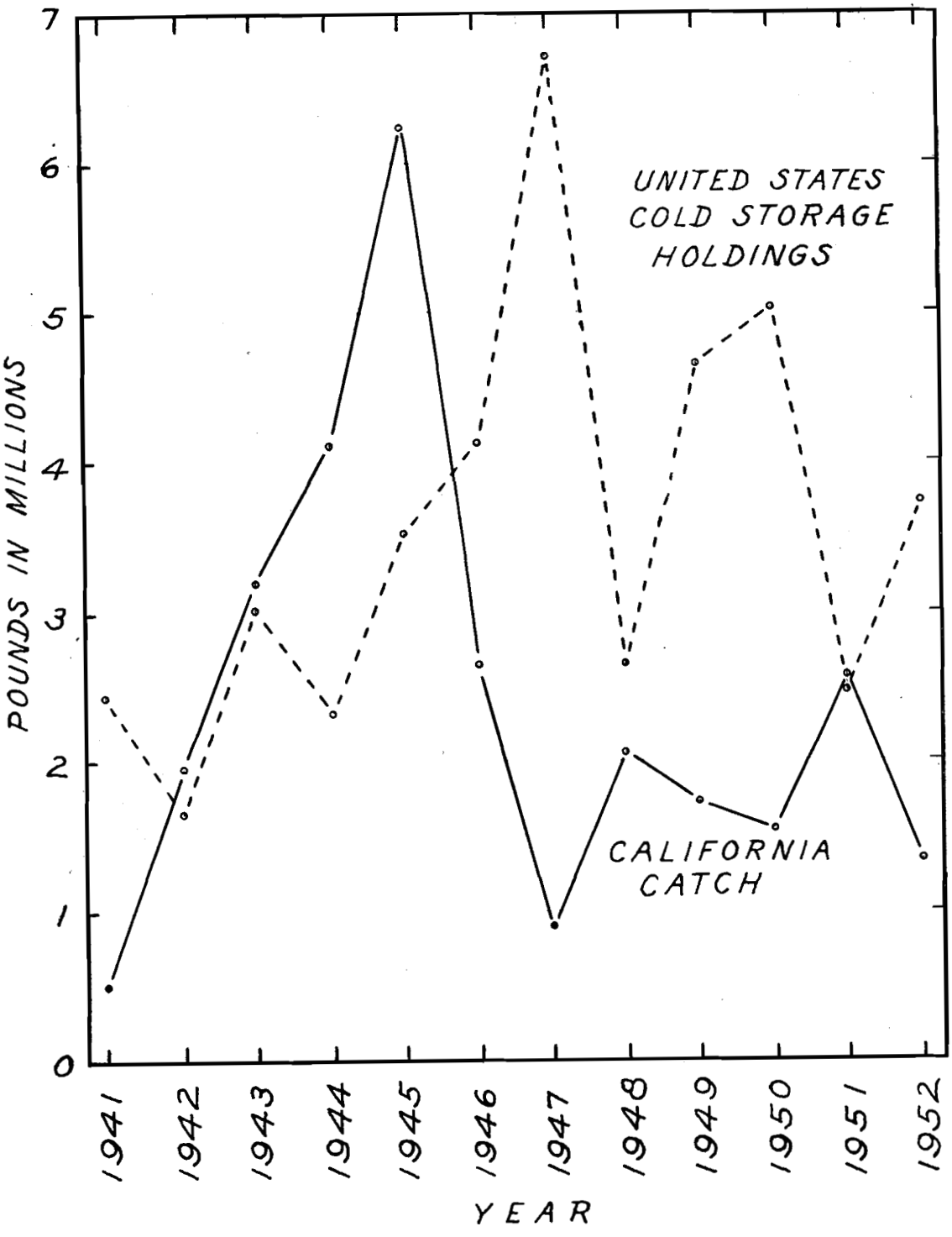

FIGURE 14. Total pounds of frozen sablefish held in cold storage in the United States, at the start of a year, and the total pounds of sablefish landed in California, during a year, for the years 1941 through 1952. (Note the high inverse correlation in the post war period—1946 or 47 to 1952.)

For the years 1950, 1951, and 1952, these imports amounted to 21 percent, 12 percent, and 40 percent of the respective California total catches for those years. Although it is obvious that imports of the magnitude represented in 1952 can have an effect on the local catch, still the effect may be compensatory. In some years, the imports may be offset by exports, one of the vagaries of American marketing methods. Although we have no records of shipments of sablefish that were made to the outside of California, we do know that certain dealers have in the past made sizeable shipments to eastern markets such as Chicago. The fairly strong inverse correlation of the California catch at the end of a year with domestic cold storage holdings at the start of a year appears to have some effect on the volume of imports. In 1950 and 1952, when the domestic cold storage holdings were above the average holdings for the 1941–1952 period, the imports into California were relatively higher than in 1951, when the cold storage holdings were below average. Fish in cold storage cannot be held indefinitely. After about a year's time, it becomes imperative that an attempt be made to clear out the old stocks, even at a low margin of profit. Not only is there an inverse correlation between the domestic cold storage holdings at the start of a year and the California catch during the year, but there is a similar inverse correlation when the Pacific Coast catch made in Alaska, Washington, Oregon, and California is combined and compared with the domestic cold storage holdings. For the 1947–1952 period, the coefficient of correlation is minus .79. In this connection, it might be pointed out that sablefish are taken only along the Pacific Coast of North America.

SUMMARY

The analysis of the condition of the stocks of sablefish is based upon the annual average pounds per delivery of the longline fleets in the Eureka, Fort Bragg, and Monterey regions during the years 1941–1952, inclusive. Ninety-five percent of the California catch in these years was made in the above regions.

The annual average pounds per delivery for the longline boats increased rapidly during the first few years and then fluctuated around a nearly horizontal trend line in later years, indicating a relative constancy in the annual return per unit of effort during the post-war years.

During the seven years following World War II, 1946–1952, the longline fleets made an annual average delivery of 1,382 pounds in the Eureka area; 1,422 pounds in the Fort Bragg area; and 683 pounds in the Monterey area.

There is a strong inverse correlation with the total United States cold storage holdings of sablefish at the start of a year and the resultant catch during that year for the post-war years.

No evidence was found to indicate a depleted condition of the stocks of sablefish in the Northern and Central California regions. The annual fluctuations in the catch are associated with demand. An inter-relationship of the coastwise fishery is indicated.

REFERENCES

CLARK, G. H.
1935. San Francisco trawl fishery. Calif. Fish and Game, Vol. 21, No. 1, pp. 22–37, 8 Figs., San Francisco.
1936. The California trawl fishery and its conservation. Calif. Fish and Game, Vol. 22, No. 1, pp. 13–26, 8 Figs., San Francisco.

CLEAVER, F. C., Editor
1951. Fisheries Statistics of Oregon. Oregon Fish Comm., Contr. No. 16, Portland.
1953. Personal Communication.

COX, KEITH
1949. Sablefish. In: The commercial fish catch of California for the year 1947 with an historical review 1916–1947. Calif. Div. of Fish and Game, Fish. Bull. 74, pp. 120–122, 1 Fig., Sacramento.

CROKER, RICHARD S.
1936. Smoked, salted and dried sea food of California. Calif. Fish and Game, Vol. 22, No. 1, pp. 1–12, 3 Figs., Sacramento.

DIVISION OF FISH AND GAME OF CALIFORNIA
1916–1926. Biennial Reports. (Includes statistics of annual, regional fish landings.) Sacramento.
1926–1951. Fish Bulletins 15, 20, 30, 44, 49, 57, 58, 59, 63, 67, 74, 80, 86, and 89. (Statistics of annual, regional fish landings.) Sacramento.

HOLMBERG, EDWIN K.
1948. Deep dragging by Eureka otter trawlers. Calif. Fish and Game, Vol. 34, No. 4, pp. 218–219. San Francisco.

JARVIS, NORMAN D.
1950. Curing of fishery products. Fish and Wildlife Service, U. S. Dept. of Int., Res. Rpt. 18, pp. 117–118 and pp. 247–249. Washington.

JORDAN, DAVID STARR
1887. The fisheries of the Pacific Coast. In: The fisheries and fishery industries of the United States, by Geo. B. Goode, Sec. 2, Pt. 16, pp. 591–629. U. S. Fish. Comm., Washington.

PACIFIC FISHERMAN. (Monthly issues and annual statistical numbers.)
1925. Vol. 23. Seattle.
1927. Vol. 25. Seattle.
1930–1953. Vols. 28–51. Seattle.

RIPLEY, WM. ELLIS
1949. Shark and shark liver. Calif. Div. of Fish and Game, Fish Bull. 74, pp. 129–134, 1 Fig. Sacramento.

SCOFIELD, W. L.
1945. The "Balloon" type otter trawl for rockfishes. Calif. Fish and Game, Vol. 31, No. 1, pp. 12–15, 1 Fig. San Francisco.
1947. Drift and set line fishing gear in California. Calif. Div. of Fish and Game, Fish Bull. 66, 38 pp., 16 Figs. Sacramento.
1948. Trawling gear in California. Calif. Div. of Fish and Game, Fish. Bull. 72, 60 pp., 24 Figs. Sacramento.

U. S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE.
1941–1951. Fishery statistics of the United States. Washington.
1942–1946. Commercial Fisheries Review (Formerly "Fishery Market News"), Vol. 4–8 (Monthly issues and special supplements relating to Office of Price Administration regulations.) Washington.

WASHINGTON STATE DEPARTMENT OF FISHERIES
1952. Washington Commercial Fishing Statistics. Seattle.

WILCOX, WILLIAM A.
1895. The fisheries of the Pacific Coast. U. S. Comm. of Fish and Fisheries Report for 1893, pp. 139–304. Washington.

THE WASHINGTON AND OREGON SABLEFISH FISHERY

F. Heward Bell
International Pacific Halibut Commission

and

Alonzo T. Pruter
Washington State Department of Fisheries

Bulletin 3
Pacific Marine Fisheries Commission
Portland, Oregon, 1954

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

THE WASHINGTON AND OREGON SABLEFISH FISHERY

INTRODUCTION

The sablefish or blackcod (*Anoplopoma fimbria*) fishery has played modest but distinctive roles in the fisheries economies of Oregon and Washington, particularly of Washington. In the latter state it contributes approximately five per cent of the total annual landed value of the catch of all species, excluding salmon and halibut, and has usually ranked seventh in value, being exceeded by salmon, halibut, lingcod, Pacific oysters, albacore, and crabs.

The fishery has provided a late summer and fall operation for a considerable number of Oregon and Washington setline vessels that fish for halibut during the spring and early summer. For the recently developed offshore trawl fisheries it supplies a limited but valuable item in the catch, possessing the highest per pound value of all species landed by that gear. For many Seattle wholesale dealers the landings of sablefish in the late fall assist in providing full productive employment of unloading crews that must still be maintained for the limited receipts of troll-caught salmon and the sporadic landings of chum salmon and other fish. For the market it contributes a smoked or salted product for whose unusually high fat content there is no satisfactory substitute.

Annual production in Washington during the years 1942 to 1952 averaged 2.5 million pounds, ranging from 1.7 million in 1945 to 3.6 million in 1951. In Oregon annual production during the same period averaged about 0.5 million pounds. Washington accounted for about one-quarter of the average 9 million pound United States, Alaska, and Canadian annual total of recent years.

Major ports of landing in Washington are Seattle and Bellingham and in Oregon, Astoria, Warrenton, and Newport (Figure 1). Minor ports are Everett, Anacortes, Neah Bay, and Aberdeen in Washington and Coos Bay and Charleston in Oregon.

Over half the Washington and Oregon production is usually frozen for subsequent salting or smoking, although there is a considerable amount salted or smoked directly or sold as fresh or frozen fillets. The ultimate disposition of most of the catch is either in the salt-fish trade of the Hawaiian plantations or for the smoked-fish trade in the United States. At reasonable prices there is a steady market for all the line-caught sablefish from Cape Flattery grounds. These fish are preferred to those from elsewhere on the coast due to their firmer flesh and larger average size.

The flesh, livers, and viscera of the sablefish possess a very high vitamin A content. In some years prior to the development of synthetic vitamin A, the financial returns to the setline sablefish fishermen from livers and viscera sales represented as high as 40 per percent of the value of their fares. Even now with depressed prices the high potency of sablefish livers results in their continued retention when livers of many other species are discarded.

HISTORY OF THE FISHERY

The development of a sablefish fishery off both the Oregon and Washington coasts largely resulted from secondary activities by Seattle halibut vessels during World War I, both halibut and sablefish being taken by the same gear and on grounds in close proximity to one another. Early governmental exploratory fishing for halibut also led to the discovery of sablefish grounds.

Before 1916, full fares of sablefish were brought in only with prior agreement of buyers, as abundant supplies of the cheaper varieties of salmon largely satisfied the demand for a fat fish by the smoking and salting trades. However, a limited trade in fresh and salt sablefish had been conducted for many years. Swan (1885) reported seeing sablefish utilized by the Indians at Neah Bay as early as 1859.

In 1914 and 1915 the United States Bureau of Fisheries survey vessel "Albatross" reported (Schmitt, Johnston, Rankin, and Driscoll, 1915; Johnson, 1917) a reasonable abundance of sablefish on Heceta Bank, Oregon, and off the Washington coast from Grays Harbor to Cape Flattery. From 1916 to 1918 most of the setline fishing for sablefish was conducted between Destruction Island, Washington and Cape Beale, British Columbia. In 1918 some of the Seattle boats went south to fish off Newport, Oregon, where they had previously observed considerable quantities of sablefish while fishing for halibut. A fishery also developed on Heceta Bank, Oregon, about 1924. Oregon-based setline vessels started fishing for sablefish on Oregon banks soon after or coincidental

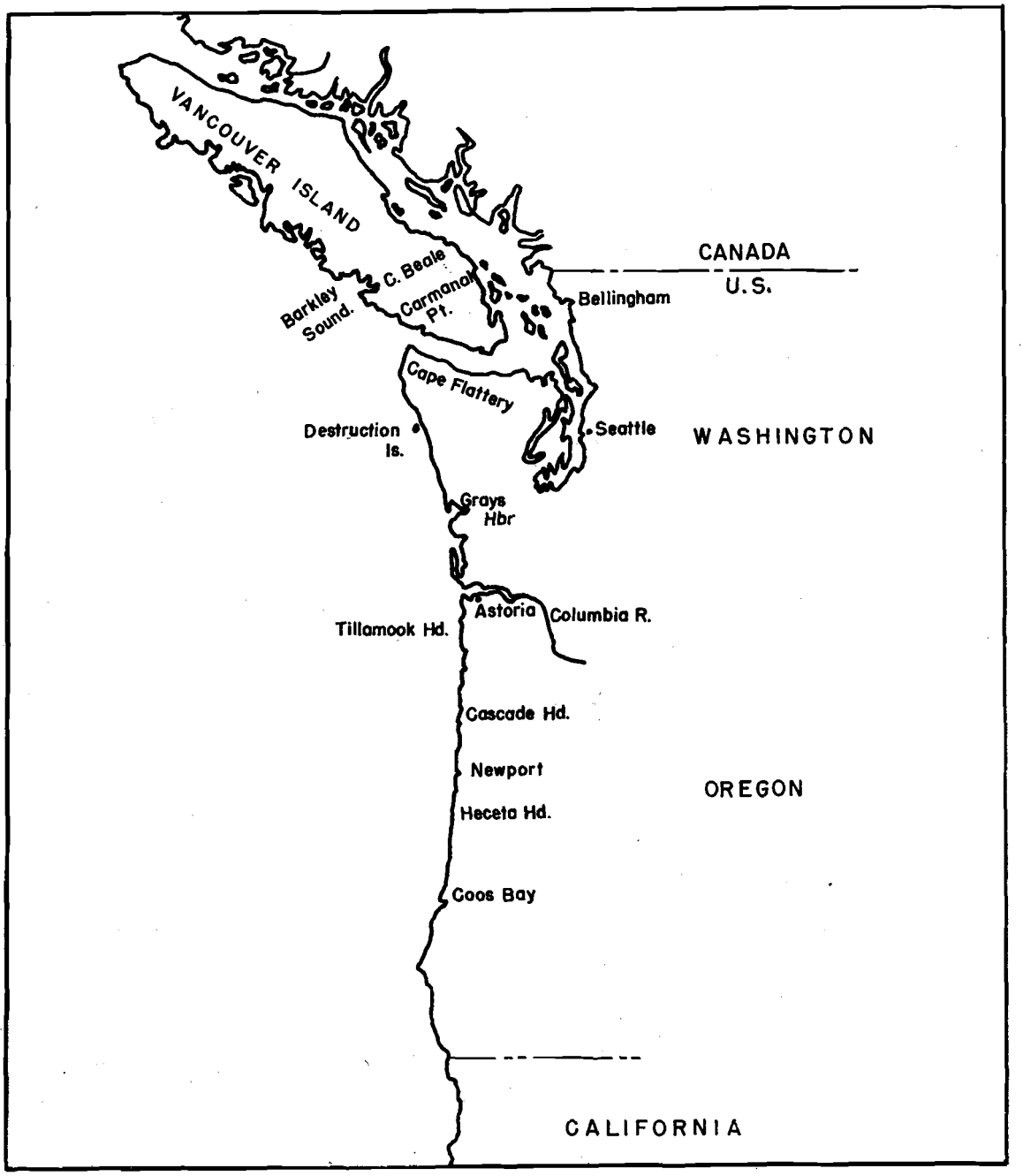

FIGURE 1. Map of Pacific Coast showing important geographical places mentioned in the report.

with their exploitation by Seattle boats. Thus by 1924 all of the major Washington and Oregon sablefish grounds had apparently been discovered and were supporting setline fisheries of some consequence.

Until 1940 these grounds were primarily exploited by setline vessels. However, the spectacular growth of the trawl fisheries during World War II resulted in a sharp increase in the percentage of the total sablefish landings taken by that gear.

LANDINGS IN OREGON AND WASHINGTON

The general development of the fishery is reflected in the landings as shown in Table 1 and Figure 2 compiled from various sources including the *Pacific Fisherman*, the U. S. Bureau of Fisheries and its successor, the Fish and Wildlife Service, the Oregon Fish Commission, the Washington

State Department of Fisheries and files of the International Pacific Halibut Commission. The catches are presented as four-year averages to conserve space, with the exception of the years 1915–1918 and 1939–1952, which include the two wartime periods of expansion. The landings prior to 1941 are given as dressed weights, but the Oregon trawl-caught component after 1941 and the Washington trawl landing from 1941 to 1947, inclusive, include some round-weight poundage which is only separable by an estimate based on a limited sample of the landings and experience with the fishery.

TABLE 1. WASHINGTON AND OREGON LANDINGS OF SABLEFISH IN THOUSANDS OF POUNDS, 1915–1952.

Year	Washington	Oregon	Year	Washington	Oregon
1915	576	16	1942	2449	624
1916	2039	25	1943	2309	1116
1917	2430	350	1944	3081	568
1918	4355	250	1945	1711	370
1919–22*	1259	139	1946	3332	1065
1923–26*	2140	287	1947	2098	174
1927–30*	2397	247	1948	2072	484
1931–34*	1649	67	1949	2777	409
1935–38*	2799	158	1950	2218	344
1939	3067	98	1951	3571	552
1940	2438	67	1952	2302	261
1941	2295	261			

*Annual average.

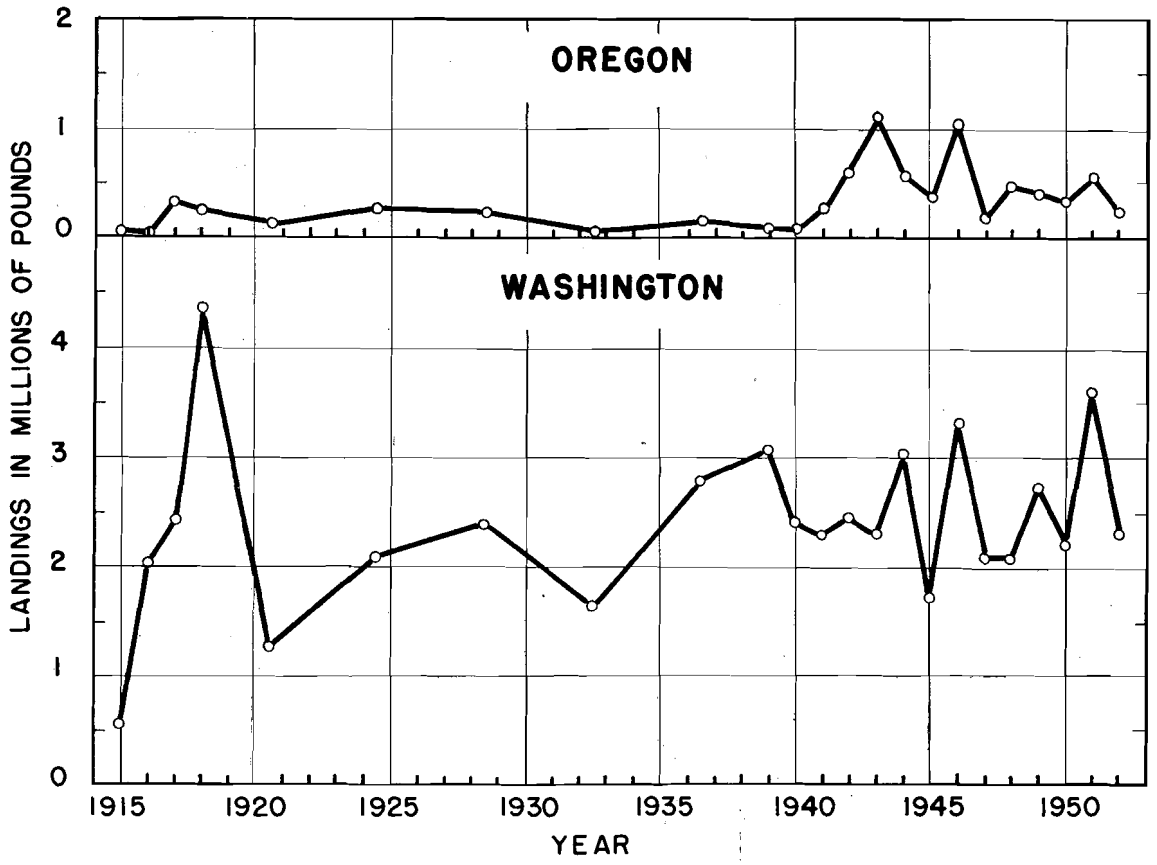

FIGURE 2. Washington and Oregon landings of sablefish. Annual averages of four-year periods shown from 1919 to 1938.

The acute World War II demand for food fish resulted in considerable quantities of very small one- to two-pound dressed-weight sablefish being marketed in both Oregon and Washington from 1943 to about 1946, and such poundage is included in Table 1. Some are still unavoidably caught but are discarded at sea and consequently not included in the statistics. In addition there are in-

significant quantities of troll-caught sablefish which are not shown in the statistical tables of this report.

From 1915 to 1941 the Oregon landings averaged about one-quarter million pounds per year. The commencement of trawling resulted in the production of about 1.0 million pounds by 1943. Since that time the trend has been downward but it is still above its early level.

The Washington production shows a typical sharp rise in the early years resulting from exploitation of virgin stocks under the impetus of a World War I market. A postwar market collapse about 1920 and a declining catch per unit of effort reduced the interest in the fishery with a consequent lowered production. From 1920 to 1940, two periods of increasing production occurred, separated by a recession in the early 1930's. These changes coincided with the commodity price trends of those two decades.

After 1940 the course of total annual landings in Washington was affected by the amount landed by the expanding trawl fishery and the sale by that fleet of considerable amounts of very small sablefish during World War II. Even when the inclusion of such small fish is discounted a general upward trend in production of recent years is still observable. The relative failure of the Northwest albacore (*Thunnus germo*) fishery, the continued shortening of the halibut fishing season, and a strong sablefish market have tended to increase the fishing intensity in the late summer and fall. The frequent repetition of alternate annual rises and declines in total production arises chiefly from the carry-over effect of frozen stocks from years of higher production.

CATCH BY GEAR

The relative magnitude of setline and trawl landings of sablefish in Oregon and Washington is shown in Table 2 and the annual proportion taken by each gear is shown in Figure 3. The heavy World War II demand for sablefish of all sizes resulted in heavy landings by trawlers which are known to have contained large proportions of very small fish from one to two pounds in weight. In Oregon, trawl gear accounted for 70 to 95 percent of the total landings during the years 1942–45. Washington trawlers also made large landings of sablefish during this period, but they did not account for as large a percentage of the total as in Oregon. They provided between 40 and 60 percent of the Washington totals in those years.

TABLE 2. WASHINGTON AND OREGON SETLINE AND TRAWL LANDINGS OF SABLEFISH IN THOUSANDS OF POUNDS, *1935 TO 1952.

	Washington			Oregon		
Year	Setline	Trawl	Total	Setline	Trawl	Total
1935	2822	10	2832	....	....	91
1936	2508	23	2531	....	....	270
1937	3019	0	3019	....	....	148
1938	2785	30	2815	....	....	124
1939	2997	70	3067	....	....	98
1940	2282	156	2438	....	....	67
1941	1903	392	2295	....	....	261
1942	2163	286	2449	76	548	624
1943	1532	777	2309	37	1079	1116
1944	1274	1807	3081	24	544	568
1945	975	736	1711	111	259	370
1946	2632	700	3332	612	453	1065
1947	1942	156	2098	119	55	174
1948	1758	314	2072	397	87	484
1949	2191	586	2777	325	84	409
1950	1720	498	2218	197	147	344
1951**	2312	1259	3571	256	296	552
1952**	1659	643	2302	61	200	261

*No segregation by gear available for Oregon prior to 1942.

Oregon **totals for 1951 and 1952 are final figures, but the breakdown by gear for these two years is subject to further revision.

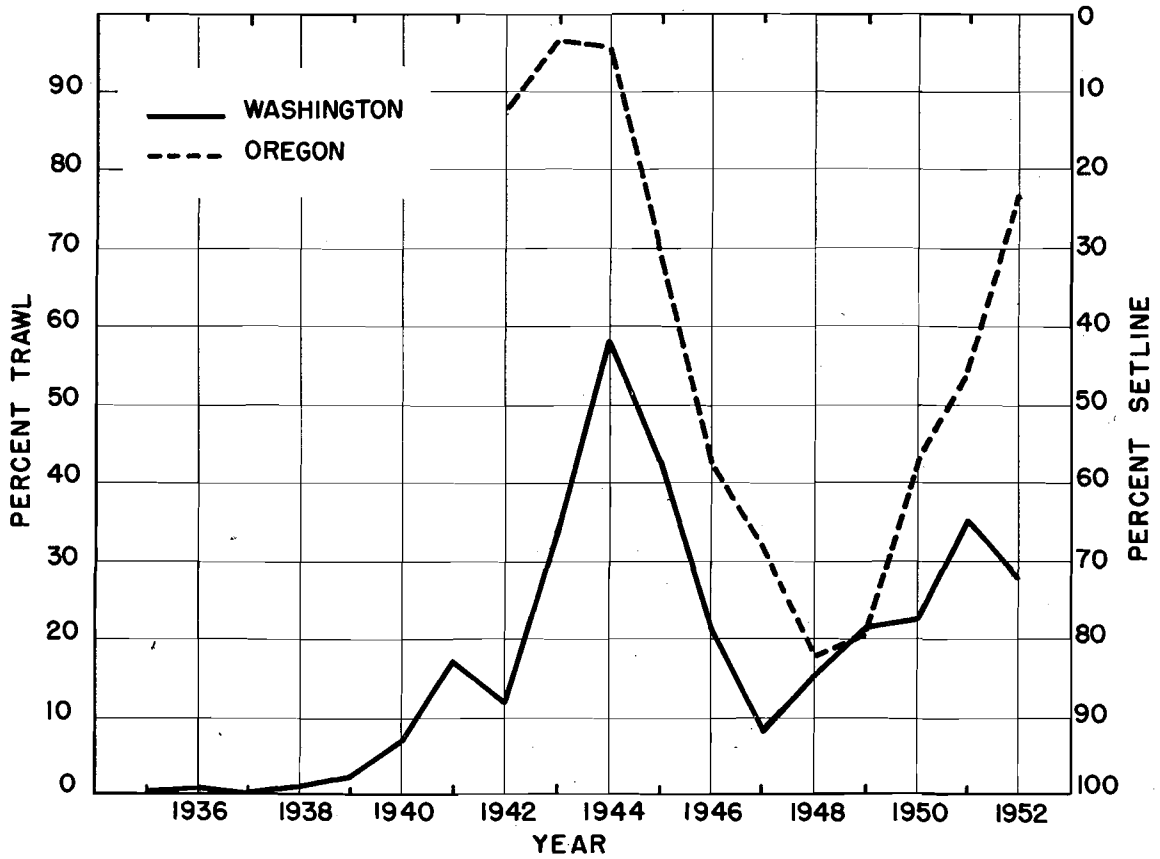

FIGURE 3. Percent of total landings of sablefish in Oregon and Washington made by setline and trawl vessels.

Latterly, the proportion caught by trawl gear by the Washington fleet has increased from a postwar low of 10 percent to a present level of about 30 percent and with the Oregon trawlers it has increased from about 20 percent to 70 percent. The recent tendency of the Oregon and Washington trawl fleets to fish in deeper water where large sablefish are found and the maintenance of a good market demand for sablefish in contrast to the decline in demand for some species of bottom fish may have contributed to the increased trawl catches of sablefish in both states.

Though the trawl catch is secondary in poundage landed, the number of fish caught exceeds that taken by line gear. In 1952 about 70 percent of the Seattle-landed trawl-caught sablefish were under five pounds in weight compared to 17 percent in the setline catches.

The market price of trawl-caught sablefish is usually about two-thirds that for the setline fish of the same size because of the superior condition of the latter. Also the fish under five pounds command but one-half the price paid for the larger sizes. These price and size differentials make the relative financial returns from the setline-caught sablefish much greater than is shown by the comparative total landings by the two gears.

SIZE OF FLEETS

During the 1947–52 period an annual average of about 47 setline vessels participated in the Cape Flattery sablefish fishery, and each made an average of approximately four trips each year. During the same period an annual average of about 13 setline vessels participated in the fishery off Oregon and made an average of slightly over two trips per boat each year. About 283 men are represented in the crews of the vessels fishing the Cape Flattery grounds each year and 86 men in the crews of vessels fishing off Oregon each year during the period.

The above figures include trips concluded in both Washington and Oregon ports during the regular sablefish season. They do not include trips made during the halibut season when sablefish are incidental to the halibut catches.

SEASON OF THE FISHERY

The present seasons of the Washington and Oregon fisheries are shown in Table 3 and Figure 4. About 90 percent of the Washington setline landings and about 75 percent of the Oregon setline landings are made in the months of August, September, October, and November. About 80 percent of the Oregon trawl landings of sablefish are made during the months of June, July, and August. Approximately 80 percent of the annual Washington trawl landings of sablefish are made during the months of July, August, September, and October.

TABLE 3. SEASONAL SETLINE AND TRAWL LANDINGS* OF SABLEFISH IN OREGON AND WASHINGTON

Month	WASHINGTON		OREGON	
	Percent Setline	Percent Trawl	Percent Setline	Percent Trawl
January	0.04	1.0	0	0.2
February	0.1	0.3	0	0.1
March	0.2	0.2	0	0.6
April	0.2	0.5	0.1	0.5
May	0.4	1.8	2.3	3.7
June	2.1	5.7	11.3	19.9
July	6.9	19.5	10.2	37.9
August	14.5	19.6	9.9	24.6
September	29.4	21.1	24.1	7.2
October	30.4	23.9	28.3	4.1
November	15.1	5.4	13.5	1.0
December	0.5	0.8	0.3	0.1

*Based on average 1942 to 1950 for Oregon and 1943 to 1952, not including 1946, for Washington.

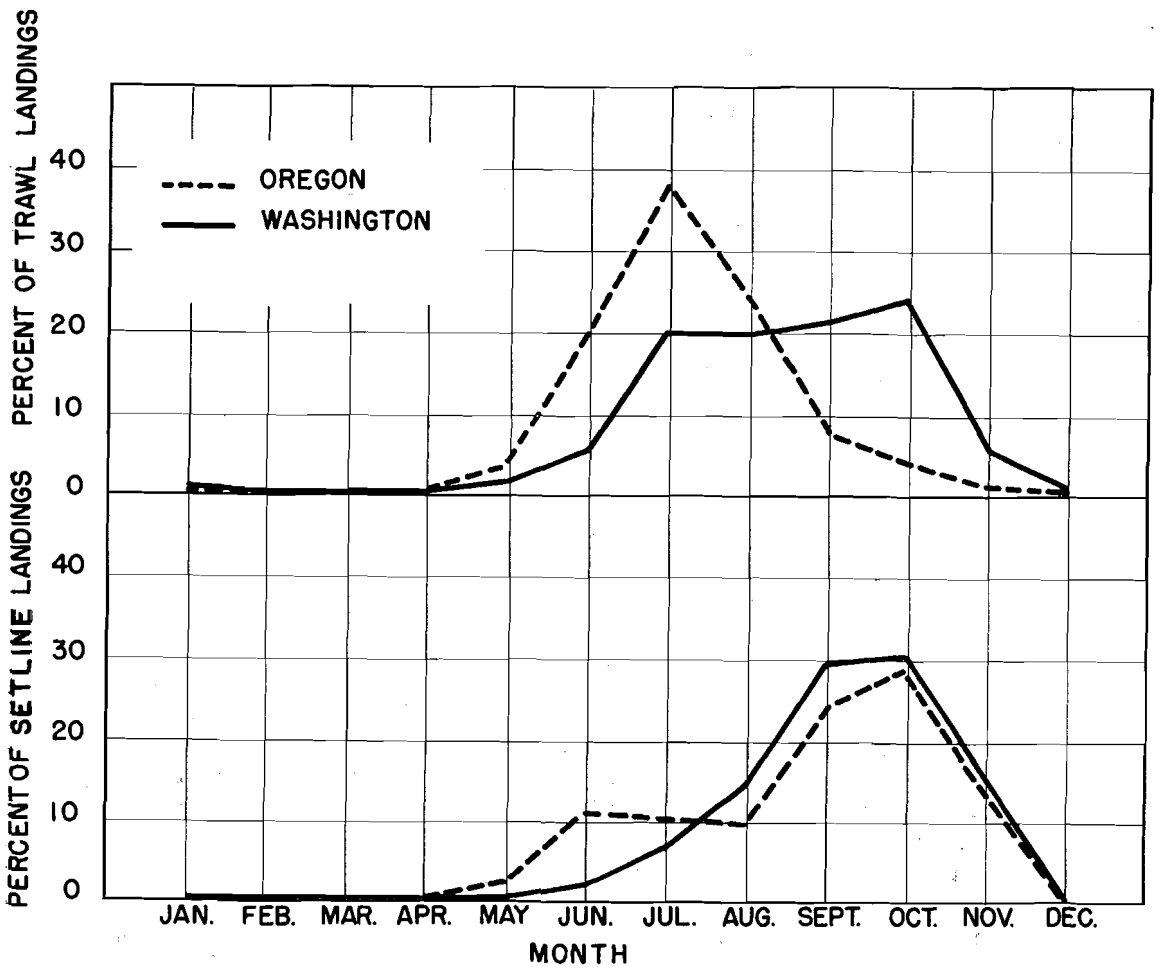

FIGURE 4. Seasonal setline and trawl landings of sablefish in Oregon and Washington.

Since there is a reasonably active trawl fishery during the other months of the year, the fall concentration of landings suggests that Washington and no doubt Oregon sablefish are relatively unavailable during the late winter and spring months. It has also been observed that Washington setline vessels fishing for lingcod on the offshore grounds during the winter and early spring rarely encounter any quantity of sablefish.

The winter period of relatively low availability corresponds to some clues concerning their spawning period. Interviews with 15 captains of long experience with Cape Flattery setline fishing revealed that the ovaries of the sablefish in that region showed signs of enlargement and that the ova increased in size and fluidity in late October and early November. Only two of the men had seen the ova in a ripe or "running" condition. Spawning appears to take place shortly thereafter as all of the few sablefish caught early in the year on the Cape Flattery grounds are in a "spent" state.

CONDITION OF THE STOCKS

In an uncontrolled fishery, such as that for the sablefish, it is probable that the stocks will be maintained at marginal economic levels of yield rather than at maximum biological levels which in most fisheries are usually higher. At stock levels determined by economic considerations, returns to the fishermen will be the lowest commensurate with the maintenance of a fishery. Under such conditions, Cape Flattery sablefish, whose high quality results in a very persistent market demand, will probably continue to be exploited when it is no longer profitable to fish other stocks.

The extent to which the Oregon and Washington stocks may be above or below their most productive levels cannot presently be ascertained. There is an insufficiency of information on many features of the sablefish stocks; such as their inter-relationships, age at maturity, natural and fishing mortality rates, age composition, and growth rates.

CAPE FLATTERY STOCKS

The Cape Flattery fishery, defined as that between Destruction Island and Barkley Sound, has shown from time to time minor shifts in location within these boundaries. In 1916 fishing was conducted between Cape Flattery and Cape Beale. In 1917 the fishery extended south to Destruction Island. Other sections were brought into production from time to time. The grounds off Carmanah Point, Vancouver Island, were explored in 1922, and from 1924 to 1940 they produced a considerable portion of the total catch. With the decline of the Carmanah grounds the yield became largely dependent upon the production from more restricted "spots" in the whole region.

Yields from Cape Flattery fishery

The proportion of the Washington State total setline catch to be credited to the Cape Flattery area as defined above has been determined by prorating the total catch according to the representation of the area in the log book records of fishing locations. As no accurate data on the area of origin of the trawl catches is available except for very recent years, estimates must be made for earlier years of the proportion of the Washington trawl total that was caught in the Cape Flattery area.

From April to September, 1953, about 70 percent of the recorded Washington total trawl catch of marketable sablefish was taken from the Cape Flattery region.

Limited returns from tagging experiments provide some indication that the trawl and setline fisheries may not proportionately utilize the same populations in the Cape Flattery area. Of 20 recoveries of setline-caught tagged sablefish 18 were recovered by that fishery and two by trawl gear. Of 42 recoveries of trawl-caught tagged fish 26 were recovered by the same gear and 16 by setline gear (Holmberg and Jones, 1954).

The two fleets also tend to fish on different parts of the area, the setliners usually in deeper water. Washington trawlers have not extended their operations to as deep water as have the Oregon boats in the latter's pursuit of dover sole (*Microstomus pacificus*) and Pacific ocean perch (*Sebastodes alutus*). Their catches also show differences in size composition though this is partly a function of the gear itself.

In order not to underestimate the total removals from the Cape Flattery stocks estimates have been made of the proportion of the total Washington trawl catch of sablefish that may be considered as additional to the setline removals from that stock. In making these estimates for each period of

the fishery consideration has been given to the widening geographical range of operations of the Washington trawl fleet, to the tagging returns that show some lack of homogeneity of the stocks fished by the two gears, and to the retention or non-retention of the very small sizes during different periods.

For 1935 to 1942 about 70 percent of the state totals of trawl-caught sablefish was considered as Cape Flattery removals. For 1943 to 1946 only 25 percent was included to discount the effect of the large landings of very small sablefish which occurred at that time. Prior and subsequent to this period such sizes were discarded at sea. After 1946 with allowances for the geographical expan-

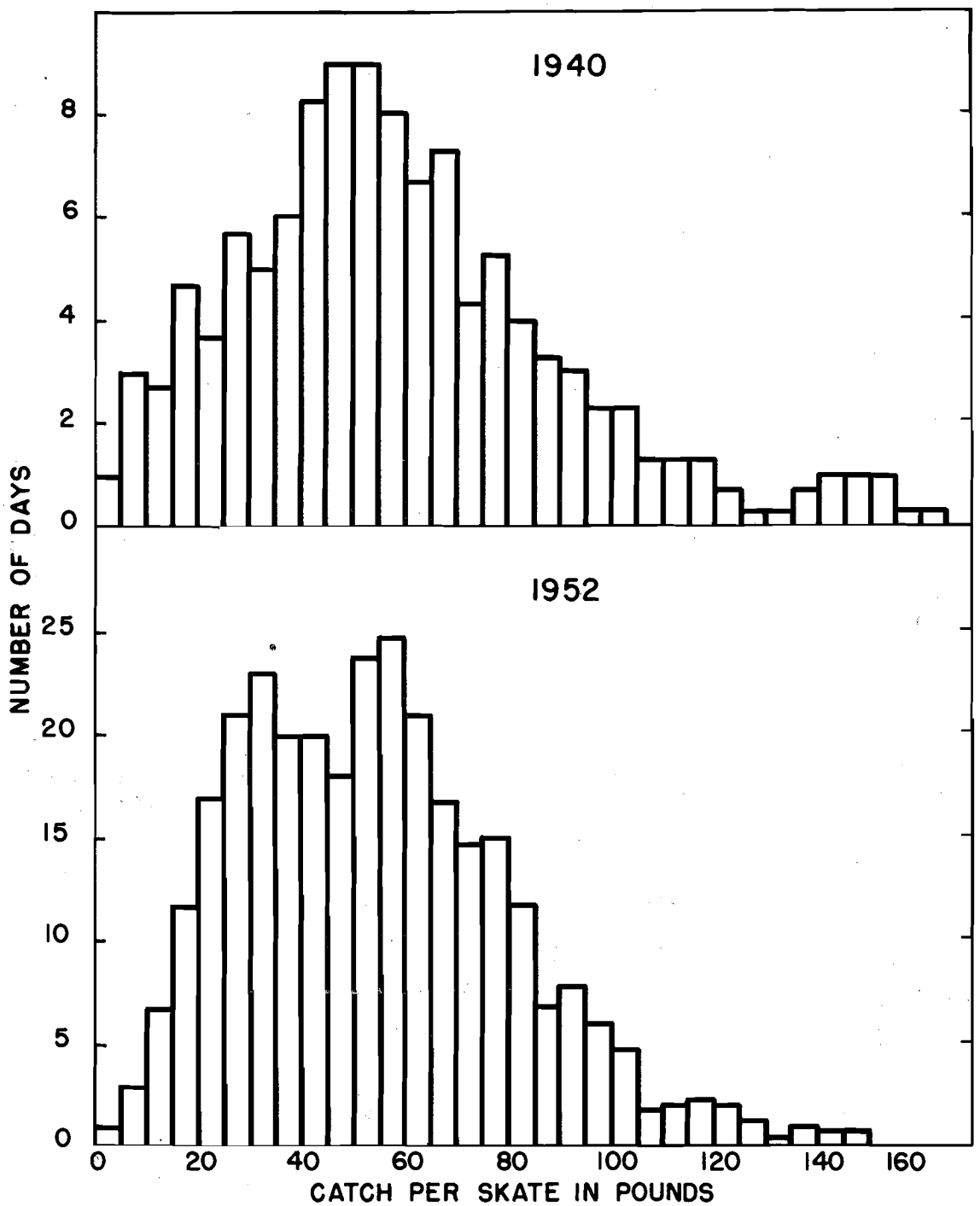

FIGURE 5. Average catch of Cape Flattery sablefish per skate of setline gear per day's fishing in 1940 and 1952. Grouped by 5 pound intervals and smoothed by a moving average of three.

sion of the fishery and the results of tagging experiments an estimated 40 percent was credited to the Cape Flattery removals.

Measures of Abundance

The International Pacific Halibut Commission has collected records of the sablefish operations of the setline fleets while obtaining log book records of the incidental catches of halibut. Since 1937 setline vessels have been permitted under the Commission's regulations to land one pound of halibut for every seven pounds of other species caught while fishing in areas closed to halibut fishing. The log book entries list the number of skates of line gear fished in individual areas each day and the estimated catches of sablefish. By dividing the catches by the number of skates of gear fished the arithmetic mean of the return per unit fishing effort is thus obtained. Such returns per unit effort can then be compared to provide a measure of the changes in relative abundance which may have occurred.

Since the mean catch per skate, as shown in Table 4, when based on a limited amount of data can be distorted by extreme individual values, there is the possibility that such a measure does not represent the average abundance for the year. The distribution of the average catch per skate per day for a randomly selected group of vessels fishing in 1940 and 1952 is shown in Figure 5. This shows the wide range in the average catch per skate, which varied in 1940 from as low as one pound to as high as about 160 pounds per skate. The modal catches, *i.e.*, the most frequently occurring value of the catch per skate both in 1940 and 1952, as shown in Figure 5, are approximately the same as were the arithmetic means for these two years, which were 54 and 56 pounds respectively. This correspondence indicates that the means were not unduly affected in any one year by anomalies caused by the effects of unusual weather, "shaking" of gear, the unrecorded diversion of attention to other species on certain days, or by errors in the log books or in the copying thereof.

On account of changes occurring in the gear from time to time, a six line, 300 fathom, hemp "skate" with hooks placed 13 feet apart was taken as standard and other types were equated to that base. The daily estimates of catch from the log books have been tested by comparison with the trip totals as subsequently weighed out to the buyer. For example the log book estimates and actual weights of sablefish in the fares landed at Seattle in 1952 were within two percent of one another. Only those daily records in which sablefish appeared to be the primary objective of fishing have been used.

In order to remove the effects of the uncertain availability and weather of the early and late season fishery on the catch per skate, only the log records for August, September, and October operations have been utilized in determining the annual average catch per skate. This period includes about 75 percent of the normal seasonal sablefish activity of the setline fleet according to a 10 year average.

TABLE 4. TOTAL LANDINGS OF CAPE FLATTERY SABLEFISH IN THOUSANDS OF POUNDS, CATCH PER SKATE IN POUNDS, AND CALCULATED NUMBER OF SKATES FISHED, 1917 TO 1952

Year	Landings	Catch per Skate	Number of Skates Fished	Year	Landings	Catch per Skate	Number of Skates Fished
1917–18*	3392	250.0	13,568	1936	2004	58.4	34,315
1919	1554	205.6	7,558	1937	2229	56.3	39,591
1920	950	180.6	5,260	1938	2305	59.9	38,481
1921	1519	157.5	9,644	1939	2300	53.6	42,910
1922	1010	129.4	7,805	1940	2150	53.7	40,037
1923	2104	113.0	18,619	1941	1961	59.4	33,013
1924	1964	108.5	18,101	1942	2096	73.8	28,401
1925	1710	111.4	15,350	1943	1624	63.2	25,696
1926	1458	108.3	13,463	1944	1495	57.0	26,228
1927	1486	99.2	14,980	1945	1130	59.0	19,153
1928	1389	95.4	14,560	1946	2278	53.6	42,500
1929	1968	88.8	22,162	1947	1662	53.7	30,950
1930	2450	79.3	30,895	1948	1625	53.7	30,261
1931	1149	76.4	15,039	1949	2291	50.1	45,729
1932	1464	73.6	19,891	1950	1757	58.0	30,293
1933	1080	70.8	15,254	1951	2750	42.4	64,858
1934	1759	68.0	25,868	1952	1584	55.7	28,438
1935†	2119	64.9	32,650				

*Average of two years.
†Totals after 1934 vary slightly from previously published figures due to different source materials.

The catch of sablefish per unit of trawling effort is not usable as an index of changes in relative abundance of the stocks due to the very secondary nature of that species in the trawl catch. Furthermore, other indices of abundance such as daily boat catch or landings per day's absence are subject to much question when the fares consist of significant amounts of several species.

Catch per skate

The annual catch per set of a standardized skate, the annual removals by both setline and trawl vessels, and the calculated total number of skates fished on the grounds in the Cape Flattery region from 1917 to 1952 are shown in Table 4 and Figure 6. The calculated number of skates was determined by dividing the total removals or catch by the catch per skate. This reduces the trawl-caught component in the catch to a setline basis as it is not possible to combine the two measures of fishing effort.

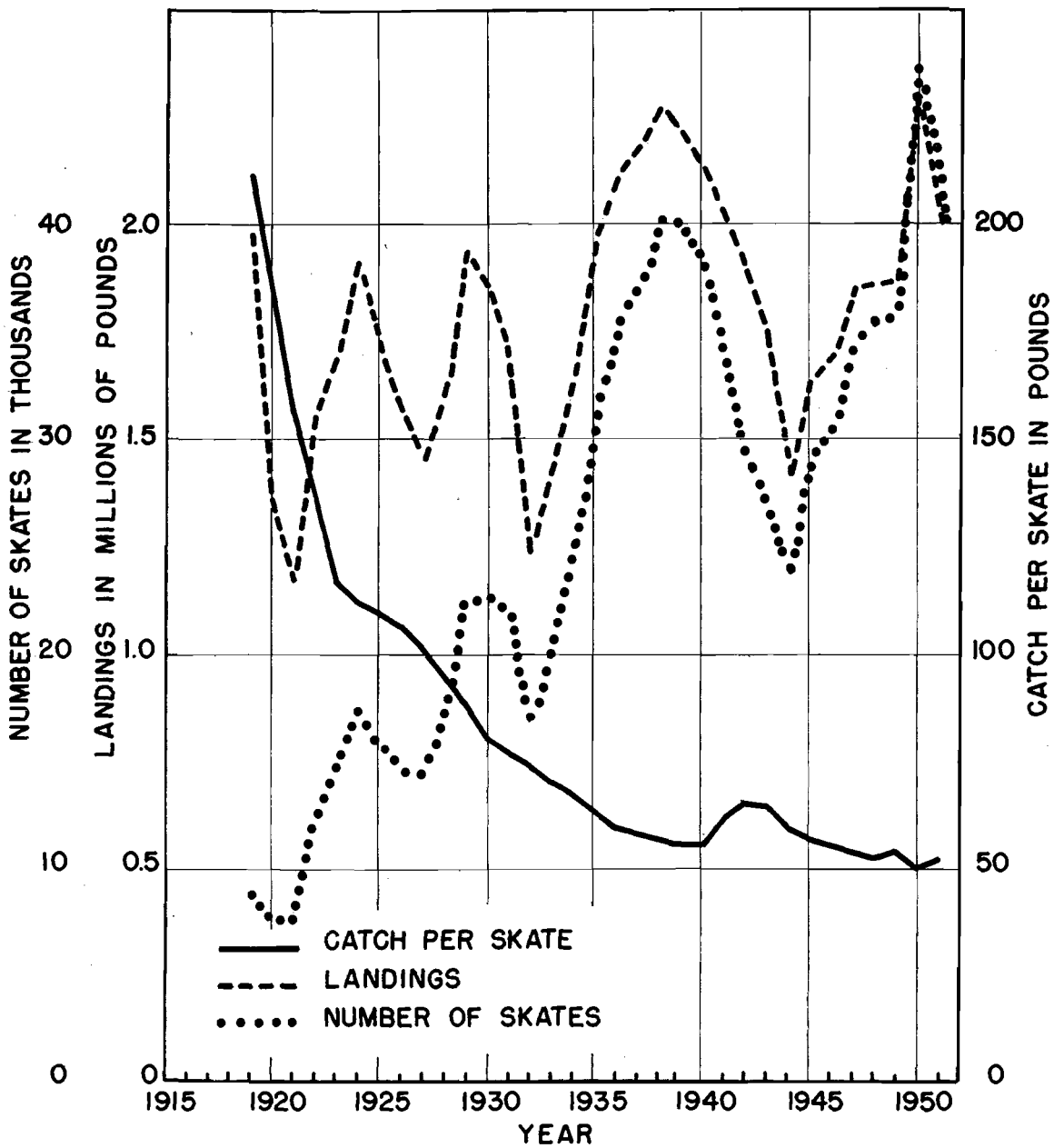

FIGURE 6. Total landings, catch per skate, and calculated number of skates fished in the Cape Flattery area. Smoothed by a moving average of three which eliminates plots for first and last year.

The catch per skate declined from approximately 250 pounds at the time of the first heavy fishing in 1917–1918 to 54 pounds in 1939–1940. The temporary improvement in 1942 and 1943 was not sustained, and the catch per skate reached an all time low of about 42 pounds in 1951. Short term changes in the catch per skate have become more pronounced in recent years, probably partly as a result of the increasingly "spot-fishing" nature of the fishery. Also the effects of varying availability may be more pronounced at low stock levels and the reduction in average size reduces the buffering effect of more numerous year classes in the fishable stock.

There are three distinct phases observable in the general decline of the catch per skate. They can be better seen in Figure 7 where the logarithms of the catch per skate, the calculated number of

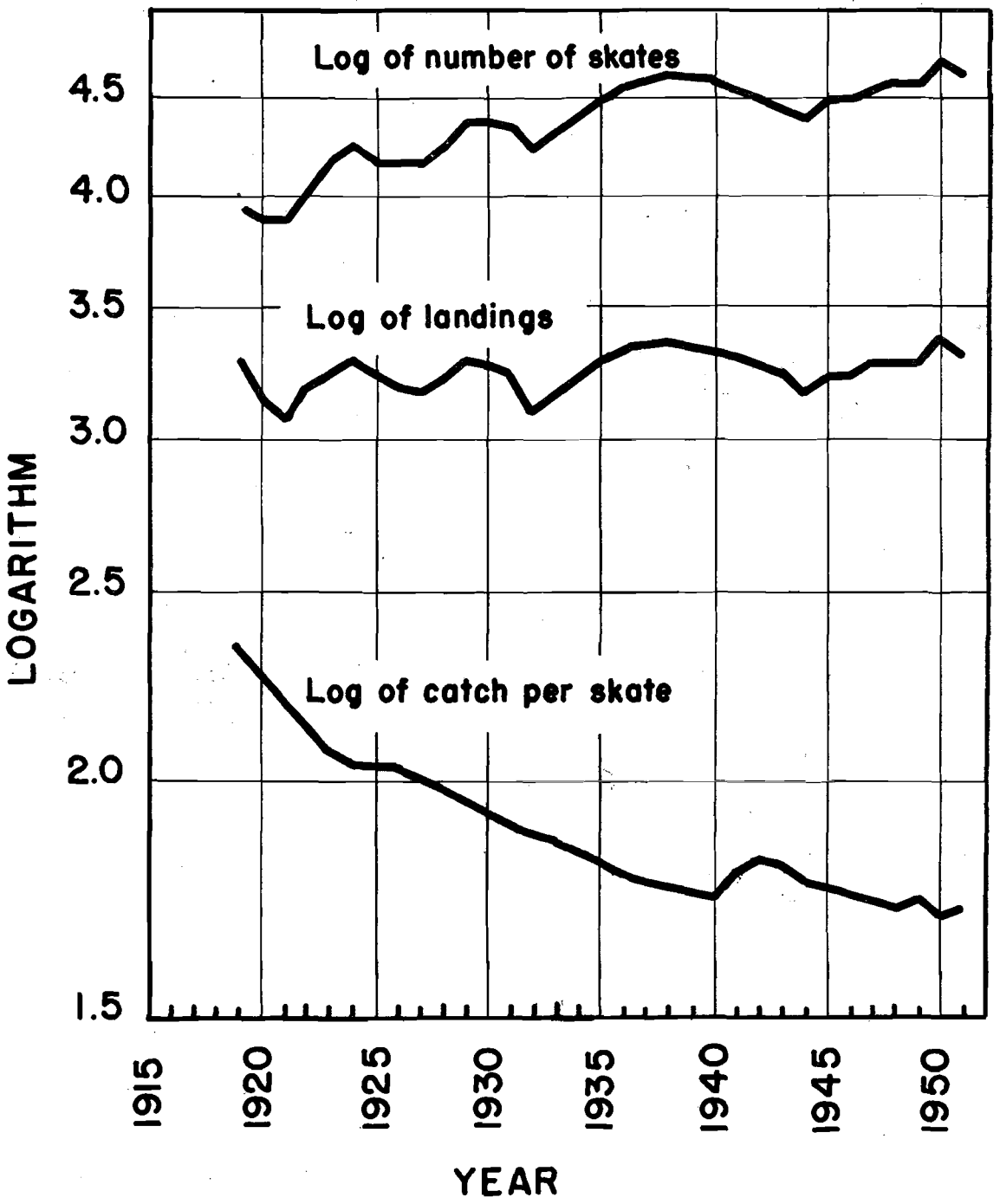

FIGURE 7. Logarithms (smoothed by moving average of three) of landings of sablefish, catch per skate, and calculated number of skates fished in the Cape Flattery area.

skates fished, and the total landings each year from 1917 to 1952 are plotted as three-year moving averages. As in Figure 6, smoothing eliminates plots of the first and last year.

The initial sharp decline in abundance which occurred following 1917–18 was a normal reaction of a virgin stock of fish to a fishery. In the few other marine fisheries where measures of early stock size are available, similar declines have been noted.

A peculiarity common to these fisheries is that the early declines in stock size appear to be entirely disproportionate to the removals. When the same production is taken from a more mature fishery, the rate of decline appears to be much less. The catch per skate of sablefish declined from 250 pounds in 1917 to 129 in 1922, a 48 percent drop from the virgin state as a result of total removals of 11,800,000 pounds. In contrast, the drop in abundance in the five years from 1923 to 1927 of only 12 percent resulted from a removal of 8,700,000 pounds.

Such disproportionate declines have also been observed in several instances in the Pacific halibut fishery such as on west of Cape Spencer grounds from 1915 to 1918 (Thompson, Dunlop and Bell, 1931) in the Barents Sea plaice fishery, 1906 to 1912 (Russel, 1942) and in the Bear Island halibut fishery, 1931 to 1936 (Devold, 1938). They are inevitable results arising from the basic forces controlling the population size of any living organisms and from the manner in which fishing is usually conducted on previously unfished stocks. It would be naive to attribute all such abrupt declines to some cataclysmic natural change.

In the primeval state the stock levels on the average may be regarded as relatively stable wherein growth and reproduction are in balance with natural mortality. Consequently at the outset of fishing most of the yield comes from the accumulated stock. Very sharp declines are inevitable because there is no immediate compensating acceleration in the buildup forces, namely reproduction, growth, and recruitment to the fishable stock. However, once fishing is underway lowered natural mortality, accelerated growth and recruitment make their contributions to the yield.

The character of fishing on new or virgin stocks possesses certain distinctive features that also contribute to the apparently disproportionate decline in abundance. Discovery and early exploitation of new grounds has usually been by relatively few vessels which at the outset concentrate their operations on the very productive "discovery claims." The catch per unit effort declines sharply as the limited fleet has not been drawing upon the total stock but only upon a limited portion of it in the "discovery" section. As time goes on the usually expanded fleet distributes itself over a broader area and the catches become more representative of the whole stock.

The second phase, 1925–1941, of the decline in catch per skate of the Cape Flattery sablefish stocks was at a lesser rate and not unlike that observed for the decline in abundance of halibut between Cape Scott and Dixon Entrance between 1913 and 1927 (Thompson, Dunlop and Bell, 1931).

The third phase, 1942 to 1952, shows a rate of decline similar to that of the second phase but on a higher level due to a notable but short term increase in the catch per skate between 1940 and 1942.

Decline in Average Size

A considerable decline in the average size of Cape Flattery sablefish is evident from the log records which gave counts and weights of fish and from the testimony of the fishermen. In 1917 and 1918 the fish averaged 15 to 17 pounds and from 1930 to 1940 averaged 12-13 pounds. By 1952 the average weight of line-caught sablefish on these grounds had declined to about 8 pounds.

Fishing Intensity in Relation to Yield

The Cape Flattery fishery since 1917–18 has been characterized by a generally increasing fishing intensity accompanied by a downward trend in abundance. The trend of landings has been maintained only by continually increasing the amount of gear fished.

Within these general trends three distinct phases are evident both in the landings and in the intensity of fishing. These are best seen in the logarithmic curve (Figure 7) and they appear to reflect changes in general economic conditions.

The drop in yield and intensity in 1919 and 1920 coincides with post World War I market recession and the sharp decline in abundance. Increasing intensity of fishing in the 1920's may be attributed to rising prices in that decade. It was not accompanied by a proportionate increase in landings due to continued decline in the catch per unit effort. With the depression and collapse of

prices in the early 1930's and the continued fall in abundance, the vessels were forced to reduce their activity and landings declined.

After the depression the rising price scale encouraged an increase in fishing and production rose. During World War II both fishing and landings declined partly as a result of diversion of the fleets to other more profitable fisheries such as for soup-fin shark (*Galeorhinus zyopterus*). This decline in fishing intensity and reduction in the removals may have contributed in part to the improvement in the catch per skate which occurred at this time. The very low production in 1945 with little carry-over of frozen stocks coupled with the sharp rise in the price of sablefish and the failure of other fisheries stimulated greater activity in 1946 with a consequent rise in production.

OREGON STOCKS

As was noted earlier, the production of sablefish off the Oregon coast has never approached the magnitude of that from the Cape Flattery region although sablefish were found in commercial quantities in the two areas about the same time.

The most important Oregon grounds are located off the Columbia River, off Newport, and on Heceta Bank. Other "spots" have been fished at various times, the two most prominent being off Tillamook and Cascade Heads.

Yields and Catch per Skate

The Oregon landings shown in Table 1 and Figure 2 do not show the full extent to which the Oregon stocks have been exploited. During the 30 years, 1922–1952, log records indicate that a

TABLE 5. LANDINGS OF OREGON SABLEFISH IN THOUSANDS OF POUNDS BY WASHINGTON AND OREGON VESSELS, CATCH PER SKATE IN POUNDS, 1915 TO 1952

Year	Washington Setline Landings	Oregon Landings		Total Landings Setline and Trawl	Catch per Skate
		Setline	Trawl		
1915		16		16	
1916		25		25	
1917		350		350	
1918		250		250	
1919		300		300	
1920		100		100	
1921		100		100	
1922	4	57		61	
1923	5	250		255	
1924	66	161		227	
1925	630	348		978	125
1926	625	387		1012	
1927	940	366		1306	
1928	863	280		1143	
1929	283	152		435	
1930	209	190		399	119
1931	150	64		214	116
1932	227	79		306	
1933	200	24		224	119
1934	500	102		602	
1935	700	91		791	73
1936	350	270		620	
1937	600	148		748	
1938	450	124		574	
1939	626	98		724	
1940	250	67*		317	71
1941	216	261*		477	85
1942	267	76	548	891	65
1943	102	37	1079	1218	66
1944	230	24	544	798	
1945	29	111	259	399	76
1946	529	612	453	1594	88
1947	342	119	55	516	63
1948	259	397	87	743	54
1949	134	325	84	543	51
1950	162	197	147	506	79
1951	66	256	296	618	24
1952	332	61	200	593	81

*Includes an unknown quantity of trawl-caught fish.

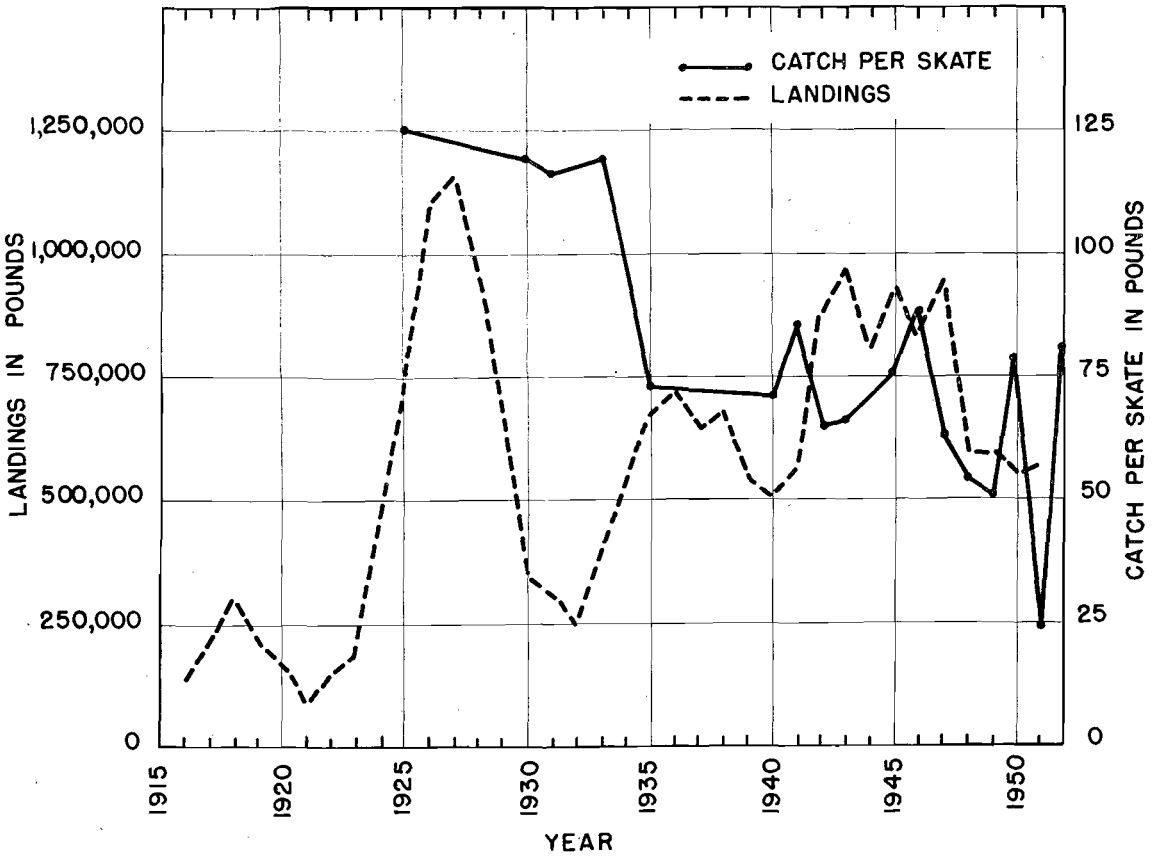

FIGURE 8. Landings by Oregon and Washington setline and trawl vessels of Oregon-caught sablefish and catch per skate. Landings smoothed by a moving average of three.

minimum of some 10.5 million pounds of Oregon-caught sablefish were landed by Washington setline vessels in Seattle. The yearly totals of these Oregon line-caught fish landed in Washington are shown in Table 5 along with all the Oregon landings of both setline and trawl vessels. The catch per skate for those years for which some log data were available, though meager, is also included in the table.

Results of tagging experiments have indicated that the Oregon trawl and setline fisheries may be largely based upon the same population or populations of sablefish, as contrasted to the somewhat separate nature of the two fisheries in the Cape Flattery area. Of 15 recoveries of sablefish which were tagged aboard setline vessels off Oregon, 9 were recovered by setline and 6 by trawl vessels and of 32 recoveries of fish tagged aboard trawl vessels, 17 were subsequently caught by setline and 15 by trawl vessels (Holmberg and Jones, 1954), the ratio of returns between gears being of the same general magnitude in both cases.

The limited extent of the fishery and of the data thereon precludes any emphasis being placed upon the trends shown in Figure 8, particularly that of the catch per skate. The long term production trend appears to be upward unless one places undue weight upon the 1925 to 1928 high points. Pronounced short term changes have also occurred from time to time. As in the case of the Cape Flattery fishery the short term changes appear to have resulted from changing economic conditions and to some extent from the changes in stock size as shown by the catch per unit effort. There was a decline about 1920–1922, during the post World War I recession, then a sharp increase with the rising prices of the later 1920's and an abrupt decline which was extended by the depression of the early 1930's. Thereafter production increased with the rise in prices but declined again by 1948. The lowered returns per unit effort and the greater attractiveness of other fisheries to the setline fleet such as those for albacore and soupfin shark caused the interest in sablefish to fluctuate from time to time.

The decline in the albacore and other fisheries tended to direct the setline vessels back to the sablefish fishery. The strong market demand has made production possible in spite of the decline in catch per unit effort.

The catch per unit effort data shown in Table 5 is based upon fishing records of Seattle vessels collected by the International Pacific Halibut Commission. They are from a few vessels possessing a high degree of local knowledge of the Oregon grounds, hence the average catch per skate may be higher than would be secured from a more comprehensive sample. As in the case of the Cape Flattery fishery the long term trend has been downward.

The sharp fluctuations since 1949, which also occurred on each subsection of the Oregon coast, can be attributed to unexplainable year-to-year changes in availability and to the increasing dependency of the setline fleet upon small isolated "spots."

Decline in Average Size

That the Oregon sablefish have also declined in average size is evident from testimony of fishermen and from log records. According to the former, the fish averaged about 12 pounds in weight in the late 1920's. Log records show an average weight of about 9 pounds in the early 1940's and between 7 and 8 pounds in 1952.

CONCLUSION

Though the Washington and Oregon fisheries are of very different magnitudes, their character and the reactions of their stocks to fishing are very similar. Both have shown a general decline in abundance. Fluctuations in their annual yields show evidence of being in response to economic conditions. Both fisheries supply a supplemental catch for the trawl fleet and a late summer and fall occupation for setliners. Since 1947 a growing proportion of the catches has been taken by trawl gear. Declining prices coupled with low yield per unit of setline effort will probably accelerate this trend. The non-dependence of trawl gear upon any single species for its earnings will permit such gear to fish at stock levels below those possible for setline vessels.

In both Oregon and Washington it appears that the stocks are being maintained at levels of yield determined by economic conditions. Knowledge of the stocks is insufficient to judge whether the present levels are above or below their biological optima.

While the ultimate aim in managing a fish stock may be to secure the maximum yield, some consideration may be given to whether the stock level required to produce such a yield may be the most profitable one. Thus, if the Cape Flattery stocks are still above their optimum biological level, some increase in fishing might add to the yield, but the larger total yield might have less market value due to the smaller average size of fish. It is also possible that any further decline in catch per unit effort and average size of fish might require that most of the catch be taken by gear not dependent upon sablefish alone for all its earnings.

On the other hand, if the Cape Flattery stocks are below their most productive level and are being fished on a more or less marginal economic basis it would be profitable to consider raising the stock levels at least to some intermediate point. At such a level fishing costs would be lower particularly for setline vessels and the larger individual fish caught would be more valuable. A more stable fishery might ensue that would be less responsive to short-term fluctuations in economic conditions. Such intermediate levels are more readily attained and do not require the costly research necessary to solve the biological problems involved in securing the maximum yield.

ACKNOWLEDGMENTS

Most of the statistical material up to 1943 and the salient historical features on the Washington fishery have been taken from an earlier paper by the senior author and John T. Gharrett (1945). Fishing records of both states have been secured from the files of the International Pacific Halibut Commission with the permission of its Director of Investigations, Harry A. Dunlop. Olaf E. Eriksen, formerly of that Commission, collected most of the log records for years prior to 1943. From 1943 to date several persons were responsible for the collection including William H. Hardman, who in addition analyzed the 1944 to 1947 Cape Flattery data.

The junior author, assisted by Eldon Korpela, collected and analyzed some of the data concerning the Oregon fishery while employed by the Oregon Fish Commission.

The authors wish to express their thanks to John T. Gharrett, Pacific Marine Fisheries Commission; George Y. Harry, Jr., Oregon Fish Commission; and Donald E. Kauffman, Washington State Department of Fisheries, for their critical review of the manuscript.

BIBLIOGRAPHY

BELL, F. H. and J. T. GHARRETT
1945 The Pacific coast blackcod, *Anoplopoma fimbria*. (Copeia (2): 94-103. Ann Arbor, Mus. Zool.).

DEVOLD, F.
1938 The north Atlantic halibut and net fishing. (Rept. Norweg. Fish. and Mar. Invest. 5 (6): 5-68. Bergen, John Griegs.).

HOLMBERG, E. K. and W. G. JONES
1954 Results of sablefish tagging experiments in Washington, Oregon, and California. (Pac. Mar. Fish. Comm. Bull. 3: 103-119).

JOHNSTON, E. C.
1917 Survey of the fishing grounds on the coasts of Washington and Oregon in 1915. (App. VI, Rept. U. S. Comm. of Fish., 1915: 5-20).

RUSSELL, E. S.
1942 The overfishing problem. (130 pp. Cambridge, England. Univ. Press).

SCHMITT, W. L., E. C. JOHNSTON, E. P. RANKIN, and EDWARD DRISCOLL
1915 Survey of the fishing grounds on the coasts of Washington and Oregon in 1914. (App. VII, Rept. U. S. Comm. of Fish., 1914:3-30).

SWAN, J. G.
1885 Report on blackcod of the north Pacific Ocean. (Bull. U. S. Fish. Comm. 5 (15):225-234.)

THOMPSON, W. F., DUNLOP, H. A. and F. H. BELL
1931 Biological statistics of the Pacific halibut fishery. (1) Changes in yield of a standardized unit of gear. (Intern. Fish. Comm. Rept. 6:108 pp. Seattle, The Commission).

THE SABLEFISH FISHERY OF BRITISH COLUMBIA

K. S. KETCHEN
and
C. R. FORRESTER

Pacific Biological Station
Fisheries Research Board of Canada

BULLETIN 3
PACIFIC MARINE FISHERIES COMMISSION
Portland, Oregon, 1954

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

THE SABLEFISH FISHERY OF BRITISH COLUMBIA

INTRODUCTION

The sablefish (*Anopoploma fimbria*) has long been an important food source and valuable contributor to the fishery economy of British Columbia. During the past 40 years the Canadian fishery, conducted traditionally by long-line vessels, on the average has accounted for about one quarter of the annual total production of sablefish from the waters of the northeast Pacific.

Over the past decade there has been a substantial increase in fishing effort, arising not only from increased demand but also from progressive shortening of the halibut season through international regulation. Among some sections of the industry it is considered that the present day fishery is producing to or beyond the limit of its capacity.

The purpose of this paper is to draw together existing records of the history and development of the British Columbia sablefish fishery and to determine whether or not the records of catch and effort indicate any extensive changes in abundance.

ACKNOWLEDGMENTS

Much of the catch-effort material presented herein has been obtained from the files of the International Pacific Halibut Commission. Particular thanks are due Mr. F. Heward Bell for his interest and guidance in the abstracting of data from these files. The abstracting was carried out by Miss Y. Bishop of the Pacific Biological Station.

Mr. R. M. Wilson and Mr. W. G. St. Clair, port observers for the Pacific Biological Station, collected supplementary catch-effort data from long-liners and otter-trawlers.

Suggestions and criticisms given by Mr. F. H. Bell and Drs. R. E. Foerster, J. L. Hart and W. E. Ricker were much appreciated in the preparation of the manuscript.

HISTORY OF THE FISHERY

1. The Indian fishery

Early publications of the Canadian Department of Marine and Fisheries (1879 and 1883) and a report by Swan (1885) state that the sablefish was utilized in early times by the Makah Indians of Cape Flattery and by the Haida Indians of the Queen Charlotte Islands. At Cape Flattery this species was called the "beshowe", while on the Queen Charlottes it was known as the "skil". The mainland Indians in the Knight Inlet area called it the "kwakewlth," but apparently had no use for it as a food supply.

The sablefish was highly prized by some coast Indians because it was much less common in their catches than such species as salmon, halibut and herring. The reason for this lay in its relative inaccessability. Since the sablefish is an inhabitant of deep water it could be caught only at considerable distance from shore and only with gear which could be operated at great depth (usually in excess of 100 fathoms). The fact that so many other species could be caught in abundance closer to shore and in shoaler water, offered little incentive to extensive fishing specifically for sablefish. As late as 1880, the sablefish was virtually unknown to the white settlers.

The Indian method of fishing was the forerunner to the modern methods of long-lining and consisted of ingeniously designed hooks fashioned from knots of hemlock wood and fishing lines constructed from the long stipes of the kelp *Nereocystis*. The gear has been described in detail by Swan (loc. cit.) and well illustrated by Niblack (1890).

According to early reports, the Indian fishery of British Columbia was restricted to the neighbourhood of the Queen Charlotte Islands. The Haidas of Skidegate Inlet made their catches off the west coast of the Islands and brought them through Skidegate Channel to the eastern or Hecate Strait side. The natives at the north end of the Islands, living at Masset, did most of their fishing adjacent to Langara Island in Dixon Entrance. The catches, valued for their production of edible oils, presumably were on a very small scale in comparison with those of the subsequently developed commercial fishery.

2. Early Commercial Fishery.

The superior market qualities of the sablefish did not receive general recognition until the reports of Swan (1885) were published. He salted sample quantities of fish at Skidegate village and shipped these south to Victoria. The samples were very favourable received, as were those which were dispatched to the east on the newly completed transcontinental (U.S.) railroad.

Exploratory commercial operations were undertaken on a small scale in 1885 (Canada Dept. Fish. Rept.). However, not until 1888 were schooners specially outfitted for exploitation of sablefish (Canada Dept. Fish. Rept.). That year marked the first official commercial landing—450 barrels (90,000 pounds) of salted fish. In the following year the catch rose to 1560 barrels (330,000 pounds). Bell and Gharrett (1945) state that commercial salting was carried out in 1890 and 1891 on the west coast of the Queen Charlottes and that a saltery existed on the shore of Milbanke Sound from 1908 to 1911.

During the last decade of the 19th century and the first of the 20th century the fishery remained a local one with limited demand. Development of the fishery apparently was hindered by the abundant annual supply of salted salmon. As late as 1914, sablefish were regarded by halibut fishermen as being of no value and consequently large quantities were returned to the sea.

Between 1910 and 1915 there occurred several years of serious shortage in production of salmon for salting and this provided the incentive for an expansion of the sablefish fishery (Pacific Fisherman, 1913). By 1915, fish dealers were unable to keep up with the demand for sablefish as its quality became better known to the public. This rapid acceptance and expansion of the markets to eastern parts of the continent accounted for the marked rise in the annual total catch shown in Figure 1 (data from Appendix 1) for the years 1913–1916. By 1916 the Canadian catch had exceeded the six million pound mark.

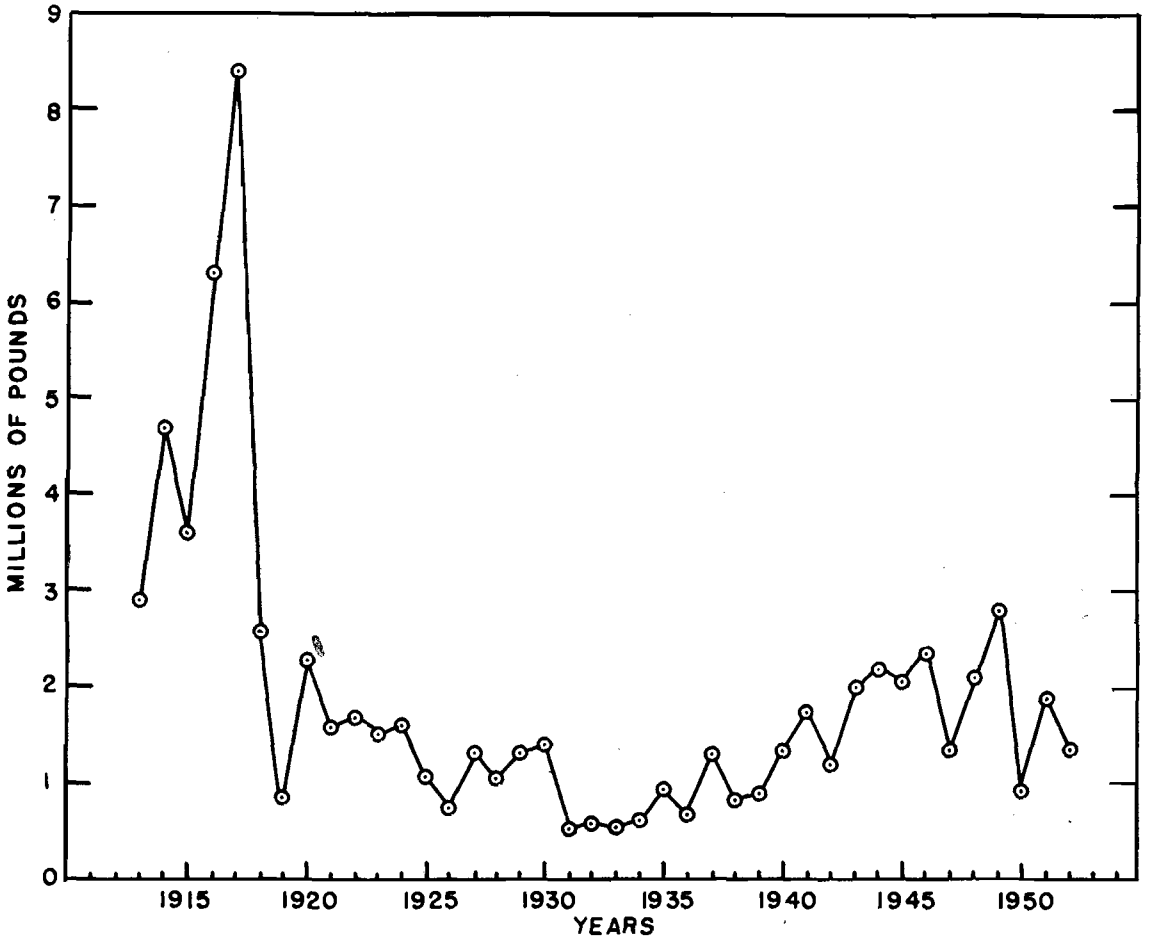

FIGURE 1. The total annual landing of sablefish in British Columbia as reported in the Fisheries Statistics of Canada.

In 1917 a vigorous publicity campaign was launched both in Canada and the United States to encourage a greater home consumption of fish products to offset the war-time shortage of meat. The resulting increased demand caused the catch in that year to rise to an all-time high of 8.4 million pounds. This landing had a marketed value of nearly $880,000 and placed the sablefish in fourth position of importance in the British Columbia fisheries.

The fishery of World War I presumably was concentrated off the west coast of Vancouver Island and in Queen Charlotte Sound, since the major part of the catch was landed in southern ports of British Columbia. As will be pointed out later (Figure 5), almost 88 per cent of the large catch of 1917 was reported from southern ports (Dept. of Fisheries Administrative Districts 1 and 3). Presumably because of over-production and decline in demand in some markets, the catch in 1918 fell sharply to little more than 2.5 million pounds, and continued to decline slowly over the succeeding 16 years. During the depression years of the early thirties, the annual catch was less than three quarters of a million pounds. After 1933, the trend was reversed by a gradual increase in the annual landing through to the present time.

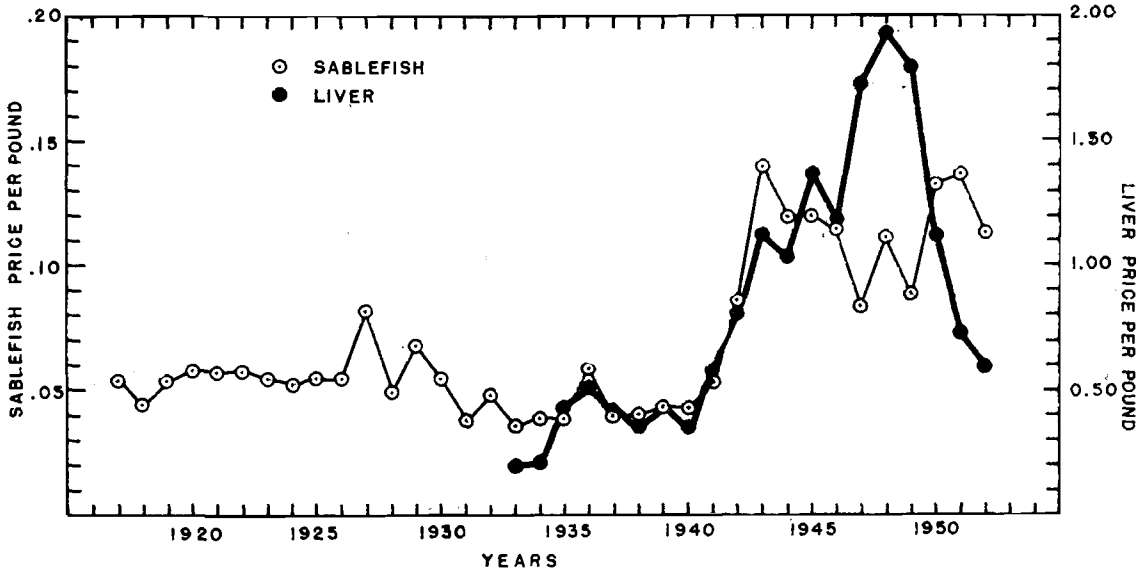

FIGURE 2. The annual average landed price of sablefish and liver in British Columbia as reported in the Fisheries Statistics of Canada.

There is no well defined relationship between these early trends in the fishery and market prices (Figure 2—data from Appendix 1). The price paid for sablefish between 1917 and 1931 underwent no obvious decline, nor was there a substantial increase between 1943 and 1940. The explanation lies presumably in the prevalence of contract fishing (pre-arranged price agreement between fishermen and buyer on a limited catch). The improvement in catch between 1934 and 1940, despite no marked change in price, to a certain extent may be explained on the same ground, but it was no doubt affected by conditions in the halibut fishery and the demand for the livers. Between 1933 and 1940 the halibut season off British Columbia and southeastern Alaska was gradually shortened by nearly three months, with the result that more effort probably was directed to fishing specifically for sablefish as a supplemental activity for the halibut fleet.

3. **Recent Commercial Fishery.**

(a) **Production.**

For present purposes the recent commercial fishery will be considered as the period beginning in 1940 and extending through to the present time.

Early in World War II, the demand for food fish and liver (vitamin A) products provided the impetus for a strong advance of the British Columbia sablefish fishery. Figure 2 shows that in a period of three years after 1940 the average price offered for sablefish increased from $0.045 to $0.14 per pound, and that the price for sablefish livers increased from $0.35 to $1.12 per pound. Although the price on the food product went no higher than the 1943 level in succeeding years, the

price on liver continued to rise until 1948 when it reached $1.94 per pound. After 1949, however, the market for liver products suffered a sharp decline because of a reduced demand and price for natural vitamin A with the development of the synthetic vitamin product.

The catch of sablefish in 1949 was the highest since 1917 and reached a total of 2.8 million pounds (Figure 1). A large carry-over had a marked effect on the fishery of 1950, for the catch in that year amounted to less than a million pounds. The relatively low catch in 1947 following the high catch in 1946 is apparently another example of the effects of over-production. This situation was closely paralleled in the Oregon, Washington and Alaska fisheries.

Although the decline in demand in 1947 is evident in the price trend (Figure 2), it is not evident for the year 1950. The lack of correlation is presumably attributable to contract fishing. Furthermore, there is a base price below which the fleet cannot afford to fish at present stock levels and low liver values.

In 1945 a size regulation was introduced in the British Columbia fishery regulations for economic reasons, to the effect that no sablefish may be landed which weighs less than five pounds, dressed with head on. In 1948, the terms of the size control were amended and a four and one-half pound limit set for dressed fish with heads off. It is improbable that this regulation had measurable influence on the long-line fishery in subsequent years. A marked decline in catch per unit of effort by Canadian vessels between 1945 and 1947 was closely paralleled in the Alaska fishery which was unaffected by size regulation (personal communication from Q. Edson, Alaska Dept. of Fisheries). The size limit seems to have affected more markedly the conduct of the small trawl fishery for sablefish, which, operating as it does in shallower water, encounters a higher proportion of the fish belonging to the smaller size group.

(b) **The Regions of Exploitation.**

The British Columbia sablefish fishery extends along 1200 miles of the open coast from Cape Flattery in the south to Middleton Island (Gulf of Alaska) in the north. For the purposes of the present report the fishery has been divided into four major areas. Discussion of the distribution of fishing effort within these areas is based on trip interviews.

Description of the four divisions of the fishery and their relative importance is given below and is based on the average of conditions which prevailed in the 1951–53 period.

(i) **West Coast of Vancouver Island.**

The 1951–53 fishery in this area accounted for little more than 12 percent of the total British Columbia landing. Approximately 20 percent of this amount was taken by trawlers which operate chiefly between Barkley Sound and Cape Flattery (Figure 3)*. The majority of long-line vessels operate further north along 60 miles of the coast between Cape Cook and Cape Scott. As much sablefish is removed from this section as is removed from the 180 miles of water lying between Cape Cook and Cape Flattery.

(ii) **Queen Charlotte Sound.**

This area lies between Cape Scott and Cape St. James and encompasses the Cape Scott bank and the Goose Island bank. The fishery for sablefish occurs mainly along the northwestern edge of the Cape Scott bank and in the trench which separates this bank from the Goose Island bank. A small fishing area occurs at the entrance to Queen Charlotte Strait and scattered fishing takes place along the edge of the continental shelf between Cape Scott and Cape St. James.

The Canadian fishery in Queen Charlotte Sound is undertaken almost exclusively by long-line vessels and in the 1951–53 period accounted for approximately 13 percent of the total landings for the province.

(iii) **West Coast of Queen Charlotte Islands and Dixon Entrance.**

Off the west coast of the Queen Charlotte group the continental shelf is narrower than at most other locations along the coast, and hence the sablefish grounds occur relatively close to the shore

*Because of a change in the reporting of catches off the Alaska coast in 1953 it was necessary to construct Figure 3 on the basis of 1951–52 records only.

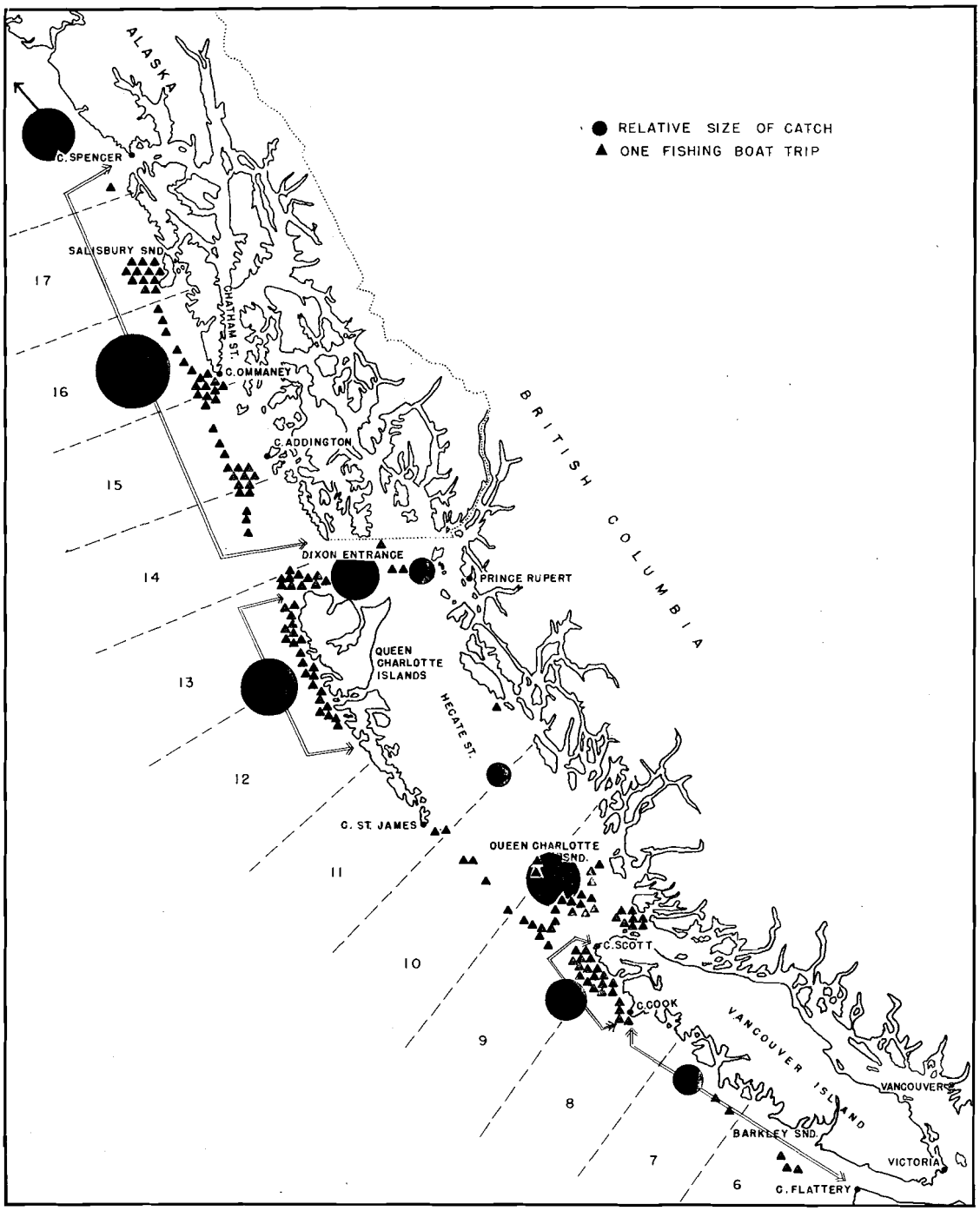

FIGURE 3. The distribution of fishing effort and catch of sablefish by the fishing fleet of British Columbia in 1951 and 1952. Each triangle represents the fishing area reported by one vessel. Areas of the circles are relative to the size of the catch. The numbered divisions are the statistical areas of the International Pacific Halibut Commission.

(Figure 3). This is the site of the original fishery by the Haida Indians from Skidegate. The fishery off Dixon Entrance occurs mainly in the vicinity of Langara Island (off the northwest end of the Queen Charlottes) and is the site of the original fishery by the Indians from Masset.

About 21 percent of the annual total catch for the province came from these waters adjacent to the Queen Charlotte Islands in the 1951–53 period.

At this point it should be mentioned that the Hecate Strait area (lying off the east coast of the Queen Charlotte group) is of little importance as a sablefish producer. In the 1951–53 period, 8 percent of the total catch came from this area. The catch by Canadian otter-trawlers is not significant.

(iv) **Offshore Waters of Southeastern Alaska.**

Almost half of the annual British Columbia catch is made in extra-territorial waters adjacent to the islands comprising southeastern Alaska. Although the fishery extends from Forrester Island (near Dixon Entrance) northward into the Gulf of Alaska, there appear to be regions where effort is concentrated within this range (Figure 3). These regions lie adjacent to Cape Addington (off the west coast of Prince of Wales Island), Cape Ommaney (off the southern tip of Baranof Island) and adjacent to Salisbury Sound (off the southern end of Chichagof Island). Catches are also recorded from areas west of Cape Spencer (Halibut regulatory Area 3) but precise identification has not been possible. Some of these presumably are made near Cape Spencer, since lack of shelter and long running distance to suitable depths to the westward would tend to discourage extensive operation. It is known, however, that a few Canadian vessels operate 300 miles west of Cape Spencer near Middleton Island in the Gulf of Alaska.

In recent years the fishery in international waters off southeastern Alaska has been conducted largely by Canadian vessels. The Alaska fleet operates mainly in the territorial waters of Chatham Strait and Frederick Sound and west of Cape Spencer (personal communication from Q. Edson).

In the 1951–53 period the Canadian catch from the southeastern Alaska area averaged approximately 46 percent of the annual Canadian total from all areas.

(c) **Seasons of Exploitation.**

From area to area along the British Columbia coast there is some variation in the average peak month of production. Off southeastern Alaska, in Dixon Entrance and in Hecate Strait, production was greatest during the month of July (Figure 4) in 1951–53. In Queen Charlotte Sound the peak was reached in September, and so also in the trawl fishery off the west coast of Vancouver Island. Production by the line fishery in the latter area was slightly better in October than in September.

The production period off the west coast of the Queen Charlotte Islands was markedly different from those in other areas. Over 75 percent of the catch was made during the first five months of the year and the peak of production took place in March and April. Negligible quantities of fish were taken from these grounds during the summer and fall months when the other grounds were producing.

Considering the British Columbia fishery as a whole, during the seven year period ending with 1953, about 83 percent of the annual catch was landed between the months of June and October, inclusive. Because of the important role played by the fishery off Alaska, nearly 50 percent of the total landings have occurred in the months of July and August. A peak in the over-all production has occurred either in July or August and is in contrast to the situation in Washington and Oregon, where maximum production is reached later, either in September or October.

The present fishery is influenced to a large extent by the halibut fishery and by weather conditions. The majority of long-line vessels do not turn their attention to the capture of sablefish until the halibut season comes to an end. Thus, the catches are always light during the months of May and June. Recent changes in halibut regulations to permit fishing for that species during late July and early August have been largely responsible for the shift in the peak of the sablefish landing from August to July.

Some incentive to long-line fishing, after the regular halibut season is over, is no doubt provided by regulations of the International Pacific Halibut Commission, which since 1937 have per-

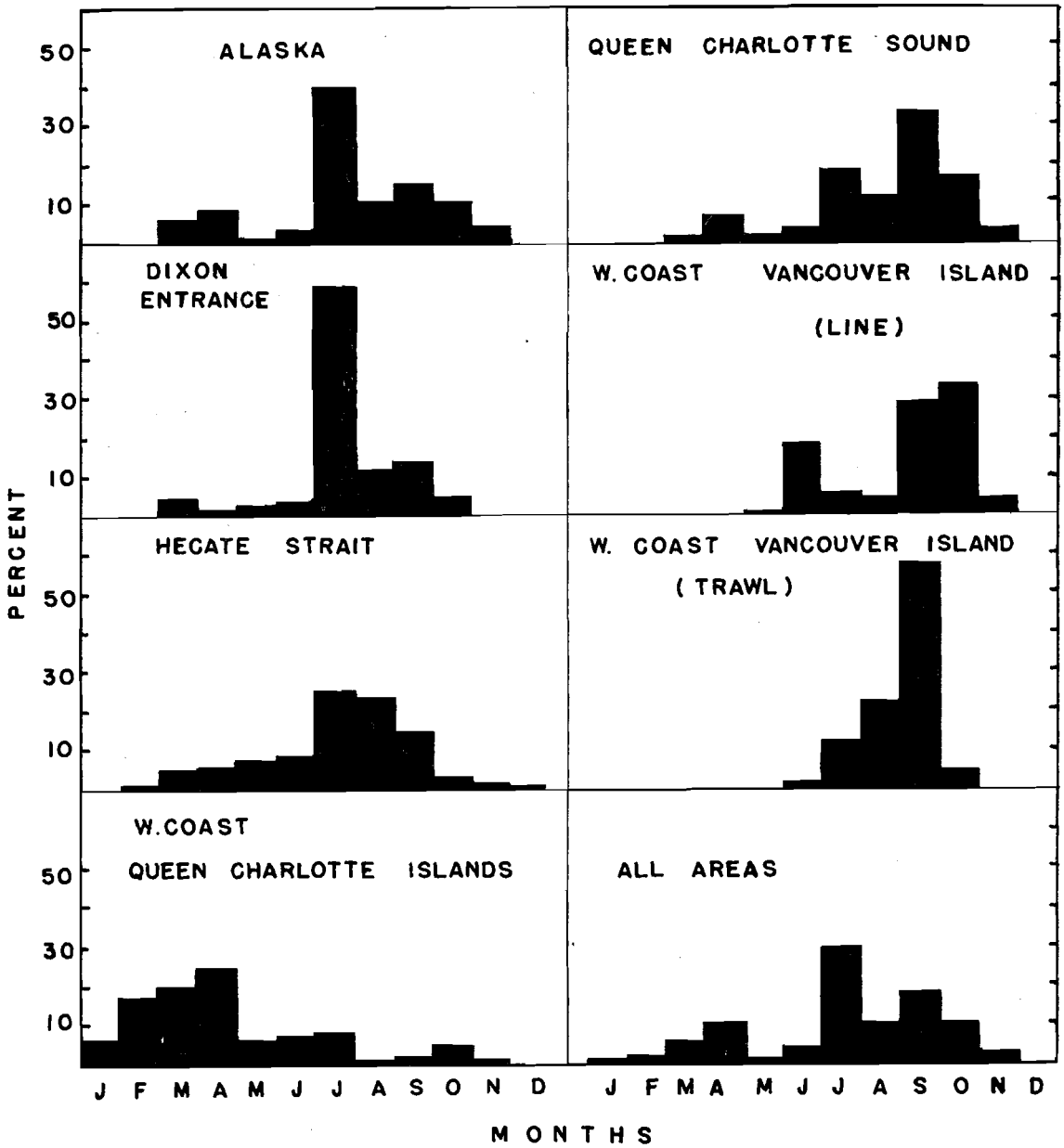

FIGURE 4. The seasonal distribution of the sablefish catch from various areas along the coasts of British Columbia and Alaska (an average computed from 1951-53 data).

mitted a limited percentage landing of halibut in the post-season period. Termination of the permit period in November together with the advent of unfavourable weather contributes to the suppression of the present sablefish catch during the winter and spring months. Between November and the end of May the landings average less than 18 percent of the annual total.

ABUNDANCE TRENDS

The analysis of catch-effort records for trends in abundance has been handled in two ways. Since it is possible to make an approximate division of the catch according to the north and south coast statistical districts, records of catch per unit of effort for areas within the two districts have been combined for comparison.* This is the first approach. The second deals briefly with the catch per unit of effort data for regions described earlier under "Regions of Exploitation." Unfortunately,

*Districts 1 and 3 include all Canadian ports of landing south of Queen Charlotte Sound, while District 2 includes those ports from Queen Charlotte Sound northward to the Alaska boundary.

interpretation of such records is limited since the Fisheries Statistics of Canada do not permit separation of the catch according to these sub-districts.

1. Treatment by Districts.

The British Columbia landings in Departmental administrative Districts 1 and 3 in general account for the exploitation off the west coast of Vancouver Island and in Queen Charlotte Sound. The majority of catches made in northern waters (Dixon Entrance, west coast of the Queen Charlotte Islands and off the southeastern Alaska coast) are landed in administrative District 2. For the purposes of the present discussion, Districts 1 and 3 will henceforth be referred to as the Southern District and District 2 the Northern District. Although a small proportion of the catch from the northern grounds is landed each year in the Southern District, this factor is not considered to affect

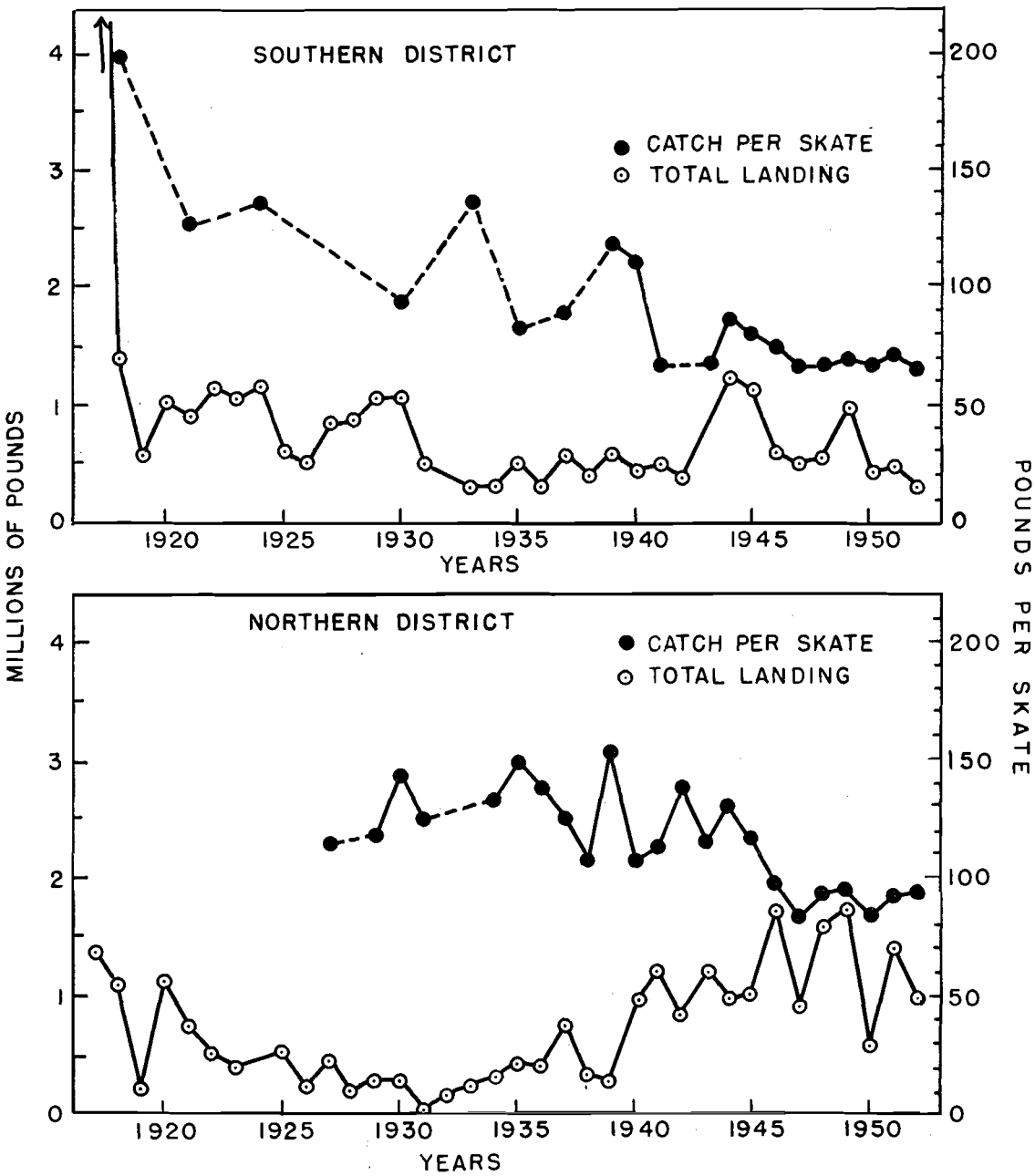

FIGURE 5. The annual landings of sablefish in the Southern and Northern Districts and the average annual catch per skate on the southern and northern grounds.

seriously the assumption that landings in the Northern and Southern Districts are indicative of the removal from the northern and southern grounds, respectively.*

(a) **Production.**

The trends in catch in the two Districts over the past 35 years have been different in a number of respects (Figure 5). The fishery in the Northern District responded more markedly to the decline in demand following World War I. The catch in the Southern District followed a less obvious decline and in general has been more stable than in the north. This is in keeping with present day observations that the Southern District is less affected by market conditions than that in the north.

It will be noted that although the war-time demand of the early forties created a strong advance in the northern fishery, the expansion of the southern fishery was short-lived.

Figure 6 shows the change in relative importance of the Southern District since the first World War. Prior to 1935 the greater part of the annual catch came from the southern area. In the years since 1935, however, the Northern District has accounted for the bulk of the catch.

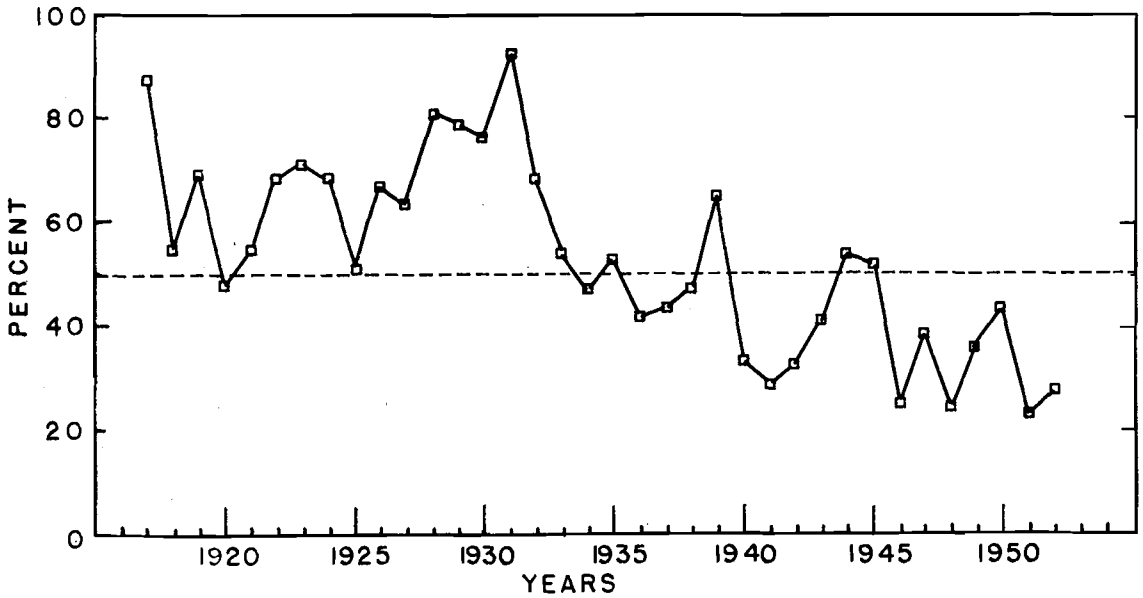

FIGURE 6. The trend in annual landings of sablefish in the Southern District, expressed as a percentage of the total for the province.

(b) **Availability.**

The records of catch per skate shown in Figure 5 (data from Appendix 2) have been obtained from the files of the International Pacific Halibut Commission. No estimates have been included where computations were based on records of less than 100 skates of gear.† Nevertheless, it is probable that the lack of stability in the annual estimates is partially attributed to inadequate sampling. This applies more particularly to the earlier days of the fishery.

The records of catch per skate from the Southern District show a general decline in availability from the twenties through to the early forties. In the Northern District there was no definite indication of a decline throughout the thirties and early forties. However, a pronounced downward trend occurred between 1944 and 1947. In both Districts a period of apparent stability began in 1947 and has continued through to the present.

Between 1930 and 1940 in the Southern District, the average annual catch per skate was 105 pounds. In the 1947–52 period the average was approximately 70 pounds, or 60 percent of the earlier condition. In the Northern District the 1930–40 average annual catch per skate was 132 pounds, and in 1947–52 it had fallen to 89 pounds. This is 67 percent of the earlier condition.

*In the years since 1946 an average of only 12 percent (range 5.1-18.4 percent) of the fish caught on the northern grounds was landed in the Southern District.

†The skate of gear has been standardized to a 6-line, 13-foot hemp basis. This procedure for accounting for changes in the unit of gear over the past 50 years, is the same as that used in the treatment of halibut data. Description of the treatment is given by Thompson et al. (*1931*).

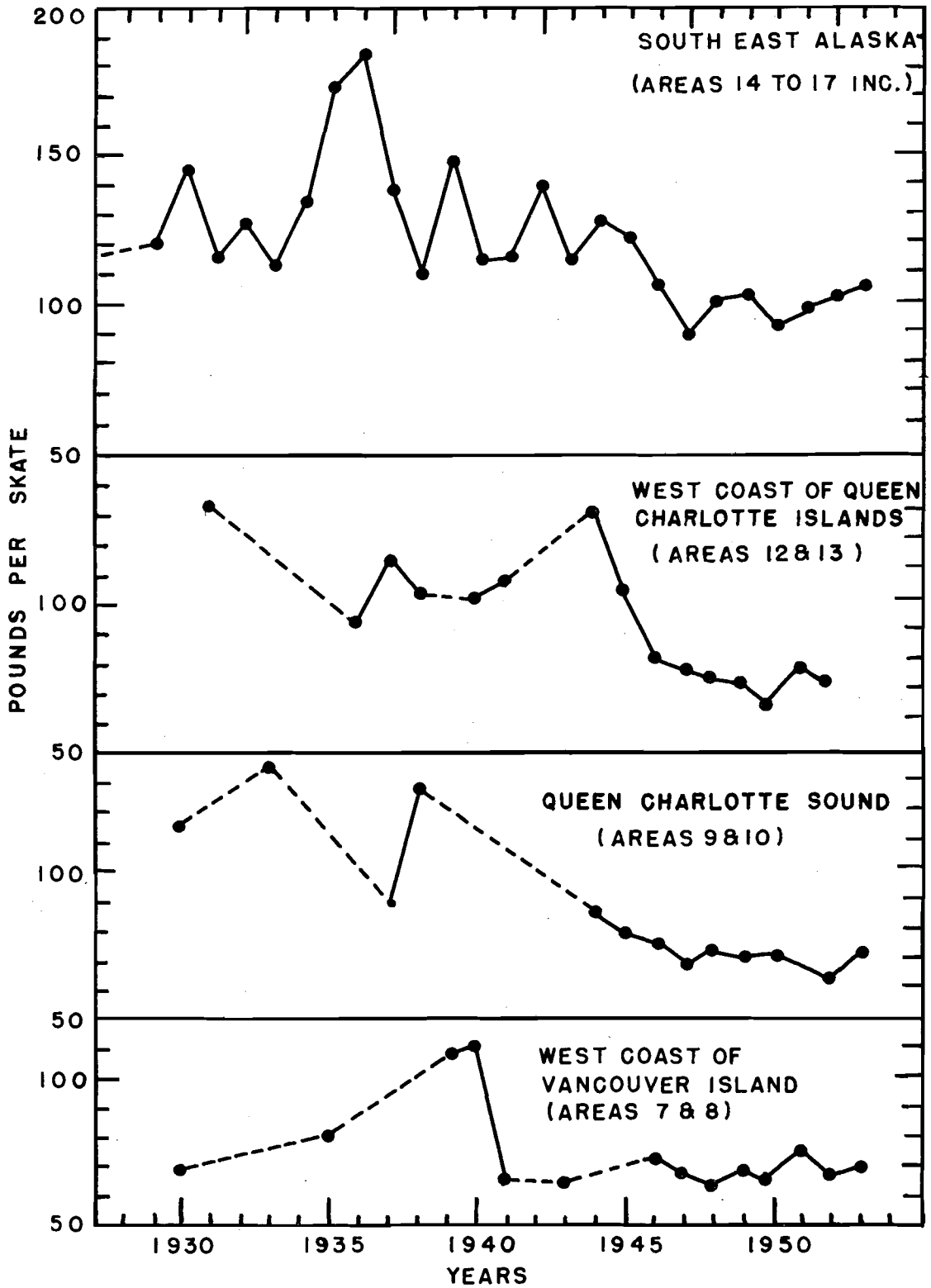

FIGURE 7. Availability of sablefish on various grounds exploited by the Canadian long-line fleet.

2. Treatment of Availability by Sub-Districts.

The Northern and Southern Districts have been divided into a number of Sub-Districts which conform with groups of statistical areas employed in regulation of the halibut fishery (see Figure 3). The most southerly division is the west coast of Vancouver Island (halibut areas 7 and 8); the next is Queen Charlotte Sound (halibut areas 9 and 10). This is followed to the northward by the west coast of the Queen Charlotte Islands (areas 12 and 13); then the west coast of the Alaskan Archipelago (areas 14 to 17, between Dixon Entrance and Cape Spencer). The availability trends in each of these Sub-Districts are illustrated in Figure 7 (data from Appendix 2).

With the exception of the west coast of Vancouver Island area, the records for all areas along the coast suggest that availability through the nineteen thirties and early forties was at a higher level than that in the period following World War II. All show a period of relatively stable availability from 1946 or 1947 to the present.

The lack of a long-term change in availability off the west coast of Vancouver Island may be attributed to the low state of the fishery prior to the period of study. Bell and Gharrett (loc. cit.) show that a precipitous decline in catch per skate in the adjoining Cape Flattery area occurred during the 1917–35 period, and that in the years after 1935 the rate of decline diminished greatly. Disregarding the records for 1939 and 1940, it is apparent that a similarly low rate of decline has occurred at the site of the Canadian fishery. The period of relatively low availability seems to have been entered prior to World War II.

The levels at which the various fisheries have become stabilized are compared in Table I. Use has been made of the average catch per skate during the 1946–52 period. For purposes of completeness, data from the Cape Flattery area (Bell and Pruter, 1954) have also been included.

TABLE I. AVERAGE AVAILABILITY DURING THE PERIOD OF APPARENT STABILITY (1946–52)

Fishing Area	Availability (Pounds per Skate)
Cape Flattery	52.5
West Coast of Vancouver Island	68.3
Queen Charlotte Sound	70.7
West Coast of Queen Charlotte Islands	75.4
Southeastern Alaska	98.7

The level at which each of the fisheries has stabilized in respect to catch per skate, seems to be directly related to the distance from railhead markets and hence presumably to the cost of production. The fishing grounds adjacent to Vancouver Island which have been exploited longest and which apparently took the brunt of the heavy fishing during World War I, show the lowest yield per unit of effort.

Similarity of the averages for the west coast of Vancouver Island and Queen Charlotte Sound, suggest that the two stocks are now in approximately the same condition.

The availability in the southeastern Alaska area is the highest for the coast and apparently is a reflection of distance from large market centers and the difficulty of access to the grounds.

Unfortunately, detailed information on the trend in size composition during this period of apparent stability, is not available for comparison. The catch per skate could presumably remain stable in the face of declining abundance of large fish, if increasing dependence was being placed on the younger members of the stock.

In all areas except the west coast of Vancouver Island, the average catch per skate during the present period of apparent stability (1946–52) is between two-thirds and three-quarters of that which prevailed during the period 1930–40. In the Queen Charlotte Sound area it is 75 per cent of the earlier condition; off the west coast of the Queen Charlotte Islands it is 68 per cent and off southeastern Alaska it is 72 percent. Although the reduction in stock is proportionately the same in all areas, it has occurred as mentioned above, at different absolute levels along the coast. These levels are probably related to the cost of production in the different areas.

In the absence of information on growth and mortality rates in the sablefish stocks contributing to the British Columbia fishery, it is impossible to say whether the present rate of exploitation is under or over the optimum level for maximum yield.

SUMMARY

1. Throughout the past 35 years the sablefish (*Anoplopoma fimbria*) has ranked as a valuable contributor to the fisheries of British Columbia. The annual catch in the years following World War II has averaged close to 2 million pounds and has accounted for about one-quarter of the total average annual catch by all political divisions operating in the northeast Pacific.
2. Although commercial exploitation began as early as 1888, the fishery did not achieve importance until the years of World War I. Production declined rapidly after the war because of reduced demand. After reaching a low point in the early thirties, it began to rise again, mainly as a result of increasing effort, brought about by the growing demand for the livers and the progressive shortening of the halibut fishing season. A sharp rise in price in World War II, provided the impetus for continued expansion of the fishery. Decline in the liver market and periodic over-production has brought about a decline in yield in recent post-war years.
3. In the 1951–53 period, approximately 46 percent of the annual catch was made adjacent to southeastern Alaska. About 21 percent of the catch came from the west coast of the Queen Charlotte Islands, while the remaining 33 percent came mainly from the waters adjacent to the northern end of Vancouver Island.
4. In the seven year period ending in 1953, about 83 percent of the annual catch was made between the months of June and October. The month of peak production is either July or August. In one area only (west coast of the Queen Charlottes) the bulk of the production occurs between February and April.
5. Over the past 35 year period there has been a steady increase in the importance of the northern grounds. Whereas the majority of the landings were made at the southern B. C. ports prior to 1930, these have declined to 30 to 40 percent of the total in more recent times. During World War II, the fishery off southern B. C. did not expand to the same extent as did that in the north, which suggests that it is producing to or beyond its capacity.
6. Both the northern and southern grounds have shown a change in abundance within the past two decades. The catches per unit of effort on the northern and southern grounds are now ⅔ of their values during the thirties.
7. On the majority of fishing grounds along the coast the period of most pronounced decline in catch per skate was between 1944 and 1947. From 1947 to the present a condition of relatively stable availability has occurred. The level at which each fishery has stabilized seems to be related to the history and intensity of the fishery and probably to the cost of production as affected by the distance from major railhead markets. The catch per skate on grounds off southeastern Alaska is now at a level 40 percent higher than that off the west coast of the Queen Charlottes and in Queen Charlotte Sound and 100 percent higher than that off Cape Flattery.

LITERATURE CITED

BELL, F. H. and J. T. GHARRETT
1945 The Pacific coast blackcod, *Anoplopoma fimbria*. Copeia 1945, No. 2, 94–103.

BELL, F. H. and A. T. PRUTER
1954 The Washington and Oregon Sablefish fishery. Bull. Pac. Mar. Fish. Comm. (No. 3, 39–56).

BRITISH COLUMBIA COMMISSIONER OF FISHERIES
1915 Report with appendices; 1914, Victoria.

CANADA, BUREAU OF STATISTICS. FISHERIES DIVISION
1919–1953 Fisheries Statistics of Canada 1917–1952. Ottawa.

CANADA, DEPARTMENT OF FISHERIES
1886–1889 Annual report with appendices. No. 2-5. 1885–1888, Ottawa.

CANADA, DEPARTMENT OF MARINE AND FISHERIES
1880–1884 Annual report, No. 12-16, 1879–1883, Ottawa.

NIBLACK, A. P.
1890 The coast Indians of southern Alaska and northern British Columbia. Ann. Rept. Smithsonian Inst., 1888, U. S. Nat. Mus., Sect. III, 225–386.

PACIFIC FISHERMAN
1913 Annual statistical review, XI (1), Seattle.

SWAN, J. G.
1885 Report on blackcod of the North Pacific Ocean. Bull. U. S. Fish Comm. V (15), 225–234.

THOMPSON, W. F., H. A. DUNLOP and F. H. BELL
1931 Biological statistics of the Pacific halibut fishery. (1) Changes in yield of a standardized unit of gear. Rept. Internat. Fisheries Commission 6, 108 pp.

APPENDIX 1

STATISTICS OF CATCH AND VALUE OF SABLEFISH LANDED BY CANADIAN VESSELS IN BRITISH COLUMBIA

Year	Landings (millions of lbs.)*			Landed Value per lb. ($)	
	Dist. 1 & 3	Dist. 2**	Total	Foodfish	Liver
1913			2.920		
1914			4.720		
1915			3.590		
1916			6.340		
1917	7.375	1.378***	8.408	.054	
1918	1.433	1.160	2.594	.044	
1919	0.592	0.204	0.859	.054	
1920	1.088	1.172	2.264	.058	
1921	0.905	0.747	1.651	.057	
1922	1.167	0.536	1.704	.057	
1923	1.069	0.429	1.498	.055	
1924	1.147	0.489	1.652	.053	
1925	0.597	0.542	1.165	.055	
1926	0.505	0.245	0.752	.055	
1927	0.850	0.483	1.336	.083	
1928	0.896	0.216	1.113	.049	
1929	1.071	0.285	1.356	.068	
1930	1.097	0.329	1.423	.055	
1931	0.496	0.034	0.532	.038	
1932	0.411	0.195	0.604	.048	
1933	0.306	0.259	0.565	.036	0.20
1934	0.303	0.336	0.639	.039	0.22
1935	0.513	0.458	0.970	.038	0.44
1936	0.305	0.415	0.720	.058	0.52
1937	0.583	0.758	1.341	.040	0.42
1938	0.403	0.344	0.846	.041	0.36
1939	0.592	0.315	0.907	.044	0.44
1940	0.469	0.925	1.393	.043	0.35
1941	0.513	1.235	1.747	.054	0.58
1942	0.407	0.821	1.228	.086	0.82
1943	0.870	1.227	2.096	.140	1.13
1944	1.241	0.992	2.233	.120	1.04
1945	1.079	1.020	2.099	.120	1.37
1946	0.604	1.775	2.379	.115	1.18
1947	0.508	0.821	1.309	.084	1.73
1948	0.535	1.645	2.180	.111	1.94
1949	1.016	1.770	2.786	.089	1.80
1950	0.426	0.529	0.955	.133	1.12
1951	0.492	1.340	1.897	.137	0.73
1952	0.466	0.880	1.346	.113	0.51

*Landings as recorded represent dressed weights.

**From time to time, according to International Pacific Halibut Commission records, some sablefish has been landed in southeastern Alaska by Canadian vessels, the maximum in any one year amounting to about 230,000 pounds in 1945, and ranging down to none in recent years.

***Between 1917 and 1930 an indeterminate amount of District 2 receipts may have been duplicated in Districts 1 and 3 totals, as a result of reporting practices during that period.

APPENDIX 2.

RECORDS OF CATCH PER SKATE (POUNDS) IN REGIONS EXPLOITED BY THE CANADIAN SABLEFISH FLEET

	1	2	3	4	5	6*	7**	8***
Year	West Coast Vancouver Island	Queen Charlotte Sound	West Coast of Queen Charlotte Islands	West Coast of Prince of Wales Island	West Coast of Baranof and Chichagof Islands	South-eastern Alaska	Southern District	Northern District
1918	199	...	...	...	...	...	199	...
1919	...	...	...	...	...	...	...	...
1920	...	...	...	...	...	...	...	...
1921	126	...	...	...	...	...	126	...
1922	...	...	...	...	...	...	...	...
1923	...	...	...	...	...	...	...	...
1924	134	...	...	...	...	...	134	...
1925	...	...	...	...	...	...	...	...
1926	...	...	...	...	...	...	...	...
1927	...	...	...	125	108	117	...	117
1928	...	...	...	...	...	...	...	...
1929	...	...	...	120	...	120	...	120
1930	69	118	...	...	145	145	94	145
1931	...	...	134	...	115	115	...	125
1932	...	...	...	...	128	128	...	128
1933	...	137	...	...	112	112	137	112
1934	...	...	...	125	142	134	...	134
1935	81	...	104	170	175	173	81	150
1936	...	...	96	...	183	183	...	140
1937	...	90	116	143	132	138	90	130
1938	...	...	107	...	110	110	...	109
1939	107	129	...	142	154	148	118	148
1940	110	...	103	...	114	114	110	109
1941	66	...	109	...	116	116	66	113
1942	...	...	...	...	139	139	...	139
1943	65	...	...	93	135	114	65	114
1944	...	88	132	...	128	128	88	130
1945	...	80	106	100	143	122	80	116
1946	72	78	83	105	106	106	75	98
1947	...	68	68	90	87	89	68	82
1948	62	74	77	98	103	101	68	93
1949	68	72	75	114	95	105	70	95
1950	66	72	69	92	...	92	69	81
1951	75	67	81	104	92	98	71	92
1952	67	64	75	96	109	103	66	93
1953	70	74	...	115	98	107	72	107

*Arithmetic Mean of columns 4 and 5.
**Arithmetic Mean of columns 1 and 2.
***Arithmetic Mean of columns 3, 4 and 5.

APPENDIX 3.

SEASONAL TREND IN CATCH BY AREAS
(Av. 1951–53 in Thousands of Pounds)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ALASKA													
Av. Catch	.....	.....	35.9	61.6	10.6	23.9	268.8	71.2	102.3	71.3	26.9	.....	672.4
Percent	.....	.....	5.3	9.2	1.6	3.6	40.0	10.6	15.2	10.6	4.0	.....	
DIXON ENTRANCE													
Av. Catch	.....	.....	6.9	0.5	2.6	4.0	84.1	17.9	20.1	5.9	.....	.....	142.0
Percent	.....	.....	4.9	0.4	1.8	2.8	59.1	12.6	14.1	4.1	.....	.....	
HECATE STRAIT													
Av. Catch	.....	0.3	6.8	7.4	9.1	11.0	32.3	29.6	17.7	3.8	2.3	0.3	120.6
Percent	.....	0.2	5.6	6.1	7.5	9.1	26.8	24.6	14.7	3.2	1.9	0.2	
Q. CHARL. ISLANDS													
Av. Catch	11.3	29.6	35.5	43.7	10.7	12.7	14.4	0.2	2.0	9.2	2.3	.....	171.6
Percent	6.6	17.3	20.6	25.5	6.3	7.4	8.4	0.1	1.2	5.4	1.3	.....	
Q. CHARL. SOUND													
Av. Catch	.....	.....	3.3	13.6	3.5	7.1	35.3	21.2	62.6	32.9	7.2	.....	186.7
Percent	.....	.....	1.8	7.3	1.9	3.8	18.9	11.4	33.5	17.6	3.9	.....	
W. COAST VANC. IS.													
Av. Catch	.....	.....	.....	.....	0.7	24.8	8.4	7.4	38.5	43.0	6.9	.....	129.7
Percent	.....	.....	.....	.....	0.5	19.1	6.5	5.7	29.7	33.2	5.3	.....	
W. COAST VANC. IS.													
Av. Catch (Trawl)	.....	.....	.....	.....	.....	0.9	5.5	9.8	25.8	2.3	.....	.....	44.3
Percent	.....	.....	.....	.....	.....	2.1	12.4	22.1	58.3	5.2	.....	.....	

PRELIMINARY REPORT ON THE ALASKA SABLEFISH FISHERY

QUENTIN A. EDSON
Alaska Department of Fisheries

BULLETIN 3
PACIFIC MARINE FISHERIES COMMISSION
Portland, Oregon, 1954

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PRELIMINARY REPORT ON THE ALASKA SABLEFISH FISHERY

INTRODUCTION

Research on sablefish (*Anoplopoma fimbria*) or blackcod, as it is commonly called in Alaska, was initiated by the Alaska Department of Fisheries in 1950. This species was selected for investigation because of its importance to Alaskan fishermen and because practically no previous research had been done on this species in Alaska. The Japanese fishing treaty was another factor leading to the study of this fish. Sablefish are not included in the treaty and cannot be until research work has been carried on.

The sablefish fishery supplies an important part of the Alaska long-line fishermen's income. While the majority of the long-liners fish for sablefish before and after the halibut season, there are a few small boats who devote the entire season to this fishery. During the past ten years, sablefish, including livers and viscera, have brought an annual average income of approximately $500,000 to Alaska's fishermen.

FISHING AREAS

Sablefish are fished in nearly all of the deep water areas from Dixon Entrance to Kodiak Island. Clarence Strait, Frederick Sound and Chatham Strait, all in Southeastern Alaska, support the most concentrated fisheries in the inside waters (Figure 1). The offshore waters of Prince of Wales Island, Baranof Island, Cape Cross to Cape Fairweather, and from Middleton Island to Portlock Bank constitute the fishing grounds in the outside area. From these grounds sablefish are landed in several ports, the major ones being Ketchikan, Wrangell, Petersburg, Juneau, Pelican, Sitka and Cordova. The majority of the catch is frozen after landing and shipped to various points throughout the United States. The present legal fishing season for the inside waters extends from May 1 to November 30 and some fishing is carried on throughout this entire period. There is no closure to fishing in the waters outside the territorial limits, but weather permits fishing on these grounds only from the latter part of April through September.

FISHING METHODS

All sablefish landed in Alaska are caught by long-lines. Until 1948 this type of fishing gear was the same as that used for halibut with slight modifications for fishing in deeper waters. The buoy line, ground line, gangion and hook size, however, was identical to halibut gear. In 1948 a change in sablefish gear was introduced in Alaskan waters by fishermen on the boat "Wolverine." Instead of the large halibut hooks, smaller, eyed hooks were used and attached to the ground line by a nylon gangion 9 or 13 feet apart instead of 13 or 18 feet apart as on the conventional halibut gear. The use of this small hook gear prevents a large number of fish from spinning themselves free from the gear as they would otherwise do. Now a considerable number of boats use this type of gear.

Small hook gear was used very successfully during tagging operations in Chatham Strait. To test the effectiveness of the gear, one skate of large hooks was placed midway between four skates of small hooks in each five skate string. The skate of large hooks produced an average catch of 12 fish while the small hook gear averaged 40 fish per skate. There were twice the number of hooks on the small hook gear as on the large, but correcting for this difference by doubling the large hook catch the effectiveness is still significantly greater. The number of fish injured from this gear was also noticeably less, but this point will be discussed later.

TAGGING PROGRAM

Sablefish were tagged for the first time in Alaskan waters by the Department in 1951. Tagging was conducted from commercial long-line vessels in northern Chatham Strait during March, October and November of that year. A total of 989 sablefish were tagged during this period. Metal strap tags were tried during a portion of this experiment but were found to be unsuitable because the opercular bones were too thin to properly hold this type of tag and further, they were difficult to recognize upon recovery. Peterson tags were then used for the remainder of the operation, being

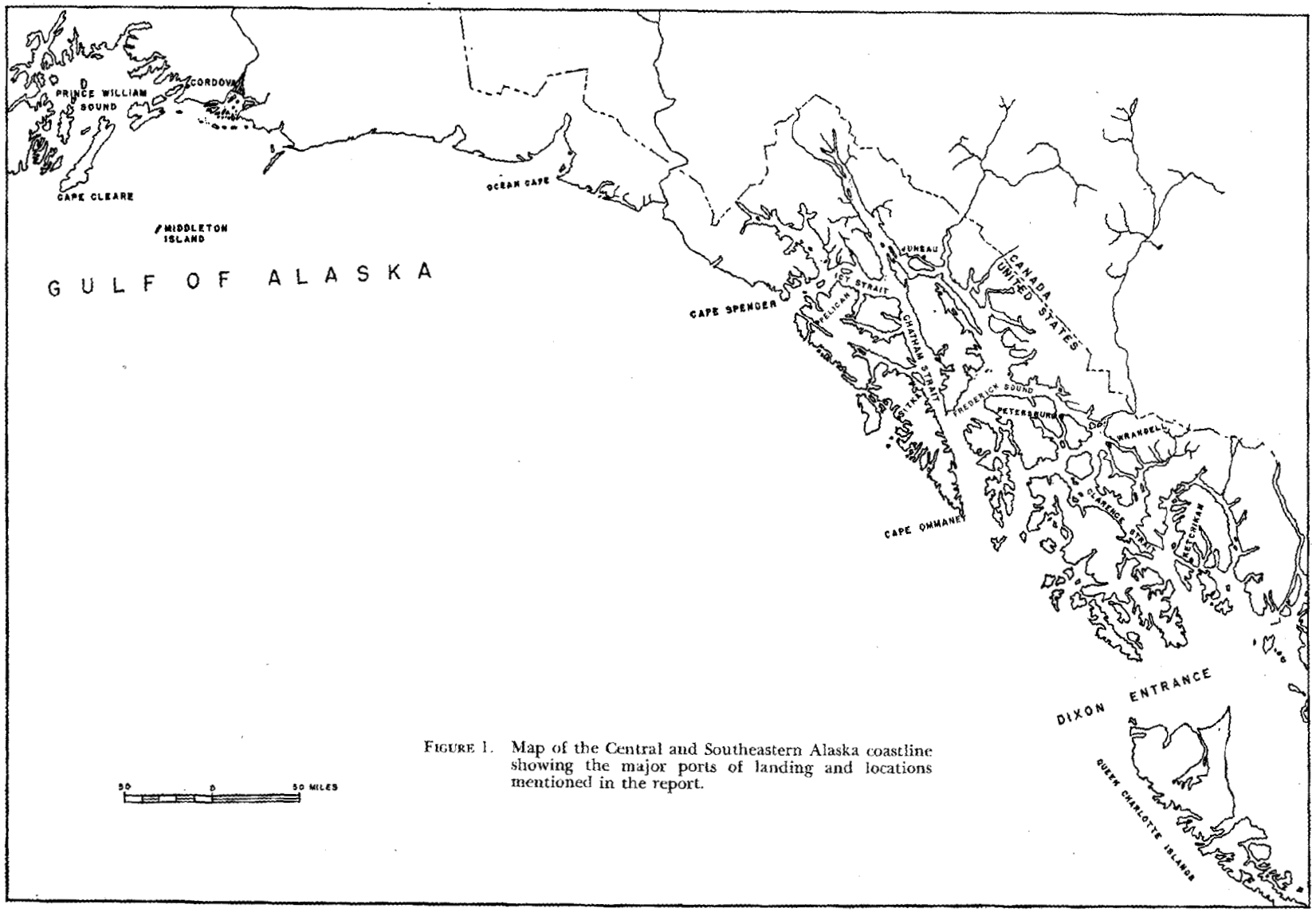

FIGURE 1. Map of the Central and Southeastern Alaska coastline showing the major ports of landing and locations mentioned in the report.

affixed to various parts of the fish to determine the most satisfactory tagging procedure. It was believed that a yellow or white Peterson tag attached to the opercle by a pure nickel pin would be the most suitable method of tagging.

From the tagging in 1951, six recoveries were made in 1952 and three recovered in 1953 as of September. These nine recoveries summarized in Table 1, were free an average of 405 days and migrated an average minimum distance of 10 miles from the point of tagging. Probably one of the reasons for this low recovery rate was the low fishing intensity in this area during 1952 caused by the unattractive price of sablefish to the fisherman. This condition held true in all areas for sablefish in 1952.

TABLE 1. RECOVERIES OF SABLEFISH TAGGED IN NORTHERN CHATHAM STRAIT, 1951

Fork Length Inches	Date Tagged	Date Recovered	Days Free	Minimum Miles Traveled
23.0	10/24	10/15/52	357	5
26.0	10/25	9/17/52	326	8
26.0	10/28	10/17/52	354	32
30.0	10/30	9/21/52	326	8
30.0	10/30	10/14/52	349	5
30.5	11/9	9/5/52	299	25
32.0	10/24	8/22/53	667	10
28.0	10/23	9/10/53	687	0
28.5	10/24	9/10/53	686	0

The program was intensified in 1952 with tagging and sampling being conducted from southern Chatham Strait to Middleton Island in the Gulf of Alaska. Middleton Island, Cape Spencer and Chatham Strait were selected for tagging areas since the latter two fishing grounds have supported the greatest concentrated fishery in recent years on an annual basis. These areas were also chosen because they are far enough apart to show either intermigration or complete separation of stocks. The Middleton Island area includes all waters adjacent to that island and westward along the edge to the Seward Gully. The Cape Spencer area is composed of the offshore waters from Cape Cross on Yakobi Island northwestward to Icy Point on the mainland. The Chatham Strait area includes the waters of that strait from Point Retreat, at the north end of Admirality Island, southward to Cape Ommaney on the southern end of Baranof Island.

All tagging was carried on from a commercial long-line vessel and all fishing procedures were identical to normal commercial operations. As each fish was landed aboard the fishing vessel, it was carefully examined for any injury which might have occurred from the gear. The fish were held up by the tail making possible examination of the esophagus for hook injuries. Quite often fish were hooked in the esophagus and later freed themselves but were hooked again in the mouth before being able to escape from the gear. Only those sablefish which were hooked in the mouth alone were selected for tagging. The remainder of the catch were sampled and marketed. The majority of the catch was unsuitable for tagging, the percentage of which is presented in Table 2. Fishing operations in Chatham Strait appear to be less injurious to the fish than the outside areas. This condition could be caused by the action of the sea in the outside waters which creatse a heaving action on the gear thus increasing the number of injured fish. It can also be seen from the table that the small hook gear allowed a higher percentage of the catch to be landed in a condition suitable for tagging. This latter condition can best be attributed to the manner in which the gear operates.

TABLE 2. PERCENTAGE OF SABLEFISH UNSUITABLE FOR TAGGING FROM LONG-LINE GEAR BY AREA, 1952

Area	Number Caught	Number Unsuitable	Percentage Unsuitable
Middleton Island	2,722	1,753	64.40
Cape Spencer	5,209	3,754	72.07
Chatham Strait,			
Large Hooks	1,593	965	60.58
Small Hooks	4,778	2,517	52.68
Total	14,302	8,989	62.85

A total of 5,333 sablefish were tagged in 1952 in the selected tagging areas. Table 3 shows the distribution of this tagging by area. Of the 2,909 fish tagged in Chatham Strait, 935 were tagged in the northern portion and the remaining 1,974 in the southern section of that strait. Since tagging was conducted in northern Chatham Strait the previous year, the majority of the tagging effort was concentrated in the southern area. All sablefish in 1952 were tagged by a white Peterson tag affixed to the opercle by a pure nickel pin. The depths in which the fish were captured ranged from 100 to 400 fathoms, depending upon the type of bottom and concentration of fish. No harmful effects from the change in pressure were observed and all fish liberated were lively and swam directly back down toward the depths from which they were taken.

TABLE 3. SUMMARY OF SABLEFISH TAGGING BY AREA, 1952

Area	Number Tagged	Number Returned[1]	Percent Return
Middleton Island	969	2	0.21
Cape Spencer	1,455	3	0.21
Chatham Strait	2,909	7	0.24
Total	5,333	12	0.22

[1]As of September, 1953.

A total of 12 recoveries were made from 1952 tagging as of September 1953. Only two recoveries were made in 1952, one at Cape Spencer taken four days after release in this area and one in southern Chatham Strait recaptured 30 days after liberation from this locality. In 1953, ten recoveries were made from the various tagging areas. Table 4 summarizes six of these returns from southern Chatham Strait. These six recoveries were free an average of 271 days and showed an average migration of approximately nine miles from the point of tagging. This migratory pattern compares favorably with the 1951 tagging in northern Chatham Strait. The remaining four recoveries from the 1952 tagging, which were taken in the outside waters, present somewhat a different picture. While the returns from the Cape Spencer area indicate a local stock exists, the Middleton Island area results are altogether different. From the former area, two recoveries, which were free an average of 250 days, traveled an average of approximately 16 miles from the point of tagging. This distance is still well within the limits of the tagging area. The other two returns from the Middleton Island tagging show a comparatively long migration in a southerly direction. One of these fish was tagged 50 miles off Cape Cleare, which is located at the western entrance to Prince William Sound, and 265 days later was recovered off La Perouse Glacier, north of Cape Spencer, a minimum distance of 380 miles. The other was also tagged 50 miles off Cape Cleare but traveled a minimum distance of 1,230 miles where it was recaptured off Cape Flattery, on the Washington Coast 372 days later. There has been only one complete fishing season since the tagging occurred and this was one of comparatively low intensity especially in the outside area. While these recoveries indicate the nature of the stocks in Alaskan waters, it will take one, and perhaps two more seasons to give more conclusive results.

TABLE 4. RECOVERIES[1] OF SABLEFISH TAGGED IN SOUTHERN CHATHAM STRAIT, 1952

Fork Length Inches	Date Tagged	Date Recovered	Days Free	Minimum Miles Traveled
29.5	10/16	6/18/53	245	30
31.5	10/12	6/22/53	253	0
26.0	10/9	6/19/53	253	12
37.5	9/28	7/22/53	297	0
31.0	9/29	8/3/53	296	0
29.5	10/11	7/21/53	283	11

[1]As of September, 1953.

Each year concentrations of juvenile sablefish move into the shallow water areas of bays and inlets during the summer months. In an attempt to determine where and when these fish ultimately enter the commercial catch, tagging was conducted in Tongass Narrows at Ketchikan in June, 1953. These immature fish school up in large numbers, actively feeding all along the waterfront area of that city. The fish used for tagging were caught by a hand line with a barbless hook. Since the opercles of these fish are too tender to support a tag, all tags were affixed to the body at the second dorsal fin. A total of 1,114 sablefish were tagged. As of September, 1953, 23 recoveries have been recorded. All but one of these returns were recaptured in Tongass Narrows, the remainnig fish migrated to Wrangell Harbor where it was captured. All recoveries were made by hand lines and other forms of sport tackle. Many of the fishermen reported seeing the tagged fish in the water and fished deliberately for those particular fish. This is believed to be the reason for the high recovery rate in Tongass Narrows.

SIZE AND AGE COMPOSITION OF THE COMMERCIAL CATCH

Figure 2 depicts the length frequencies of the sablefish samples from Middleton Island, Cape Spencer and Chatham Strait. While the size range in all three areas is very similar, extending from about 18 to 40 inches, the size composition in the two outside areas differs from that in the inside area. This difference is also borne out by the mean lengths, presented in Table 5. The mean lengths for females in the Middleton Island and Cape Spencer areas are 29.34 and 29.35 inches, respectively, while the inside area is significantly less, being 28.47 inches. These data also support the assumption that the sablefish in Alaskan waters may be separated into inside and outside stocks.

After the small hook gear had been in use for a short time, there were reports that this gear was selecting a smaller size group of sablefish than was the gear fishing with large hooks. Both type of gear were employed in the tagging operations in Chatham Strait and a very large sample from each was obtained. The length frequency distributions are very nearly equal and possibly the reason they are not identical can be attributed to sampling error. The mean length of the distributions is also nearly equal, being 27.23 inches for the catch by large hooks and 27.54 inches for the small hook catch.

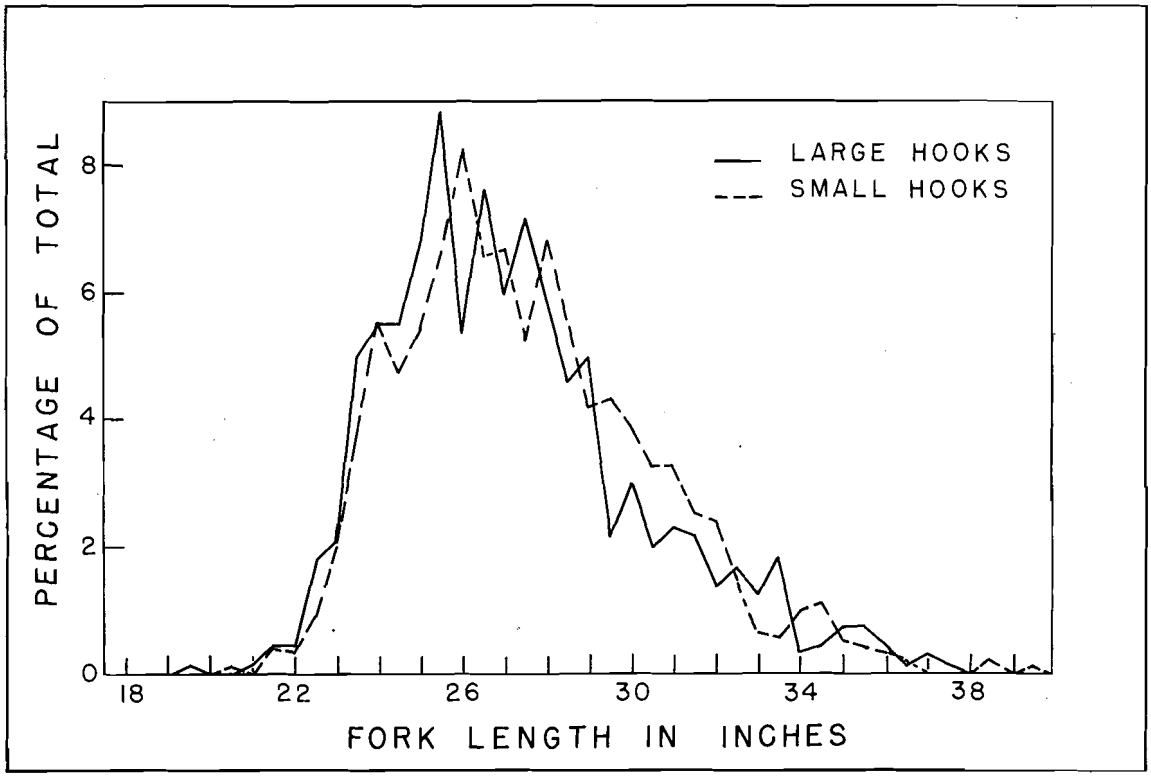

FIGURE 3. Comparison of the length frequency distributions of sablefish caught by large and small hook long-line gear in Chatham Strait.

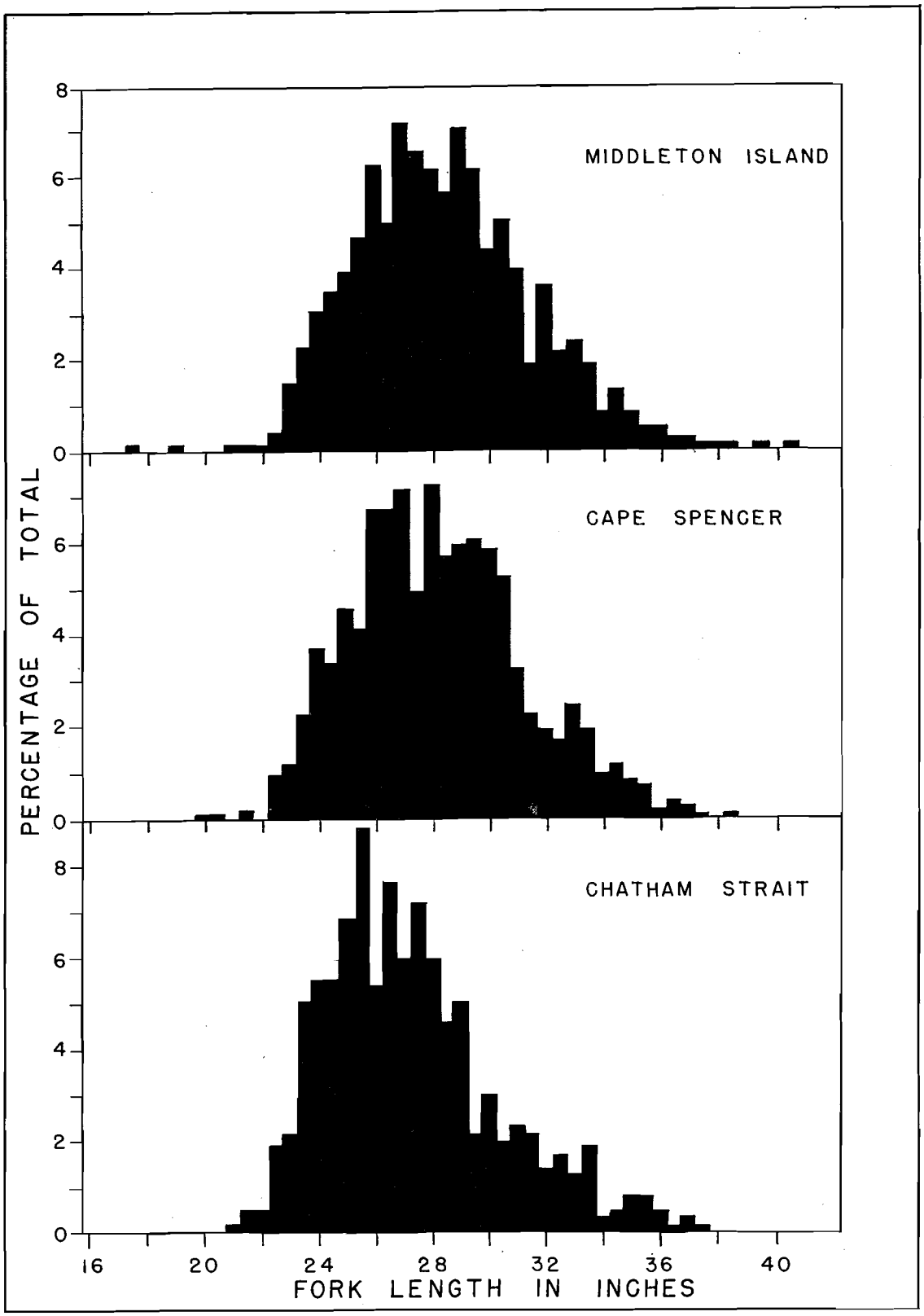

FIGURE 2. Length frequency distributions of sablefish sampled in the Middleton Island, Cape Spencer and Chatham Strait areas during 1952.

The age analysis and the rate of growth studies have not been completed as yet, but a preliminary examination of the age of the outside stocks has been undertaken. These early results show the commercial catch of sablefish to be composed of fish from three to nine years old. The majority of the catch appear to be in their sixth and seventh year. Scale measurements have not been taken and when this and other phases of the analysis are completed these early results may change. Further analysis might also show a different rate of growth and age composition of inside and outside areas which will aid in the explanation of the now apparent difference of conditions between these two major areas.

SEX RATIO AND MATURITY

The sex ratio, expressed in percentage of males and females, and the percentage of mature sablefish in the various areas are also included in Table 5. These data were compiled from samples taken during August, September and October of 1952. Existence of separate outside and inside stocks of sablefish is further indicated by these factors. The Middleton Island and Cape Spencer areas again compare favorably and both show a significant difference from the Chatham Strait composition. All data presented in Table 5 are samples obtained from the large hook gear to give a true comparison of the fishing areas.

TABLE 5. MEAN LENGTH, SEX RATIO AND MATURITY OF SABLEFISH BY PERCENTAGE OF TOTAL SAMPLE, BY AREA

Area	MALES			FEMALES		
	Total Percentage	Mean Length in Inches	Percentage Mature	Total Percentage	Mean Length in Inches	Percentage Mature
Middleton Island...	73.84	25.93	94.92	26.16	29.34	98.02
Cape Spencer.....	70.01	25.64	93.11	29.99	29.35	97.89
Chatham Strait.....	61.93	25.14	87.95	38.07	28.47	86.17

Figure 4 depicts the sex composition in relation to the length frequency. From this figure it can be seen that the larger sizes are entirely composed of females while the males dominate the smaller size groups. The distribution of sizes by sex for each area is very similar, but the percentage of sablefish which are mature as seen from Table 5 varies to a considerable degree between the outside and inside areas.

The apparent differences of characteristics between the inside and outside areas described in this and preceding sections is possibly due in part to the nature of the fishery since its origin in Alaska. Unfortunately data for a history of the fishery is not available at this time but it appears that the fishing intensity during the early years was greatest in Chatham Strait and other inside areas. If then, Chatham Strait has been fished more intensively and over a longer period of time than the outside areas, it follows that a reduction in size has taken place in the inside areas. While this condition does not appear to account wholly for the differences, it probably is responsible for some of the distortion.

RELATIVE ABUNDANCE OF SABLEFISH

Long-line fishermen have kept accurate logs listing daily catches and numbers of skates of gear fished. From these data the catch per unit of effort and average weight has been determined in the various fishing areas. Figure 5 shows the catch per skate for Chatham Strait, the outside areas and both the inside and outside areas. The catch was calculated in both numbers of fish per skate and pounds of fish per skate but since the former group of data are more complete at this time it is presented in Figure 5 only in numbers of fish. The average weight per fish is also depicted on the same graph to further show the effect of fishing. The trend of catch per skate in numbers of fish will differ from the catch per skate in pounds due to the changing average size of the fish. The trend of the catch per skate for all areas combined shown in upper Figure 5 is influenced by the proportionate representation of the fishing records from the outside and inside fishery.

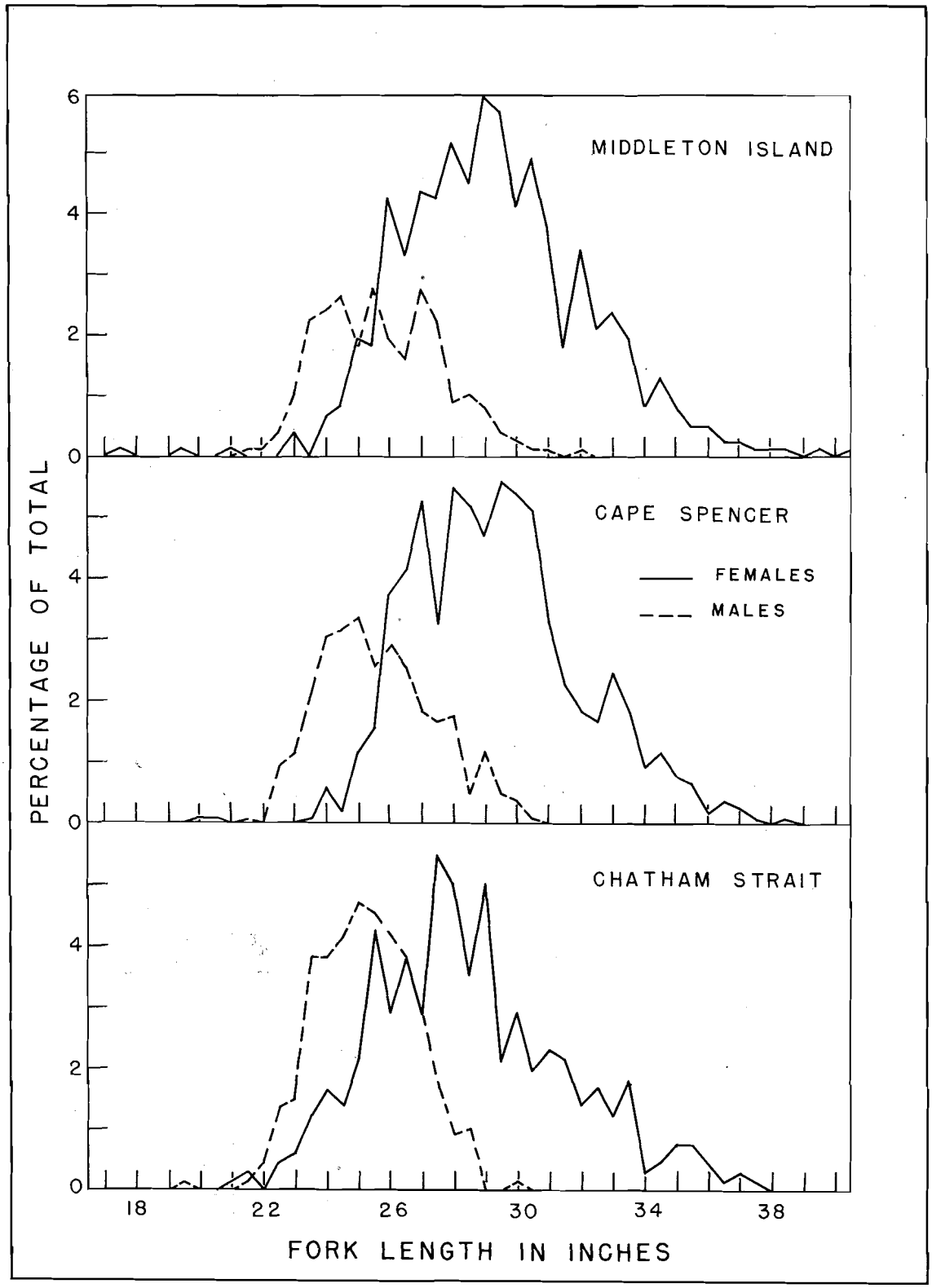

FIGURE 4. Length frequency distributions of the Middleton Island, Cape Spencer and Chatham Strait areas showing the sex composition of the commercial catch of sablefish.

The overall picture of Alaska's sablefish fishery is one of gradual decline in average size of fish and catch per unit of effort from the early years to 1947. After 1947 the intensity of the fishing lessened and the catch per skate on the longer fished grounds has ceased its decline. The average weight per fish also shows a slight increase during these latter years. Looking at this trend in the major areas, the trend of decline appears to be at different rates in the various groups of areas. While the catch per skate for the outside areas (middle Figure 5) shows a gradual decline, in inside areas as represented by Chatham Strait (lower Figure 5) the extent of the decline has been greater over the years covered by the dates. Both of these downward trends closely follow the decline in average weight per fish in their respective areas. The fishermen's log books indicate that fishing in the outside waters was less intense than the inside fishing until the late 1930's. From that time on, depending on the condition of the market, the total landings from the outside waters have been more equal to those from inside areas.

CURRENT STATUS OF THE FISHERY

The Alaska sablefish landings from 1929 to 1952 are depicted by Figure 6. These landings cannot be used as an index of abundance of sablefish since there has been such great fluctuations in fishing intensity for varied reasons. The catch rises very sharply during the years of World War II when the demand for the fish increased and the value of the liver and viscera also rose to a record figure. In 1947 when the demand for the fish was decreasing, and more important, when the market for liver and viscera became unstable, the catch fell accordingly. Since that year the catch has been very erratic and varies with the cold storage carry-over. Unfortunately, records of the total amount of gear fished in relation to the total landings are not available for the years covered. A complete history of the fishery is also not available at this time, but when it can be compiled it will greatly assist in the interpretation of these trends.

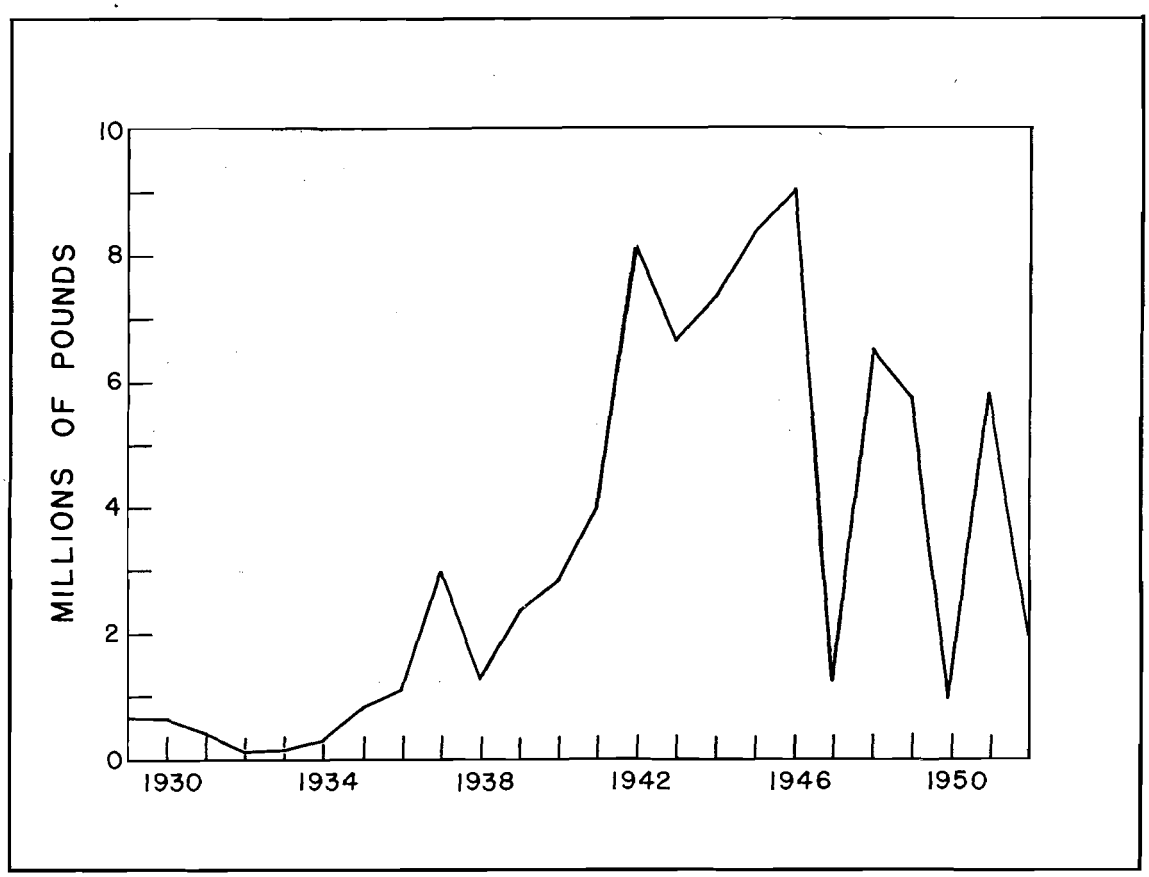

FIGURE 6. Commercial landings of sablefish in Alaska from 1929 to 1952.

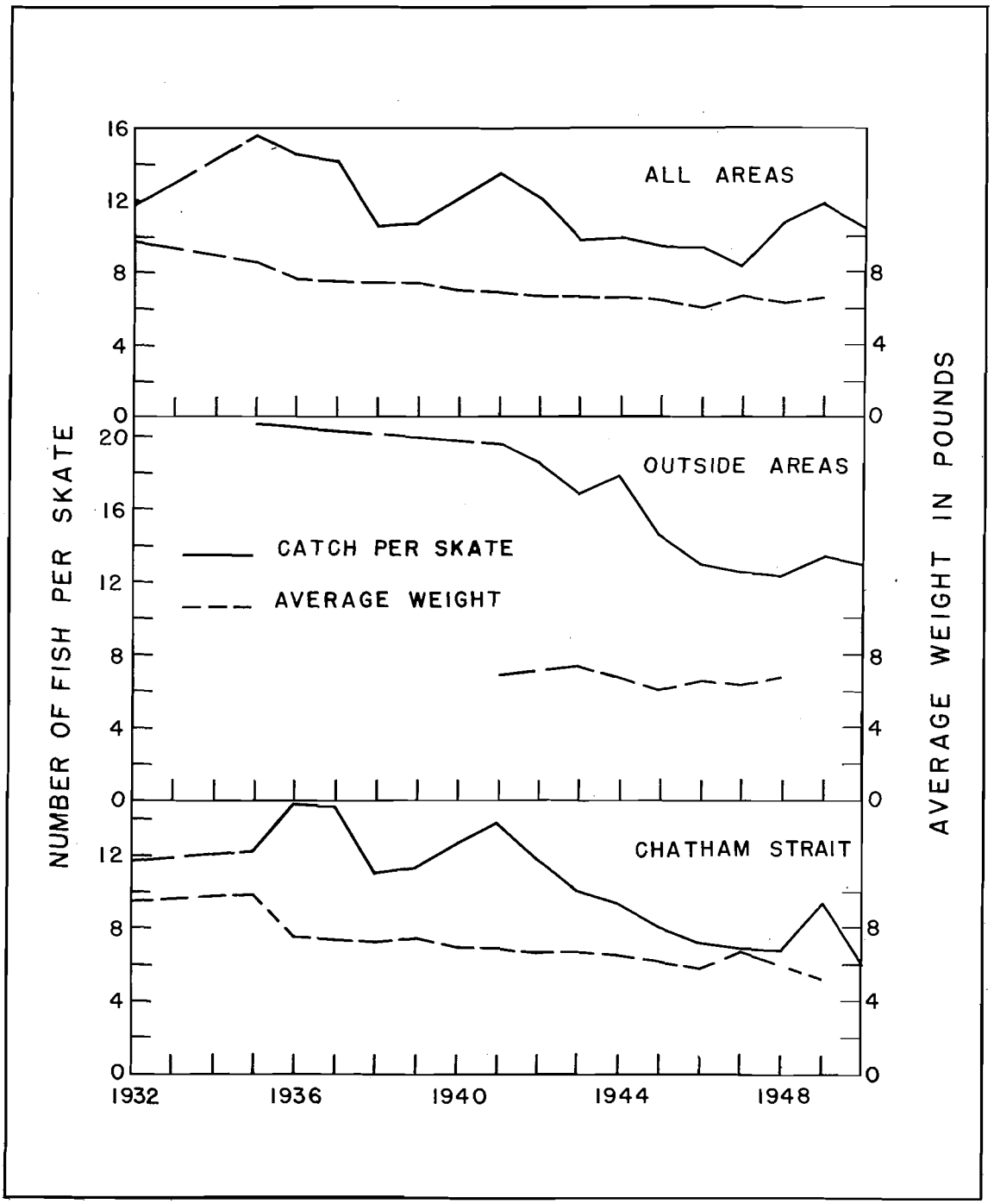

FIGURE 5. Catch per unit of gear and average weight per fish from all areas, the outside area and Chatham Strait.

The present fishing season for sablefish seems to be set to offer protection for the fish while spawning. This legal closure is effective from November 30 to May 1 of the following year. The closure appears to accomplish its purpose and is favored by the majority of the fishermen although economic reasons also apparently have been considered. From observations of the fishery and reports by the fishermen, the stocks of sablefish seem to be adequate and the fishing intensity is now a function of the market conditions.

The Department has had requests from some of the fishermen to recommend a 4½ pound minimum size limit on sablefish. At the time of the requests there was not sufficient data available to evaluate such a recommendation. Figure 4 and the maturity column in Table 5 indicates what effect a restriction of this type would have. Since a 4½ pound sablefish is about 23.5 to 24 inches in length, this measure would offer protection to a small percentage of the catch, as the smallest sablefish available to the commercial fishery is about 18 inches. Most of the fish in this lower size range are males and the majority are mature. The percentage of sablefish which are mature under 23.5 and 24 inches is summarized in Table 6. In the outside sample over 70% of the fish under 23.5 inches were mature and in Chatham Strait 46% of these smaller fish were mature. The effect of such a restriction would not protect immature sablefish as was the popular belief, but merely the smaller adults. While a regulation of this type might be of an economic value there is no biological basis to support such a measure.

TABLE 6. PERCENTAGE OF MATURE SABLEFISH UNDER 23.5 AND 24 INCHES, BY AREA

Area	Under 23.5 Inches	Under 24.0 Inches
Middleton Island	80.56	84.75
Cape Spencer	73.47	77.91
Chatham Strait	46.27	55.34

Other data pertinent to the determination of the status of the fishery has been collected but is not ready for presentation at this time. After these data have been analyzed and incorporated with the preliminary material, we shall then be better situated to determine what additional management measures, if any, should be taken to maintain Alaska's sablefish fishery on a sustained yield basis.

SUMMARY

From the early tagging returns and samples taken of the commercial landings of sablefish, it appears that the sablefish in Alaskan waters are separated into local stocks. While the stocks in the inside waters seem to be of local origin, the interrelationships of the stocks in the outside waters is not as yet clear.

The relative abundance as indicated by the catch of numbers of fish per skate shows a general decline in all areas followed by a leveling off period since 1947. The present fishery is one of varying degrees of intensity which fluctuates with market conditions and carry-over cold storage holdings.

From a biological viewpoint there appears to be no basis for a 4½ pound minimum size limit, as such a proposed restriction would only offer protection to a small percentage of the catch, the majority of which is composed of mature males.

ACKNOWLEDGMENTS

At the beginning of the sablefish investigation by the Department, the U. S. Fish and Wildlife Service and the International Pacific Halibut Commission turned over all of their available data on this species. The use of this material is hereby gratefully acknowledged. The International Pacific Halibut Commission has afforded the Department the opportunity to copy the sablefish data from Alaska's fishermen's log books for current years. Thanks are due F. Heward Bell, International Pacific Halibut Commission, for his critical review of this report.

Innumerable fishermen and buyers have also been helpful in reporting tagged fish and cooperating in the collection of data as needed during the course of the investigation.

A RACIAL STUDY OF PACIFIC COAST SABLEFISH, *ANOPLOPOMA FIMBRIA*, BASED ON MERISTIC COUNTS

J. B. Phillips
C. R. Clothier
and
D. H. Fry, Jr.

Marine Fisheries Branch
California Department of Fish and Game

Bulletin 3
Pacific Marine Fisheries Commission
Portland, Oregon, 1954

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

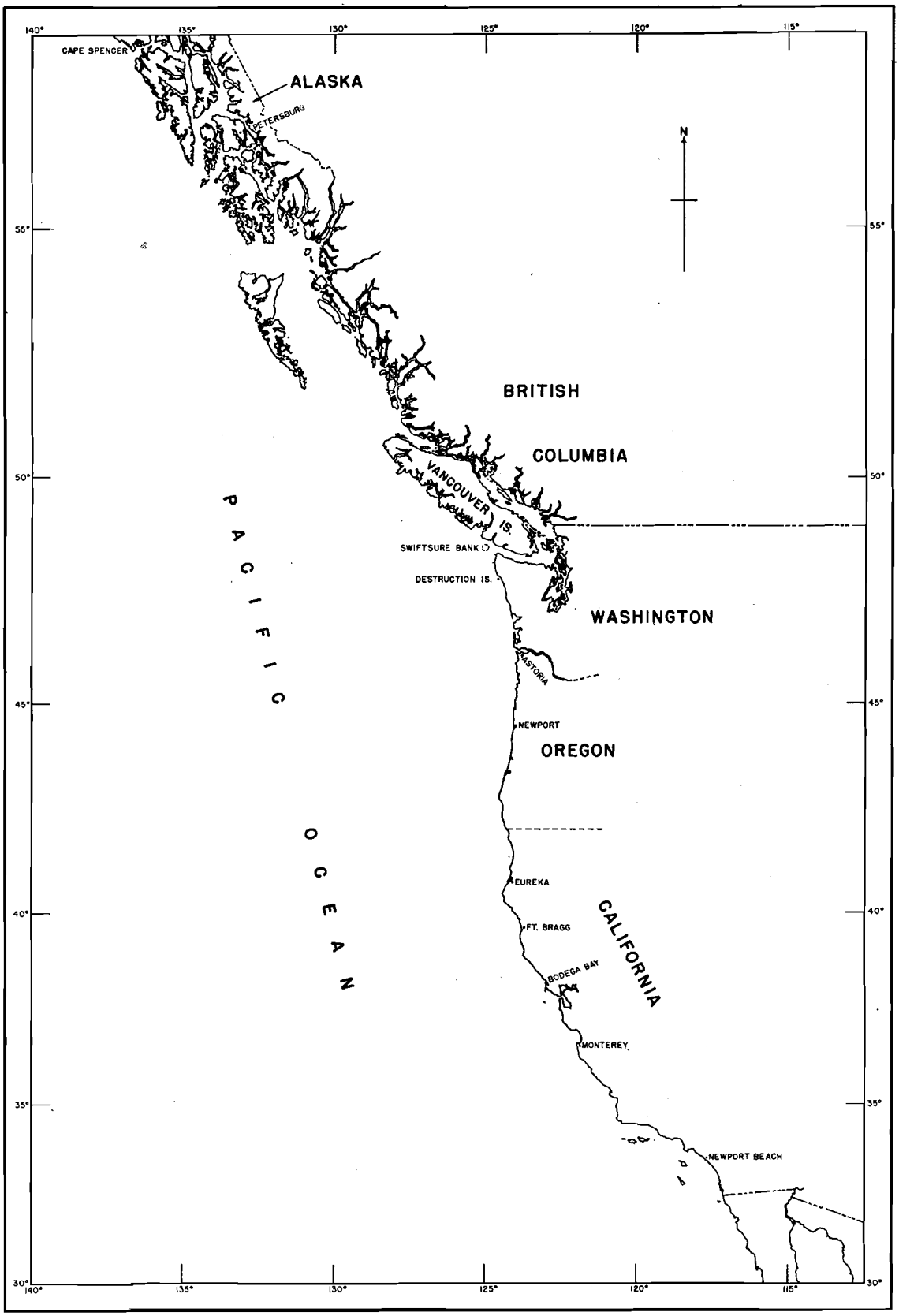

FIGURE 1. Map of the Pacific Coast showing the areas from which sablefish were taken for the racial study.

A RACIAL STUDY OF PACIFIC COAST SABLEFISH, *ANOPLOPOMA FIMBRIA*, BASED ON MERISTIC COUNTS

INTRODUCTION

Following a recommendation by the Pacific Marine Fisheries Commission, early in 1950 the different fisheries agencies along the Pacific Coast of North America outlined a joint program for a life history of the sablefish (black cod), *Anoplopoma fimbria*. Participating agencies in this study are the Alaska Department of Fisheries, Fisheries Research Board of Canada, State of Washington Department of Fisheries, Oregon Fish Commission, and the California Department of Fish and Game.

For a racial study of this species, each agency provided samples of fish from different regions along the coast (see Figure 1). These samples were shipped to the California State Fisheries Laboratory, where one author made counts on the meristic characters of all the fish that were made available. On each individual the following counts were made: number of vertebrae, including the urostyle; vertebra on which the first haemal arch occurred; vertebra on which the first haemal spine occurred; number of gill rakers; number of rays in the anal fin; number of rays in the second dorsal fin; number of spines in the first dorsal fin.

The purpose of this racial study is to determine if there are sufficient physical variations between fish from different geographical regions to indicate that there may be separate stocks between which there is little intermingling. If fish from different regions intermingle freely, various physical characteristics should not vary to any great extent. Certain characters, such as the number of vertebrae, may be strongly modified by environment. A decrease in the average number of vertebrae, from north to south in the northern hemisphere, in keeping with a transition from colder to warmer water, has been noted for a number of fishes.

In this racial study (as in most) the differences between fish from different areas are so small that statistical methods must be used to demonstrate their existence. When such differences are found, it does not mean that no movement of fish can occur between the areas in question; it does means that if such movement does occur, it is probably of small magnitude. It is desirable to conduct tagging experiments, as well as racial studies, to determine the magnitude of interchange between regions.

MERISTIC COUNT METHODS

All fish were shipped in a frozen condition. Upon arrival at the laboratory, they were placed in frozen storage and removed as needed. Two of the shipments received were of fish which had been dressed by removal of gills and viscera. In two other samples, autolysis had proceeded to such an advanced state that the internal organs, including gonads, were unrecognizable.

After the fish were thawed, they were measured and counts made of the anal rays, dorsal rays, dorsal spines, and gill rakers. The fish were boiled just long enough to permit breaking the flesh away from the backbone. Counts were then made of the total number of vertebrae (including the urostyle). The positions of the first haemal arch and the first haemal spine were also recorded.

Early in the study, after processing some of the fish, the discovery was made that the first dorsal fin spines continued on beneath the skin, sometimes completely across to the second dorsal fin, and that the anal fin might be preceded or followed by one or two rays buried beneath the skin. From then on, the two dorsal fins and the anal fin were sliced off with sufficient surrounding tissue to include any buried rays or spines. These sections were cleared with potassium hydroxide and stained with alizarin, to accentuate vestigal rays or spines. Table 1 shows the inaccuracies of the former method of counting. Four fish were selected and four biologists were asked to count the fin rays and spines. Their counts are recorded in columns A, B, C, and D. The fins were then sliced off and put through the clearing and staining process. The fifth column shows the true counts after clearing and staining. Except in the comparison between males and females the fin ray and spine counts include only stained specimens.

TABLE 1. FIN RAY AND SPINE COUNTS MADE BY FOUR BIOLOGISTS (A, B, C, D) ON THE SAME FOUR FISH. THE TRUE COUNTS, AFTER STAINING, ARE SHOWN AT RIGHT. SPINES ARE INDICATED BY ROMAN NUMERALS AND RAYS BY ARABIC NUMERALS.

Fish No.	A		B		C		D		True Counts (After Staining)	
	Dorsal Fin	Anal. Fin	Dorsal Fin	Anal. Fin	Dorsal Fin	Anal. Fin	Dorsal Fin	Anal. Fin	Dorsal Fin	Anal. Fin
1	XX-18	17	XXI-18	18	XX-18	17	XX-17	18	XXII-18	18
2	XXI-18	18	XXII-18	18	XXI-18	18	XXII-18	18	XXVI-18	19
3	XXI-17	19	XXII-17	19	XXIII-17	19	XXII-17	19	XXIV-17	19
4	XX-18	18	XX-18	18	XX-18	18	XX-18	18	XXIV-18	18

To make the gill raker counts, the first gill arch on the left side was removed. The gill rakers were somewhat variable. In some specimens the end rakers were distinct, while in others the end rakers were reduced to mere nubs. All nubs were counted as rakers. The count used was the total of all rakers on the first gill arch.

The first haemal arch is defined as being on the first vertebra, counting posteriorly from the skull, on which the pair of haemal processes are connected by a bridge of bone, thus forming an arch.

The first haemal spine is defined as being on the first vertebra, counting posteriorly from the skull, on which the ends of the haemal processes have united to form a single point. In some cases a reading glass was necessary to determine if the haemal processes were bifurcate or fused to a single point.

CLASSIFIED SUMMARIES OF SAMPLE DATA

The catch information for the samples of sablefish that were used for the meristic counts are itemized in Table 2. These samples ranged from off Cape Spencer, Alaska, latitude 58° 10′ N., to off Newport Beach, Southern California, latitude 33° 37′ N. It was not always possible to use all the fish in a sample for each of the various counts because of an occasional malformation or damage to some part.

TABLE 2. CATCH DATA ON SAMPLES OF SABLEFISH USED FOR MERISTIC COUNTS.

Sample No.	Date Collected	Locality of Catch	No. of Fish
1	March, 1950	150 fms., off Newport Beach, California	25
2	June, 1950	off Astoria, Oregon	16
3	September, 1950	off Newport, Oregon	20
4	March, 1950	250 fms., off Monterey, California	67
5	September, 1950	65 fms., Swiftsure Bank-Umatilla Reef, Washington	42
6	Aug.-Nov., 1950	Barkley Sound-Swiftsure Bank, British Columbia	75
7	Aug.-Sept., 1950	Strait of Georgia, British Columbia	63
8	September, 1950	off Petersburg, Alaska	15
9	June, 1951	88 fms., N. W. of Eureka, California	79
10	June, 1951	150 fms., off Newport Beach, California	13
11	March, 1951	240 fms., off Fort Bragg, California	47
12	March, 1952	120 fms., off Bodega Bay, California	189
13	April, 1952	54 fms., off Destruction Island, Washington	51
14	April, 1952	off Astoria, Oregon	56
15	August, 1952	50 fms., off James Island, Washington	24
16	August, 1952	250 fms., S. by W. of Cape Spencer, Alaska	40

Classified summaries of the various meristic counts that were made on sablefish are shown in Table 3 for each sample. In the analysis of the data some of the samples were combined. This was done where there was more than one sample from an area. Where these combinations were made, they are shown as an extension of Table 3. Henceforth, comparisons are made by areas, and where combined samples are not shown for an area, an individual sample represents an area. These areas, from north to south, are listed in Table 4.

TABLE 3. CLASSIFIED SUMMARIES OF THE MERISTIC COUNTS MADE IN PACIFIC COAST SABLEFISH.

		Sample Numbers										
		1	2	3	4	5	6	7	8	9	10	11
	Count	No. of Fish	No. of Fish	No. of Fish	No. of Fish	No. of Fish	No. of Fish	No. of Fish	No. of Fish	No. of Fish	No. of Fish	No. of Fish
Total number of vertebrae, including the urostyle.	61	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	62	4	2	2	15	3	4	3	.....	7	3	9
	63	10	8	8	39	15	34	27	4	27	4	26
	64	10	6	8	9	20	34	29	10	37	5	12
	65	.....	.....	2	4	4	2	4	1	7	1	.....
	66	.....	.....	.....	.....	.....	1	.....	.....	1	.....	.....
Vertebra on which the first haemal arch occurs.	Total Fish.....	25	16	20	67	42	75	63	15	79	13	47
	Average Count...	63.16	63.25	63.50	63.03	63.60	63.49	63.54	63.80	63.59	63.31	63.06
	26	1	.....	.....	2	.....	4	1	.....	1	.....	3
	27	2	3	4	15	3	15	12	1	20	4	8
	28	12	8	10	31	19	34	32	7	37	6	24
	29	10	4	3	18	15	16	15	6	16	2	11
	30	.....	1	3	.....	4	4	1	1	5	1	1
	31	.....	.....	.....	1	1	2	2	.....	.....	.....	.....
Vertebra on which the first haemal spine occurs.	Total Fish.....	25	16	20	67	42	75	63	15	79	13	47
	Average Count...	28.24	28.19	28.25	28.03	28.55	28.09	28.14	28.47	28.05	28.00	27.98
	30	1	.....	.....	.....	.....	1	.....	.....	1	1	1
	31	12	5	6	29	7	20	13	2	22	4	18
	32	12	11	11	31	26	51	37	10	44	8	25
	33	.....	.....	3	6	8	3	13	3	12	.....	3
	34	.....	.....	.....	1	1	.....	.....	.....	.....	.....	.....
Total number of gill rakers on the first gill arch.	Total Fish.....	25	16	20	67	42	75	63	15	79	13	47
	Average Count...	31.44	31.69	31.85	31.69	32.07	31.75	32.00	32.07	31.85	31.54	31.64
	18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
	19	.....	.....	.....	.....	.....	1	.....	.....	1	.....	.....
	20	1	.....	1	6	.....	4	2	.....	5	2	6
	21	9	3	5	18	.....	16	15	3	18	7	11
	22	9	6	9	26	.....	29	29	4	25	3	19
	23	5	5	4	13	.....	16	11	6	21	1	6
	24	1	2	1	4	.....	7	4	1	7	.....	4
	25	.....	.....	.....	.....	.....	1	2	1	1	.....	.....
Number of anal fin rays.	Total Fish.....	25	16	20	67	*	74	63	15	78	13	47
	Average Count...	21.84	22.38	21.95	21.87		22.08	22.10	22.53	22.09	21.23	21.72
	16	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....
	17	.....	.....	.....	2	2	5	2	3	1	.....	.....
	18	.....	.....	.....	16	19	15	22	6	15	3	14
	19	.....	.....	.....	15	14	32	25	5	42	9	23
	20	.....	.....	.....	3	5	17	13	.....	16	1	9
	21	.....	.....	.....	.....	.....	3	1	.....	5	.....	1
Number of dorsal fin rays.	Total Fish.....	**	**	**	36	42	72	63	14	79	13	47
	Average Count...				18.53	18.43	18.97	18.83	18.14	19.11	18.85	18.94
	16	.....	.....	.....	.....	2	.....	3	.....	1	1	1
	17	.....	.....	.....	9	12	11	11	3	19	.....	12
	18	.....	.....	.....	18	21	44	33	9	35	6	19
	19	.....	.....	.....	7	6	14	14	2	21	6	13
	20	.....	.....	.....	1	.....	1	2	.....	3	.....	2
	21	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....
Number of dorsal fin spines.	Total Fish.....	**	**	**	36	41	70	63	14	79	13	47
	Average Count...				18.08	17.76	18.07	18.02	17.93	18.08	18.31	18.06
	19	.....	.....	.....	5	.....	1	1	.....	.....	.....	.....
	20	.....	.....	.....	6	2	4	8	2	2	1	1
	21	.....	.....	.....	3	12	11	11	1	10	.....	7
	22	.....	.....	.....	7	11	22	20	1	15	3	7
	23	.....	.....	.....	4	9	21	11	3	21	3	12
	24	.....	.....	.....	5	4	6	5	4	12	2	9
	25	.....	.....	.....	1	1	6	5	1	9	4	4
	26	.....	.....	.....	1	.....	2	1	.....	3	.....	4
	27	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	2
	28	.....	.....	.....	2	2	.....	1	.....	3	.....	1
	29	.....	.....	.....	.....	.....	.....	.....	.....	3	.....	.....
	30	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....
	Total Fish.....	**	**	**	35	41	73	63	12	79	13	47
	Average Count...				22.23	22.39	22.51	22.25	22.75	23.48	23.31	23.38

*Gill rakes were removed before shipment.

**Samples evaluated and then discarded before staining for sub-surface rays and spines was commenced.

TABLE 3. (CONCL'D) CLASSIFIED SUMMARIES OF THE MERISTIC COUNTS MADE ON PACIFIC COAST SABLEFISH

Sample Numbers

		12	13	14	15	16	8 & 16	6 & 7	13 & 15	2 & 14	1 & 10
	Count	No. of Fish	No. of Fish	No. of Fish	No. of Fish	No. of Fish	No. of Fish	No. of Fish	No. of Fish	No. of Fish	No. of Fish
Total number of vertebrae, including the urostyle.	61	1	.....	.....	.....	.....	.....	.....	.....	.....	1
	62	20	1	3	3	.....	.....	7	4	5	7
	63	81	23	27	9	10	14	61	32	35	14
	64	68	22	21	12	18	28	63	34	27	15
	65	17	5	5	.....	11	12	6	5	5	1
	66	1	.....	.....	.....	1	1	1	.....	.....	.....
	Total Fish.....	188	51	56	24	40	55	138	75	72	38
	Average Count.	63.44	63.60	63.50	63.38	64.08	64.00	63.51	63.53	63.44	63.21
Vertebra on which the first haemal arch occurs.	24	1	.....	.....	.....	.....	.....	.....	.....	.....	.....
	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	26	6	3	6	2	.....	.....	5	5	6	1
	27	37	13	12	5	7	8	27	18	15	6
	28	94	23	20	12	15	22	66	35	28	18
	29	43	9	18	4	15	21	31	13	22	12
	30	7	1	.....	1	3	4	5	2	1	1
	31	.....	2	.....	.....	.....	.....	4	2	.....	.....
	Total Fish.....	188	51	56	24	40	55	138	75	72	38
	Average Count.	28.02	27.96	27.89	27.88	28.35	28.38	28.12	27.93	27.96	28.16
Vertebra on which the first haemal spine occurs.	30	2	3	1	.....	.....	.....	1	3	1	2
	31	72	17	17	5	2	4	33	22	22	16
	32	91	28	30	17	17	27	88	45	41	20
	33	23	3	7	2	19	22	16	5	7	.....
	34	.....	.....	1	.....	2	2	.....	.....	1	.....
	Total Fish.....	188	51	56	24	40	55	138	75	72	38
	Average Count.	31.72	31.61	31.52	31.88	32.52	32.40	31.86	31.69	31.79	31.47
Total number of gill rakers on the first gill arch.	19	.....	.....	.....	.....	.....	.....	1	.....	.....	.....
	20	7	1	.....	.....	2	2	6	1	.....	3
	21	43	4	9	4	5	8	31	8	12	16
	22	64	23	22	11	13	17	58	34	28	12
	23	63	14	21	6	14	20	27	20	26	6
	24	11	9	4	3	4	5	11	12	6	1
	25	1	.....	.....	.....	2	3	3	.....	.....	.....
	Total Fish.....	189	51	56	24	40	55	137	75	72	38
	Average Count.	22.16	22.51	22.36	22.33	22.48	22.49	22.09	22.45	22.36	21.36
Number of anal fin rays.	17	12	.....	2	.....	3	6	7	.....	2	.....
	18	42	4	14	4	17	23	37	8	14	3
	19	94	32	21	15	15	20	57	47	21	9
	20	35	14	19	4	4	4	30	18	19	1
	21	4	.....	.....	1	.....	.....	4	1	.....	.....
	22	.....	1	.....	.....	.....	.....	.....	1	.....	.....
	Total Fish.....	187	51	56	24	39	53	135	75	56	13
	Average Count.	18.88	19.25	19.02	19.08	18.26	18.42	18.90	19.20	19.02	18.85
Number of dorsal fin rays.	16	3	.....	1	.....	1	1	3	.....	1	1
	17	22	5	12	2	6	9	22	7	12	.....
	18	86	24	26	7	21	30	77	31	26	6
	19	63	18	15	14	8	10	28	32	15	6
	20	11	4	2	1	1	1	3	5	2	.....
	21	2	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Total Fish.....	187	51	56	24	37	51	133	75	56	13
	Average Count.	18.34	18.41	18.09	18.58	18.05	18.02	18.05	18.47	18.09	18.31
Number of dorsal fin spines.	19	4	.....	.....	.....	.....	.....	2	.....	.....	.....
	20	6	3	2	2	1	3	12	5	2	1
	21	17	13	10	2	2	3	22	15	10	.....
	22	46	12	10	8	5	6	42	20	10	3
	23	35	9	15	4	15	18	32	13	15	3
	24	33	7	7	5	6	10	11	12	7	2
	25	16	4	4	1	4	5	11	5	4	4
	26	9	1	3	2	4	4	3	3	3	.....
	27	8	.....	.....	.....	.....	.....	.....	.....	.....	.....
	28	9	2	3	.....	.....	.....	1	2	3	.....
	29	4	.....	1	.....	1	1	.....	.....	1	.....
	30	.....	.....	1	.....	.....	.....	.....	.....	1	.....
	Total Fish.....	187	51	56	24	38	50	136	75	56	13
	Average Count.	23.42	22.63	23.29	22.79	23.53	23.34	22.39	22.68	23.29	23.31

TABLE 4. GEOGRAPHICAL AREAS USED IN THE COMPARISONS OF MERISTIC COUNTS OF PACIFIC COAST SABLEFISH.

Sample No.'s	Area		No. of Fish
16 and 8	Cape Spencer and Petersburg,	Alaska	55
6 and 7	Barkley Sound to Swiftsure Bank and Strait of Georgia,	British Columbia	138
5	Swiftsure Bank to Umatilla Reef,	Washington	42
13 and 15	James Island and Destruction Island,	Washington	75
2 and 14	Astoria,	Oregon	72
3	Newport,	Oregon	20
9	Eureka,	California	79
11	Fort Bragg,	California	47
12	Bodega Bay,	California	189
4	Monterey,	California	67
1 and 10	Newport Beach,	California	38

TABLE 5. RESULTS OF THE CHI-SQUARE TESTS ON THE VARIOUS MERISTIC CHARACTERS OF SABLEFISH THAT WERE COMBINED FOR CERTAIN AREAS.

Sample Number										Meristic Character						
16	8	6	7	13	15	2	14	1	10							
Alaska (Cape Spencer)	Alaska (Petersburg)	British Columbia (Barkley Sound to Swiftsure Bank)	British Columbia (Strait of Georgia)	Washington (James Island)	Washington (Destruction Island)	Oregon (Astoria)	Oregon (Astoria)	California (Newport Beach)	California (Newport Beach)	Vertebrae	First Haemal Arch	First Haemal Spine	Gill Rakers	Anal Fin Rays	Dorsal Fin Rays	Dorsal Fin Spines
X	X									N	N	?	N	N	N	N
		X	X							N	N	S	N	N	N	N
				X	X					N	N	N	N	N	N	N
						X	X			N	N	N	N	*	*	*
								X	X	N	N	N	N	*	*	*

LEGEND
N—Not significant (P = > .05)
?—Questionable significance (P = .05 to .01)
S—Significant (P = <.01 to .001)
*—No comparisons possible
>—Greater than
<—Less than

Whenever two samples were combined, the various meristic counts were subjected to chi-square tests in order to determine if the samples were compatible (Table 5). Twenty-nine comparisons

were made, and twenty-seven of these showed no significant difference. The position of the first haemal spine in the comparison of the two Alaska samples showed possible significance, and in the comparison of the two British Columbia samples this same test showed a barely significant difference ($P = .01$). A minor difference may be indicated between the fish from the two Alaska localities and between those from the two British Columbia areas, but the present evidence appears insufficient to prohibit the combination of the samples in question.

Figure 2 portrays the averages of the various meristic counts that were made on sablefish from the different areas along the Pacific Coast.

Table 6 lists the length frequencies, by two-centimeter groupings, of the fish in the samples used in the meristic counts. Where certain samples have been combined to form an area, these are indicated at the bottom of the table in the summaries of the total number of fish and average size.

TABLE 6. LENGTH FREQUENCIES, BY 2-CM. GROUPINGS, OF PACIFIC COAST SABLEFISH IN SAMPLES USED FOR MERISTIC COUNTS.

Fork Lgt. Cms.	Alaska		British Columbia		Washington			Oregon			California						Tot. Lgt. In.
	Sample Numbers																
	16	8	6	7	5	13	15	2	14	3	9	11	12	4	1	10	
26			8														10.8
28			32										1				
30			24										17				
32			3			6		1	2		2		60				
34				4		14		5	8		13		66				14.2
36				8		25	1	1	17		12		25				
38			2	30		6	5	3	11		2		8		2		
40			2	14			11		2				5				
42			1	5	1		6				5		5	1	1		17.5
44				2			1			1	20		2	4	7	2	
46					1						15			4	6	1	
48					1					4	6	1		8	6	4	
50	1				1			2		4	1	7		8	3	3	20.9
52					3					3	2	13		17			
54	1		1		4					2	1	16		6		1	
56	2	1								3		6		8		1	
58	8	1	1		1					1		1		5		1	24.2
60	5	2			1			3		2				6			
62	7	2			2												
64	4	1			2			1									
66	1	3			8												27.6
68	2	2			6												
70					4												
72					3												
74					1												30.8
76																	
78		1															
80		1															
82		1															34.2
84					1												
86																	
88																	
90					1												37.4
Total Fish....	31*	15	74*	63	41*	51	24	16	40*	20	79	47	189	67	25	13	
Avg. Cms.....	60.4	66.4	30.2	38.4	63.7	35.2	40.0	43.5	36.2	52.3	41.7	52.9	33.8	52.1	45.6	49.5	
Total Fish....	46		137			75		56							38		
Avg. Cms.....	62.4		34.0			36.8		38.3							46.9		

*Some fish in sample could not be measured because of damaged tails.

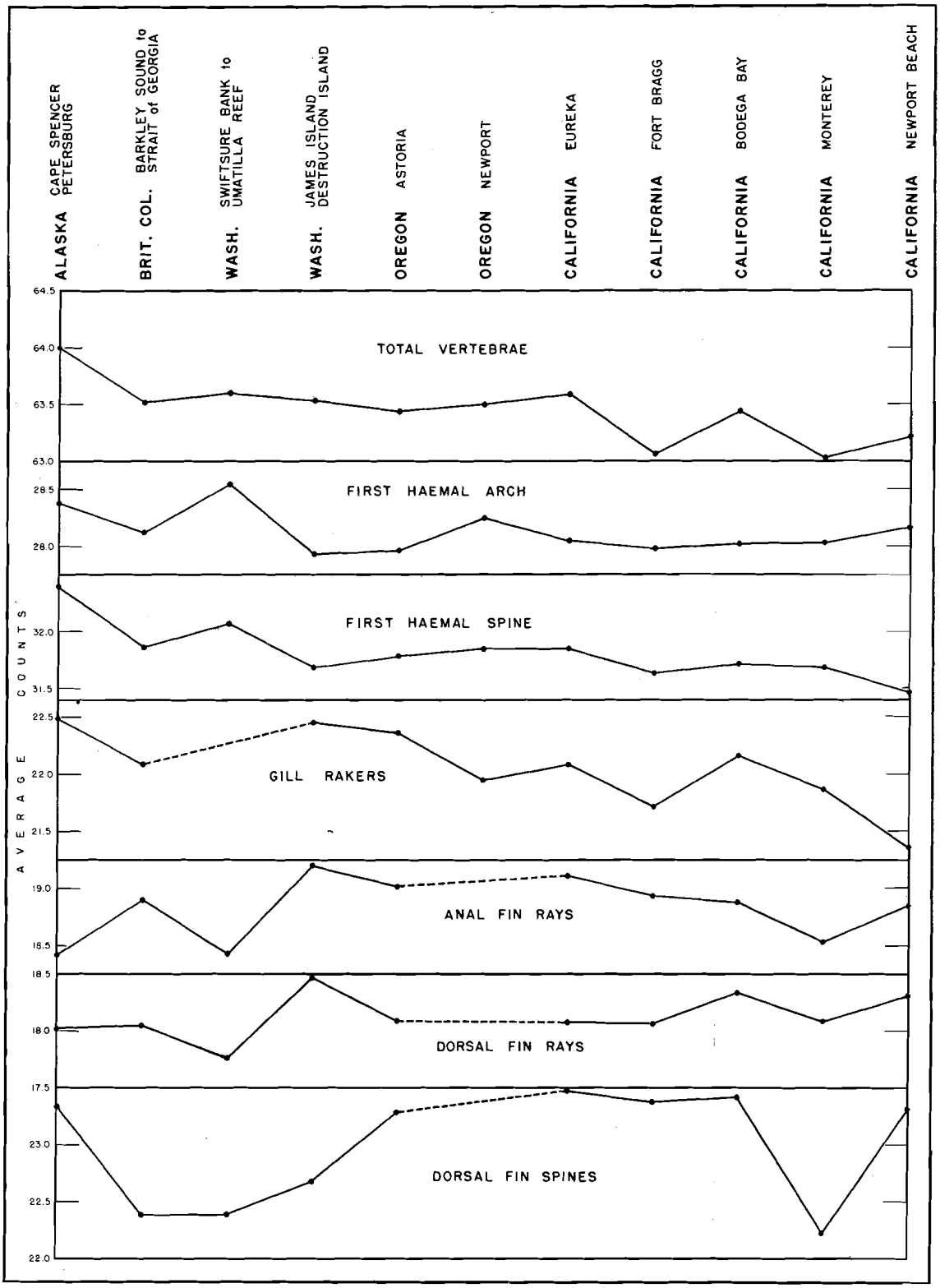

FIGURE 2. Averages of the various meristic counts that were made on sablefish from the different areas along the Pacific Coast.

MERISTIC COUNT ANALYSIS

With a number of different fishes it has been found that groups of individuals in different geographical regions may have an appreciably different average number of body segments, such as vertebrae. Such differences tend to disappear if fish from the different regions intermingle freely and have a common region for spawning. In general, fish hatched in regions of cold water and high salinity tend to have a somewhat higher number of segments than do those from regions of warm water and low salinity.[1] Temperature and salinity differences between one season and the next may result in a detectable difference between fish of two different year classes even though both were hatched in the same area.

Few of the sablefish samples which had been collected were large enough to permit a meaningful comparison of meristic counts of the fish of one year class with those of another year class. The Bodega Bay sample (No. 12) contained enough large and small fish to permit a comparison, and by combining the two British Columbia samples (No. 6 and No. 7) another comparison was possible. For these tests all sablefish 33 cm. fork length and under were assumed to be of one year class and were compared with the larger fish (which included several year classes). Seven chi-square comparisons were made for each area. The Bodega Bay fish showed no significant differences in any of the comparisons. The British Columbia fish showed no significant differences in six of the comparisons and a questionable difference in the seventh. This was the comparison of the position of the first haemal spine. P. was between .05 and .01.

Because it was difficult or impossible to determine the sex in some of the samples, the sexing of fish was discontinued after the first few samples had been processed. One of the samples shipped us had been dressed and the gills removed, and in some other lots, autolysis had developed to the point where the gonads were unrecognizable.

It is possible to present a limited comparison between males and females for the various meristic counts based on 118 fish in four samples (Table 7). Chi-square tests were made between the distribution counts of each sex in Sample 4 for Monterey, California, and Samples 2 and 3 combined (Newport and Astoria, Oregon). Sample 8 from Petersburg, Alaska, is shown in Table 7, but there were too few individuals to permit a meaningful chi-square comparison.

In comparing fin ray counts, in the above samples, only the externally visible spines and rays were compared because the technique for staining, etc., to show buried spines and rays had not been developed until after most of these fish had been examined. The results of the tests indicated no significant differences between sexes in the Monterey sample for any of the seven meristic counts. For the Newport and Astoria, Oregon, samples, no significant differences were indicated for six of the comparisons. The seventh comparison, that for the anal ray counts, showed a difference of questionable significance ($P = .04$).

In an analysis of the various meristic counts that were made on the sablefish taken in the different areas along the coast, the chi-square test was employed as the most acceptable measure to describe similarity or dissimilarity between counts for respective meristic characters. Where appreciable differences exist between counts that are classified by frequency of occurrence, the result of a chi-square test is quite satisfactory in stressing the likelihood that these differences are not due to chance but due to inherent differences between the groups of fish being tested. Where appreciable differences do not exist between counts being compared, and the test indicates a considerable degree of apparent homogeniety between fish in the different areas, there is still the possibility that the indicated homogeniety does not mean extensive intermingling between the areas. It is still possible that certain hindrances may be operating to prevent extensive intermingling. Tagging returns should help to define more clearly the extent of intermingling between areas and regions.

In arranging the tables of frequences of the various meristic counts for the chi-square tests between areas, the extreme classes that contained uncommon occurrences were included with the adjacent classes to minimize the effect of extreme variates. In some cases several extreme classes had to be consolidated into one for a comparison. Even so, an occasional end cell lacked the recommended minimum of five expected occurrences. It is believed that such occasional deficiencies will not produce inaccuracies of any consequence.

[1]Vladykov, Vadim D., 1934, "Environment and taxonomic characters of fishes." Trans. Royal Canadian Institute, Vol. XX, Pt. 1, p. 99-140.

TABLE 7. CLASSIFIED SUMMARIES OF THE MERISTIC COUNTS, BY SEX, FOR CERTAIN SAMPLES OF SABLEFISH.

	Count	Sample 4		Samples 2 and 3		Sample 8	
		No. of Males	No. of Females	No. of Males	No. of Females	No. of Males	No. of Females
Total number of vertebrae, including the urostyle.	62	2	13	1	3		
	63	17	22	7	9	2	2
	64	5	4	5	9	7	3
	65	2	2	1	1		1
	Total Fish.....	26	41	14	22	9	6
	Average Count.	63.27	62.88	63.43	63.36	63.78	63.83
Vertebra on which the first haemal arch occurs	26	2	1				
	27	5	10	4	3		1
	28	14	16	7	11	4	3
	29	5	13	2	5	4	2
	30			1	3	1	
	31		1				
	Total Fish.....	26	41	14	22	9	6
	Average Count.	27.85	28.10	28.00	28.36	28.67	28.17
Vertebra on which the first haemal spine occurs.	31	10	19	5	6	2	
	32	14	17	8	14	6	4
	33	2	4	1	2	1	2
	34		1				
	Total Fish.....	26	41	14	22	9	6
	Average Count.	31.69	31.68	31.71	31.82	31.89	32.33
Total number of gill rakers on the first gill arch.	20	4	2	1			
	21	5	13	2	6	1	2
	22	10	16	6	9	3	1
	23	6	7	4	5	4	2
	24	1	3	1	2	1	1
	Total Fish.....	26	41	14	22	9	6
	Average Count.	21.81	21.90	22.14	22.14	22.56	22.33
Number of anal fin rays.	17	3	2	1		3	
	18	9	19	1	10	2	4
	19	12	15	8	8	3	2
	20	2	5	4	2		
	21				1		
	Total Fish.....	26	41	14	21*	8*	6
	Average Count.	18.50	18.56	19.09	18.71	18.00	18.33
Number of dorsal fin rays.	16				1	1	
	17	9	11	6	8	1	1
	18	8	24	4	9	6	3
	19	8	4	4	1	1	1
	20	1	2		1		
	Total Fish.....	26	41	14	20*	9	5*
	Average Count.	18.04	17.93	17.86	17.65	17.78	18.00
Number of dorsal fin spines.	18		3				
	19	5	6	2	4	2	
	20	5	16	3	6	1	1
	21	10	6	7	7	2	2
	22	3	7	2	5	3	1
	23		3				
	24	2					
	Total Fish.....	25*	41	14	22	8*	4*
	Average Count.	20.76	20.41	20.64	20.59	20.75	21.00

*An occasional fish in a sample could not be used because of an irregularity.

The results of the chi-square tests on each meristic character for the fish taken in the different geographical areas are summarized in Table 8. The areas and the sample(s) that represent an area are shown in the left-hand portion of the table, while the different meristic characters are shown in the right-hand portion of the table. The areas compared are represented by an "X." Each row is for a separate comparison.

TABLE 8. RESULTS OF THE CHI-SQUARE TESTS ON THE VARIOUS MERISTIC CHARACTERS OF SABLEFISH TAKEN IN THE DIFFERENT AREAS ALONG THE PACIFIC COAST.

Sample Numbers											Meristic Character						
16 8	6 7	5	13 15	2 14	3	9	11	12	4	1 10	Vertebrae	First Haemal Arch	First Haemal Spine	Gill Rakers	Anal Fin Rays	Dorsal Fin Rays	Dorsal Fin Spines
Alaska (Cape Spencer and Petersburg)	British Columbia (Barkley Sound to Strait of Georgia)	Washington (Swiftsure Bank to Umatilla Reef)	Washington (James Island and Destruction Island)	Oregon (Astoria)	Oregon (Newport)	California (Eureka)	California (Fort Bragg)	California (Bodega Bay)	California (Monterey)	California (Newport Beach)							
X	X	X	X	X	X	X	X	X	X	X	HS	N	HS	S	HS	HS	S
X	X										HS	?	HS	?	?	N	HS
	X	X									N	N	N	*	?	?	N
	X		X								N	S	?	*	HS	HS	N
			X	X							N	N	N	N	N	?	N
				X	X						N	N	N	N	*	*	*
					X	X					HS	N	N	N	N	N	N
						X	X				S	N	N	?	N	?	N
							X	X	X		HS	N	N	N	?	N	S
									X	X	?	N	N	N	N	N	N
						X			X		HS	N	N	N	S	N	N
							X		X		N	N	N	N	?	N	N
						X		X			N	N	N	N	N	?	N
			X	X	X	X	X	X			N	N	N	?	N	?	N
							X	X	X	X	S	N	N	?	N	N	N
X	X					X			X		HS	N	HS	S	HS	S	HS

LEGEND

N—Not significant (P = > .05)
?—Questionable significance (P = .05 to .01)
S—Significant (P = <.01 to .001)
HS—Highly significant (P = <.001)
*—No comparisons possible
> —Greater than
<—Less than

RACIAL SEPARATION AS INDICATED BY TESTS

When all eleven areas along the Pacific Coast are compared simultaneously, all of the chi-square tests, except the one based on the occurrence of the first haemal arch, indicate significant differences (Table 8). These data would seem to indicate that all the sablefish along the coast do not intermingle freely, and that there is more than one stock or race of fish.

As the first step in delimiting areas between which intermingling is restricted enough to cause such significant differences, pairs of adjacent areas were tested, from north to south. The results of these tests indicate that the most northern and the most southern areas are responsible for the greatest discordance in the lumped data. That is, the fish in the Southern Alaska area and in the combined Monterey-Newport Beach areas, representing Central and Southern California, have characteristics that differ greatly enough from the remaining areas to consider these areas as having separate stocks of fish.

In the remaining broad region from off Southern British Columbia to Bodega Bay, California, the evidence indicates that there could well be a restricted intermingling of fish between certain areas. For example, the fish in the Southern British Columbia and the Northern Washington areas are similar enough to be considered as one stock, but these, in turn, differ in several respects from the fish in the Central Washington area around Destruction Island. The latter area can be coupled with the two Oregon areas and the Eureka, California, area as a broad region in which the fish have similar characteristics. The fish in the Eureka area differ from those in the adjacent Fort Bragg area and more nearly resemble specimens from Bodega Bay, which is still farther south. Fort Bragg fish, in turn, have many characteristics that resemble those found in fish from the Monterey area, which is south of Bodega.

To determine if the differences that appear in the Fort Bragg and Bodega Bay fish preclude their being grouped with either the fish from farther north or with those from the south, the specimens in the areas from the Central Washington coast to Bodega Bay were compared simultaneously. Similarly, the Fort Bragg and Bodega Bay fish were compared simultaneously with those from Monterey and Newport Beach. The results of these two tests indicate that fish from the two areas in question, when considered jointly, have characteristics that differ less from those of northern fish. The inclusion of these two areas with the adjacent northern region is quite tolerable.

In summarizing the results of the various tests, it appears that the following regions can be established which, for the most part, contain stocks of fish that are separate from those of the other regions named:

1. Southern Alaska coast from Cape Spencer to Petersburg. (Samples 16 and 8.)
2. Southern British Columbia and the Northern Washington coasts. (Samples 6, 7, and 5.)
3. Central Washington coast to the Northern California coast. (Samples 13, 15, 2, 14, 3, 9, 11, and 12.)
4. Central and Southern California coasts. (Samples 4, 1, and 10.)

The grouping of the fish from the different areas into four regional stocks does not nullify the significant differences that appear when all components of the population along the coast are compared at the same time. (See first and last tests in Table 8.) The complexities that appear in the population as a whole can be resolved by a separation of this population into the several components as indicated. In the present study the sub-division of the population has been made as broad as feasible.

SUMMARY

The following fisheries agencies participated in a racial study of the sablefish population along the Pacific Coast of North America by furnishing samples of fish from different localities between Alaska and Southern California: Alaska Department of Fisheries, Fisheries Research Board of Canada, State of Washington Department of Fisheries, Oregon Fish Commission, and the California Department of Fish and Game.

The following meristic counts were made on all fish that were included in the samples: total number of vertebrae, including the urostyle; vertebra on which the first haemal arch occurred; vertebra on which the first haemal spine occurred; total number of gill rakers on the first gill arch; number of rays in the anal fin; number of rays in the second dorsal fin; number of spines in the first dorsal fin. All counts on all fish were made by one person.

The discovery was made that staining was necessary to detect vestigal dorsal fin spines that were sub-dermal. These buried spines followed the last visible spine that projected above the skin. Occasionally, a sub-dermal dorsal ray or anal ray preceded those fins. Except in the comparison between males and females, this study includes the elements that were accentuated by staining.

Meristic count comparisons between large and small fish from the same samples showed only minor differences.

Meristic count comparisons between male and female fish in four samples showed only minor differences.

The chi-square test was employed to describe similarity or dissimilarity between counts for the fish in the different geographical areas or regions. The tests indicate that there are several stocks of sablefish along the Pacific Coast, presumably with minor intermingling. The complexities that appear in the population as a whole can be resolved by a separation of this population into the following components or stocks of fish between which there is little apparent intermingling:

1. Southern Alaska coast from Cape Spencer to Petersburg. (Samples 16 and 8.)
2. Southern British Columbia and the Northern Washington coasts. (Samples 6, 7, and 5.)
3. Central Washington coast to the Northern California coast. (Samples 13, 15, 2, 14, 3, 9, 11, and 12.)
4. Central and Southern California coast. Samples 4, 1, and 10.)

In the present study the sub-division of the population has been made as broad as possible. Further separation of these stocks may become apparent from a study of tagged fish returns.

RESULTS OF SABLEFISH TAGGING EXPERIMENTS IN WASHINGTON, OREGON, AND CALIFORNIA

EDWIN K. HOLMBERG
and
WALTER G. JONES

Fish Commission of Oregon

BULLETIN 3
PACIFIC MARINE FISHERIES COMMISSION
Portland, Oregon, 1954

TABLE OF CONTENTS

LIST OF TABLES

RESULTS OF SABLEFISH TAGGING EXPERIMENTS IN WASHINGTON, OREGON AND CALIFORNIA

INTRODUCTION

For the purpose of determining the extent of migration of sablefish, *Anoplopoma fimbria*, along the Pacific coast of North America the research agencies of California, Oregon, and Washington undertook similar tagging experiments at the instigation of the Pacific Marine Fisheries Commission. These experiments were a part of a cooperative research program designed to discover the racial structure, life history, habits, and condition of the stocks of sablefish.

Sablefish are found from northern Alaska southward into Mexico, and they are taken commercially by setline and otter-trawl fishermen from central Alaskan waters to southern California. The problem was to discover if the fishery exploits a single, large, freely migrating stock of fish or a group of small, localized stocks of fish having limited inter-migration. If the stocks are localized they should be regulated as local units, but if they intermingle to any great extent, they should be regulated as one large, single unit.

Fish were tagged from commercial vessels in the principal fishing areas from central Vancouver Island, British Columbia, southward to Monterey, California. The number of tagged fish recovered was small, but the degree of migration and some indication of the growth can be shown. The factors affecting the recovery rates will be discussed separately.

ACKNOWLEDGMENTS

Each member of the fishing industry who aided a biologist during the tagging operations or returned a tag contributed to the success of the tagging experiments.

Mr. Donald E. Kauffman directed the work in Washington, and Messrs. Oren Logan, Wallace Hublou, Thomas Lopp, and Ernest Salo did the actual tagging. Messrs. George Y. Harry, Jr., and Alonzo T. Pruter planned the Oregon work, and all the tagging was done by Mr. Pruter. Mr. Donald H. Fry, Jr., directed the tagging in California; Mr. Julius B. Phillips tagged the California fish and he was assisted in the Monterey region by Messrs. Robert N. Morris and Thomas N. Fast.

METHODS

The tagging in California was conducted from commercial vessels fishing setline gear. In Oregon and Washington the tagging was accomplished from both setline and otter-trawl fishing vessels. The Washington records include 191 otter-trawl caught fish taken by the crew of the vessel John N. Cobb in conjunction with the exploratory otter-trawl work of the Exploratory Fishing and Gear Development Section of the U. S. Fish and Wildlife Service.

Plastic disk tags of the Petersen type were used in all three states. In addition, 93 fish were tagged with nylon streamer tags in Oregon, but there were no recoveries, and they are not considered in this paper. The disk tags were placed under the first dorsal fin in the California experiments, and stainless steel wire pins were used to secure the tags except for the first 85 fish which were tagged with nickel pins. Nickel pins were used in Oregon until 1951 when German silver and stainless steel pins were used. The first 295 Oregon fish were tagged below the first dorsal fin, and the remainder below the second dorsal fin. The change was made in an attempt to prevent the loss of tags by entanglement in the meshes of the otter-trawl nets. The Washington tags in 1950 were secured by nickel pins and in 1951 by German silver pins. Most Washington tags were placed just below the middle of the first dorsal fin. Some tags were placed under the second dorsal fin on a trial basis, but this position was abandoned as it was reasoned that the greater muscular activity in this part of the fish would result in greater injury to the fish by the tag and pin.

Washington and Oregon scientists measured the length of the fish upon tagging from the tip of the snout to the fork of the tail. The length in California was taken from the tip of the snout to of the longest rays in the tail fin. Measurements in all experiments were made to the nearest millimeter with the fish lying on the measuring device. When possible, length measurements of recovered fish in the round were made in the same manner as that used at tagging. Scale samples were collected from alternate Oregon tagged fish with the hope that scales taken from recovered fish would be useful in checking age studies. However, there were not enough recoveries to use the scales for this purpose.

In each state the apparent condition of the fish to be tagged was recorded. The notation of good, fair, or poor was made in Washington and California experiments while in Oregon a notation of 1, 2, and 3 was used to indicate good, fair, and poor condition, respectively. As the California experiment progressed only the fish in good condition were tagged and the notation became unnecessary. Criteria for the estimation of condition are difficult to standardize, and in practice it became the personal judgment of each tagger to determine the chance each fish had for survival. Observing the head and mouth for hook damage and noting the time the fish required to recover and swim away after being returned to the water were the principal methods employed.

The recovery methods were similar in the three states but varied with the individual circumstances. Occasionally the tagged fish were found fresh and kept whole until a biologist could measure the fish, collect the fishing information pertinent to the recovery, and, in Oregon, take a scale sample. Often the fish were dressed before the tags were discovered. Many times the tags were simply mailed in with no information as to how, when, and by whom the tags were recovered. In this case a biologist would first try to collect the recovery information personally, and if this was not possible a letter was written to gain the required information. Every effort was made to collect complete and accurate recovery data. The low number of returns for which recovery data are unknown attests to the effort spent collecting these data. Letters of acknowledgment, and in California special commendation cards were sent to persons who returned tags with adequate information. The letters and cards gave the tagging, growth, and migration information for the particular fish. A fifty-cent reward was paid by Washington for the return of tags, but it was felt that the reward contributed little toward insuring the return of the tags.

RESULTS AND DISCUSSION

Tagging Programs

Most of the tagging by the three states was done in 1950 and 1951. In addition, 57 tags were placed on sablefish incidental to a flatfish tagging program during 1948 and 1949 in Oregon waters, and tagging was extended into 1952 by the California scientists to complete their program. Consequently, recoveries were still being made in California in October, 1953, when this paper was written.

A total of 9,511 sablefish were tagged. In California the 4,073 tagged sablefish were divided among the three principal fishing areas as follows: Monterey 1,318, Fort Bragg 1,386, and Eureka 1,369. More fish, 2,209, were tagged in the Coos Bay, Oregon, area than in any other region along the coast. Off Newport, Oregon, 845 fish were tagged, and 43 were tagged off the Columbia River, making a total of 3,097 tagged in Oregon. Of the 2,341 fish tagged by Washington biologist, 2,015 were in the area off northern Washington and southern Vancouver Island. This group can be divided by a line following the submarine canyon off the Straits of Juan de Fuca. There were 935 fish tagged to the north and 1,080 tags to the south of this line. The additional 326 tagged fish were located as follows: 137 off central Vancouver Island, 172 southwest of James Island, and 17 southwest of Destruction Island. The latter two islands are located off northern Washington.

Eighty-six percent of the sablefish tagged off Canada were tagged from setline geared vessels. Ninety-five percent of the fish tagged off Washington were tagged from otter-trawl vessels.

Tag Returns

Through October, 1953, 243 or 2.55 percent of the 9,511 tagged sablefish were recovered. The number of returns by state were as follows: California 129 tags (3.16 percent), Washington 67 tags (2.86 percent), and Oregon 47 tags (1.52 percent). Compared to the returns from tagging ex-

periments on other species the returns from this study are considered low. The factors that are thought to have contributed to the low number of returns are discussed later.

As will be brought out in later tables and discussion, the following percentages of the total returns were made within five months of release: 64 percent in California, 59 percent in Washington, and 36 percent in Oregon. Fish cannot be expected to grow much or migrate far during such a short period of time.

The Washington data show that of the 983 fish tagged by setline gear 20 were recovered, 18 by setline gear and two by otter-trawl gear. Of the 1,358 tagged using otter-trawl gear 26 were recovered by otter-trawl and 16 by setline. There were five recoveries for which the type of gear used was unknown. Forty-four fish were recovered by the same gear used for tagging, and 18 fish were recovered by gear other than that used in tagging. The latter figures seem to indicate that the two types of gear are used to fish different groups of fish, but this is undoubtedly a result of tagging and fishing with the two types of gear in separate regions.

A greater number of fish, 2,099, were tagged from the otter-trawl catches in Oregon than in Washington. Thirty-two of these were recovered, 15 by otter-trawl and 17 by setline. Of the 998 tagged from setline gear 15 were recovered, 9 by setline and 6 by otter-trawl. The comparison of fish tagged and recovered by the same gear (24) with the fish recovered by gear other than that used in tagging (23), indicates that the two types of gear probably fish similar groups of fish which, in general, is thought to be the case.

The comparison of returns by gear is easier in California as the tagging was all done from setline vessels. The California regions are rather widely separated and give different results. They are, therefore, analyzed separately. In Eureka, 40 of the 50 recoveries were made by setline gear. Nine returns were made by otter-trawl gear, and the gear used for one recovery was unknown. The apparent separation of the two fisheries results because the setline fishery takes place over rougher ocean floor than the otter-trawl net fishery (Phillips, personal communication). Thirty recoveries were made of fish tagged near Fort Bragg, 18 by setline and 12 by otter-trawl. Here the two fisheries seem to exploit the same groups of fish. All 49 of the Monterey tags were recovered by setline gear.

Migration

Figure 1 shows the migration of sablefish between principal fishing areas. Table 1 gives the recoveries by area as well as the total recoveries from each tagging area, the total number tagged, and the approximate mileage between areas. Heavy lines have been drawn in Table 1 for the purpose of separating political regions. Seventeen of the 21 recoveries of fish tagged in British Columbia waters were recaptured in British Columbia waters, and four were recovered in Washington waters. Thirty-seven of the recoveries of fish tagged in Washington were recaptured in Washington. Five Washington tagged fish moved northward into Canadian waters, and none were taken in Oregon or California waters. The area of recovery could not be determined for four of the Washington recoveries.

Forty-two of the 47 Oregon-tagged fish were recaptured in Oregon waters. Two tags were recovered in Washington waters and the same number were found in California. Recovery area was unknown for one fish. Least interchange between political subdivisions was shown from the California recoveries. One hundred twenty-six of the recoveries were within state waters. One fish moved north and was recovered in Washington waters. This migrant was tagged 579 days earlier near Fort Bragg and was recaptured approximately 450 miles northward off Grays Harbor. This was the longest migration recorded. The area of recovery was not known for two California-tagged sablefish.

Table 2 shows the degree of straying north and south from the point of release. The recoveries were divided into those taken 30 miles or less from the point of tagging and those captured over 30 miles, because there was a rapid decline in the number of recoveries beyond 30 miles from the point of tagging. The Oregon fish exhibit the greatest amount of apparent movement which may possibly be due to the more intense fisheries to the north and south and longer time at liberty. Thirteen Oregon fish were recovered farther than 30 miles from the point of tagging. Three Washington fish and six California fish were recovered farther than 30 miles from the tagging area. Of

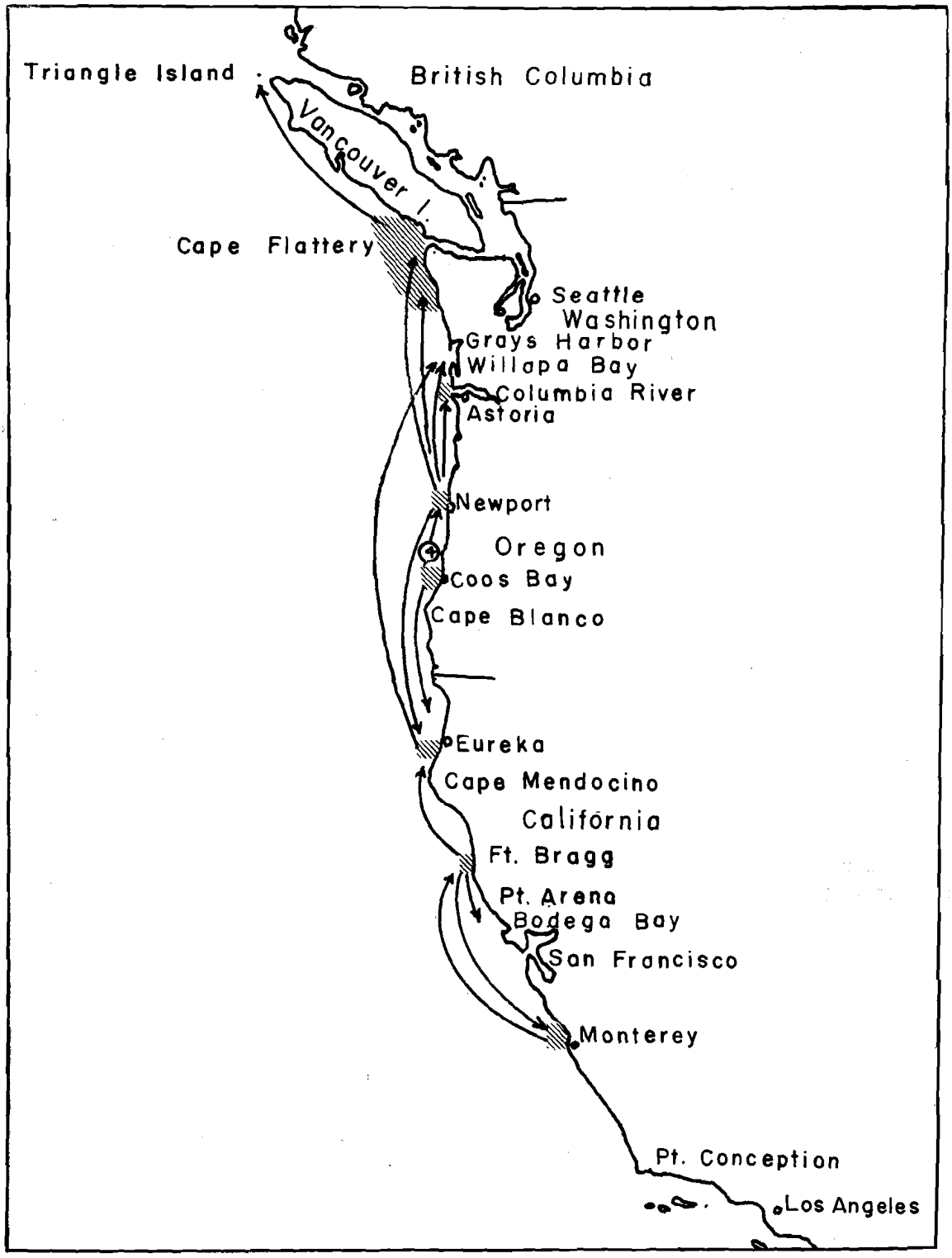

FIGURE 1. Chart of the Pacific Coast showing tagging areas (shaded) and individual migrations of tagged sablefish in the experiments conducted by Washington, Oregon, and California. Each arrow represents the migration of one fish. Only migrations between principal fishing areas have been shown.

the fish that migrated more than 30 miles, the number which moved north or south are divided fairly equally in each state.

TABLE 1. RECOVERIES OF TAGGED SABLEFISH, BY AREAS TAGGED AND RECOVERED
(HEAVY LINES INDICATE BOUNDARIES OF POLITICAL SUBDIVISIONS)

Area Tagged	Area Recovered (Area Numbers Same as Area Tagged)															Total	Nos. Tagged	Approximate Nautical Miles Approximate Between Areas
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
1. N. Vancouver Is., B. C.																0	0	100
2. Central Vancouver Is., B. C.		1														1	137	60
3. S. Vancouver Is., B. C.	1		15	3	1											20	935	24
4. North Washington			5	30	2											37	1,080	18
5. S.W. James Island				1	4											5	172	15
6. S.W. Destruction Is.																0	17	47
7. Grays Harbor																0	0	16
8. Willapa Bay																0	0	28
9. Columbia River									1							1	43	92
10. Newport, Oregon				2					2	10	2		1			17	845	75
11. Coos Bay										2	25	1				28	2,209	150
12. Eureka												49				49	1,369	83
13. Fort Bragg							1					1	25	2	1	30	1,386	65
14. BodegaHd.-Pt.Arena																0	0	110
15. Monterey													1		47	48	1,318	
	Recovery Area Unknown															7		
																243	9,511	

TABLE 2. MIGRATION OF SABLEFISH FROM POINT OF RELEASE,
PERCENTAGES IN PARENTHESES

	30 Miles or Less	Greater Than 30 Miles N	Greater Than 30 Miles S	Unknown	Total
Washington	60 (90)	2 (3)	1 (1)	4 (6)	67
Oregon	32 (68)	6 (13)	7 (15)	2 (4)	47
California	121 (94)	3 (2)	3 (2)	2 (2)	129
Total	213 (88)	11 (5)	11 (5)	8 (3)	243

One fish tagged off Newport, Oregon, was recovered 315 miles south off Fort Bragg, California, 390 days later. The longest migration made by a fish tagged by Washington biologists was 210 miles from Cape Beale, British Columbia, to a point west of Triangle Island off the northern end of Vancouver Island, British Columbia, 310 days later. The local nature of the stocks is indicated by the limited number of migrants recovered more than 30 miles from the point of release. The balanced north and south migrations seem to have no relationship to season and are thought to be an indication of the random nature of the movements found. No relationship was found between the size of fish tagged and the distance migrated (Table 3).

TABLE 3. COMPARISON OF DISTANCE MIGRATED AND SIZE OF SABLEFISH AT TAGGING (COMBINED DATA FROM ALL STATES)

Distance in Miles	Total Length of Fish at Tagging in Centimeters						
	40–49	50–59	60–69	70–79	80–89	90–99	Total
0–30	7	51	87	55	10	2	212
31–90	1	5	1	3	0	0	10
91 plus	0	3	2	3	2	0	10
Total	8	59	90	61	12	2	232
						232 plus 11 unknown equals	243

The migrations in depth were considered, but the small number of recoveries did not indicate a pattern. The tagged fish apparently scattered throughout the depths fished. There is no way of knowing where the fish traveled other than where they were recaptured. This could explain why no seasonal movements were found. If there were a movement into deeper water in the winter, it could not be detected from tagging because there was no winter fishery in deeper water to recover the tagged fish.

TABLE 4. NUMBER OF TAGS RECOVERED IN MONTHLY INTERVALS FOLLOWING TAGGING

Days at Liberty	California		Washington		Oregon	
	Number Recovered	Percent Recovered	Number Recovered	Percent Recovered	Number Recovered	Percent Recovered
0– 31	30	24.8	13	20.3	6	12.8
32– 61	24	19.8	15	23.4	4	8.5
62– 92	13	10.7	8	12.5	2	4.3
93–122	6	5.0	1	1.6	4	8.5
123–153	5	4.1	1	1.6	1	2.1
154–183	4	3.3				
184–214	1	0.8				
215–244	9	7.4			1	2.1
245–275	9	7.4			1	2.1
276–305	2	1.7	1	1.6	2	4.3
306–336	5	4.1	2	3.1	4	8.5
337–366	1	0.8	1	1.6	5	10.6
367–397	2	1.7	6	9.4	6	12.8
398–427	2	1.7	7	10.9	3	6.4
428–458			7	10.9	3	6.4
459–488	1	0.8	1	1.6	1	2.1
489–519	1	0.8	1	1.6	1	2.1
520–549						
550–580						
581–610	1	0.8				
611–641						
642–671					1	2.1
672–702	2	1.7			1	2.1
703–732	1	0.8				
733–763	2	1.7			1	2.1
764–793						
794–824						
Totals....	121	99.9	64	100.1	47	99.9

Length of Time at Liberty

The elapsed time between tagging and subsequent recovery has been divided into approximate monthly periods by state, and the percentage each monthly interval contributes to the state total is shown in Table 4. The seasonal nature of the fishery is evident to the north by the lack of recoveries between the seasonal modes of recovery. Fishing evidently takes place during more months of the year in California which explains the lack of pronounced modes for the California recoveries.

The time of tagging in the fishing season had an effect on the number of days at liberty. Most of the California tags were placed on the fish just prior to or at the beginning of the season. Consequently, all tagged fish were available to the fishery during the entire first season, and in California, 69 percent of the total recoveries were made the first season. The tagging in Oregon was conducted throughout the season. Many of the fish were, therefore, not available to the fishery the entire first season, and were taken the second season at liberty. The high percentage returns, 57 percent, in Oregon the second season is evidence of this factor. Washington is intermediate with a 41 percent recovery the second season. The totals in Table 4 are not the same as other totals in this report because the number of days at liberty could not be determined accurately for some recoveries. No apparent relationship was found between time at liberty and either distance migrated (Table 5) or size of fish (Table 3) when these data were graphed, and consequently no further statistical tests were made.

TABLE 5. COMPARISON OF LENGTH OF TIME AT LIBERTY WITH DISTANCE MIGRATED USING TOTAL TAG RETURNS

Distance	Days at Liberty					
	0–92	93–183	184–275	276–366	367–458	459+
0–30 miles	111	18	19	21	25	11
31–90 miles	2	2	1	0	6	2
91 miles plus	1	2	0	2	3	1

Growth

The growth analysis from the recoveries of tagged sablefish must necessarily be of a rather gross nature because of the small number of recoveries and other factors which will be mentioned later.

As has been noted previously, the sablefish recoveries for California, Oregon, and Washington for all years combined were 129, 47, and 67 respectively. Of these, 81 California tagged fish, 29 Oregon tagged fish, and 45 Washington tagged fish were measured after recovery. Many of the sablefish were caught by the fishery soon after tagging. Table 6 shows that approximately two-thirds of the recovered and measured California fish were recaptured within 90 days of the tagging date. In Oregon about one-sixth, and in Washington a little over one-half of the measured recoveries of sablefish were returned within a 90-day period.

TABLE 6. COMPARISON OF THE NUMBER OF MEASURED RECOVERIES OF SABLEFISH WITH THE TOTAL RECOVERIES BY TIME PERIODS

	California	Oregon	Washington
Total recoveries	129	47	67
Total measured recoveries	81	29	45
Total measured recoveries returned within 90 days	52	5	23
Total measured recoveries at liberty longer than 90 days	29	24	22

The growth of the sablefish which were recovered and measured after being free 30 to 90 days is shown in Table 7, according to the year and the state in which they were tagged. The average growth of the fish tagged off Washington shores and free for 30 to 90 days was approximately the same for both 1950 and 1951, 1.54 and 1.56 centimeters. Also, it can be noted that for this time period out, the average growth, 1.56 centimeters, of the Washington fish tagged in 1951 is almost twice the average growth, 0.85 centimeters, of the California sablefish which were tagged the same year.

TABLE 7. INCREASE IN LENGTH OF SABLEFISH FREE 30–90 DAYS

Year of Release																	
1950						1951						1952					
California		Oregon		Washington		California		Oregon		Washington		California		Oregon		Washington	
Length at Release	Growth	Length at Release	Growth	Length at Release	Growth	Length at Release	Growth	Length at Release	Growth	Length at Release	Growth	Length at Release	Growth	Length at Release	Growth	Length at Release	Growth
cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.
None		57.5	1.0	38.0	2.9	55.0	2.0	None		41.8	0.7	51.5	0.0	None		None	
		59.5	1.0	49.5	0.0	55.0	1.5			47.0	1.0	58.0	0.0				
				51.0	1.3	57.0	0.5			57.0	1.0	59.5	0.0				
				61.0	3.5	57.5	0.0			57.0	4.0	61.5	0.0				
				62.5	0.0	60.0	0.5			65.0	0.0	63.5	0.7				
						61.0	0.5			70.0	4.5	65.0	0.5				
						62.0	1.5			71.0	0.0	65.5	0.0				
						63.5	0.0			71.0	1.9	65.5	0.5				
						64.0	2.0			72.0	1.5	66.0	0.4				
						69.0	0.0			79.0	1.0	66.5	1.3				
												66.5	1.5				
												67.0	1.5				
												69.5	0.5				
												69.5	1.5				
												69.5	1.0				
												70.0	1.0				
												70.0	1.0				
												71.5	0.5				
												71.5	0.5				
												73.0	0.8				
												74.0	0.4				
												74.0	0.5				
												74.5	0.5				
												77.0	0.0				
												78.5	1.5				
Average Growth .			1.0		1.54		0.85				1.56		0.64				

Tables 8 and 9 give the length at tagging and the growth of the tagged fish which were recovered by the fishery approximately 1 year, 1½ years, and 2 years after tagging. The average growth of the sablefish shown in the tables was computed without regard to size or age of the fish tagged. Average growth by size was not computed because of the small numbers of fish recovered. The age of the tagged or recovered fish was not determined. Consequently, only the average growths of the groups are used for comparison.

The average annual growth of the tagged sablefish recaptured in waters off the three states approximately one year after release can be compared to give a relative indication of the differences in the growth of these fish. As computed from Table 8, the seven sablefish recaptured off California about one year after release show an average annual growth of 1.43 centimeters. Eleven Oregon sablefish recaptured one year after tagging showed an average annual growth of 0.64 centimeters, while 10 Washington sablefish showed an average annual growth of 3.54 centimeters for the same time period at liberty.

The average growth of Washington tagged sablefish at liberty about one year was 3.75 centimeters, but for those out about 15 months the average growth was 8.41 centimeters. However, the fish at liberty one year averaged about 11 centimeters longer when tagged than those out 15 months, and the difference in size might have affected the amount of growth. The smaller fish would be expected to grow faster than the larger ones. Furthermore, considerable variation might be expected because of the small number of recoveries.

The greatest growth of any of the tagged sablefish measured after recovery was attained by two Washington tagged fish recovered after 15 months at liberty. One fish apparently grew 14.0 centimeters and the other 12.5 centimeters in this time period. Both fish were tagged 6 miles south-southwest of Tatoosh Island and were recovered in about the same locality. It is possible that mistakes could have been made in taking the original measurements. Even though great care is taken, the conditions encountered at sea are not always conducive to accurate measurements.

The amount of growth given in the tables may be less than the actual growth attained by the fish. This is because no adjustment has been made for shrinkage in the length of the fish which probably occurs between the time the fish was caught and the time it was measured. The recovered sablefish were measured in various stages of freshness, and no studies were made to determine how much, if any, should be allowed for shrinkage under these conditions.

Size of Fish Tagged

The sizes of the fish tagged and the percentage returns for each size class are given in Table 10. The greatest range in size of fish tagged was in Washington. The California fish covered the least range in size. The medium sized fish, 50 to 79 centimeters, were tagged in most abundance, and probably for this reason gave the most consistent percentage of returns. Within this size range the percentage of returns increased to the 70–74 centimeter group and then fell off again. Where the numbers tagged in any group are small, a few chance recoveries gave excessive percentages. Size of fish tagged has already been compared with other factors in previous sections.

Factors Affecting Recoveries

No satisfactory explanation is apparent for the low recovery rates obtained from the experiments in all three states. It is sometimes possible to use tag recoveries for determining fishing intensity, but it is difficult to believe that the well established sablefish fishery is operating at the low fishing rates indicated by these experiments. It is possible that sablefish may simply not survive the treatment received in the fishing and tagging processes.

The low fishing intensity in Oregon is considered to be the principal factor causing the lower numbers of recoveries compared with the other two states. It was not possible to determine the relative fishing intensities for the two gear types used in the three states for the time period covered by this study. Chi-square comparisons show that Oregon recoveries differ from the returns made in Washington and California with P values less than 0.01 in each test. No significant difference was found between Washington and California recoveries although different metals were used in the tagging pins, but other factors may have masked any difference from this cause. No significant difference in returns was found between years in any state.

TABLE 8. INCREASE IN LENGTH OF SABLEFISH FREE APPROXIMATELY ONE YEAR (320–410 DAYS)

Year of Release																	
1950						1951						1952					
California		Oregon		Washington		California		Oregon		Washington		California		Oregon		Washington	
Length at Release	Growth	Length at Release	Growth	Length at Release	Growth	Length at Release	Growth	Length at Release	Growth	Length at Release	Growth	Length at Release	Growth	Length at Release	Growth	Length at Release	Growth
cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.
None		55.0	0.0	52.0	1.2	52.0	1.0	None		67.0	1.6	67.0	1.6	None		None	
		58.0	0.5	52.0	4.0	60.0	0.2					67.0	1.8				
		60.5	0.0	54.5	5.1	61.0	1.0					77.0	2.0				
		60.5	1.5	55.0	2.0							79.0	2.4				
		61.0	0.5	55.9	8.1												
		61.5	1.0	66.0	2.4												
		63.5	2.5	67.0	4.1												
		65.0	0.5	67.2	2.9												
		66.0	0.5	85.0	4.0												
		75.0	−0.5														
		90.0	0.5														
Average Growth .			0.64		3.75		0.73				1.6		1.95				

TABLE 9. INCREASE IN LENGTH OF SABLEFISH FREE APPROXIMATELY 1¼ YEARS (430–490 DAYS)

Year of Release																	
1950						1951						1952					
California		Oregon		Washington		California		Oregon		Washington		California		Oregon		Washington	
Length at Release	Growth	Length at Release	Growth	Length at Release	Growth	Length at Release	Growth	Length at Release	Growth	Length at Release	Growth	Length at Release	Growth	Length at Release	Growth	Length at Release	Growth
cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.
None		None		38.0	7.7	66.5	3.5	60.0	6.0	65.0	0.0	68.0	6.6	None		None	
				48.2	9.9												
				48.5	14.0												
				49.5	12.5												
				53.0	4.2												
				53.3	3.2												
				53.3	3.2												
				65.6	7.9												
Average Growth .					8.41		3.5		6.0		0.0		6.6				

INCREASE IN LENGTH OF SABLEFISH FREE APPROXIMATELY 2 YEARS (685–775 DAYS)

None		66.5	8.5	None		54.5	0.0	None		None							
		72.0	6.2			56.0	1.5										
						56.5	3.0										
						58.0	3.0										
						60.0	−0.5										
Average Growth .			7.33				1.40										

TABLE 10. LENGTH-FREQUENCY DISTRIBUTIONS OF TAGGED SABLEFISH AND PERCENTAGE RECOVERY FOR EACH SIZE GROUP, BY STATE

Fork Length (cm.)	WASHINGTON			OREGON			CALIFORNIA			Total		
	Number Tagged	Number Recovered	Percent Recovered	Number Tagged	Number Recovered	Percent Recovered	Number Tagged	Number Recovered	Percent Recovered	Number Tagged	Number Recovered	Percent Recovered
25–29	2	0	.....							2	0	.....
30–34	7	0	.....	3	0	.....				10	0	.....
35–39	170	3	1.8	10	0	.....	3	0	.....	183	3	1.6
40–44	70	1	1.4	12	0	.....	60	0	.....	142	1	0.7
45–49	82	6	7.3	140	2	1.4	298	5	1.7	520	13	2.5
50–54	408	10	2.1	512	2	0.4	1,174	25	2.1	2,094	37	1.8
55–59	465	9	1.9	656	8	1.2	1,022	32	3.1	2,143	49	2.3
60–64	318	7	2.2	587	8	1.4	881	30	3.4	1,786	45	2.5
65–69	298	11	3.7	508	12	2.4	509	25	4.9	1,315	48	3.7
70–74	256	10	3.9	342	9	2.6	90	7	7.8	688	26	3.8
75–79	141	4	2.8	185	4	2.2	13	1	7.7	339	9	2.7
80–84	56	1	1.8	87	1	1.2	3	0	.....	146	2	1.4
85–89	21	1	4.8	30	0	.....				51	1	2.0
90–94	11	0	.....	10	1	10.0				21	1	4.8
95–99	2	0	.....	9	0	.....				11	0	.....
100–104	1	0	.....	1	0	.....				2	0	.....
Totals[1]	2,308	63		3,092	47		4,053	126		9,453	236	

[1]Missing measurements cause the anomalies between these and other totals.

TABLE 11. NUMBERS AND PERCENTAGES OF SABLEFISH TAGGED AND RECOVERED BY MONTH AND BY STATE

Month	WASHINGTON				OREGON				CALIFORNIA			
	Number Tagged	Percent Total	Number Recovered	Percent Recovered	Number Tagged	Percent Total	Number Recovered	Percent Recovered	Number Tagged	Percent Total	Number Recovered	Percent Recovered
January												
February									522	12.8	20	3.83
March									250	6.1	5	2.00
April					4	0.1	0	0	359	8.8	3	0.84
May					349	11.3	8	2.29	1,115	27.4	47	4.22
June					146	4.7	5	3.42	960	23.6	42	4.38
July	1,061	45.3	36	3.39	256	8.3	5	1.95	255	6.3	0	0
August	941	40.2	27	2.87	1,035	33.4	12	1.16	583	14.3	11	1.89
September	169	7.2	2	1.18	1,299	41.9	16	1.23				
October	170	7.3	1	0.59	8	0.3	1	12.50				
November												
December									29	0.7	0	0
Total	2,341	100.0	66	2.82	3,097	100.0	47	1.52	4,073	100.0	128	3.14

The season of tagging was thought to affect the recovery percentage because the fish tagged early in the season were available to the fishery the same season while those tagged later might not have been available until the next season and had to survive through the winter. Tagging in May and June produced the greatest percentage of returns in California, closely followed by the February tagging (Table 11). For Oregon the bulk of the tagging was done in August and September, but higher percentage returns were gained from tagging done in May, June, and July. The bulk of the tagging in Washington was done in July and August, and the best returns were obtained from tagging in those months. Chi-square tests made on these data were too involved with other factors such as fishing intensity, type of metal pin used, and small numbers of returns to show any significant differences in recovery between months.

Tag losses were suspected but could not be proven. Tags can be lost off fish in at least three ways. The metal pins may break after being weakened by corrosion. The cellulose acetate of which the disks are made has been noted to break and to soften upon soaking which allows the head of the pin to pull through the hole in the disk (Fry and Hughes, 1951). Growth of the fish applies pressure on the disk which aggravates the first two causes of tag loss and possibly forces open the knot made in the wire pin. The latter method of tag loss has been suspected but has not been definitely established. Nickel, German silver, and stainless steel were used in the pins for attaching the disks, but no significant difference could be found in the returns according to type of metal.

Tests made with aquarium held striped bass (Calhoun, Fry, and Hughes, 1951, and Calhoun, 1953) showed nickel to be highly corrosive while stainless steel did not corrode. German silver was not tested in the aquarium, but it is a mixture of dissimilar metals (copper, zinc, and nickel) and would be expected to be subject to internal electrolysis and therefore be highly corrosive.

Table 12 gives a comparison of the number of fish tagged and returned according to the various grades of apparent condition at tagging. The grading according to condition was explained in the discussion of methods. California is not listed in the table because in that state only fish in good condition were selected for tagging. More fish were tagged in the fair and poor grades in Oregon, but no significant chi-square difference could be found in the recoveries between condition grades in either Oregon or Washington.

In the Oregon experiments scales were collected from alternate tagged fish. Collecting scales did not affect the chances for survival for the fish as no significant difference was found between the number of recoveries of scaled and unscaled fish using the chi-square test.

TABLE 12. NUMBERS AND PERCENTAGES OF FISH TAGGED AND NUMBERS RECOVERED BY CONDITION WITH PERCENTAGE RECOVERIES FOR OREGON AND WASHINGTON

Condition	Washington				Oregon			
	Number Tagged	Percent Total	Number Recovered	Percent Recovered	Number Tagged	Percent Total	Number Recovered	Percent Recovered
Good (1).....	1,666	71.2	52	3.1	1,959	63.3	35	1.8
Fair (2).....	394	16.8	8	2.0	668	21.6	10	1.5
Poor (3).....	246	10.5	3	1.2	300	9.7	1	0.3
Unknown.....	35	1.5	4	11.4	170	5.4	1	0.3
Totals.....	2,341	100.0	67	2.9	3,097	100.0	47	1.5

SUMMARY

Before any recommendations for the management of the sablefish fishery could be made, the amount of movement of the sablefish stocks had to be known. If the stocks migrate extensively coastwise they would have to be managed as a single unit. If the stocks are divided into local groups of fish remaining in one area, they could be managed as distinct units. The California, Oregon, and Washington research agencies agreed at the recommendation of the Pacific Marine Fisheries Commission to study the problems of sablefish migration, and tagging programs were conducted in each

state for this purpose. Incidental information was expected on age and growth of sablefish in conjunction with the tagging experiments.

There were variations in the methods used in the three states, but, in general, plastic disk tags of the Petersen type were affixed with metal pins to the dorsal surface below the dorsal fins of 9,511 sablefish. The tagging was done mainly from commercial vessels in regular fishing areas. Fish were tagged from both setline and otter-trawl geared vessels in the Washington and Oregon experiments, but from setline geared vessels only in California. Nickel, stainless steel, and German silver pins were used.

Of the 9,511 sablefish tagged along the coast, 243 (2.55 percent) were recovered. The Californians tagged the most fish, 4,073, and obtained the greatest percentage of recoveries, 3.16 percent (129 fish). The Washington experiment resulted in the next best recovery rate, 2.86 percent or 67 of the 2,341 fish tagged. The 3,097 tagged fish placed Oregon second in numbers of fish tagged, but the percentage of recoveries, 1.52 percent (47 fish), was the lowest of the three states.

Most of the tagged fish were recovered near the region of initial release, and only a few individuals made long migrations. The greatest number of returns were made within 30 miles of tagging, which indicates the local nature of the stocks although many recoveries were made within five months of tagging which may not have allowed much time for migration to take place. The north-south migration was fairly well balanced in all areas. The tagged fish were found to scatter throughout the depths fished. No relationships were found between size of fish and direction or extent of migration. There was no fishery in deeper water to detect any seasonal movement had it occurred.

The sablefish in the Washington offshore waters appeared to grow faster than either the Oregon or California fish. Most of the California and Washington recoveries were made the same season that the tagging was accomplished, and the most recoveries were made the second season after tagging in Oregon. The length of time at liberty reflected the seasonal nature of the fishery. No relationship was exhibited between length of time at liberty or size of fish and amount of migration.

The low number of recoveries in these experiments is difficult to explain. Tagging mortalities could have been high, and tag losses may have been great producing low tag returns. The fishing activity for sablefish appeared to be low off the Oregon coast and this is believed to account for the low recoveries relative to the other states. Also many Oregon fish were tagged late in the season making them subject to winter losses before being available to the fishery in the following season. Recovery percentages varied directly with the condition of the fish estimated at tagging. Fish in good condition gave the highest percentage recovery, although no statistically significant difference was found between the number of recoveries in the three grades of condition.

LITERATURE CITED

CALHOUN, A. J.
1953 Aquarium tests of tags on striped bass. California Fish and Game. Vol. 39, No. 2, p. 209–218, 3 figs.

CALHOUN, A. J., D. H. FRY, JR. and E. P. HUGHES
1951 Plastic deterioration and metal corrosion in Petersen disk fish tags. Calif. Fish and Game. Vol. 37, No. 3, pp. 301–314, figs. 141–143, 3 tables.

FRY, DONALD H., JR., and ELDON P. HUGHES
1951 The California salmon troll fishery. Pacific Mar. Fish. Comm. Bull. No. 2, pp. 7–42, 18 figs., 9 tables.

AGE AND GROWTH OF THE OREGON SABLEFISH, *ANOPLOPOMA FIMBRIA*

ALONZO T. PRUTER
Washington State Department of Fisheries

BULLETIN 3
PACIFIC MARINE FISHERIES COMMISSION
Portland, Oregon, 1954

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

AGE AND GROWTH OF THE OREGON SABLEFISH, *ANOPLOPOMA FIMBRIA*

THE USE OF SCALES FOR DETERMINING AGE

The only published age determinations of sablefish are those by Bell and Gharrett (1945) who used scales for that purpose. Since their work was of a preliminary nature, this study of the use of the scales for age determination was undertaken.

Figure 1 shows a scale of a 61 centimeter female. Near the posterior margin of the scale is a small clear area, the focus. Striations, concentric with the anterior margin, are found on the anterior field. These striations are the circuli, marking successive stages in growth of the scale. On closer examination, seven distinct areas of the scale may be found in which the circuli are spaced quite close together. These closely spaced circuli represent periods of retarded growth, and as in many other fishes, some evidence suggests that one such band is formed each year.

The scale shown in Figure 1 is not the most frequently occurring type. A typical scale is considerably wider along the lateral (dorso-ventral) axis and shorter along the antero-posterior axis (Figure 2). The circuli on a typical scale are so closely spaced over the entire anterior field as to make it nearly impossible to delimit the annuli. Consequently, all scales described in this paper are of the oblong, or non-typical type shown in Figure 1 in which the annuli are separated. They were obtained from the portion of the body between the first dorsal fin and the lateral line and constituted less than ten percent of the scales normally present in that region.

Regenerated scales were very numerous often totaling as high as 70 to 90 percent of those examined. These scales, which are of no value in estimating age, cannot be distinguished by the unaided eye but are readily recognized under magnification.

Selected scales of the type shown in Figure 1 were soaked in an ordinary household detergent solution for 12 to 24 hours and then cleaned with a stiff stencil brush. After cleaning, three scales from each fish were dry mounted between a cover slip and a glass slide. Approximately one hour was required to clean and mount scales from ten fish.

Scales were also experimentally mounted in various liquid media; such as, sodium silicate, polyvinyl alcohol, glycerine, corn syrup, and various kinds of glue. However, all such media rendered them too transparent for use.

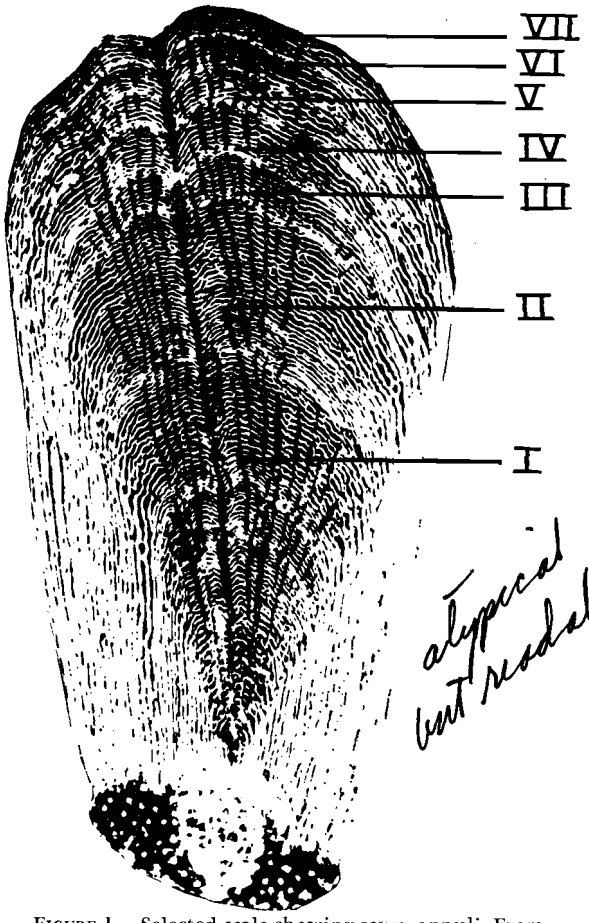

FIGURE 1. Selected scale showing seven annuli. From a 61 centimeter female captured off the Oregon coast in August 1950.

FIGURE 2. Typical scale. Annuli obscured. From a 65 centimeter female captured off the Oregon coast in September 1950.

After the scales were dry mounted, they were projected on a white surface at a magnification of approximately 35 diameters by use of a scale projection device known as a "Rayoscope." Better results were obtained with a Rayoscope than by viewing the scales through a microscope. A permanent record of the scale readings was obtained by projecting the image on paper and drawing a line from the focus to the anterior margin of the scale. Marks coinciding with the outer margins of the annuli were made across this line, which permitted accurate comparison of readings.

READABILITY OF SCALES

The consistency of age readings of specific scales does not necessarily validate their use for age determinations. However, such consistency, or lack of consistency, is a measure of their readability, and hence their utility. A record was therefore kept of the individual readings for each fish (Table 1). Considerable time was spent in developing techniques of preparation and reading before any "first" readings were made. The terms "first" and "second" readings were therefore arbitrarily assigned to the final two sets of readings, which were made within a short time of each other. If comparisons had been made with the preliminary readings the lack of familiarity with the general pattern of scale structure would have resulted in poorer agreement than that shown in Table 1.

During the preliminary readings a suggestion of another annulus was noted on some scales between the focus and the narrow band of circuli considered as the first annulus. Since these "accessory annuli" were indefinite in appearance and occurred on a minority of the scales they were not counted as true annuli in the final readings. Their presence on some scales, however, suggests the age readings may be one year too low, i.e., "one year olds" may be two years of age, "two year olds" may be three years of age, etc.

TABLE 1. COMPARISON OF "FIRST" AND "SECOND" SCALE READINGS BY THE SAME PERSON

Number of Annuli in Second Reading	Number of First Readings in Agreement with Second	Number of First Readings Not in Agreement with Second	Percent Agreement
1	174	10	95
2	95	5	95
3	25	5	83
4	38	11	78
5	32	12	73
6	41	13	76
7	29	10	74
8	14	9	61
9	7	8	47
	455	83	

VALIDITY OF SCALES FOR AGE DETERMINATIONS

The use of scales for age determination requires that they grow throughout life and that the "annuli" are formed yearly and about the same time each year. The first requirement was investigated for the sablefish by determining the ratio between the body length (tip of snout to fork of tail) and scale radius (focus to anterior margin) at various ages. These ratios are shown in Table 2 for ages 1+ to 9+.

TABLE 2. BODY LENGTH-SCALE RADIUS RATIOS OF OREGON SABLEFISH COLLECTED IN MAY THROUGH OCTOBER OF 1950 AND 1951. BOTH SEXES COMBINED
Number of specimens shown in parentheses.

	Age in Years								
	1+	2+	3+	4+	5+	6+	7+	8+	9+
Body-Scale Ratio	198	192	206	192	198	183	195	180	186
	(176)	(102)	(27)	(51)	(43)	(56)	(42)	(26)	(10)

Although a trend of decline in the body-scale ratios corresponding to an increase in age is suggested in the above table, the relatively small number of older specimens in the sample makes the observed decrease of doubtful significance. Because of the subjective nature of the age determinations, further studies were made by plotting the average radius of the scales against the average fork length of the body, regardless of age (Table 3).

TABLE 3. AVERAGE RADIUS OF SCALES AT VARIOUS BODY LENGTHS FOR OREGON SABLEFISH. BOTH SEXES COMBINED

Limits, in Centimeters, of Size Group Employed	Average Fork Length, in Centimeters, of Fish of Size Group	Average Radius, in Millimeters, of Scale	Number of Specimens Employed
30–35	33.4	1.73	118
36–40	38.5	1.94	89
41–45	42.4	2.19	66
46–50	48.5	2.66	25
51–55	53.7	2.78	28
56–60	58.4	3.00	52
61–65	63.3	3.35	64
66–70	68.0	3.64	42
71–75	73.0	3.72	34
76–80	78.8	3.97	12
81–90	83.3	4.01	7

The body length-scale radius relationships given in the preceding table are plotted in Figure 3. The solid line represents the actual length of the body and the radius of the scale, as shown in Table 3, while the broken line shows what the theoretical relation of the body length to scale radius would be if the ratio existing at a body length between 30 and 45 centimeters were maintained. It may be seen that the two lines remain relatively close together throughout the entire size range of the sablefish. This, coupled with the lack of a definite trend in the ratios shown in Table 2, suggests a fairly uniform body length-scale radius relationship for the sablefish.

AGE AND RATE OF GROWTH

The number, mean length, and range in length of Oregon sablefish from which scales were removed during sampling at sea in 1950 and 1951 are presented in Table 4. The table shows that male and female sablefish of ages 1+ and 2+ are about equal in size but that females are larger than males at age 3+ to 8+. The number of fish listed in the table for each age group is not necessarily proportional to the number of fish of each group in the commercial catch (age composition).

The ages of eight fish are not included in Table 4. Four of these fish were determined as 10+, two as 11+, one as 12+, and one as 13+ years of age. No fish in the samples was determined to be older than 13+.

TABLE 4. MEAN FORK LENGTHS OF OREGON SABLEFISH, AGES 1+ TO 9+

Age in Years	Males			Females		
	Number	Mean Length in Cms.	Range	Number	Mean Length in Cms.	Range
1+	85	34.8	27–42	91	35.1	30–44
2+	54	42.3	38–58	51	41.5	37–46
3+	13	50.1	46–56	15	54.6	48–60
4+	13	53.9	47–61	35	57.4	45–70
5+	10	58.3	52–65	34	62.6	52–71
6+	8	61.8	54–70	49	65.4	53–79
7+	7	66.3	61–72	36	69.5	55–80
8+	6	65.7	59–79	18	72.7	62–86
9+				9	75.9	65–84

Under ideal conditions, age readings should be determined for fish immediately after they have completed the formation of their annuli. Since the lengths presented in Table 4 were based on

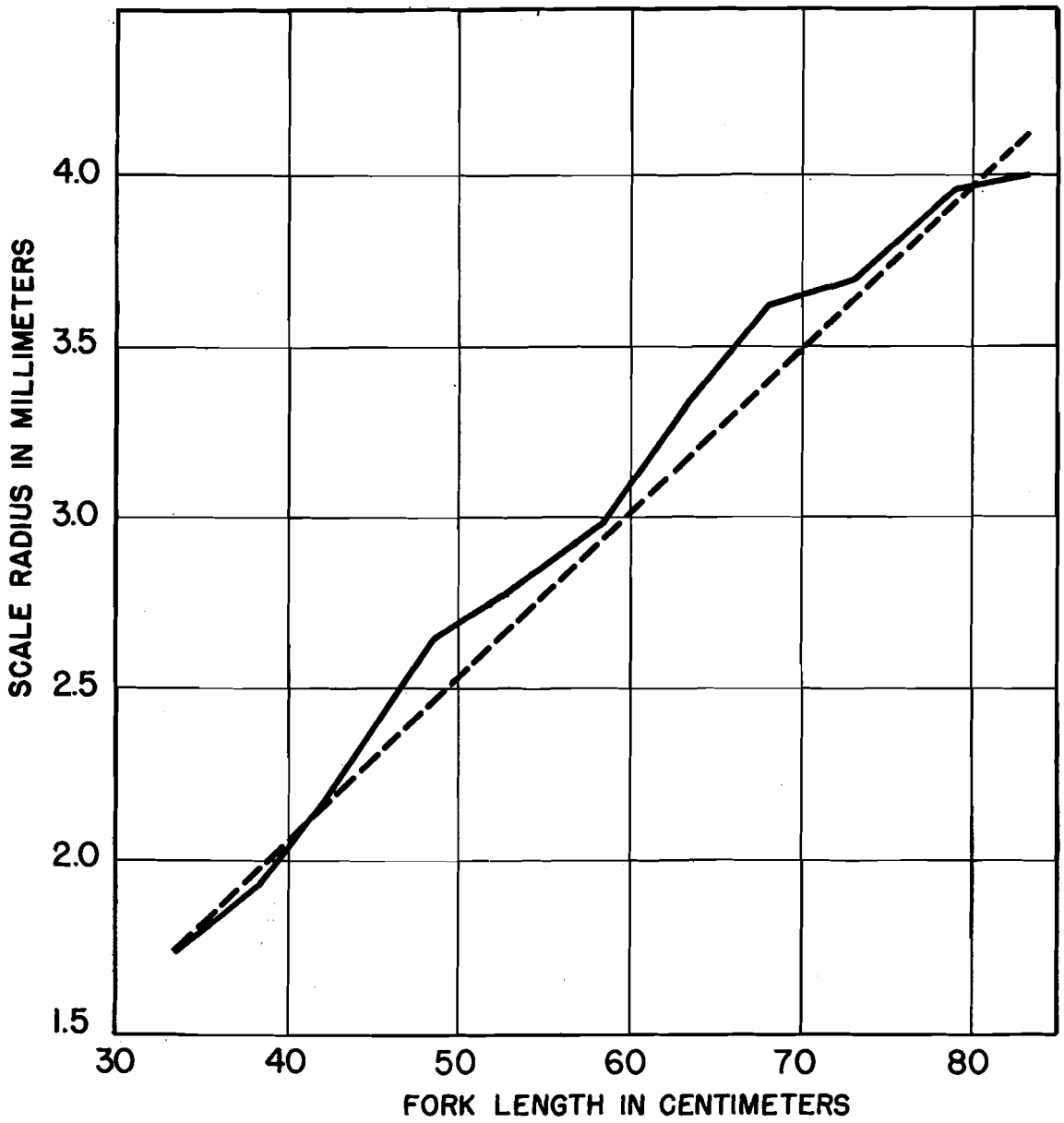

FIGURE 3. Body length—scale radius relationship of Oregon sablefish. Continuous curve based on average body lengths and scale radii shown in Table 3. Broken line shows what the relation of the body length and scale radius would be if that existing at a body length between 30 and 45 centimeters were maintained.

samples obtained at widely divergent times within the "summer growth periods" of both 1950 and 1951, lengths at various ages were calculated from the scale-fish growth relationship. The calculated lengths are those existing immediately after formation of the annuli, and hence are more exact than the average actual lengths shown in Table 4.

As was shown earlier, growth of the scales and body of the sablefish is approximately proportional throughout life which permits the calculation of the previous length of a sablefish at the end of year X of its life by use of the following general formula:

$$\frac{\text{Length of fish at capture}}{\text{Total radius of scale}} = \frac{\text{Length of fish at end of year X}}{\text{Radius of scale included in annulus of year X}}$$

Figure 4 compares the rates of growth as determined from the calculated lengths (Table 5) and the average actual lengths (Table 4) at various ages. As shown in Figure 4, the calculated lengths

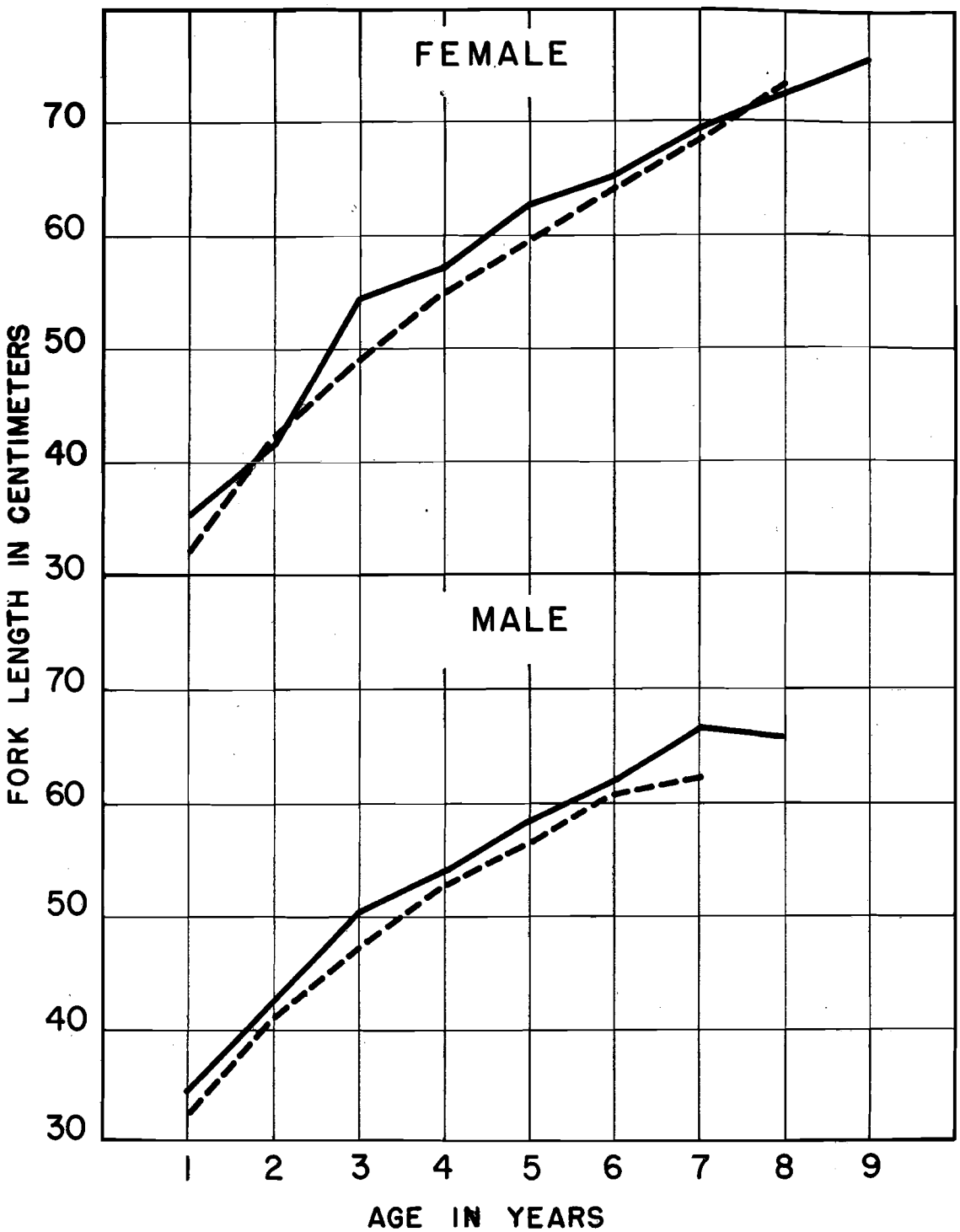

FIGURE 4. Rate of growth of Oregon sablefish according to average actual lengths and lengths calculated from scales. Broken line represents calculated lengths and solid line actual lengths.

are generally less than the average actual lengths. This results, in part at least, from the fact that the average lengths are based upon readings of scales obtained during the summer growth period, whereas the calculated lengths are those existing immediately after formation of the annuli. It may also result from any one or a combination of the following: (1) The sablefish may attain some body length before the scales are formed and the two may grow at proportional rates thereafter. (2) The

scale radius-body length relationship may not be linear as assumed but instead may be curvilinear. (3) The fishing gear may be selective in catching the larger individuals of the younger age groups, thus making the observed lengths of such fish greater than those calculated from the scales of older fish. (4) A more intensive fishery in recent years may have resulted in a significant increase in the growth rates. This would cause the fish to be larger for a given age than they were in the past, and the calculated lengths for younger ages would therefore be less than now observed.

TABLE 5. CALCULATED LENGTHS OF OREGON SABLEFISH, AGES 1 TO 8

Age in Years	Males			Females		
	Number	Mean Length in Cms.	Range	Number	Mean Length in Cms.	Range
1	110	32.7	23–43	254	32.1	21–48
2	59	41.1	32–51	202	42.0	32–59
3	46	47.5	37–58	188	49.1	39–67
4	33	52.8	44–63	151	54.9	44–72
5	23	56.6	48–66	118	59.5	47–71
6	14	60.9	51–70	70	64.0	51–84
7	8	62.4	55–73	35	68.5	57–88
8				14	73.4	60–90

SUMMARY

Scales were found to be satisfactory for determining the age of sablefish after they were allowed to soak in a detergent solution for a period of 12 to 24 hours, cleaned with a stiff stencil brush, and mounted dry.

The scales and body of the sablefish were found to grow at approximately proportional rates throughout the period of life covered by the available samples. The samples include most of the present commercial sizes.

Comparisons between the rate of growth of sablefish as determined from average actual lengths and lengths calculated from scales are presented for both males and females. Both methods indicate that male and female sablefish of ages 1+ and 2+ are about equal in size, but that females are larger than males at ages 3+ to 8+.

ACKNOWLEDGMENTS

The described study was completed while the author was employed by the Oregon Fish Commission.[1] George Y. Harry, Jr., Supervisor of Marine Fisheries Research for that Commission, assisted in planning the work.

The author wishes to express his thanks to the following individuals for their critical review of the manuscript: George Y. Harry, Jr., Oregon Fish Commission; F. Heward Bell and Harry A. Dunlop, International Fisheries Commission; and Donald E. Kauffman, Dayton L. Alverson, and William H. Bayliff, Washington State Department of Fisheries.

LITERATURE CITED

BELL, F. HEWARD and JOHN T. GHARRETT
1945 The Pacific coast blackcod, *Anoplopoma fimbria*. Copeia, No. 2: 94–103.

[1]Now employed by the Washington State Department of Fisheries.

PACIFIC MARINE FISHERIES COMMISSION

APPENDIX

PACIFIC COAST SABLEFISH CATCHES BY REGION OF LANDING

Sablefish catches are landed either as "round" (entire) or as "dressed" (eviscerated and beheaded) fish. The practices vary according to region and types of gear used. In Washington, Oregon, and California, sablefish are landed in both conditions and the official landing records represent "mixed" weights or the weights of the fish as landed. The British Columbia sablefish landing statistics represent dressed weights since practically all of the catches are marketed in that condition. In Alaska, also, all of the sablefish are dressed before landing, but for the official records, the landed weights are converted to round weights by applying the factor 1.43 to the weights of the dressed fish.

This variation in recording procedures makes difficult a comparison of the landings. Therefore, in Table 1 (page 130), the landings for 1915 to 1952 are expressed in terms of dressed weights, with conversions having been made where necessary by authors of the respective reports in this Bulletin who supplied these data (Phillips, Bell, Pruter, Ketchen, Edson). In some instances these conversions incolved a certain amount of estimation, but it is felt that such errors that may have been thus introduced are less consequential than the inconsistencies involved in the analysis of records representing both round and dressed weights.

Prior to 1915, landing records are not available for all regions.

1.43 — headed + gutted = "dressed"

TABLE 1. PACIFIC COAST SABLEFISH CATCHES BY REGION OF LANDING

In Thousands of Pounds—Dressed Weights

Year	California	Oregon	Washington	British Columbia*	Alaska†	Total
1915.....	45	16	576	3,590	152	4,379
16.....	59	25	2,039	6,340	333	8,796
17.....	637	350	2,430	8,408	1,400	13,225
18.....	349	250	4,355	2,594	1,759	9,307
19.....	234	300	1,554	859	703	3,650
1920.....	547	100	950	2,264	899	4,760
21.....	716	100	1,519	1,651	773	4,759
22.....	188	57	1,014	1,704	247	3,210
23.....	377	250	2,109	1,498	1,020	5,254
24.....	659	161	2,030	1,652	393	4,895
25.....	509	348	2,340	1,165	1,404	5,766
26.....	141	387	2,083	752	971	4,334
27.....	797	366	2,426	1,336	1,668	6,593
28.....	746	280	2,252	1,113	494	4,885
29.....	1,121	128	2,251	1,356	648	5,504
1930.....	1,103	190	2,659	1,423	681	6,056
31.....	871	64	1,299	532	332	3,098
32.....	830	79	1,691	604	128	3,332
33.....	1,028	24	1,280	565	145	3,042
34.....	1,642	102	2,259	639	261	4,903
35.....	2,110	91	2,812	970	694	6,677
36.....	840	270	2,338	720	1,008	5,176
37.....	639	148	2,829	1,341	2,517	7,474
38.....	346	124	2,734	846	1,442	5,492
39.....	642	98	3,067	907	2,100	6,814
1940.....	473	67	2,438	1,393	2,619	6,990
41.....	429	261	2,283	1,747	3,730	8,450
42.....	1,553	619	2,440	1,228	6,553	12,393
43.....	2,415	1,108	2,216	2,096	4,383	12,218
44.....	2,909	564	2,864	2,233	5,266	13,836
45.....	4,472	367	1,667	2,099	5,885	14,490
46.....	1,916	1,062	3,290	2,379	6,502	15,149
47.....	775	173	2,089	1,309	868	5,214
48.....	1,759	482	2,072	2,180	4,582	11,075
49.....	1,435	408	2,777	2,786	4,050	11,456
1950.....	1,234	343	2,218	955	668	5,418
51.....	2,024	550	3,571	1,897	4,045	12,087
52.....	1,052	260	2,302	1,346	1,329	6,289

*See footnotes Appendix 1, page 71, this Bulletin.

†Includes landings by United States boats in British Columbia ports. These are not included in the British Columbia totals. Such landings have ranged from zero in 1948 and 1950 to a total of 762,000 pounds in 1941, with an average of 236,000 pounds over the 36 year period.