CALIFORNIA FISH AND GAME

"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

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DEPARTMENT OF NATURAL RESOURCES

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October, 1942

A GAME FISH FOR THE SALTON SEA, THE TEN-POUNDER, *Elops affinis* [1]

By WILLIAM A. DILL and CHESTER WOODHULL
Bureau of Fish Conservation
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Two hundred and forty-four feet below sea level in southern California lies the Salton Sea, whose saline waters, 40 miles long and 12 miles wide, sparkle beneath the desert sun. Swimming, boating and some waterfowl shooting attract sportsmen to its shores. But to the angler it has long remained almost barren water.

With no outlet, because of its low elevation, it is fed mainly by the muddy Alamo and New rivers which are simply drainage channels for waste and excess water from the irrigation system of the Imperial Valley. Through these streams and canals it has a connection with the Colorado River. Thus, it is possible for fish to migrate from the river into Salton Sea, and most of its fishes have been derived in this way. Of late years the only fishes known to be present in fairly large numbers have been: mullet, *Mugil cephalus;* desert minnows *Cyprinodon macularius* (a native of the Salton Sink); mosquito fish, *Gambusia affinis affinis.* Carp, catfishes, and a few sunfishes also occur in the Sea, but are found commonly only near the mouths of the Alamo and New rivers where the water is fresher. Practically no game fishing has thus been afforded by the Sea.[2] At long last now, there is at least an indication that a sport fishery may be established—with the first record of ten-pounders, *Elops affinis* Regan, from the Salton Sea. (See Figs. 49 and 50.)

FIG. 49. Warden Leo Rossier with 2 ten-pounders, *Elops affinis* Regan, caught by commercial fishermen off Mullet Island, Salton Sea, California. May 24, 1942.

This game fish is common in the Gulf of California, and "* * * has been found * * * from California to Ecuador, usually in bays, estuaries, sloughs, and muddy tidal streams," according to Walford (1937). Glidden (1941) first reported its occurrence in the Colorado River at Laguna Dam, 12 miles

[1] Submitted for publication, August, 1942.

[2] Striped bass, *Roccus lineatus*, were introduced in 1929 (Anon., 1930), and again in 1930 (Anon., 1931), but evidently did not survive. Silver salmon, *Oncorhynchus kisutch*, were introduced in 1934, but failed to survive (records of State Division of Fish and Game).

above Yuba, Arizona, where he obtained two specimens, 11 and 14 inches long, in August, 1941. He then expressed the hope that "* * * this fish will establish itself in the river and find its way into Salton Sea where it would be a very desirable game fish."

His latter hope has now been fulfilled. On May 14, 1942, Mr. Leo Rossier, of the Bureau of Patrol, reported that 10 ten-pounders, from 18 to 20 inches long, were caught by commercial fishermen in the Salton Sea at Bombay Beach. These fish were taken in trial beach seine hauls for mullet.[3] On May 24th, the fishermen made their second attempts at netting mullet. This time gill nets were used off Mullet Island within a quarter mile of the shore. Two overnight sets with 3½ inch stretched mesh nets produced 20 ten-pounders in addition to a few mullet. Two other sets using 4 inch stretched mesh caught only mullet. On the same day, the authors caught one ten-pounder at Bombay Beach and 10 ten-pounders near the mouth of the Alamo River. These were caught in gill nets of 3 and 3½ inch stretched mesh. (Nets of 4 inch stretched mesh caught none.) It seems probable that the fish are well distributed in the Sea.

All of these fish were very similar in size and appearance. The 10 fish from the mouth of the Alamo River ranged in length (to fork of caudal fin) from 17.1 inches to 19.7 inches, and from 1.75 pounds to 2.5 pounds in weight. The other fish taken were within or close to this size range. All of the fish examined on May 24th (3 females from Mullet Island, 3 females and 7 males from the mouth of the Alamo River, and 1 male from Bombay Beach) were sexually mature and in spawning condition. Large quantities of milt flowed readily from the males.

The stomachs of 20 ten-pounders were examined. Twelve of these were empty. Five fish taken at Bombay Beach on May 14th contained from 1 to 9 desert minnows apiece. Three from Mullet Island taken on May 24th contained from 2 to 34 desert minnows apiece. (These minnows ranged from 1 to 2 inches in length.) One hydrophilid beetle was also found in a stomach.

It is of considerable interest to speculate on the presence of the ten-pounder both in the Colorado River and in the Salton Sea. It might have been expected that their occurrence in the Colorado River would have been better known had they been present before 1941. However, fish called "anchovies" have been reported by residents near Yuma at various times, and the description of these fish checks well with that of the ten-pounder. The so-called "gars" or "pike" also reported taken in the lower Colorado River by fishermen are also suspected of being ten-pounders.

No explanation can be offered as to why this species has not entered the Sea before. An open waterway has always existed up the Colorado River from the Gulf of California, and the fish could have gained access to the Sea through the canal system diverting from the river. (Of course, it may well be possible that the ten-pounder has been present in the Sea for some time. Since 1931 commercial fishing has been illegal and there has been but little angling. Consequently,

[3] Commercial fishing for mullet in the Salton Sea was started in 1915, abandoned voluntarily in 1921, and prohibited by law in 1931. It was resumed this year, but is still in an experimental stage—the work being done under the close supervision of the California Division of Fish and Game.

reports of its capture might have had only a small circulation. The fact remains that from 1915 to 1921, anyway, they were apparently not present—else they should have been reported by commercial fishermen.)

Be that as it may, the fish has now reached the Salton Sea, and possibly it may establish itself in sufficient numbers to form a new sport fishery there. With this in mind, the Division of Fish and Game has ordered all holders of permits to take mullet in the Sea to change their nets to a minimum size of 5 inch stretched mesh. This will still allow the taking of mullet, but will permit the ten-pounders to escape destruction. No exodus from the Sea into the Colorado River is possible because of the many barriers (drops) in the irrigation system. The establishment of a fishery is dependent, therefore, on the continued ingress of fish from the river or upon the successful completion of its

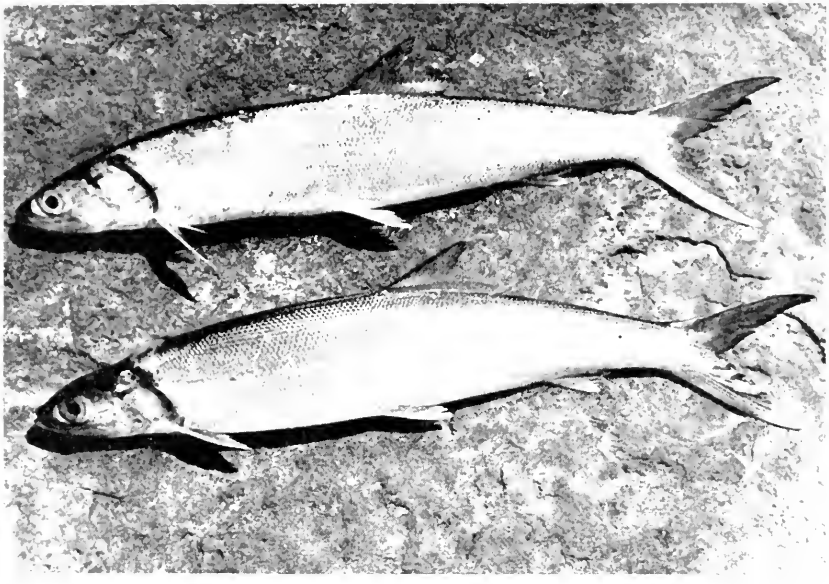

FIG. 50. Ten-pounders, *Elops affinis* Regan, caught by commercial fishermen off Mullet Island, Salton Sea, California. May 24, 1942.

life cycle in the Sea. Our knowledge of the conditions (physical, chemical and biological) necessary for the successful development of the eggs and young of this species is too slight to permit any prediction as to the outcome. Food, in the form of desert minnows and mosquito fish is apparently rather plentiful, although the former, especially, might not stand up under the inroads of a large population of ten-pounders. Possibly, some of the other fishes and invertebrates might also be utilized.

Elops saurus, a close relative of our ten-pounder, is highly esteemed by Atlantic coast sportsmen. *Elops affinis* is its equal as a game fish. Not only will it take bait but it responds to artificial lures. Walford (1937) states that "* * * it will take a No. 3 or 4 spoon with a triple hook * * *" and that it gives excellent sport on light tackle.

No one who has ever witnessed the long leaps of this streamlined fish will doubt the latter statement. It is suggested here that since the fish is known to feed on desert minnows that streamer flies with or without an attached spinner might afford an excellent method of taking it. Several people who have eaten those taken from the Sea attest to the excellent quality of its flesh. (It should be noted, however, that in the hot climate of the Salton Sink the meat may spoil quite rapidly, and care should be taken to ice the fish as soon as possible after its capture.)

It is not yet classed as a game fish by law in our inland waters, but this will be suggested in a forthcoming report on the fishery of the lower Colorado River and Salton Sea.

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LATENT MARINE FISHERIES RESOURCES OF CALIFORNIA AND WESTERN MEXICO [1]

By Richard S. Croker
Bureau of Marine Fisheries
California Division of Fish and Game

The increased need for protein food and animal fats brought about by our participation in the war can be met in part at least by an expansion of the Pacific Coast fishing industry. Bearing in mind present and past heavy exploitation of California fisheries it seems strange that we can expect any important expansion. However, fishing intensity has not been uniform. While some species and some areas have been fished much too heavily, other fisheries have been neglected. Within reach of California fishermen and at not too great distances from metropolitan markets there are great stocks of fish and shellfish virtually untapped by man. This is particularly true of Mexican waters not far to the south of California ports.

In the past, and it is still true, the only motive behind fisheries development has been profit, big profits and quick profits. Hence those areas close at hand, those species for which there was the greatest demand, have been exploited. On the other hand certain remote areas in or near California have been neglected and some species for which there was little demand or which are hard to handle have not been sought.

The increased wartime need for fish can be met by an expansion of California fisheries, but until it can be proved to present or potential operators that there is a profit in such expansion it will not occur. Patriotism is insufficient urge—after all a bankrupt canner is of no use to his Nation. It will be necessary for public agencies to demonstrate the feasibility of expansion by exploring neglected areas and by experimenting with canning, salting and refrigeration methods. The only alternative is socialization of the fishing industry, to bring about maximum production without emphasis on profit. In a nation which depends almost entirely on fish and other aquatic products for its proteins and animal fats, Japan for example, regimentation of the fisheries is a logical step. However, in the United States, with its vast production of cattle, hogs, sheep and poultry, the fisheries play a minor role and rigid Government control of operations, whether or not desirable, is not likely.

Fishing in California is entirely by private enterprise without Government subsidy. All boats and equipment are owned by the individual fishermen or by fishing or packing companies. In Mexico, fishing is carried on by members of government-sponsored cooperative organizations or by semipublic concessionaires. United States

[1] This paper was presented at the symposium "Resources of the sea for wartime economy" at the meeting of the Oceanographic Society of the Pacific, held in Salt Lake City, Utah, June 17, 1942.

fishermen may operate by permit. Thus, in California with an adequate number of boats and fishermen there is no machinery set up to direct fishing effort into those channels which would best aid the war effort, whereas in Mexico there is the organization but not enough fishermen and equipment.

Fuller utilization of our latent marine resources can take two forms—development of neglected fishing grounds and development of new uses for species of fish not now utilized or used only to a minor extent.

In all California there is but one region that is capable of any real development, and its possibilities are limited. That is the area between Bodega Head and Eureka, which is remote from large marketing centers. Along this stretch of coast there is heavy fishing for salmon and sharks between Fort Bragg and Eureka, and fairly intensive fishing for crabs near the latter port. Also trawlers fish for sole and other bottom fishes wherever sand or mud bottom is found. It would be possible to develop a long-line fishery for a variety of fishes along the rocky shores and over rocky reefs. The species which would probably be taken in greatest numbers—various kinds of rock cod, cultus, cabezone, hake and sablefish—are low-priced varieties and this fishery could not be developed without a considerable increase in price or the construction of nearby refrigeration or canning facilities which would make large scale production on a narrow margin attractive. In this area it would also be possible to expand the crab fishery enormously. Crabs are at present a high-priced luxury item, but the development of a heavy fishery along the northern California coast where they are abundant would make lower prices possible and bring this fine food within reach of everyone. Because of the necessity of marketing crabs either alive or carefully refrigerated it would be necessary to develop live-handling techniques and facilities and freezing plants. Along this stretch of coast abalones are abundant, and although the weather is often too stormy for diving it would be possible to develop a large abalone fishery.

Very little development of new fishing grounds is possible along the remainder of the California coast. Between the Oregon line and Eureka there are already rather heavy fisheries for salmon, sharks, crabs and bottom fishes. From Bodega Head to Point Sur, south of Monterey, no expansion is possible as intensive fisheries of all types are conducted in this area. From Point Sur to San Simeon it would be possible to expand the rock cod fishery somewhat, and careful exploration might disclose new trawling grounds. To the south virtually all available fishing areas are heavily exploited. In fact, fishing is already so intensive in southern California that any further increase in effort would cause damage to the stock that not even the present demand for fish would justify.

One possibility for development of new areas in California remains—the bays and lagoons which can be made to produce larger quantities of oysters and possibly clams. The California Division of Fish and Game is attempting, with considerable success, to promote the cultivation of oysters in several bays, and production has increased considerably.

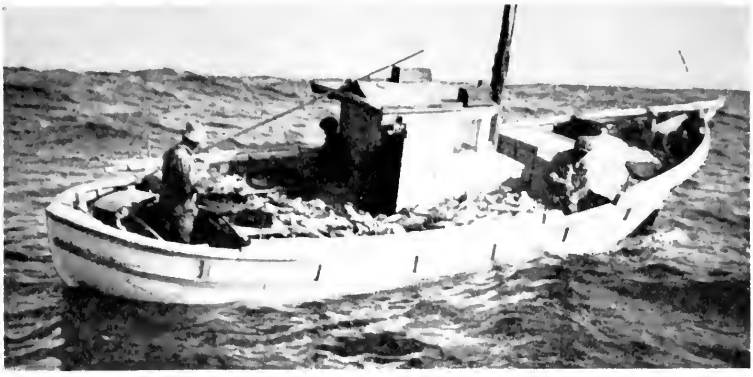

FIG. 51. Rock cod fishermen off Point Sur. Photograph by J. B. Phillips, April, 1938.

The greatest potential source of fisheries products within access of California fishing boats is along the Mexican coast. Local and United States fishermen have operated for many years along the west coast of Baja California, in the Gulf of California, and along the southern mainland coast—in fact the pearl fisheries of La Paz were developed hundreds of years ago. However, fishing has been confined to but a few species and in restricted areas. Half a dozen varieties of fish, as well as lobsters and abalones, have been rather heavily fished in certain parts of Baja California, but very great expansion is possible. In the Gulf, tuna, totuava and sharks are fished heavily in many areas, and shrimps have maintained an extremely intensive fishery near Guaymas and a few other ports. To the southward the only major fisheries are for sharks and tuna. Several canneries and freezing plants are now in operation in Mexico but the fisheries resources could support many more if capital, labor and equipment were obtainable.

Of the many areas probably capable of great expansion, the following seem to be of most promise. The vast sand-bottom expanse of shallow Sebastian Viscaino Bay and the similar bight between Abreojos and San Lázaro would probably be suitable for trawling. Exploratory fishing would reveal their potentialities. The Viscaino area would be in reach of southern California ports but the more southerly area would have to be fished on a mother-ship basis. The three huge bays of Baja California—Scammon's, San Ignacio and Magdalena—have possibilities for shrimp trawling and shark fishing and could produce quantities of herring and anchovies for canning. The magnificent clam beaches of the west coast are just now beginning to be exploited. Most of the offshore banks, although fished for tuna, remain untouched as far as bottom fish are concerned. Experimental fishing with long lines would show what could be expected from them.

The Gulf of California teems with unbelievable quantities of fish and could support a large fishery. Although far from potential markets, Gulf fishing ports have good transportation facilities. Several coastal villages on both sides of the Gulf are connected to United States

centers of population by road. Guaymas, Topolobampo and Altata have rail connections with both United States and Mexican cities and these towns as well as La Paz are served by cargo vessels. There is a need for general exploratory fishing with trawl nets, purse seines and long lines in the Gulf, as heretofore most operators have been interested in only one or two kinds of fish. South of the Gulf there are large areas that have never witnessed modern fishing methods other than live-bait tuna fishing. Fish of many kinds are abundant and possibilities for development are so great as to stagger the imagination. The greatest difficulties are the tropical climate which would require prompt and efficient refrigeration or canning, and the distance from market. Some ports, such as Mazatlán and Acapulco are connected to Mexico City by rail or highway, but throughout most of the area transportation facilities are inadequate. To make these vast supplies of fish available to the war effort of the United Nations it would be necessary to establish canneries at several points along the mainland coast from Mazatlán to Salina Cruz. These canneries could be supplied with cans and equipment by coastwise steamers and could ship their canned fish by the same carriers.

However, the development of new fishing areas, particularly in Mexico, is something for the future and little can be done that will hasten such expansion sufficiently to help during the present war emergency. We can only look forward to the possibility of these untouched grounds supplanting those already sadly depleted. The greatest promise for immediate expansion lies in those species of fish which although not utilized now to best advantage can be caught readily with existing facilities. A considerable variety of fish in this category can be taken both along the California coast and in northern Baja California.

During the war, the greatest demand will be for canned fish, as this product can be stored and shipped where and when needed. Hence the most logical way to increase production is to pack a larger quantity of a greater variety of fish. The efforts being made to can as much mackerel, sardine and tuna as possible are not enough. It is necessary to develop methods for canning other kinds of fish to supplement those now being packed. However, present government regulations do not permit this type of expansion as virtually no tin plate for cans is allotted to new products. Only primary species call for unlimited supplies, and so-called secondary varieties, such as shad, are strictly limited. As the need for canned fish grows and as substitutes for tin plate are discovered these regulations will undoubtedly change and it will be possible to expand our pack.

In California waters there are eight varieties of inexpensive fish which are abundant enough to warrant canning operations and yet are not packed at all. Four of the eight species mentioned are found in northern and central California: hake, cultus or ling cod, tomcod and herring. The hake and tomcod can be taken in trawl nets, sometimes in great numbers. The hake is also caught on salmon trolling lines and is taken in purse seines, even in southern California at times. Cultus can be taken on set lines and salmon trolling lines. Herring enter bays to spawn and can be caught with gill nets, beach seines and round haul nets. Small markets exist for fresh cultus and herring,

and some herring is salted, whereas hake and tomcod are generally discarded by the fishermen as they spoil readily and are not marketable in any event. All four are good food fish, however, and if canning techniques were developed could be canned on a moderate scale.

Two of the eight species are very abundant in central and southern California: kingfish and anchovies. Both are taken in round haul nets and the kingfish is caught also on lines and in gill nets. Fairly large quantities of kingfish are sold as fresh fish and small amounts are dry-salted. Anchovies are used extensively as live and dead bait. Both could be taken in quantities sufficient to support rather large scale canning operations.

FIG. 52. Southern California market fishing boat. This type of boat engages in many fisheries, using several kinds of nets as well as lines and lobster traps. Photograph by D. H. Fry, Jr.

The remaining two varieties are State-wide in distribution: jack smelt and sharks—in fact half a dozen species of sharks are available. Jack smelt are abundant along the coast and in the bays and supply a moderate demand for fresh fish. They are taken in round haul nets, gill nets and beach seines. This species could support modest canning operations. Sharks offer the greatest possibilities for cannery expansion. A very heavy gill net and line fishery exists at present for the production of shark liver oil which is rich in vitamin A. The bodies of the sharks are wasted to a large extent as they are worth so much less than the livers. However, quantities are made into fish meal and there is a growing market for the meat which is of good quality in spite of the opprobrium of the name "shark." The best food species are soupfin, which also possesses the most valuable liver, leopard, thresher,

bonito shark, and two species of smooth-hounds. No really good technique has been developed for canning the meat of any variety of shark. When it is, these fish will be capable of supporting large-scale operations if the public can be convinced of their quality.

In addition to the above species there are two others, shad and squid, which are packed in small quantities yet could support fairly heavy canning operations. There are many other species which although fairly abundant are relatively too costly to can profitably on an extensive scale. However, experimental packs of barracuda and rock cod have been put up during the last few months.

Present cannery facilities in central and southern California could take care of the packing of these fishes. There are no canneries north of the San Francisco Bay region, however. It is suggested that small plants, similar to the sportsmen's canneries on the Klamath River, be constructed at Fort Bragg, Eureka and Crescent City. Small catches could be kept frozen until sufficient stocks had accumulated to make canning operations worthwhile. Building of new plants would be difficult under priority regulations and in any event would not be profitable without Government subsidy.

The species listed above, as well as a few more, can also help meet increased demands for fresh fish if more refrigeration facilities are provided to handle those varieties which spoil readily, and if the public can be "educated" to accept equal quality under different names than those to which it is accustomed.

As with new fishing grounds, it is to Mexico that we must turn for our best possibilities in developing fisheries that are not now utilized. Taking into account only Mexican waters within practical range of small boats operating from southern California ports there are at least seven very abundant species of fish, the production of which could be increased enormously. If we include species which would have to be handled locally, such as anchovies and several kinds of herrings, the list would be doubled at least. In fact it would be as easy to list those species for which fisheries exist as those which are not taken in quantity.

Many times boats fishing along the Mexican coast for California tuna canneries are unable to catch full loads of yellowfin tuna, skipjack and yellowtail. Yet there are several other kinds of fish equally abundant and probably equally suitable for canning which they pass by because custom limits the packers to a narrow range of variety. Most numerous of these neglected fish is the black skipjack, vast schools of which are to be encountered at all times from Magdalena Bay south. One reliable tuna skipper told us that he saw an estimated half-million tons on one trip. These fish can be taken easily with purse seines and tuna lines. The flesh of the black skipjack is darker than that of other species of tuna, hence it is thought the public would hesitate to accept it. At present it is rumored that two canners are experimenting with this species. The sierra mackerel, one of the most delicious fish in the sea, is also abundant in Mexican waters. This species, which can be taken by trolling or live-bait fishing, would undoubtedly be satisfactory for canning tuna-style. Dolphin, amberjack and pompano are abundant south of Magdalena and would be suitable for canning.

Sierra are caught to a small extent for the fresh fish market but catches could be increased many fold if the public were made aware of their fine quality. Likewise, amberjack and dolphin are good food fishes and could augment deliveries of other species to the fresh fish markets. Two additional varieties of fresh fish are abundant, particularly in northern Baja California: rock bass and ocean whitefish. The markets of all the western United States could be supplied with adequate quantities of fresh fish by the exploitation of these five species, plus an expansion of the existing fisheries for barracuda, yellowtail, halibut, white sea bass, black sea bass, grouper and cabrilla, most of which are capable of supporting much heavier fisheries along the outer coast of Baja California. Such expansion would require the conversion of a number of small refrigerated tuna boats and purse seiners to market fishing. If the demand for fish becomes great enough it would be possible to send refrigerated mother ships and fleets of small boats down the coast.

It would also be possible to develop a large scale dry-salting industry in Mexican waters, based on yellowtail, amberjack, dolphin and other species. A small fishery of this type has existed in the past, proving the possibilities of salting southern fish. If the demand for salted fish warrants it, large vessels accompanied by small fishing boats could be sent to Mexico, in the same manner as the codfish schooners of the north.

Thus it can be seen that the fisheries of California and Mexico can be expanded to a considerable degree, and if the demand for canned, salted and fresh fish becomes great enough it will be possible to exploit additional areas and species. The fish are there and we have sufficient men and equipment to catch and handle them. Anyone trying to purchase canned or fresh fish can see that there must be a demand for these products. What is holding back development then? It is not the inability to develop new techniques for canning, refrigeration or fishing—American ingenuity has always proved equal to any challenge of that nature. It is simply the refusal of the consumer and particularly of Government buying agencies to try anything new. If there was any assurance at all that its products would meet with a sale, our fishing industry would develop the new fisheries. And if the Government really wishes to increase production of protein foods and animal fats it could do so very easily by offering encouragement to the fishing industry—or by taking it over and operating it on a socialistic basis.

THE LATENT FISHERIES OF WASHINGTON AND ALASKA [1]

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The marine fisheries of the section of the Pacific coast upon which I have been asked to report are, at the present stage of their development, some of the most productive of any similar area in the world. In the course of a year Washington and Alaska produce about one billion pounds of fish and fisheries products. This is a sizable portion of the Nation's production of animal protein, and is not being ignored in the planning of the Nation's food supply in these critical times. Therefore it may sound peculiar to hear me say that there is no section of the northern hemisphere of similar productive possibilities whose marine fisheries are less intensively prosecuted. Yet such is the case. We hear much of the tremendous fisheries of Alaska, but some 98 per cent of the product of those fisheries are salmon, herring, and halibut (Table 1). Of the 500-odd species of fish, and numerous edible shellfish, inhabiting the waters of Alaska and the Bering Sea only some 27 are fished upon commercially, and only 14 of these produce a million pounds or more annually. It is the purpose of this report to point out, within the limits of present knowledge, those fisheries which can be depended upon to produce more heavily, the general area where they can be developed, and to suggest means by which they can be exploited.

TABLE 1. THE CATCH OF FOODFISH AND SHELLFISH IN ALASKA IN 1937, 1938 AND 1939 *

Species	*1937 weight*	*1938 weight*	*1939 weight*
Salmon	593,384,000 pounds	583,706,000 pounds	452,166,000 pounds
Herring	206,446,000 pounds	179,735,000 pounds	185,462,000 pounds
Halibut	13,281,681 pounds	13,930,142 pounds	13,565,387 pounds
Cod	3,999,230 pounds	3,368,316 pounds	3,383,109 pounds
Clams	816,942 pounds	1,029,588 pounds	425,205 pounds
Crab	711,318 pounds	483,276 pounds	305,498 pounds
Shrimp	463,385 pounds	435,801 pounds	438,193 pounds
Trout	61,999 pounds	78,732 pounds	55,161 pounds
Sablefish	2,102,367 pounds	909,234 pounds	1,713,331 pounds
Rockfish	16,843 pounds	4,376 pounds	69,813 pounds
Flounders	180,000 pounds	232,145 pounds	30,323 pounds
Lingcod	3,007 pounds	2,154 pounds	1,080 pounds
Smelt	275 pounds		
Oysters			52 gallons
Totals	821,467,667 pounds	789,914,764 pounds	657,565,000 pounds

* These figures are taken from Bower (1938, 1939, and 1940). Some represent round weight, some dressed weight, some dried weight, and some the cut-out canned weight. The reader is referred to the original sources for more detailed presentation.

[1] This paper was presented at the symposium "Resources of the sea for wartime economy" at the meeting of the Oceanographic Society of the Pacific, held in Salt Lake City, Utah, June 17, 1942.

Aside from the few heavily fished species, little concrete knowledge has been available regarding the distribution in commercial quantities of Alaskan fishes. It has been the speaker's good fortune to examine an excellent manuscript, as yet unpublished, describing the results of the Alaska Crab Investigation of the U. S. Fish and Wildlife Service, and for this he is indebted to Mr. Roger Harrison, in charge of that investigation. Mr. H. A. Dunlop, Director of Investigations of the International Fisheries Commission has kindly given permission to examine unpublished data gathered by that organization. Dr. W. F. Thompson, Director of Investigations of the International Pacific Salmon Commission has given much oral information based on his years of experience in the Northeast Pacific. Such other information presented as is not available in the published literature is based on the personal experience of the speaker and oral information from numerous fishermen and fisheries biologists, who equally draw their living from the North Pacific.

Few general statements can be made regarding the present fishing intensity on any single species along the coast line extending from the Columbia River to Bering Straits. For instance the halibut is fished very intensively off British Columbia and southeastern Alaska. Yet in the southeast Bering Sea, where it is known to be in commercial abundance, it is unfished. The gray cod is fished commercially in Washington, yet the center of abundance is more than 2,000 miles to the northwest in Bering Sea, where it occurs in quantities comparable to those found on the Grand Banks. In general the intensity of the fishery for all species, except for such valuable fish as the salmon, decreases in proportion to the distance from Seattle, and only a relatively few are prosecuted at any great distance from that port. Fifty-five species of fish and shellfish are fished commercially in the State of Washington. All of these species except two are present in Alaska, and, for the most part, in much greater quantities than in Washington; yet only 24 of them are fished at all in Alaska, and only 12 are fished to any considerable extent.

Latent Fisheries of the State of Washington

The commercial fisheries of the State of Washington are rather highly developed. Many of them must be guarded carefully to see that overfishing does not reduce the supply, and the emphasis in most cases must be on restraining the fishery, not in encouraging it to further expansion. Yet there are others which can be made to produce more heavily without neglecting proper conservation principles, and there are some that have been relatively untouched up to the present time.

Skates:

Two species of skates (*Raja binoculata* and *R. rhina*) are present in commercial quantities in Puget Sound and along the open coast. At present they are being fished heavily, in common with the other elasmobranchs of the coast, for the vitamins in their livers. The carcasses are either thrown away at sea or made into fish meal. Little use is made of the excellent meat of the wings.

It should be mentioned also that a tremendous wastage of food results from the dogfish shark, soup-fin shark, and other elasmobranchs along our coast. A process has now been developed by the Columbia River Packers Association for the smoking of the flesh of the soup-fin shark on a commercial scale, and the product is said to be as tasty as could be desired. The successful marketing of this product would bring another large fishery into full production. The principal difficulty with the processing of all elasmobranchs is that there is such a high retention of the nitrogenous products of metabolism in the body that when the fish are held for any length of time after landing ammonia is given off in copious quantities. During the last war dogfish shark were canned as grayfish, but due to the lack of technological advancement in the trade at that time the canned product was not satisfactory because of ammonia liberation in the container. The difficulty with most elasmobranchs is not one of taste but of the technology of their processing, problems that are susceptible to scientific study and successful treatment.

Anchovy:

The northern anchovy occurs in tremendous schools off the coast of Washington and in Hood Canal. Not infrequently they are met with elsewhere in Puget Sound in commercial quantity. In the summer months, at least, they enter Grays Harbor and Willapa Bay and the mouth of the Columbia River in enormous schools. While scouting for pilchard by airplane last year during the height of that fishery off the Washington coast the schools of anchovy, which for the most part lay close inshore, seemed much more extensive and regular in appearance than did the pilchard. They were a continual source of annoyance to the pilchard fishermen because they are of just the right size to gill in their seines. I saw one boat come in last summer with about 14 tons of anchovy gilled in their net. They were two days working with a steam hose getting their net back in shape for fishing. I think that it would be no exaggeration to say that along the Washington and British Columbia coasts the annual take of anchovy would be measured in thousands of tons if the market would absorb them. They are every whit as tasty as the European species of the same genus, which, before the war, brought such high prices in our delicatessen stores. Here again the problems are of a technological and marketing nature; there would be no trouble with the supply. At the present time their only use is for bait in the albacore fishery off Oregon and Washington.

Flounder:

A number of species of flounder, called "sole" by the trade, are fished commercially in Washington. Chief among these are the Cape sole, English sole, rock sole, starry flounder, flathead sole, rex sole, C-O sole, slippery sole, bastard halibut, etc. The fishery was long ago brought to its maximum production in Puget Sound, although the fishery was, and is, unevenly distributed upon the various species. But the development of the otter trawl fishery off the open coast did not start until 1935. Since that year it has increased by leaps and bounds

until this year it is probable that the landings will be in excess of 10,000,000 pounds. The maximum development of the fishery has not yet been reached by any means, because all species taken are not now landed and the potential grounds are not as yet exploited. In the early years of the fishery practically all of the landings were of the cape sole. The other species, which were also caught in abundance, were discarded, although those same species formed the backbone of the Puget Sound fishery. Most of the production is brought in from the banks near the mouth of the Strait of Juan de Fuca. The stocks of fish off Grays Harbor and the Columbia River are just beginning to be fished. Fish are still abundant enough that the fishermen need not venture to the farthest banks, nor is it necessary to bring in the lower priced species. To date the expansion of the fishery has been impeded by the lack of development of the market, and of the proper means of handling the catch, rather than as a result of the limitation in the supply of fish. It is probable that the present wartime prices will serve to stimulate the fishery to its proper proportion without other effort.

Mackerel:

The mackerel occurs in considerable quantities along the open coast of Washington in the spring and summer at least, in with the schools of pilchard. Numbers of mackerel are brought in incidental to the landings of pilchard, but they are not sorted out of the catch and, if the catch has been in the hold for more than a few hours, the mackerel are no better fitted for human consumption than are the pilchard. They pass on into the reduction plants. There is no regular fishery for the species, and few of those brought in from other fisheries are marketed.

Black Cod:

The black cod, or sablefish, occurs in large concentrations along the coast of Washington and British Columbia. From 2,500,000 to 3,000,000 pounds are landed annually in Seattle, but those catches are, in large part, made incidental to the halibut and flounder fishery. Without a doubt the species could produce a great deal more than it now does along our coast. We are faced here with the same problem that prevents the development of some of the hook and line fisheries of Alaska, and that is that under the present regulation of the halibut fishery of the North Pacific the vessel owners voluntarily restrict the trips which each boat makes to the banks. Therefore during the regular halibut season the fisherman fills his limited hold space with the most valuable species, the halibut. Recent changes in the halibut regulations to allow black cod fishermen to land a certain portion of their fare as halibut after the regular halibut season is closed has resulted in stimulating the black cod fishery.

Rock Cod:

Thirty species of rock cod (*Sebastodes* and *Sebastolobus*) occur in the waters of Washington. *Sebastodes caurinus* and *S. maliger* form the basis for a growing sport fishery and a moderate commercial

fishery in Puget Sound. Other species occur in limited, but commercial, quantities in these enclosed waters. However, it is off the ocean coast that these fish are most abundant. There *Sebastodes rubrovinctus* and *S. pinniger* are met with, as well as other species collectively called by the fishermen "red snappers," or "canary birds." Scarcely a more delectable fish swims the sea, but except for certain periods, the catches are mostly made incidental to the halibut and otter trawl fisheries.

Sea Cucumber:

The sea cucumber (*Stichopus californicus*) forms the basis for a small fishery in Puget Sound, where it is canned as "rollops." The product is tasty, but the fishery has never been developed to approach maximum productivity. The species is abundant throughout Puget Sound, and, for that matter, along the British Columbia and Alaska coasts. Sea cucumbers form the basis of an extensive fishery in the South Seas where they are dried under the name of "Trepang." They are also considered something of a delicacy by Alaskan natives.

Crab:

The crab of commerce in Washington is the Dungeness crab. The species is now landed in excess of 3,000,000 pounds annually, but the maximum productivity of the fishery has not yet been reached. The fishery is developing rapidly, however, under the impetus of the high prices caused by the stoppage of Japanese imports of canned crab, and it will soon be necessary to restrict, rather than encourage, production.

A second species, the red crab (*Cancer productus*), is found in abundance in Washington waters but is not fished at all. It is smaller than the Dungeness crab and is therefore ignored, but it compares favorably in size with the highly touted blue crab (*Callinectes sapidus*) of the Atlantic coast and will undoubtedly form the basis of a fishery in the future.

Abalone:

The green abalone (*Haliotis wallalensis*) occurs in abundance along the open coast of Washington and British Columbia. In Washington it supports no fishery whatever and it is probable that because of its habitat (rocky coasts mostly below mean low water) relatively few people know of its existence. While smaller in size ($5\frac{1}{2}$ to 6 inches) it is no less tasty than its southern relative, the red abalone, which is so highly esteemed in California.

Octopus:

The fishery for octopus produces about 50,000 pounds a year in Washington. The production could be increased many times if the market were developed. Nearly all the catch now comes from a restricted area around Port Angeles, although the abundance of the species is no greater there than elsewhere in Puget Sound. Few people realize how delicious chopped octopus is in chowder, cocktails, or salads.

Latent Fisheries of Alaska

While the fisheries of Washington are important, they do not, and never will, compare in productiveness with those of Alaska. They produce scarcely a fifth as much poundage as do those of that territory, and, while they are well developed, those of Alaska have only been touched. Few people realize the extent of the coast line of Alaska, or that its nearly 8,000 miles of coast line is longer than that of the eastern sea coast of the United States. When one travels without a halt night and day for two weeks in a halibut schooner without getting half way along the coast, the enormous size of the territory becomes apparent. In all these waters edible fish and shellfish occur in profusion. The hordes of salmon that inhabit every creek and river in the territory are famous the world over. Less well known are those gardens of the sea, the offshore banks, such as the Yakutat Grounds, Portlock, Albatross, Sanak, Baird, Slime Banks, etc. What the rolling countryside of Iowa is to the farmer, so is the fertile plain of the eastern Bering Sea to the fisherman. Had I the choice of the land of Alaska with its rich mines, farm lands, timber, furs, etc., or its waters, I should not hesitate a moment in taking the latter. Mines once worked are done, forests once cut are slow in regrowing, but year after year into eternity the seas of Alaska can be made to give up 1,000,000,000 to 2,000,000,000 pounds of fish. Developed with any care at all there could be no exhaustion.

The salmon, herring, and halibut which yield more than 95 per cent of the present catch of fish in Alaska are being exploited to such an extent that constant care must be exercised to prevent their depletion. Little additional can be expected of them without cutting into the spawning stock, and of them I shall speak no more. Nor will I refer to the numerous "minor" fisheries which will one day bulk large in the total output of Alaskan waters. I shall speak only of those fisheries, now relatively undeveloped, which can be depended upon to be great fisheries, with annual landings counted in millions of pounds. These are the crab, trout, gray cod, pollack, rock cod, and black cod.

Crab:

Three types and four species of crab of commercial size occur in Alaskan waters: two species of king crab, the Dungeness crab, and the Tanner crab. Other species of edible crab occur, but of these four species the prospecting for occurrence is well started, thanks to the Alaska Crab Investigation of the Fish and Wildlife Service, the methods of canning are worked out, and the market is available and crying for the product.

For many years the United States has been largely dependent upon Japan for canned crab meat. Imports of canned king crab in recent years have accounted for 95 per cent of the canned, and over half of the entire crab meat consumption of the United States. In the past 30 years the United States has paid to Japan more than $100,000,000 for canned crab meat. The peculiar part of this is that a large part of the Japanese pack came from those parts of the Bering

Sea that we consider American and were taken to Japan for subsequent shipment to this country. Furthermore the Japanese have manipulated the American market with sufficient care that American producers could not risk the hazards of packing our own crab for our own market. The onset of war has abruptly altered the situation by stopping Japanese exports. Domestic canned crab which before the war brought $9 per case, and had been at times depressed to $6, now brings $16 and the demand can not be filled.

The Alaska Crab Investigation (Tables 2 and 3) found a large population of king crab in Bering Sea, and smaller, but still commercially important, stocks in Pavlof and Canoe Bays on the south side of the Alaska Peninsula, around Kodiak Island, and in lower Cook Inlet. Two hundred and thirteen experimental hauls with an otter trawl, scattered over an area of 100,000 square miles in Bering Sea, yielded 19,164 king crab for an average of more than 80 crab per hour of fishing. When it is remembered that these crab average about 6.5 to 11.5 (males) pounds each the amount of meat in this area becomes clearer. In thinking of the results of this investigation it must be born in mind that they were prospecting hurriedly over tremendous areas, not staying to fish where they located crabs. Their results are those of more or less random sampling and thus, to a degree, representative of the entire area. Under these circumstances it would appear that the available stock of king crab in this area is surprisingly large, and it is no wonder that the Japanese were able to make money fishing so far from home. The Alaska pack of king crab amounted to 7,600 pounds (dressed weight) in 1939 and 24,312 pounds in 1938, or, for practical purposes, nothing at all.

TABLE 2. SUMMARY OF KING CRAB CATCH *

Area	*Trawl catch*			*Tangle net catch*			
	Fishing efforts	*Number of crab*	*Catch per effort per hour*	*Fishing efforts*	*Number of crab*	*Catch per effort*	*Actual catch by both gear*
Southeastern	5	1	0.2	0			1
Yakutat	6	4	0.8	0			4
Kayak Island	11	0	0.0	0			0
Prince William Sound	10	184	6.4	3	34	11.3	218
Cook Inlet	13	939	23.1	16	541	33.8	1,480
Shelikof Strait	31	175	5.1	1	26	6.5	201
Kodiak Island	133	2,685	32.9	29	61	2.1	2,746
Shumagin Island and Alaska Peninsula	59	380	7.9	11	164	14.9	544
Pavlof Bay	11	2,886	69.8	16	410	25.6	3,296
Canoe Bay	88	6,801	136.8	11	1,054	75.2	7,855
Bering Sea (Area XI) inshore	133	12,492	80.3	48	3,607	75.1	16,099
offshore	80	6,672	83.4	0			6,672
Bering Sea (Area XII)	26	150	6.2	0			150
Total	699	33,369		141	5,897		39,266

* This table is abbreviated from Table 1 of the Report of the Alaska Crab Investigation. The reader is referred to that source for a proper understanding of the figures. The fishing efforts of the first column do not include efforts when the net snagged or fouled. The fishing efforts of the fourth column each include two shackles of gear, each 100 fathoms long and each effort represents 30 to 45 minutes of vessel effort.

The Alaska fishery for Dungeness crab has simmered along for years producing from 300,000 to 500,000 pounds of meat per year, most of which was sold as fresh picked meat. No canner of crab

meat in that area could dare put up a large pack in the face of his high costs and the Japanese control of the American canned crab meat market. It is well known in the fish trade that the very large stocks of Dungeness crab that are exploited along the California, Oregon, and Washington coasts continue along the coasts of British Columbia and southeastern Alaska to Prince William Sound, and that the stocks in the north are practically untouched. The results of the Alaska Crab Investigation (Table 3) confirmed this and also showed them to be abundant around Kodiak Island, and present along the south side of the Alaska Peninsula.

The Tanner crab has not yet been exploited at all in Alaska. Yet the Crab Investigation actually caught more of them than they did of the two species of king crab for which they were fishing. They were found in particular abundance in southeast Alaska, Cook Inlet, around Kodiak Island, in Canoe Bay (on the south side of the Alaska Peninsula), and in the Bering Sea north of the Pribilof Islands. How valuable a part of the Alaskan stock of crab this species will represent when the fishery is developed can only be conjectured, but it will not be small.

Trout:

Two species of trout occur in abundance in the marine waters of Alaska, the Dolly Varden and the steelhead. In 1939, 55,161 pounds of trout were recorded as having been caught in Alaska, and sold, and in 1938, 78,732 pounds. Many are the salmon traps in Alaska where that poundage of trout is discarded each season, not only as waste but as a nuisance. Dolly Varden are so abundant to westward as to be thought by some to be a serious detriment to the stocks of salmon. For years the Fish and Wildlife Service paid a bounty on this fish to encourage the lessening of its abundance. Yet no commercial fishery has been developed for it. The quality is good, but trout are more difficult to process than salmon, and cold storage facilities are not developed to an extent necessary to handle a large frozen pack.

It should be pointed out here that from the standpoint of conservation no qualms should be felt for instituting a fishery for trout in the marine waters of Alaska. Every species and stock of fish will support a fishery of some size without becoming diminished to extinction, in the same way that a herd of cattle will yield beef without being wiped out. Failure to harvest this surplus is no less poor conservation than overfishing, and about as sensible as letting a herd of beef cattle increase until they have eaten all the grass off the range and died of starvation. Because trout are hard to get in Pennsylvania, Wisconsin or Montana, is no reason why they should be allowed to go to waste in Alaska. That is not conservation.

Cod:

The gray or true cod is found in moderate to great abundance along the entire Pacific Coast from northern California to Bering Strait, but in its southern range it tends to be small, not particularly good in quality, and restricted in quantity. On the banks from Kodiak Island to westward the reverse is true, and in the vast stretches of

TABLE 3. SUMMARY OF OTTER TRAWL CATCHES (OTHER THAN KING CRABS) BY AREA, 1941 *

Area	Number tows	Pounds										
		Dungeness Crab	Tanner Crab	Gray Cod	Alaska Pollock	Halibut	Starry Flounder	Rock Flounder	Lemon Flounder	Yellow Tail Flounder	Sand Flounder	Flathead Flounder
Southeastern	5	5	1,552	6	342	17	3,100	1,000	30	20	0	0
Yakutat	6	9	10	0	0	10	1,950	100	25	25	0	0
Kayak Island	11	111	120	53	50	35	20	0	0	55	0	25
Prince William Sound	40	1,559	1,169	17	18	80	2,985	1,375	965	1,450	150	275
Cook Inlet	43	161	6,173	83	120	142	12,300	125	3,450	3,500	2,750	125
Shelikof Straits (west side)	31	19	532	62	0	57	345	250	80	350	0	75
Kodiak Island	133	1,960	9,300	380	25	90	22,000	15,300	6,900	18,800	0	9,000
Shumagin Islands and Alaska Peninsula	59	121	143	155	0	123	14,500	9,500	3,500	13,500	0	7,000
Pavlof Bay	44	42	2,425	400	75	50	6,500	17,700	1,800	38,000	0	2,500
Canoe Bay	88	0	10,066	57	5	15	36,500	8,000	1,300	44,200	0	1,000
Bering Sea (Area XI):												
Inshore	133	0	700	3,021	49,000	408	23,500	93,000	7,500	110,000	0	9,000
Offshore	80	0	2,800	3,200	13,300	259	0	54,000	8,000	123,000	0	16,000
Bering Sea (Area XII)	26	0	2,700	300	11,000	5	0	850	50	9,700	0	0
Totals	699	3,987	37,690	7,734	73,935	1,291	123,700	201,200	33,600	362,600	2,900	45,000

* These figures were taken from Table 6 of the Report of the Alaska Crab Investigation. In addition to the above, miscellaneous items were caught in approximate amounts as follows: 2,000 Korean or horse crab (all from Bering Sea); 4,617 pounds of shrimp (practically all from Olga Bay, Kodiak Island); 590 scallops (practically all from Shelikof Straits); 11,800 pounds of Rockfish (of which 11,000 pounds was from Kodiak Island); 210 pounds of sablefish (practically all from the Shumagin Islands); 276 pounds of tom cod (Bering Sea); 155 herring; 16,340 pounds of bullheads (mostly from the Bering Sea); 90 dogfish; 700 sea poachers (Bering Sea); 1,011 skates (mostly from the Bering Sea); 2,775 pounds of turbot; and 6 wolf fish (Bering Sea).

the eastern Bering Sea there is an amazing quantity of these fish, large in average size, and of first class quality. The Alaska Crab Investigation in 213 hauls with an otter trawl, which was hung to catch crab, and which were scattered all over the area, averaged 30 cod per haul.

As Pacific fisheries go the fishery for cod in Alaska is an old one. Records of catches are available back as far as 1863. It is not now an inconsiderable fishery, for in the neighborhood of 12,000,000 pounds (round weight) are caught annually. But these landings are not a reflection of the abundance of the fish; they represent, rather, the lack of a properly developed market. During the last war, when prices were high, the annual landings stayed above 3,800,000 fish from 1914 to 1919, or about 40,000,000 pounds per year. In this most expanded period of the fishery only from 15 to 21 vessels were engaged in it (Cobb, 1927), and certainly no considerable portion of the known cod banks were heavily fished. What can be expected from the cod fishery of Alaska in the future is anybody's guess, but it will certainly exceed by far anything that it has produced in the past. The Bering Sea has not been fished commercially for cod far north of the Slime Bank and the banks along the Aleutian Islands have never been put into production. Commercial fishing, because of the labor involved in longlining, has always followed most intensively the shallow banks, and has seldom reached into waters over 75 fathoms in depth, although it is known that the fish are abundant in considerable depths and that those fish are larger and of better quality than those from the shallower banks.

To my mind the proper development of the cod fishery has always been impeded by the manner in which the product is processed and the shape in which it reaches the market. I imagine that the Basque fishermen, who are said to have fished cod on the Grand Banks before Leif Erickson visited those parts, were putting up a product comparable in quality with some that I have seen offered for sale. Those people who like salt cod think it wonderful, but those people are decreasing in numbers all over the world and it is not practical to expand a fishery for a declining market. What is needed worse than anything else is a new approach to the packaging and processing of cod which will permit placing on the market anywhere in the world a product that can compete on even terms of attractiveness with any other fisheries product. Then the cod fishery would not have to depend upon the cheap Old World and Midwest markets, where ignorance of what good fish taste and look like is a strong selling point.

Pollack:

The Pacific pollack occurs in similar quantity as the cod, and over the same range on our side of the ocean. From the little that is known about its abundance it apparently follows the cod in being most abundant in the Bering Sea and on the banks south of the Alaska Peninsula. It is said to occur in incredible numbers in the Bering Sea, where it is reported to be a mainstay in the diet of the huge fur seal herd in its northern range (Lucas, 1899), and according to Cobb (1927), "Alaska pollack seemed to be the main food of the cod." The Alaska Crab Investigation in 239 otter trawl hauls all over the eastern Bering Sea

caught 73,300 pollack, or an average of 307 per haul. In spite of the great quantities of pollack known to exist, and its good taste, it has never been caught commercially.

Two other species of cod-like fish occur in abundance along the northern part of the Pacific, the tom cod and the hake. The tom cod, while small, is an excellent food fish. The hake, which to my taste is nothing to get excited about, nevertheless supports a large fishery in the Atlantic, and will do so one day in the Pacific. At the present time the fresh market absorbs a few tom cod, but no hake are caught commercially in the North Pacific.

Except for those fishes that come close to shore, or ascend streams to spawn, the public at large is not aware of the great abundance that fish life assumes in northern seas. This is especially true of the bottom or subsurface feeders like the cod-like fishes and the flatfish, which, while they occur in bays and inlets, are typically fishes of the high seas. It remains for the deep-sea fishermen, and the biologists who follow their efforts, to appreciate this wealth of food which is going to waste. An experience I had in May of 1940 is a case in point. Hake are not thought of as abundant in Washington waters. One morning just after daybreak I came out on the beach at Seaview to dig razor clams and found to my surprise that the beach for about 10 miles was covered with large hake that had apparently chased a school of anchovy into shallow water and had been stranded by the receding tide. In the two miles between Seaview and Long Beach I counted more than 2,200 of these fish, which average about five pounds in weight.

Flounder:

It is hard to say which of the Alaskan fisheries of which I am speaking will be the most productive when they all become fully exploited, but that for flounders will be among the greatest, and it will dwarf in size the fishery for that other flatfish, the halibut, for which the North Pacific is now famed. Twenty-seven species of flatfish other than halibut occur in Alaska and the Bering Sea. Most of these are present not only in commercial abundance but in great abundance. If I did not have figures of actual catches to give you I should not attempt to describe the quantities of flounder available in those waters, for you would simply not believe me.

Let us again refer to the results of the Alaska Crab Investigation (Table 3). In 669 hauls with an otter trawl, scattered all along the coast of Alaska from Southeastern, Yakutat, Shelikof Strait, Kodiak Island, the Shumagins, along the south side of the Alaska Peninsula, and all over the Bering Sea to as far north as St. Lawrence Island, and over all types of bottom, they caught 769,000 pounds of flounder, or an *average* of better than 1,100 pounds per haul. They not only were not fishing for flounder, but those fish were a nuisance to their work, to be avoided when possible. They say: "In Bering Sea the quantity of edible flatfish was phenomenal. Two hundred and forty tows, spread at random over more than 100,000 square miles of area, at depths ranging from 10 to 60 fathoms, averaged almost a ton to the drag. In the more productive sections of this area, average catches often ran as high as 2 tons, and single tows as high as 9,000 pounds were recorded.

In contrast to the schooling of king crabs, which was pronounced during the mating and moulting season, the "sole" were spread quite uniformly over all the favorable bottom. They were taken in considerable quantity almost everywhere except where other organisms, such as starfish, sponges, or crabs, predominated."

Let us contrast this with the average catch per haul in the successful otter trawl fishery of Puget Sound. In 55 hauls listed by Smith (1936) (Table 4) the average catch was 250 flounders, or something less than 500 pounds per haul. This is a highly developed fishery in which the area of the fishery has been thoroughly prospected, the fishermen are experienced and specialized, and each haul is carefully laid in the area in which the experience of the captain indicates that the largest catch is to be made, not in a random manner as were those of the crab investigation. The coast of Washington is small in comparison with that of Alaska. Its rapidly expanding offshore otter trawl fishery has not yet reached its maximum development, but this year the State will yield about 10,000,000 pounds of flounder. Contrast this with the yield of the Alaska flounder fishery which in 1938 landed 232,145 pounds and in 1939 30,323 pounds, and you have an idea of the expansion that can take place in that fishery.

TABLE 4. LANDINGS OF FLOUNDER IN PUGET SOUND 1935-36 FROM SMITH (1936)

Location of hauls	*Georgia Straits*	*Bellingham Bay*	*Saratoga Passage*	*Hood Canal*	*Total fish*
Number of hauls	13	27	7	8	55
English Sole	494	887	3,457	338	5,176
Starry Flounder	1	803	621	13	1,438
Sand Sole	33	1,533	158	3	1,727
Flathead Sole	58	1,556	271	0	1,885
Bellingham Sole	34	2,083	12	1	2,130
Rock Sole	17	144	346	544	1,051
Arrowtooth Halibut	69	31	0	2	102
Sand dab	1	3	9	1	14
Slender Sole	0	0	25	0	25
Rex Sole	4	19	17	0	40
Cape Sole	0	0	1	0	1
C-O Sole	0	1	20	15	36
Halibut	1	0	0	0	1
Slippery Sole	3	2	5	0	10
Hybrid Sole	0	0	2	0	2
Total	715	7,062	4,944	917	13,638

Rock Cod and Black Cod:

The rock cod, or red snapper, and the black cod may be spoken of jointly because their habitat is more or less similar and the present method of fishing them is the same. They are both by-products of the set-line fishery for halibut.

Twenty-one species of rock cod are found in Alaska and Bering Sea. They occur literally everywhere that the water is salty, from the shore to depths far greater than it is possible to fish commercially. Next to halibut they are perhaps the most prominent feature of the hook and line fishery in the northeast Pacific. In the absence of adequate data it would be ridiculous to make statements as to their abundance, and I will merely say that it is tremendous. It is not an infrequent occurrence that the halibut men will haul in their gear and find on every hook a large rock cod, much to their disgust. One morning just after daybreak I saw three salmon purse seiners make sets within half a mile of each other on Swiftsure Bank. Now a purse

seine, which is built to fish at, and shortly below, the surface, is the last type of gear one would pick to catch rock cod, but these three boats hit the jack-pot. It is probable that 8,000 fish would not be an exaggeration of their combined catches. The men on one boat were well into the afternoon clearing their net. All of the fish were, of course, thrown away, and I have pictures of the ocean as far as can be seen covered with the floating white bellies of the dead fish.

There would be no point with the present restricted data in discussing the relative abundance of the different species of rock cod. This will undoubtedly vary greatly from area to area, with the type of bottom, and with the depth. In the halibut fishery of southeast Alaska and British Columbia it is probable that *Sebastodes ruberrimus,* a large species, and *S. pinniger* predominate.

TABLE 5. FISH CAUGHT ON HALIBUT GEAR FROM THOMPSON (1916)

Date	*March, 1914*				*December, 1915*		*Total*
Halibut	37	44	31	26	35	20	193
Blackcod	22	4	22	11	11	13	83:
Arrow tooth halibut	8	16	7	12	1	0	44:
Dogfish	3	0	24	3	0	0	30:
Skate	2	2	2	3	0	0	9 :246
Red cod	3	1	4	3	21	36	68:
Gray cod	2	0	5	4	0	0	11:
Chimaera	1	0	0	0	0	0	1:
Total fish	78	67	95	62	68	69	439
Species	12	12	13	15	15	15	

Little information is available on the fish actually taken by the halibut fishery besides halibut. Thompson (1916) lists a few catches (Table 5). It will be seen that other fish are taken in greater number than halibut, and that black cod and rock cod form a much more important part of the catch than is reflected in the landings. It should be kept in mind that most of these catches resulted after active effort of the halibut fishermen to avoid both rock and black cod, and for this reason no figures from the halibut fishery would accurately reflect the abundance of the other species. The landings of black cod from Alaska now run from one to two million pounds per year, and of rock cod less than 100,000 pounds. What will happen with these species is reflected in the tremendous expansion of the landings of the related rosefish of the east coast, where in a few years the fishery has developed from practically nothing to the point where about 150,000,000 pounds (round weight) are caught annually.

Such a brief review can not do justice to the latent potentialities of the fisheries of Alaska. I have not mentioned the clams, scallops, squid, shrimps, skates, "Atka" mackerel, smelt, etc., or the stock food that could result from a more complete utilization of the flesh of the herd of fur seals, that now includes more than 2,500,000 individuals. In reference to the latter herd of animals there can be made an interesting commentary on the lack of development of the fisheries of the northeast Pacific. From such data as are now available it would appear that this herd, at a minimum figure, consumes in excess of 2,500,000,000 pounds of fish and squid each year in the area from the Pribilof Islands to California. This is roughly the annual production of food fish by all the commercial fisheries in Alaska, British Columbia, Washington, Oregon, and California. Yet the complaints of fishermen

regarding the depredations of seals on the food fishes along this coast are based almost entirely upon hair seals and sea lions. Seldom does one hear complaints about the fur seal, which generally stay out to sea and are not often found within 15 miles of the coast. Where do these animals get such a tremendous quantity of fish without interfering materially with our own efforts in that direction? Most of their food must be taken in Alaskan waters, and probably the greater share of it is taken in and about the Bering Sea, where our efforts are so slight. This situation does indicate, however, what an expansion can be made in the prosecution of the Alaskan fisheries.

In the present state of our National affairs the enumeration of the stores of fish which we have left yet to tap in the North Pacific has little more than academic interest unless these stores can be placed on the shelves of the grocers of the country. How is this to be accomplished? First by creating a demand which will raise the price high enough so that the fishermen will put their effort in on the fishery which it is desired to develop. The recent tremendous growth of the shark fishery along this coast is an example in point of how a fishery can grow to large size quickly under the stimulus of an increased price. The reason, of course, why the landings are not made now is that the fishermen can make more money with the same amount of effort fishing for the higher priced species, and there is not enough profit in the ventures to interest new capital and new fishermen. It is not simply a matter of cost in all instances, however. Some fish, such as rock cod and black cod do not keep under light refrigeration as easily as halibut do. Much research is needed on several species to develop methods of putting them in the hands of the consumer in as good a condition as when they left the sea. The careless handling of fish between the net and the consumer is probably the greatest single deterrent to the marketing of most fish, for a consumer who has been fooled once on a fish will not buy that kind of fish again. There is also the fact that the war has made it possible that the entire area of which I am speaking may be a theater of enemy action.

In these days no considerable new effort could be made toward the development of these new fisheries without the consent and desire of the National Government, because of the scarcity of boats, manpower, and everything from hooks to rope that a fisherman must have in his business. It will therefore be the task of the administration to decide whether these products are of sufficient value to the war effort to divert to them the materials and energy needed for their catching, and we will have fulfilled our function by pointing out that they lie there ready for the gathering. It is interesting to note, along these lines, that word has recently come from the administration that the Navy would cease requisitioning fishing boats along this coast unless the emergency became great; that the National Government has undertaken to insure the entire Alaskan salmon fishery this year against loss due to enemy action, in order to ensure the flow of this food resource; that it has been announced that the salmon canners will be permitted to obtain the tin-plate needed to put their product in; and that draft boards are deferring experienced fishermen. These items indicate that the administration is aware of the desirability of keeping up the flow of fish from the northeast Pacific. That any of the latent fisheries that I have

mentioned will be encouraged is, however, problematical at the present time because of the belligerant activities in the western Alaska and Bering Sea areas.

There is a fundamental deterrent to the development of the great fisheries of the Bering Sea either in peace or war time, and that is that the need for capital investment is far above the ability of the individual fisherman to provide. Therefore it can not be expected that these fisheries will be developed, as have most of the fisheries on both of our coasts, by the initiative and enterprise of individuals working generally on a slender shoestring for capital. The distances to travel and the hazards to be met and overcome are too great in proportion to the profits to be realized for the effort to be undertaken by any except adequately financed ventures. The Japanese have proven the practical nature of the mother ship and auxiliary fishing boat combination in these very waters, as did the British in the Greenland halibut fishery, and the various whaling ventures in the Antarctic. It is without doubt that the development of the crab, cod, pollack, and flounder fisheries of the Bering Sea will need to develop along these lines. The hand line will go, and in its place will be the great otter trawl, and the miles of gill and tangle nets. In the mother ship the flounders will be filletted and sharp frozen, the cod cured and packed, the crab canned, and every scrap of offal saved for vitamins, meal and fertilizer. It will also be necessary for the industry to quit treating every fish that is caught as salmon or halibut, and to develop for the new products new techniques of processing, new ideas in packaging, and new methods of marketing which will be individually suited to each product. In this we would not go far wrong in following the experimental initiative shown by the Japanese in developing their export fish trade. They were able at least to catch our own fish and shellfish and sell them back to us at a nice profit. These, however, will be large undertakings, and the companies which start them must be well enough financed so that they can stand the losses that will almost inevitably ensue during the first year or two, while a background of experience is being built up.

With the resumption of a peace economy, if it ever is resumed, the fisheries of the Gulf of Alaska will develop naturally with the present methods as the markets develop.

May I interject here a few remarks concerning the treatment that our valuable and heavily exploited fisheries should receive during the period when the economy of total war is in effect. Until the last iota of effort is necessary to keep the people of our country and of our allied countries from starving to death no one would be willing to advocate the slaughter of our herds of cattle, the brood sows, the setting hens, or any other of our live stock that is needed for the reproduction of their kind. Yet it is inevitable that with the artificially high prices brought about by the war every administrator of fisheries in all of our maritime States will be under heavy and continuous pressure to relax the regulations which in too many cases are the only things that are keeping the now so badly needed fisheries from being destroyed entirely. Have we not got enough National sense to treat our fish stocks with the same amount of care that we give our live stock, and can we not forego the joy of the immediate profit for the greater long term good?

It is also necessary that in our vast new industrial developments we provide adequate safeguards for the fish stocks which will be affected. Anyone who has watched with his eyes open our rapid transition from an economy of superabundance to an economy of the strictest scarcity, and who has followed the struggle of our British allies to provide themselves with the minimum necessities of food, will realize that there will be times in the future of our country when ten million pounds of salmon from, say, the Columbia River, will be of more value to us than the same number of kilowatts of electricity from that stream. By this I do not mean that the industrial effort should be impeded by a sentimental desire to protect fish to the exclusion of all else. But there is seldom a case where industrial development and fisheries protection clash that both, by the reasonable use of judgment and engineering skill, can not be developed side by side satisfactorily. The objection always brought up is the amount of money that it takes to provide the necessary protection for the fish. Fortunately we often have been able to show that saving the fish is a money making proposition, but I feel that it is time for us to face the fact that values are relative, and that they may change in these days with startling swiftness. You will go a long way today to find a man who will sell you a set of tires for twice what he paid for them six months ago. Fish are food and there come times when food is more valuable than money or electricity in any quantity. A salmon run once destroyed is not easily replaced, if at all.

Common and Scientific Names of Organisms Mentioned in This Report

Abalone (green)	*Haliotis wallalensis*
Anchovy	*Engraulis mordax*
Alaska pollack	*Theragra chalcogramma*
Arrowtooth halibut	*Atheresthes stomias*
Atka "mackerel"	*Pleurogrammus monopterygius*
Barracuda	*Sphyraena argentea*
Bellingham sole	*Isopsetta isolepis*
Black cod	*Anoplopoma fimbria*
Bullheads	Cottidae
Cape sole	*Eopsetta jordani*
Chimaera	*Chimaera colliei*
C-O sole	*Pleuronichthys coenosus*
Dogfish	*Squalus suckleyi*
Dolly Varden	*Salvelinus malma*
Dungeness crab	*Cancer magister*
English sole	*Parophrys vetulus*
Flathead sole or Flounder	*Hippoglossoides classodon*
Gray or True cod	*Gadus macrocephalus*
Hake	*Merluccius productus*
Halibut	*Hippoglossus stenolepis*
Herring	*Clupea pallasii*
Hybrid sole	*Inopsetta ischyra*
King crab	*Paralithodes camtschatica* and *P. platypus*
Korean or horse crab	*Erimacrus isenbeckii*
Lemon flounder	*Pleuronectes quadrituberculata*
Lingcod	*Ophiodon elongatus*

Common and Scientific Names of Organisms Mentioned in This Report (Continued)

Mackerel	*Pneumatophorus diego*
Octopus	*Polypus* sp.
Oysters	*Ostrea gigas*
Red cod, Red snapper or Rock cod	*Sebastodes* and *Sebastolobus* sp.
Rex sole	*Glyptocephalus zachirus*
Rock sole or flounder	*Lepidopsetta bilineata*
Sablefish or skilfish	*Anoplopoma fimbria*
Salmon	*Oncorhynchus* sp.
Sand dab, sole or flounder	*Citharichthys* sp.
Scallop	*Pecten* sp.
Sea cucumber	*Stichopus californicus*
Sea poacher	Agonidae
Skate	*Raja* sp.
Slender sole	*Lyopsetta exilis*
Slippery sole	*Microstomus pacificus*
Smelt	Osmeridae
Soup-fin shark	*Galeorhinus zyopterus*
Squid	*Loligo opalescens*
Starry flounder	*Platichthys stellatus*
Steelhead trout	*Salmo gairdnerii*
Tanner crab	*Chionoecetes bairdii*
Tom cod	*Microgadus proximus*
Turbot	*Atheresthes stomias*
Wolf fish	Anarrichidae
Yellowfin flounder	*Limanda aspera*

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THE KELP RESOURCES OF SOUTHERN CALIFORNIA[1]

By J. F. Wohnus
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During the years 1916-1918 the large beds of *Macrocystis pyrifera* which occur off the Pacific coast supported an extensive industry. Commercial interest in kelp predated this period by a great many years but it remained for World War I to stimulate active interest in the utilization of products obtained from the domestic kelp beds. During this first period of the California kelp industry the basic products obtained from processing kelp were iodine, inorganic salts, and organic solvents. The most important of these products were high grade (95-98% pure) potassium chloride, acetone, ethyl acetate, and the amyl acetate substitutes, ethyl propionate and ethyl butyrate.

Two very different methods were devised to obtain these products. The first or so-called char method was used primarily to obtain potassium chloride, sodium chloride, iodine, and a high grade of decolorizing carbon. This was the simpler of the two methods and may be described best by a plant flow sheet diagram (Fig. 53) showing the principal steps involved. The second or fermentation process was developed by the Hercules Powder Company.

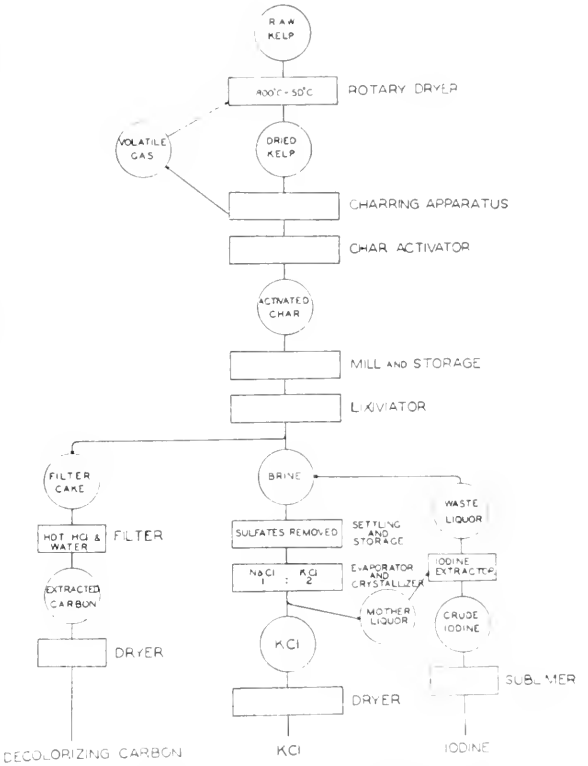

Fig. 53. Plant flow sheet diagram showing the main steps in the char method of processing kelp.

[1] This paper was presented at the symposium "Resources of the sea for wartime economy" at the meeting of the Oceanographic Society of the Pacific, held in Salt Lake City, Utah, June 17, 1942. (Contributions from the Scripps Institution of Oceanography, New Series, No. 176.)

This procedure involved different methods of handling the raw-products and necessitated a tremendous amount of research work on the part of this company. One of the outstanding features of the Hercules plant was its Tank Farm for the initial fermentation. This consisted of 150 tanks, each of a 50,000 gal. capacity. Aside from this feature the process again may be described by a flow sheet diagram (Fig. 54).

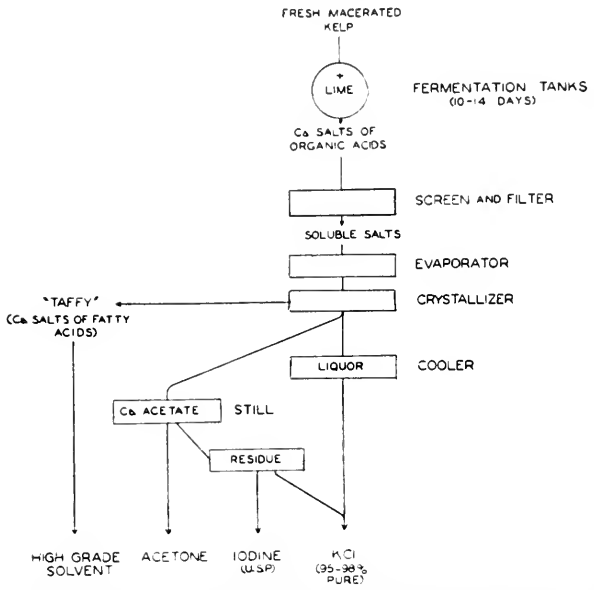

FIG. 54. Plant flow sheet diagram showing the principal steps in the fermentation process developed by the Hercules Powder Company.

It is of interest to point out that discussions of this first phase of the kelp industry emphasize that wartime economy was necessary to enable these industries to function and that the only claim to permanence which could be made for the kelp industry was the fact that the products were all of a high degree of purity. This is also demonstrated by the fact that nearly all of the companies stopped operations immediately following the war. In the Facts of Current Interest column of "California Fish and Game" for October, 1921, the following statement appears, "The kelp industry, which grew to importance during the war, is now a memory, all the plants having closed down."

In reporting this fact it would have been better in the light of later developments to state that the first phase of the kelp industry was over. Actual production had ceased but there were still a group of people actively interested in utilizing kelp as a natural resource.

In addition to the utilization of kelp as a source of chemical products, the dried and ground material was found to be a good chicken, fox, and cattle food supplement. This usage aided materially in maintaining and renewing interest in the kelp industry. Moreover, uses were being found for a group of products previously believed to be chemical oddities. These products, the alginates, are metallic salts of alginic acid and have proven to be of value in a number of diverse fields. New uses are being found for these products and this industry, although small in comparison with the fisheries, is certainly making valuable contributions to the war effort.

The processing of kelp to obtain alginates utilizes a modification of the wet process used during the early years of the kelp industry of

Scotland. Here again the use of a flow sheet (Fig. 55) enables one to examine and describe the process. In brief the process now employed utilizes the organic constituents of the kelp plant, and the products previously prepared are not utilized.

Since the alginates have such a diverse application a brief summary of some of their uses is of interest. These may be arbitrarily divided into three groups. The first includes those which are primarily for a peace time economy. The second group includes those which were in use prior to the outbreak of war but have direct application in the war effort. The third group consists of the applications developed since the beginning of war and are essential for war purposes.

In the first group the utilization of sodium alginate as a stabilizer for dairy products, ice creams and chocolate milk, would be considered most important. In addition the use of sodium alginate as an ingredient in cosmetics and dentifrices would be considered as would that of less pure and unbleached sodium alginate as a dye vehicle for cloth printing and as a binder for printers ink.

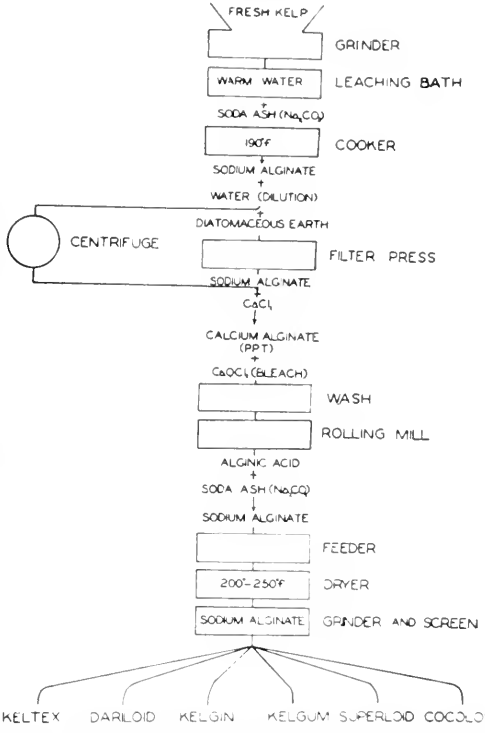

FIG. 55. Plant flow sheet diagram showing the principal steps in the modified wet process in use at the present time.

The second group includes the use of ammonium alginate in cream latex to increase the solid content and prevent the coagulation of rubber shipments; the addition of alginates to asphalt paints for steel plates and insulated wires to prevent the painted surfaces from adhering to each other; and the use of sodium alginate as an ingredient in boiler compounds to prevent or retard the development of boiler scale. In addition the use of alginates by baking companies in the preparation of jams and jellies is being increased under the existing lend-lease program.

The third group consists of the utilization of alginates as stabilizers for camouflage paints and of copper alginate as a dressing for canvas and burlap to prevent mildew. Under the stress of war necessity new and more important uses are being sought and without doubt many more will be found which will have a direct or indirect application to the current war effort.

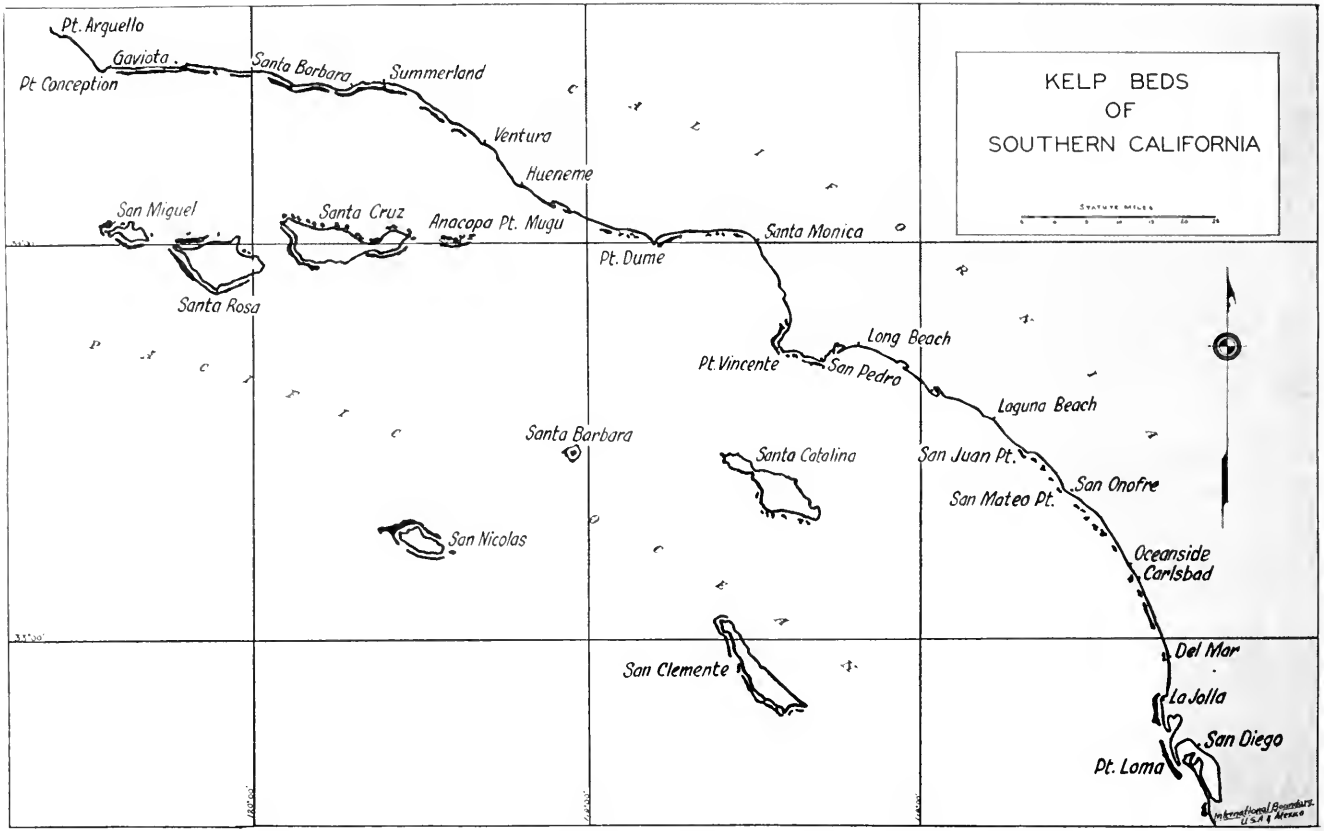

FIG. 56. Distribution of kelp in southern California. (Kelp beds shown in solid black.)

Mention should be made of another important use, namely, as a substitution product. With the curtailment of agar imports and the accompanying demand placed on local industries it has been found that alginates may be used for a number of purposes previously reserved for agar. Thus the dental profession has employed alginate-agar mixtures for denture impressions. It has also been found that these mixtures may be used for bacteriological gels. This "dilution" of the agar supply will doubtless have the effect of making the existing stock of this essential material go further.

In any industry dependent on natural resources it is natural to be concerned over the supply of that resource. During the past two years increasing concern has been felt concerning the kelp supply. Certain kelp beds had decreased alarmingly in size as well as density and during the past year a study has been made of this situation.

TABLE 1. CHANGES IN AREAS OF THE KELP BEDS IN THE LA JOLLA-SAN DIEGO REGION

Bed	Year	Area	Change over 1911		Change over 1934		Remarks
			Actual	Per cent	Actual	Per cent	
2	1911	1.4					Heavy
	1934	0.88	−0.52	−37%			Scattered
	1941	(Est.) 0.5	−0.9	−66%	−0.38	−43%	Very thin
3	1911	4.08					Heavy
	1934	2.77	−1.31	−32%			
	1941	2.14	−1.94	−47.5%	−0.63	−22.7%	Thin
4	1911	2.1					Heavy
	1934	2.6	+0.5	+23.8%			
	1941	2.5	+0.4	+19%	−0.1	−3.8%	Medium

A map (Fig. 56) of the southern California coastline will serve to show the distribution of the important harbors: Hueneme, San Pedro and San Diego. It can be seen at once that the kelp beds are found close to the shore of the mainland and of the offshore channel islands. In general, the beds in the southern California region are restricted to water of five to fifteen fathoms and their location with respect to distance from the shore line is governed in part by the occurrence of water of this depth. Actually the distance from any particular kelp bed to the adjacent shore is seldom greater than one mile. Much of the survey has been curtailed with the restrictions placed on offshore boat travel and a great deal of important information is lacking. However, the San Diego region (Fig. 57) has been carefully surveyed and compared with previous surveys and the results may be shown in table form (Table 1). The remaining areas supporting growth of kelp have been discussed with the captains of the kelp harvesters and fishermen, and, in general, it may be stated that there are definite signs of improvement in the condition of the kelp beds. In some areas they have not yet regained the extensive growth described in previous surveys, but, at the same time, there are a few regions in which kelp is now

growing where it had not been reported previously. With care and proper regulation it is believed that the supply of this natural resource can be maintained and the present yield increased.

The San Diego region, although it represents approximately 10 per cent of the entire kelp bed area, presents many important considerations. The increase in kelp as one proceeds north along the shore is of interest, especially if it is pointed out that Bed 4, off La Jolla, has yielded the most kelp in the past year, whereas Bed 2, off Pt. Loma, further south, has not been harvested.

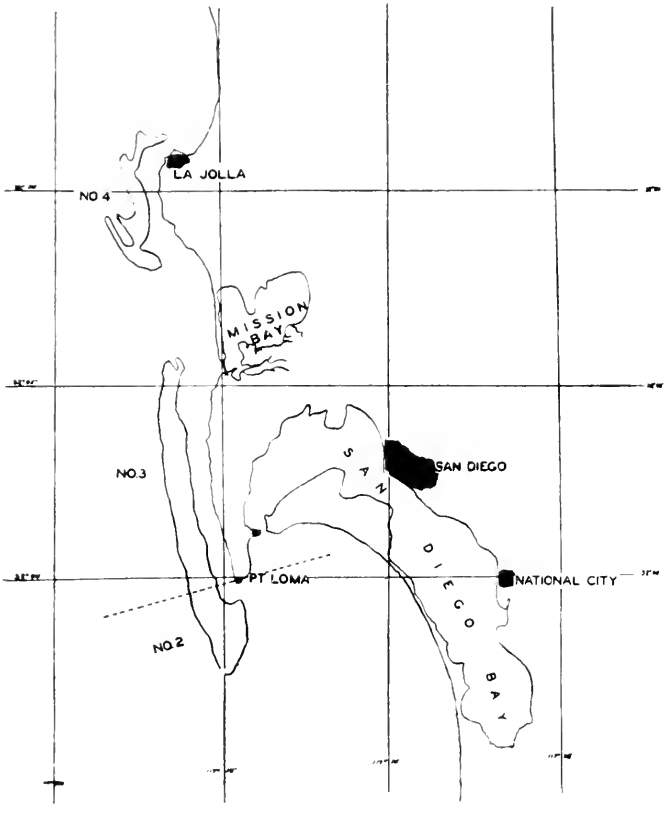

FIG. 57. Map of the La Jolla-San Diego region showing the location of the kelp beds in that area.

Preliminary examination of this region by divers has shown that bottom conditions are all satisfactory for the growth of kelp. It therefore remains to hypothesize why the area of kelp in this region has been reduced so much. The statistics of the changes in area show that this reduction has taken place over a rather long period of time and it may well be that the present condition represents the culmination of a serious alteration in environmental conditions.

Located as it is at the mouth of a bay (San Diego Bay), Bed 2 is subjected to a great many factors which are not present in the other kelp beds. Siltage (producing poor light conditions), contamination,

and lack of nutrients may have united to produce the reduction in the area of kelp in this region. It is of interest to point out that the kelp in this region has shown an increase during the past six months, which may reflect an improvement in some one of these basic conditions.

During this discussion the attempt has been made to demonstrate the contributions which can be made by the kelp industry to the war emergency. This may require diverting some of its products from civilian uses to those considered essential to the war effort. With the possibility of an improved supply of raw material, and with the work being done in seeking new applications for its products, certainly an optimistic view may be held for the California kelp industry.

PLANT RESOURCES OF THE SEA ALONG THE NORTHWEST COAST AND ALASKA[1]

By George B. Rigg
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University of Washington

Along the northwest coast of North America, the kelps are the most conspicuous plants of the sea. Three of these (*Nereocystis luetkeana*, *Macrocystis pyrifera* and *Alaria fistulosa*) attain large enough size, and occur in sufficient abundance and in deep enough water, so that they could be readily harvested by floating machinery. *Alaria fistulosa* is a leaf-like kelp reaching a length of 70 feet and a width of 2 to 6 feet. It is abundant in Cook Inlet and at other places along the Alaska shore. *Macrocystis* which is abundant along the California coast occurs to some extent in the Strait of Juan de Fuca and in southeastern Alaska. *Nereocystis* (bladder kelp) is the most abundant and the most widely distributed of the three, so that any utilization of kelps in this region would naturally be based mainly on it.

Other kelps of considerable size and abundance grow on the rocks either between high and low tide or just below low tide and could be harvested only by hand. Those which would seem to have the greatest possibilities for utilization belong to the following genera: *Laminaria*, *Cymathaere*, *Egregia*, *Alaria*, *Lessoniopsis*, *Costaria*, and *Agarum*.

All plants belonging to the family *Laminariaceae* of the brown algae are called kelps. The word is often used in a broader sense to include all of the brown algae and is sometimes even extended to include all algae.

The rockweeds (*Fucus*) are medium sized plants belonging to the family *Fucaceae* of the brown algae. They occur between high and low tide throughout our region and often cover rocky beaches completely.

Several of the red algae are large enough to merit consideration. The most important ones that can be reached at low tide belong to the genera *Gigartina*, *Iridaea*, *Porphyra* and *Prionitis*. Some others such as *Rhodymenia*, *Callophyllis* and *Dasyopsis* can be obtained only by dredging. All of the red algae mentioned in this list have a more or less leaf-like body called a thallus and are thus distinguished from the small filamentous red algae.

The leaf-like green alga known as sea lettuce (*Ulva*) is abundant between high and low tide. Slender green algae belonging to the genus *Enteromorpha* occur with or near Ulva. Diatoms are important microscopic plants in the sea. They are treated in the paper by Professor Kincaid.

[1] This paper was presented at the symposium "Resources of the sea for wartime economy" at the meeting of the Oceanographic Society of the Pacific, held in Salt Lake City, Utah, June 17, 1942.

A few seed plants occur in the sea in our region. The commonest and most abundant one is eel grass (*Zostera*) whose rootstocks grow in mud or sand under shallow quiet water in protected places and send up narrow, ribbon-like leaves, which are in many cases completely exposed on the beach at low tide. The leaves form dense growth in the water and where they grow above low tide they form a complete covering on the sand or mud at low water. Another seed plant resembling eel grass is sea basket-grass (*Phyllospadix scouleri*). Its rootstocks cling to the rocks in heavy surf and it is much less abundant than eel grass. Another species of this same genus (*Phyllospadix torreyi*) occurs along exposed ocean shores and quantities of it are often rolled up on ocean beaches.

In addition to all of the above, the plants of salt marshes should be mentioned on account of their abundance, their fleshy character and their rather pleasant salty taste. The best known of these is called salthorn or saltwort (*Salicornia*).

All plants growing in the sea must be considered as factors in our resources in the long run, since they all take their part in the cycle of transformation of organic and inorganic compounds in the sea and in the adjacent atmosphere. In a critical time such as the present we seek plants and animals that have immediate uses, but in long range planning the sea and all organisms living and dying in it must be considered as a whole. Organisms which have no direct economic importance may be essential for the life of organisms that have immediate usefulness. We approach the study of the sea through the science of oceanography in much the same way we approach the study of land through the science of agriculture. In a sense sea water is the "soil" in which marine plants grow. Perhaps it is more exact to say that sea water for marine plants corresponds to the "soil solution" for land plants. All physical and chemical facts about sea water and its movements, as tides, currents and waves, must be considered in long range planning for conservation and use of plants growing in the sea.

Kelps and some other plants naturally accumulate potassium from sea water. Though this element is much less abundant in sea water than sodium is, the amount of it in kelps is many times that of sodium. The investigations begun in 1911 by the U. S. Bureau of Soils showed that we have along the Pacific coast of North America 389 square miles of kelp beds which contain 59,000,000 tons of kelp by fresh weight. The amount of potassium chloride in these is estimated as 2,666,000 tons. The beds covering this enormous area are mostly composed of *Nereocystis* (an annual plant) and *Macrocystis* (a perennial). These kelps could produce every year several times as much potash as we use in this country, but this is not of any importance at present because we produce all that we need from salt basins in southwestern United States.

Kelps and rockweeds are commonly used as fertilizer in gardens along the Alaska coast and to some extent on other portions of our coast. In the vicinity of Kodiak a small wad of seaweed is placed in each hole with a piece of potato and excellent crops are produced. Seaweeds have an advantage over manure because no weed seeds are brought in with them. Probably the two positive qualities of seaweeds that are the largest factors in their fertilizer value are their mineral

content and their colloidal material which tends to keep a desirable moisture content in the soil near the pieces of seaweed.

The following table gives in pounds the quantities of the materials mentioned that are contained in a ton (2,000 pounds) of fresh kelp. It gives the averages of a considerable number of analyses.

	Water	Potassium chloride	Other salts	Iodine	Crude fiber	Nitrogen	Algin
Nereocystis luetkeana	1,834	52.7	25.1 to 37.7	0.22	8.4	2.9	23.4
Macrocystis pyrifera	1,736	52.5	26.7 to 55.7	0.61	19.3	4.3	44.4
Alaria fistulosa	1,726	39.9	27.6	Trace	No data	7.1	No data

There seems to be no doubt that much larger direct use of seaweeds as fertilizers might be made in gardens near the seashore, where the labor necessary for gathering and handling is not too expensive. Experiments in using kelps on a larger scale in fields have been tried with some success. Fresh kelp decays quickly if piled up and it is best to put it into the soil very soon after it is collected.

Kelp meal imported from China and Japan has been used as an ingredient of dairy feed and chicken feed. Considerable quantities of this material have been imported through Seattle in recent years, and there is no indication so far that any is being produced here to take the place of this supply. We have plenty of kelp available and there is a demand for kelp meal for dairy and poultry feed. One of the advantages of kelp meal is that it contains iodine.

Attractive foods for human beings have been prepared from kelps. A substitute for preserved citron was put on the market under the trade name "seatron" some years ago and various kinds of candy were also made. The writer has eaten these and found them excellent. The process of manufacture consisted in cooking in dilute acetic acid to destroy color and taste and then cooking in sugar and flavoring material. The patent on this process has expired.

Some marine red algae of our region (especially *Porphyra*) are good sources of vitamins B and C, comparing favorably with fruits and vegetables. Sea lettuce (*Ulva*) is a green alga which is a good source of vitamin C. Some species of algae are as rich in Vitamin C as lemons bought on the local market. Algae growing on shore between high and low tide tend to be richer in vitamin C than algae dredged at depths of five to ten fathoms.

Considerable use is made of dried red algae as food by natives along the coast of Alaska, British Columbia and Washington. A soup prepared from dried algae and a seal flipper is a common food of natives of Yakutat, Alaska. Before the present war, dried brown and red algae were commonly sold in oriental stores in Seattle. A recent survey indicates that few Chinese stores have any stock of these now. One dealer had some that he had obtained from the California coast and another had some obtained from a Puget Sound fisherman.

Several manufacturers in the Puget Sound region have put kelp soap and kelp shampoo on the market. At least one of these products is for sale in stores now. The writer has found that the soap can be satisfactorily used to remove grease from the hands in cold sea water.

Sodium alginate is an important article of commerce obtained from kelp at the present time. It finds its largest use as a stabilizer in ice cream and chocolate milk. Some technical uses for it have also been found. It is reported that 50 per cent of a preparation from kelps has been mixed with agar without decreasing the qualities of agar for bacteriological work. Agar on this coast is produced mainly along the southern California coast. Its production there or elsewhere should be greatly increased.

One important fact to consider in the utilization of kelps is their property of holding water persistently. The table in this paper shows their high water content. It is almost impossible to remove this water by pressure, but the material will dry readily if exposed to dry air, particularly in wind.

Eel grass is abundant on our coast. It has important economic uses on the east coast but so far as is known to the writer it has not been utilized on this coast. Eel grass nearly disappeared on the east coast and in some parts of Europe a few years ago, due to a disease probably caused by a fungus. It is coming back now. Eel grass has now become somewhat scarcer on this coast. In some places it is estimated that the supply has decreased 50 per cent. There is, however, still a good deal of it growing in many places and judging from experience elsewhere it seems probable that it will in the course of time come back to its former abundance. Eel grass is important as food for black brant and other water birds. It is commercially used for stuffing furniture and for mattresses and for heat insulation.

In general it may be said that we have a vast supply of plants in the sea but we are making very little commercial use of them. An economy of abundance has kept our attention on land plants and has led to very little interest in marine plants. In an economy of scarcity we may turn to the sea.

THE BIOTIC AND ECONOMIC RELATIONS OF THE PLANKTON[1]

By Trevor Kincaid
Department of Zoology
University of Washington

As a vehicle for the transformation of chemical substances at the organic level, the plankton of the sea stands unsurpassed. The ocean's annual production of living material per unit of area rivals that of terrestrial meadow land, and its drifting life represents a reservoir of organic compounds at the volume of which man can but dimly guess. It also is a stupendous, globe-encircling storehouse of organically bound solar energy, from which mankind has learned to divert merely a few driblets to satisfy some of his more immediate necessities. Here and there a tithe is gathered by some pelagic fishing industry or by some shore installation, which takes an infinitesimal toll at the borderline where the sea spills part of its riches upon the land.

The attack upon the problems of the plankton has been made from many angles, and the results lie upon our library shelves in the form of numerous ponderous tomes, varying from vast seas of figures attempting a statistical analysis of the plankton dwellers, to detailed studies of the structure and physiology of individual organisms. Through these researches we have learned a great deal about the plankton, both quantitatively and qualitatively.

The tiny denizens of the sea have been classified and analyzed, and their relation to the chemical and physical substrata have been established by biologists, chemists and physicists. The dependence of these multitudinous microcosmic beings upon the vast macrocosmic master dynamo represented by the sun, is the most fundamental idea that has been extracted from the observation of this complicated web of life, whose interlacing network reaches from the gloomy depths of the sea's abyss to the blue waters that race in splashing billows across the equatorial expanse.

Within the plankton the capture and transformation of solar energy goes on apace. The elaboration of living beings in limitless quantity and endless diversity proceeds in ever widening ecological circles, till we see the end products in the schools of fishes and marine mammals disporting themselves in the surface waters; or in the myriads of furtive and little-known dwellers in the icy depths of the submarine world.

Along with the complicated elaboration of the living world there goes on the corresponding degradation of organic compounds, leading back to the inorganic level from which the cycle started. Death follows life with remorseless steps, and all living things either perish through the lapse of their natural tenure of existence and are turned back into the general reserve of the biota, or they are added to the storehouse

[1] This paper was presented at the symposium "Resources of the sea for wartime economy" at the meeting of the Oceanographic Society of the Pacific held in Salt Lake City, Utah, June 17, 1942.

represented by the bodies of organisms constituting the next higher rung in the biological ladder. Microscopic plants succumb to the appetite of small animals only slightly superior in order of magnitude, and these in their turn meet their fate in the maw of some more powerful organism that makes them captive to its needs.

Eventually we see the unfolding drama of ultra-microscopic and microscopic life terminate in its final ramifications in the powerful predators that maintain a possessive overlordship in the competitive struggle for existence, and even these must fight out the battle for survival among those of their own order of magnitude, or even succumb to the inroads of minute parasitic forms of whose very existence they are unconscious, and to whose attack they can offer no resistance beyond the recuperative powers of their sustaining tissues. Even the mightiest behemoths of the ocean highways must however eventually succumb to the inevitable, and yield back to the sea that which they have merely borrowed from the borrowers that preceded them on the restless tide of ascending life.

Moreover, even in life there is death. During every moment of its existence each living organism returns to the sea materials which are on their way back to the inorganic level from which they originally came. Respiration of animals tosses back into the sea a vast volume of carbonaceous material to form the framework of new adventures in living, while the nitrogenous waste resulting from the breakdown of protein substances in the functioning protoplasm yields up its residue in the simplified compounds of nitrogen, sulphur and phosphorous, together with a long list of the building materials that lie at the foundation of organic synthesis. Over all of these phenomena there spreads the incessant activity of the bacterial world, operating at all levels of the degradational chain, and initiating or hastening the return of organic compounds to a state where they again become available for constructive processes. The bacteria are in their turn overtaken by fate in the form of many marine animals that have developed mechanisms for the mass ingestion of organisms that individually would hardly seem to be worthy of serious attention on the part of energy-seeking creatures. It has been shown that many animals can exist upon pure cultures of bacteria, and can thus extract from these tiny globules the elements that serve for their metabolic advancement.

A beginning has also been made in tracing the pattern of organic synthesis through the tortuous maze of interlocking relationships in the biota. In some cases these cycles are short, and the return to the inorganic level is immediate. A small member of the phytoplankton is born to an independent existence, but almost immediately may be thrust into some unfavorable physical environment which causes its death, and its dissolution returns its contained material to the sub-vital level; or it may be eaten by some small animal which starts the contained energy on an ascending spiral of synthesis, which may be unbroken till it forms part of the body of some fish or giant leviathan of the deep.

As the organic cycle runs its ramifying course we can follow the elaboration of structural and physiological complexity, in which a resynthesis occurs at each ascending level. Compounds such as glycogen and oils would seem to require but slight reorganization, whereas

the proteins apparently must return to the level of the constituent amino-acids before they can be built into new vital structures. Along the way we have the elaboration of hormones and vitamins of many types which must constantly direct, regulate and vivify the ascending series at each level.

The relation of man to the plankton has up to this time been almost entirely indirect. In a few cases advantage has been taken of certain elements of the plankton by maritime industries. The oyster growers of France discovered that the plankton of the open coastal waters did not contain sufficient foods for the massed volume of oyster life developed through an artificial system of culture, and as a result they developed highly specialized methods involving the construction of claires or shallow ponds in which they learned to control the production of certain plankton organisms, and were thus able to multiply the food supply of the oysters far in excess of the normal limits. It thus became possible to produce a marketable product from that which, without artificial control, would have been of little value. It seems likely that some such system will be necessary in connection with the oyster industry of the Pacific Coast, where the crowding of immense numbers of large oysters in confined bays has put such a strain upon the available water-borne food supply there results a great number of animals that are slow of growth and poor in quality. Experiments performed by the writer go to show that the food of the oyster in the form of minute flagellates and other micro-organisms can be greatly increased through the addition of ordinary commercial fertilizer to the sea water. It will of course require experiments on a commercial scale to determine whether any practical application can be made of these initial observations. The principle seems to be perfectly sound.

Another interesting and rather alluring problem relates to the production of oils. At present man takes the usufruct of oil from its storage in the tissues of fishes and whales. It is well known that the synthesis of oils is well under way at the level of the phytoplankton, especially in the dominant group of marine plants, the diatoms. This material is recast or resynthesized at each ascending level, particularly in the case of crustaceans of the copepod and euphausid types, from which the pathway of oil synthesis leads either directly into the oily fishes such as the herring, sardine and smelt, or indirectly through the smaller plankton-feeding fishes to the larger predators, such as the sharks and fish-eating whales.

The question has been raised as to whether there is any point in the upward swing of oil reorganization below the level of the fish where it might be practicable to tap the system for oil. The most logical phase would seem to be that involving the pelagic crustaceans, such as the copepods, euphausids and mysids. It is known that these organisms contain a considerable volume of oils, measuring approximately seven percent of their dry weight. These oils seem to be essentially the same as those found in oily fishes. It is needless to say the crux of this problem relates to the concentration of these crustaceans in such numbers as to make their capture and processing practicable in a competitive system. The information at present available on this point is rather scanty, but it seems probable there are few areas in the Pacific

Ocean in the lower latitudes that would be at all suitable for this purpose. Presumably those regions in the arctic and sub-arctic zone where the plankton-feeding whales resort at certain times to build up their wasted fatty tissues would be the most promising regions for exploration in search of the necessary supplies of raw materials for the establishment of such a new industry. We read, in the accounts of whaling operations off Norway and in the arctic regions, of extensive areas where the water appeared to be soupy with swarming plankton organisms. More exact quantitative data are desirable, covering considerable areas and extending over the periods of the year when such operations would be practicable from the standpoint of weather conditions. Inventive genius would also be called into play to design suitable equipment for removing the plankton from the water, presumably by large centrifugal pumps and suitable rotors or strainers for concentrating the plankton. There would also be the problem of separating the oil from the animals by pressure or other means, and reducing it to a form where it could be utilized commercially. It is also an interesting problem as to what might be done with the residue remaining after the removal of the oil. The high protein content of this material would suggest its possible use as a fertilizer or as an ingredient in animal food. It might be pressed into cakes by means of a hydraulic press, or reduced to a powder. The possible derivation of vitamins from the extracted oils is also a moot point.

If the practicability of this idea should be established it would probably lead to the construction of special vessels, mechanical whales if you will, for the harvesting and processing of the plankton. They would be designed to gather, reduce, and prepare the resulting products for commercial use, as is now being done in the extraction of bromine from sea water. A collateral result would be the reduction of the present heavy pressure upon the whale population which seems headed toward extinction.

It might not be necessary to use costly vessels with a high overhead for the purpose of assembling the oleaginous material, since there probably are areas in protected localities where strong tidal currents pass swiftly between convenient land masses. In such situations installations could be established that would permit the collection of plankton by equipment patterned after the floating salmon traps of Alaska or the fish wheels of the Columbia River, using the current itself as a source of power. By some such system plankton might conceivably be secured at a very slight cost.

The answer to most of these questions must presumably be left to the future, when a return of peace in the Pacific will make possible a renewed attack upon oceanographical problems not related to the war effort. Some lines of approach are, however, available from the shore stations in contact with shallow water areas, and these should be exploited to their fullest.

Another interesting possibility lies in the practicability of the direct use of plankton for human food. While it is not likely that our population will be driven for some time to seek new sources of supply based upon the sea, there are emerging situations where the use of plankton might be of importance, especially under war conditions. For instance, if it can be shown that the mixed plankton, usually

abundant in the surface water, could be used as an emergency ration by shipwrecked mariners, it might tide over the danger of starvation. Mixed plankton contains a high percentage of protein together with glycogen and oils in a proportion representing a well balanced ration, and the only question is as to whether it could be gathered in sufficient quantities to sustain life and be put in a palatable form. It is reported that the Prince of Monaco on certain occasions, when traversing areas of the ocean where plankton was abundant, had suitable nets employed and in a short time was able to secure sufficient material to furnish the chef with the ingredients for a palatable dish, which was served to the numerous guests on board his palatial yacht. It has been stated, although the writer cannot recall the reference, that the Russian explorers who drifted down from the arctic regions several years ago utilized their plankton nets to tide them over a shortage in their commissary.

It is undoubtedly true as has been pointed out by Dr. George L. Clark (Science, 89: 602, 1939) that the quantity of plankton present in sea water fluctuates greatly, and to place dependence upon it as a source of food supply might well lead to disappointment. Samples taken at the Oceanographical Laboratories located at Friday Harbor during the month of July were relatively poor in plankton, but during the greater part of August phytoplankton became extremely abundant. Tows made from a rowboat using a small net with a diameter of eight inches yielded in a thirty minute haul sufficient material when boiled to yield about 250 cc. of soupy material that was not unpalatable, even without the addition of the usual condiments. It seems probable this material would have a nourishing quality equal in potency to a plate of the usual vegetable soup derived from land plants. It is necessary of course to remove the greater portion of the contained salt by replacing the sea water with fresh water. This might prove a stumbling block if there was a shortage of fresh water, a situation which frequently exists in the case of emergencies at sea. Only by suitable experiments, conducted under conditions that simulate the results of a marine disaster, could one determine the practicability of such a scheme. If it should be discovered that this plan promises some reasonable measure of success, it might be advisable to furnish a suitable plankton net to go in the lockers of life boats designed to transport shipwrecked persons for considerable distances over the ocean. Such nets should be made of nylon fabric with a mesh of about 100 fibers to the inch. The ring should have a diameter of about one meter and should be made of metal or plastic in four sections that can be clamped together when put in use. A short set of instructions explaining the manner in which the net is to be used and the handling of the plankton after it has been secured should go in the kit. The whole outfit need not weigh more than a few ounces. In the absence of a proper plankton net an equipment might be extemporized from such thin fabrics as might be on board. Under certain conditions it is quite possible that valuable lives might be saved by this means.

The possibility of using bacteria as food for animals or for man would seem to be a far fetched idea, but the fact that many animals, the oyster for instance, are equipped to extract bacteria from the sea and thrive when all other sources of food supply are eliminated, points

the way to the possible direct use of the bacteria, paralleling the extensive exploitation of the yeasts, which after all are little more than big sisters of the bacteria. If it can be shown they contain stimulating hormones or vitamins, methods of culture on a large scale could be initiated, and they could thus be brought in line with their useful relatives derived from the fresh water and from the land.

Under certain conditions the plankton assumes medical and industrial interest through the periodic development of great swarms of the poisonous dinoflagellate *Gonyaulax* in the inshore waters of our western coast. When these are ingested by mussels and clams the poison carried by the flagellate is accumulated in the liver of the mollusks, and the latter then become highly toxic, the poison acting upon the human nervous system after the fashion of strychnine. A number of deaths have been reported as due to this cause, and as a result the health departments of the several states keep close watch upon the situation so as to be in a position to warn the public when signs of danger appear.

These suggestions are thrown out as illustrations of the nature of the problems that confront those engaged in the study of the plankton, when brought face to face with the application of pure science to a workaday world. Many others will no doubt appear as further accumulations of data are brought into correlation with the practical affairs of life.

EDITORIALS AND NOTES

FISH AND GAME BOATS GO TO WAR

On August 17, 1942, at Terminal Island, the transfer of the patrol boats "Broadbill," "Tuna" and "Yellowtail" to the U. S. Coast Guard, 11th Naval District, was completed.

These boats go to the Coast Guard under a charter which may be cancelled on thirty days' notice, and which provides for the return of the vessels in good condition at the end of the war, or for adequate compensation in case of loss or damage.

The transfer of the patrol boat "Bluefin" and of the research vessel "N. B. Scofield" is in process under similar charters.

In the 12th Naval District the Coast Guard is negotiating for outright purchase of the "Perch," "Quinnat III" and "Sturgeon."

On the completion of these transfers, only the "Bonito" and the "Rainbow III" will be left to the Division of Fish and Game out of the 10 units which comprised its fleet.—*L. F. Chappell, Chief, Bureau of Patrol, Division of Fish and Game, September, 1942.*

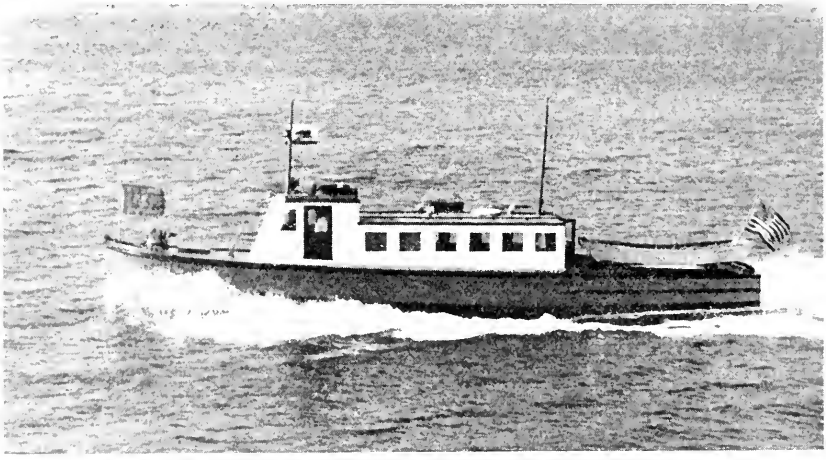

FIG. 58. California Fish and Game Patrol Boat *Tuna*. Photograph by D. H. Fry, Jr., January, 1939.

RESOURCES OF THE SEA IN WARTIME

The resources of the sea are vast, almost beyond our powers to conceive, and only a very small proportion of them are utilized by the people of the United States. This is the conclusion that one reaches after reading the five papers published in this issue which were originally presented at the Oceanographic Society of the Pacific's symposium "Resources of the Sea for Wartime Economy" held at Salt Lake City, Utah, on June 17, 1942.

Not only are very few of these resources now utilized by us, but the chances of their extensive utilization in anything but the remote future seem slight. In peace time there is no incentive, under the conditions of plenty in which we are so fortunate as to dwell, for their exploitation. In wartime the incentive exists but the man-power and equipment of the Nation must be devoted to more pressing needs—except in the few cases where the sea can be made to yield substitutes for materials normally imported from foreign shores. Kelp, whose utilization received an impetus from the First World War, is definitely in this class. Whether sufficient market interest can be aroused in any of the potentially enormous but now latent fisheries to permit their exploitation without Government subsidy seems doubtful, unless our needs and those of other nations whom we must feed now or after the war become so great as to bring upon us what until this point in our history has seemed unimaginable—the threat of famine.—*Brian Curtis, Editor, California Fish and Game.*

SALMON CAUGHT IN MEXICAN WATERS

On August 4, 1942, the halibut boat, *American Star*, of San Diego, reported catching a salmon ten miles south of Cape Colnett, Mexico, and about one-half mile off the mouth of a small river known locally as the Sweetwater. The fishermen had eaten a portion of the fish so it was impossible to make an identification other than its being a salmon, although a member of the crew who had fished salmon claimed it was a Silver. The fish, caught in a trammel net, was reported to weigh about ten pounds and contain small eggs. This record probably establishes a new southern limit for these fish.—*Robert D. Byers, Bureau of Marine Fisheries, California Division of Fish and Game, August, 1942.*

TWENTY-FIVE YEARS AGO IN CALIFORNIA FISH AND GAME

The October, 1917, issue of California Fish and Game began with a paper by Dr. E. C. Starks on "The Sharks of California" which seems noteworthy in view of the recent development of the shark fishery as a vitamin source.

Other leading articles were a discussion by Will F. Thompson (now Director of the International Pacific Salmon Fisheries Commission) of the effect of temperature on the albacore catch, and a description of "Mountain Lion Hunting in California" by Dr. H. C. Bryant (former editor of this journal and now Director of Grand Canyon National Park), in which allusion was made to the increase in the bounty on female lions from $20 to $30, at which figure it stands today.

Commentary notes on the size of the 1917 sardine catch, and the excellence of sport fishing for tuna and broadbill swordfish at Catalina Island were also included.—*Brian Curtis, Editor, California Fish and Game.*

IN MEMORIAM

ALDEN R. AINSWORTH

On August 8, 1942, Warden Alden R. ("Jack") Ainsworth died in a hospital as a result of injuries received from a fall.

Stationed in Santa Maria for the last 10 years, Ainsworth had been detailed for temporary patrol duty in Cuyama Valley. On the morning of August 5th he arose prior to 4 o'clock, from his bed on a sleeping porch of the cabin which served as his headquarters. In the darkness, he apparently walked off the porch at a point where the distance to the ground was over 10 feet, and fell to a gravelled road below, suffering a fractured skull. His daughter Janet, who was sleeping in the cabin, was awakened by his groans, procured medical attention, and had him transferred to a hospital in Santa Maria, but he never regained consciousness. He died on the evening of August 8th.

Warden Ainsworth was born in Milo, California, on October 26, 1896. He started his work as a deputy for the Division of Fish and Game in 1927 at Taft. He was always an active hunter and fisherman, and was well liked by the sportsmen, who knew him as an efficient and impartial officer. He is survived by his wife and his daughter Janet as well as by a sister and four brothers.

We of the Division mourn the loss of a friend and valued worker and extend our sympathies to his family.—*L. F. Chappell, Chief, Bureau of Patrol, Division of Fish and Game, August, 1942.*

JAMES L. STINNETT

James L. Stinnett, Fish Hatchery Foreman, in charge of the Brookdale Hatchery, died at Santa Cruz, September 3, 1942. He had suffered from reeurring periods of illness during the past year but intervening periods of convalescenee had led his many friends to hope for his eventual recovery.

Jim first came to work for the Division of Fish and Game in 1917 and was then employed as a Fish Hatchery Assistant at the old Domingo Springs Hatchery near Lake Almanor. The following year he was transferred to the Klamath River district and for about twelve years he had charge of the egg-collecting stations in that area with headquarters at the Beaver Creek Station. During the summer months he was usually engaged in construction work for the Bureau of Fish Conservation.

In 1931, Mr. Stinnett was appointed Fish Hatchery Foreman and assigned to the Feather River Hatchery. His transfer to Brookdale was made in 1937. At the new station Jim took a very active interest in developing a conservation program for the area served by the hatchery and worked in close cooperation with local sportsmen's organizations. He soon came to be respected and liked for his straight-forward

attitudes on fish conservation, particularly those concerned with the steelhead of the San Lorenzo River.

Jim was also active in working for the interests of his fellow employees and in giving assistance to the younger men who worked with him. His many friends both within and without the Bureau of Fish Conservation are deeply grieved that his association with them could not have been extended beyond the allotted sixty-four years.—*A. C. Taft, Chief, Bureau of Fish Conservation, Division of Fish and Game, September, 1942.*

REPORTS

STATEMENT OF REVENUE

For the Period July 1, 1941, to June 30, 1942, of the Ninety-third Fiscal Year

Revenue for Fish and Game Preservation Fund:

License revenue:

1942 series—		
Angling	$303,837.50	
Hunting	172 50	
Trapping	2 00	
Fish packer and shell fish dealer	20 00	
Deer tags	6 00	
Fish tags	2,008 73	
Game tags	65 31	
Market fishermen	38,870 00	
Fish importers	85 00	
Fish party boat permits	212 00	
Fish breeders	290 00	
Game breeders	1,067 50	
Game management licenses	180 00	
Game management tags	5 50	
Kelp license	40 00	
Antelope permits	2,500 00	
Total 1942 series		$349,362 12
1941 series—		
Angling	$594,855 00	
Hunting	630,230 50	
Commercial hunting	1,025 00	
Commercial hunting club operator	385 00	
Trapping	2,168 00	
Fish packer and wholesale shellfish dealer	950 00	
Deer tags	173,647 00	
Fish tags	2,170 47	
Game tags	278 28	
Market fishermen	52,100 00	
Fish party boat permits	146 00	
Fish breeders	15 00	
Game breeders	140 00	
Game management licenses	$220 00	
Game management tags	130 02	
	350 02	
Kelp license	30 00	
Total 1941 series		$1,458,450 27
1940 series—		
Angling	$868 00	
Hunting	8,557 00	
Fish packers and wholesale shellfish dealers—Citizen	5 00	
Deer tags	399 00	
Market fishermen	100 00	
Total 1940 series		$9,929 00
Total licenses, 93d fiscal year		$1,817,741 39
Other revenue:		
Court fines	$51,097 42	
Deer meat permits	6,423 00	
Lease of kelp beds	1,334 50	
Kelp tax	1,868 74	
Publication sales	159 01	
Fish packers tax	342,341 01	
Salmon packers tax	19,691 16	
Miscellaneous	9,687 14	
Total other revenue		$432,602 01
Grand total revenue all years, Fish and Game Preservation Fund		$2,250,343 40

STATEMENT OF EXPENDITURES

For the Period July 1, 1941, to June 30, 1942, of the Ninety-third Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Administration:					
Demolition of exposition exhibits		$57 54	$29 65		$87 19
Education and public information	$1,096 96	20 67			1,117 63
Executive	7,349 92	356 50	5,544 80	$5 00	13,256 22
Exhibits	66 60	169 77	800 76		1,037 13
Fish and game magazine		3,284 31			3,284 31
Library	2,358 10	36 72	133 11	299 16	2,827 09
Office	11,611 84	4,801 63	83,004 37	340 46	99,758 30
Total Administration	$22,483 42	$8,727 14	$89,512 69	$644 62	$121,367 87
Patrol and Law Enforcement:					
Cannery inspection	$19,020 96	$484 76	$2,908 69		$22,414 41
Executive	14,062 34	429 23	2,339 02	$3,690 60	20,521 19
Junior patrol	2,720 00	187 02	817 92	3 66	3,728 60
Land patrol	281,867 27	41,651 46	72,095 44	16,259 55	411,873 72
Marine patrol	94,490 11	19,856 56	53,912 92	12,012 85	180,272 44
M. V. *Bluefin* Galley		−983 15			−983 15
N. V. *Scofield* Galley		−749 25			−749 25
Office	7,208 48	297 69	1,190 02	188 40	8,884 59
Pollution patrol	18,544 03	2,720 75	5,320 42	1,538 26	28,123 46
Total Patrol and Law Enforcement	$437,913 19	$63,895 07	$138,584 43	$33,693 32	$674,086 01
Marine Fisheries:					
Central Valleys Investigation	$7,052 90	$1,328 44	$3,657 38	$142 25	$12,180 97
Executive	7,760 00	215 48	921 36	781 35	9,678 19
Field supervision	640 00	104 27	129 12		873 39
Fish cannery auditing			3,556 88		3,556 88
Office	12,298 22	860 43	507 35	22 88	13,688 88
Research and statistics	61,428 12	5,715 55	10,766 30	2,679 12	80,589 09
Total Marine Fisheries	$89,179 24	$8,224 17	$19,538 39	$3,625 60	$120,567 40
Fish Conservation:					
Biological survey	$12,809 00	$1,484 10	$1,832 36	$358 65	$16,484 11
Executive	11,205 00	125 84	753 97		12,084 81
Field supervision	6,348 39	496 22	1,172 74	21 23	8,038 58
Fish food unallocated		37,243 18	7,794 49		45,037 67
Fish planting	1,327 68	942 33	1,935 53	1,584 51	5,790 05
Fish rescue	9,549 53	681 31	2,550 58	1,064 45	13,845 88
Office	7,305 00	1,101 19	857 59	127 22	9,391 00
Pollution inspection	5,207 15	348 46	695 44	45 30	6,296 35
Shark liver analysis	220 00				220 00
Statistical	2,370 00	496 91	1,356 00		4,442 91
Structural maintenance	630 00	67 48	270 04		967 52
Alpine Hatchery	1,613 40	261 38	282 38	7 77	2,164 93
Arrowhead Lake Egg Collecting Station	8,215 64	949 11	1,395 57	69 06	10,629 38
Basin Creek Hatchery	5,649 01	1,799 44	929 68	107 55	8,485 68
Bear Lake Egg Collecting Station	602 00	22 65			624 65
Benbow Dam Experimental Station	1,804 84	90 19	50 98	7 55	1,953 56
Black Rock Springs Ponds	182 40	46 41	27 95	81 39	338 15
Blue Lakes Egg Collecting Station	166 67	12 18			178 85
Bogus Creek Egg Collecting Station	354 67	68 58	120 80		544 05
Brookdale Hatchery	7,245 99	1,228 93	648 29	15 27	9,138 48
Burney Creek Hatchery	5,526 13	219 90	360 59		6,106 62
Central Valleys Hatchery	2,867 58	1,072 90	1,534 49	191 53	5,666 50
Copco Egg Collecting Station	690 00	4 08	97 95		792 03
Cotton Lake Egg Collecting Station	153 22		112 25		265 47
Coy Flat Hatchery	294 20				294 20
Experimental Hatchery	653 33	30 59			683 92
Fall Creek Hatchery	6,810 64	591 51	176 58	29 71	7,608 44
Feather River Hatchery	4,912 00	817 14	469 34	18 57	6,217 05
Fern Creek Hatchery	704 85	127 22	350 67		1,182 74
Fillmore Hatchery	6,182 18	324 54	1,219 75	16 66	7,743 13
Fishing Creek Project			150 00		150 00
Forest Home Hatchery		16 53			16 53
Fort Seward Hatchery	3,362 26	357 33	374 61	3 66	4,097 86
Hot Creek Hatchery	9,220 03	8,857 91	2,365 17	346 84	20,789 95
Huntington Lake Hatchery	1,285 15	407 04	456 50	209 08	2,357 77
Kaweah Hatchery	3,975 00	1,140 28	1,621 38	20 51	6,757 26
Kern Hatchery	2,896 01	517 52	470 14	204 68	4,088 35
King Salmon Experiment Station			5 76		5 76
Kings River Hatchery	6,372 27	2,964 04	1,687 57	37 74	11,061 62
Kirman Lake Egg Collecting Station	243 02		20 90		263 92
Klamathon Egg Collecting Station	475 38	131 57	75 85		682 80
Lake Almanor Hatchery	6,274 66	613 68	1,118 99	71 50	8,078 83
Lake Eleanor Egg Collecting Station	778 06				778 06

STATEMENT OF EXPENDITURES

For the Period July 1, 1941, to June 30, 1942, of the Ninety-third Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Fish Conservation—Continued:					
Little Walker Lake Egg Collecting Station	$477 10		$7 60		$484 70
Mad River Egg Collecting Station	690 00	$50 70			740 70
Madera Hatchery	2,216 62	214 90	786 82	$9 94	3,228 28
Mt. Shasta Hatchery	48,635 70	6,537 60	3,088 15	2,333 07	60,594 52
Mt. Tallac Hatchery	4,061 30	1,784 04	462 45	55 93	6,363 72
Mt. Whitney Hatchery	16,242 54	6,026 22	4,169 71	628 36	27,066 83
Mud Creek Egg Collecting Station	99 67				99 67
Prairie Creek Hatchery	5,078 61	1,107 20	638 41	123 62	6,947 84
Rearing Reservoir	4,877 18	1,049 55	1,342 80	16 83	7,286 36
Rush Creek Egg Collecting Station	529 03	30 12	45 30		604 45
San Lorenzo Egg Collecting Station		161 87	86 74		248 61
Sequoia Experimental Station	[illegible] 92 25	222 67	731 35	113 76	2,630 03
Shackleford Creek Egg Collecting Station			50 00		50 00
Shasta River Egg Collecting Station	700 00	34 17	112 19	17 47	863 83
Snow Mountain Egg Collecting Station	1,606 80	408 20	86 77		2,101 77
Tahoe Hatchery	8,239 67	450 87	1,001 99	45 15	9,737 68
Upper Truckee Egg Collecting Station			10 00		10 00
Waddell Creek Station	1,890 00	153 74	146 23		2,189 97
Yosemite Hatchery	5,157 63	1,352 79	593 93	17 79	7,122 14
Yuba River Hatchery	4,448 40	438 56	208 83	130 17	5,225 96
Total Fish Conservation	$252,994 93	$85,682 87	$48,912 15	$8,132 53	$395,722 48
Engineering:					
Engineering	$12,575 43	$983 88	$3,800 11	$66 75	$17,426 17
Executive	4,740 00	281 61	950 67	699 36	6,671 64
Inspection fish screens	1,350 00	1,304 57	100 11		2,754 68
Office	1,630 00	9 71	27 67	4 45	1,671 83
Total Engineering	$20,295 43	$2,579 77	$4,878 56	$770 56	$28,524 32
Game Conservation:					
Duck rescue	$1,697 21	$381 66	$452 73	$7 16	$2,538 76
Elk refuge	2,040 00	257 38	266 62		2,564 00
Executive	10,020 00	839 50	1,521 84	1,739 69	14,121 03
Game management	13,835 83	2,835 77	2,774 25	1,862 11	21,307 96
Grey Lodge Refuge	4,597 75	981 03	448 02	68 24	6,095 04
Imperial refuge	2,935 96	102 79	136 39	1 92	3,177 06
Los Banos Refuge	4,102 76	1,052 39	487 35	1,601 71	7,244 21
Office	3,760 00	125 39	1,657 26	163 15	5,705 80
Predatory Animal—lion hunting	6,687 86	820 71	6,400 66	3 96	13,913 19
Predatory Animal—trapping	39,833 52	5,578 60	7,650 66	4,216 50	57,279 28
Research	8,373 97	1,506 52	1,745 43	1,015 43	12,641 35
Statistics	2,363 43	261 93	1,317 22		3,942 58
Suisun refuge	3,114 22	488 12	393 92	154 34	4,150 60
Winter feeding and salting of game		576 63			576 63
Total Game Conservation	$103,362 51	$15,808 42	$25,252 35	$10,834 21	$155,257 49
Game Farms:					
Executive	$3,937 14	$106 45	$668 58		$4,712 17
Game Bird Distribution, Los Serranos	2,776 30	2,027 76	890 52	$722 44	6,417 02
Game Bird Distribution, Yountville	11,817 38	3,868 17	2,095 51	171 95	17,953 01
Game management	1,677 00	90 08	209 84	17 15	1,994 07
Los Serranos game farm	11,268 14	2,302 67	1,081 06	366 05	15,017 92
Office	1,170 00	23 21	14 11	1 49	1,208 81
Yountville boarding house	525 44	1,243 18	1 11		1,769 73
Yountville game farm	14,002 29	6,506 30	1,980 03	1,025 20	23,513 82
Total, Game Farms	$47,173 69	$16,167 82	$6,940 76	$2,304 28	$72,586 55
Licenses:					
Executive	$3,937 14	$133 53	$211 56		$4,282 23
License distribution	15,990 29	25,730 55	83,392 79	$73 56	125,187 19
Office	1,573 89	259 15	110 06	17 33	1,960 43
Total Licenses	$21,501 32	$26,123 23	$83,714 41	$90 89	$131,429 85
Construction of Fish Screens and Stream Improvements:					
Unallocated				$21,860 32	
Snow Mountain Egg Station improvement				32 96	
Check dams in El Dorado National Forest				1,500 00	
Woodbridge fish ladder improvement				90 80	23,484 08
Total, Fish Screens				$23,484 08	$23,484 08
Grand total, excluding Special Support items					$1,723,026 05

FISH CASES

April, May, June, 1942

Offense	Number arrests	Fines imposed	Jail sentences (days)
Abalones: No license, undersized and transporting abalones without affidavit	49	$1,000 00	
Alien purchasing and using citizens license	1	150 00	
Angling: No license, closed season, within 150 ft. of dam, set lines, after sundown, two poles, too close to fish ladder, and in refuge	111	1,925 00	40
Barracuda: Overlimit	3	23 00	
Bass: Undersized, closed season, no license, two lines, overlimit	68	1,510 00	27
Catfish: Closed season, undersized, no license	11	327 50	
Clams: Out of shell, overlimit, undersized, no license, possession clam forks in District 18A	41	943 00	17
Commercial fishing: No license	4	75 00	
Crabs: Overlimit	1	25 00	
Crappie: Closed season	11	175 00	180
Croakers: Spearing	2	110 00	
Failure to show license on demand	4	40 00	
Gill net: Before sunrise, and set net	4	300 00	
Halibut: No license, undersized	2	5 00	10
Lobster: Closed season	2		20
Operating drag boat in District 11B.5	2	300 00	
Paranzella net in 3 mile limit	3	300 00	
Perch: No license, closed season	4	110 00	
Pollution	19	2,350 00	
Sardines: Reduction with no permit	1	25 00	
Sturgeon	4	75 00	10
Sunfish: Closed season, no license	30	800 00	10
Throw net	1	100 00	
Transfer of license	1	10 00	
Trout: Closed season, overlimit	31	637 50	
Tuna: Closed area	42	Dismissed	
Round haul net in District 20	34	1,425 00	
Totals	486	$12,741 00	314

GAME CASES

April, May, June, 1942

Offense	Number arrests	Fines imposed	Jail sentences (days)
Antelope: Hunting with no permit, and killing female antelope	5	$210 00	
Beaver pelts	1	25 00	
Deer: Closed season, doe, allowing dogs to run deer, hunting in game refuge, failing to tag deer	27	874 00	53
Deer meat: Closed season, female	24	1,102 50	100
Doves: Closed season	5	300 00	
Ducks: Closed season, shooting from automobile	19	525 00	
Eggs: Illegally taken game bird eggs	1		12½
Firearms: Discharging firearms in game refuge	4	45 00	
Geese: Closed season	1	50 00	
Hunting: No license, failure to show license on demand, transfer of license, hunting in refuge	33	440 00	
Meadow Lark	1	50 00	
Mudhens: Closed season	6	130 00	
Nongame birds	4	50 00	4
Pigeons: Closed season	6	90 00	20
Pheasants: Closed season	20	890 00	205
Quail: Closed season	2	40 00	
Rabbits: Closed season, no license	54	740 00	
Shooting from automobile	7	130 00	
Tree squirrel	1	75 00	
Totals	221	$5,766 50	394½

SEIZURES OF FISH AND GAME

April, May, June, 1942

Fish:	
Abalones	103
Abalones, red	23
Abalones, green	9
Barracuda	15
Bass, rock	23
Bass, black	53
Bass, striped	18
Bass, pounds	740
Catfish	80
Catfish, pounds	258
Clams, eockle	3,581
Clams, Washington	45
Crappie	58
Crappies, pounds	20
Croakers, spotfin	44
Croakers, pounds	4
Fish traps	9
Halibut	6
Halibut, pounds	375
Lobster traps	33
Perch	61
Sardines, pounds	52,220
Sunfish	299
Trout	57
Trout, rainbow	89
Yellowtail	12
Game:	
Antelope	2
Beaver pelts	4
Deer	3
Deer hides	4
Deer meat, pounds	562
Doves	33
Ducks	87
Geese	2
Mudhens	4
Pigeons	17
Pheasant	35
Quail	69
Rabbits, brush	29
Rabbits, cottontail	124
Rabbits, jackrabbit	2

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BUREAU OF ENGINEERING

JOHN SPENCER, Chief.....San Francisco
Clarence Elliger, Assistant Hydraulic Engineer.....San Francisco
Samuel Kabakov, Jr., Civil Engineer.....San Francisco

BUREAU OF LICENSES

H. R. DUNBAR, Chief.....Sacramento
L. O'Leary, Supervising License Agent.....Sacramento
R. Nickerson, Supervising License Agent.....Los Angeles
Emil Dorig, License Agent.....San Francisco

ACCOUNTS AND DISBURSEMENTS

D. H. BLOOD, Departmental Accounting Officer.....Sacramento

BUREAU OF PATROL

E. L. MACAULAY, Chief of Patrol (absent on military leave).....San Francisco
L. F. CHAPPELL, Chief of Patrol.....San Francisco

CENTRAL DISTRICT (Headquarters, Sacramento)

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Northern Division

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Jos. H. Sanders, Captain.....Sacramento
A. H. Willard, Captain.....Rocklin
E. O. Wraith, Captain.....Chico
L. E. Mercer, Warden, Butte County.....Chico
Chester Ramsey, Warden, Butte County.....Oroville
Taylor London, Warden, Colusa County.....Colusa
Albert Sears, Warden, El Dorado County.....Placerville
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Earl Hiscox, Warden, Nevada County.....Nevada City
Nelson Poole, Warden, Placer County.....Auburn
E. J. Johnson, Warden, Plumas County.....Quincy
George Shockley, Warden, Plumas County.....Portola
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Charles Sibeck, Warden, Sacramento County.....Sacramento
Earl Caldwell, Warden, Shasta County.....Burney
Chas. Love, Warden, Shasta County.....Redding
Don Chipman, Warden, Siskiyou County.....Dunsmuir
Brice Hammack, Warden, Siskiyou County.....Yreka
Louis Olive, Warden, Lassen County.....Susanville
Fred R. Starr, Warden, Siskiyou County.....Dorris
R. E. Tutt, Warden, Sierra County.....Downieville
A. Granstrom, Warden, Sutter County.....Yuba City
R. W. Anderson, Warden, Tehama County.....Red Bluff
Harold Erwick, Warden, Tehama County.....Corning
C. L. Gourley, Warden, Trinity County.....Weaverville
C. O. Fisher, Warden, Yolo County.....Woodland
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G. Seymour, Warden, Lassen County.....Susanville

Southern Division

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John O'Connell, Captain.....Stockton
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W. I. Long, Warden, Tulare County.....Visalia
Roswell Welch, Warden, Tulare County.....Porterville
F. F. Johnston, Warden, Tuolumne County.....Sonora

COAST DISTRICT (Headquarters, San Francisco)

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Northern Division

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J. D. Dondero, Captain—Lakeport
Henry Lencioni, Captain—Santa Rosa
Ray Diamond, Warden, Del Norte County—Crescent City
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John Hurley, Warden, Humboldt County—Eureka
W. F. Kaliher, Warden, Humboldt County—Fortuna
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Bert Laws, Warden, Sonoma County—Petaluma
Victor Von Arx, Warden, Sonoma County—Santa Rosa
Jack Sawyer, Sonoma County—Cloverdale

Southern Division

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F. H. Post, Warden, Monterey County—Salinas
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Lee C. Shea, Warden, San Francisco County—San Francisco
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Orben Philbrick, Warden, San Luis Obispo County—Paso Robles
C. R. Peek, Warden, San Mateo County—San Mateo
M. S. Clark, Warden, Santa Clara County—Palo Alto
C. E. Holladay, Warden, Santa Clara County—San Jose
F. J. McDermott, Warden, Santa Cruz County—Santa Cruz
J. E. Hughes, Warden, Solano County—Dixon
R. C. O'Connor, San Francisco County—San Francisco

SOUTHERN DISTRICT (Headquarters, Los Angeles)

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E. H. Ober, Captain, Special Duty—Los Angeles

Western Division

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Walter Shannon, Warden, Los Angeles County—Los Angeles
Walter Emerick, Warden, Los Angeles County—Palmdale
Theodore Jolley, Warden, Orange County—Orange
E. H. Glidden, Warden, San Diego County—San Diego
Chester Parker, Warden, San Diego County—Julian
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W. Greenwald, Warden, Ventura County—Fillmore
John Spicer, Warden, Ventura County—Ojai

Eastern Division

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James Loundagin, Warden, Mono County—Leevining
W. C. Blewett, Warden, Riverside County—Indio
W. L. Hare, Warden, Riverside County—Elsinore
A. L. Stager, Warden, San Bernardino County—Upland
W. C. Malone, Warden, San Bernardino County—San Bernardino
Erol Greenleaf, Warden, San Bernardino County—Big Bear Lake
Otto Rowland, Warden, San Bernardino County—Victorville

MARINE PATROL

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Lars Weseth, Master, M.V. *N. B. Scofield*—Terminal Island
A. Wallen, Assistant Warden, Cruiser *Bonito*—Newport Harbor
Kenneth Webb, Warden, Cruiser *Broadbill*—San Diego
Ralph Dale, Cruiser *Perch*—Antioch
Kenneth Hooker, Warden, Cruiser *Quinnat III*—San Rafael
G. Whitesell, Assistant Warden, Cruiser *Quinnat III*—San Rafael
K. Lund, Warden, Cruiser *Rainbow III*—Martinez
Otis Wright, Assistant Warden, Launch *Sturgeon*—Monterey
Walter Engelke, Captain and Warden, Cruiser *Tuna*—Santa Monica
Robert Mills, Cruiser *Yellowtail*—Santa Barbara
John Barry, Warden—Ventura
Ellis Berry, Warden—San Luis Obispo
W. J. Black, Warden—Antioch
J. R. Cox, Warden—Watsonville
N. C. Kunkel, Warden—Terminal Island
Leslie E. Lahr, Warden—Terminal Island
Ralph Miller, Warden—San Francisco
Tate F. Miller, Warden—Terminal Island
T. W. Schilling, Warden—Terminal Island
G. R. Smalley, Warden—Richmond
T. J. Smith, Warden—San Diego
L. G. Van Vorhis, Warden—Terminal Island
E. L. Walker, Warden—Terminal Island
Frank Felton, Assistant Warden—San Diego

POLLUTION DETAIL

Paul A. Shaw, Chemical Engineer—San Francisco
Don Hall, Warden—Oakland
H. L. Lantis, Warden—Long Beach
R. L. Schoen, Warden—Wilmington
Walter R. Krukow, Assistant Warden—Santa Barbara
J. A. Reutgen, Assistant Warden—Martinez

MARINE PATROL AND RESEARCH BOATS

Motor Vessel *N. B. Scofield*, Terminal Island
Motor Vessel *Bluefin*, Monterey
Cruiser *Bonito*, Newport Harbor
Cruiser *Perch*, Antioch
Cruiser *Quinnat III*, San Francisco
Cruiser *Rainbow III*, Martinez
Launch *Sturgeon*, Monterey

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