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DEPARTMENT OF COMMERCE

BUREAU OF FISHERIES

HUGH M. SMITH, Commissioner

SURVEY OF THE FISHING GROUNDS ON THE
COASTS OF WASHINGTON AND OREGON
IN 1915

By EDWARD C. JOHNSTON
U. S. Bureau of Fisheries

APPENDIX VI TO THE REPORT OF THE U. S. COMMISSIONER
OF FISHERIES FOR 1915

Bureau of Fisheries Document No. 835

WASHINGTON
GOVERNMENT PRINTING OFFICE

1916

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Appendix VI to the Report of the U. S. Commissioner
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SURVEY OF THE FISHING GROUNDS ON THE COASTS OF WASHINGTON AND OREGON IN 1915.

By EDWARD C. JOHNSTON.

INTRODUCTION.

For many years rumors have been current among the fishermen of Seattle that there exist, 200 or 300 miles off the Washington coast, banks or shoal waters from which large schools of halibut come every spring. The existence of such banks is apparently the most plausible explanation of the fact that large schools of first-class halibut very often arrive on the western edge of Flattery Bank, remain for a short time, and then disappear. These schools do not appear on the eastern side of the bank, and halibut are seldom found to be plentiful along the coast of Vancouver Island. Upon the banks off the Columbia River large catches of fine halibut were made in May, 1915, but later the proportion of mushy fish became so large that fishing was discontinued.

It is believed that halibut are never notably plentiful south of the Columbia River, and it would therefore appear that these schools of halibut found on the banks off Washington and Oregon must come from the west or northwest.

The belief that such banks exist has been supported from time to time by vessels which have reported discolored water or comparatively shallow soundings. Such reports have located the supposed banks anywhere between 60 and 200 or 300 miles offshore and between the latitudes of Cape Scott, the northern end of Vancouver Island, and the Columbia River.

In the spring of 1915 several small patches of good halibut bottom were discovered by fishermen off the mouth of the Columbia River. The Bureau of Fisheries steamer *Albatross* was therefore detailed during the months of July, August, and September, 1915, to investigate the existence of fishing banks offshore, and to locate the new fishing grounds off the Columbia River, as well as in the region between the Columbia River and Flattery Bank.

The investigation was a continuation of the work started in 1914, and includes: (a) Soundings made on July 9 off the Columbia River; (b) a sounding and fishing trip, July 19 to 28, covering the region between Grays Harbor and Flattery Bank and including four fishing

trials; (c) a sounding trip August 9 to 19, over a strip 60 miles wide and approximately 300 miles long west of Cape Flattery; (d) a sounding trip September 2 to 11, extending from Grays Harbor south to Cascade Head. No fishing trials were made on the second and third trips.

Credit is given to the commanding officer of the steamer *Albatross*, Lieut. Commander J. J. Hannigan, United States Navy, and to the officers under him for their willing and efficient cooperation during the investigation. The expert knowledge and advice of Mr. Edward Driscoll, in charge of the fishing operations, contributed largely to the success of the work. The fishermen of Seattle have contributed much in the way of advice and information, and the files of The Pacific Fisherman have supplied many items of valuable information.

RÉSUMÉ OF PREVIOUS INVESTIGATIONS.

Since the year 1885 various desultory fishing trials have been made off the Washington and Oregon coasts. Early in that year the Portland Deep Sea Fish Co., of Portland, Oreg., sent out a small schooner equipped with a 40-foot beam trawl. In 1887 another trial was made, and although flounders, soles, red rock cod, and a very few halibut were taken by both of these vessels, the trips were not successful.

In 1888-1890 the steamer *Albatross* carried on an investigation off the coast from Cape Flattery southward, and found four banks,^a as follows:

1. Flattery Bank, 1,100 square miles, least depth 27 fathoms, off Cape Flattery.
2. Willapa Bank, 110 square miles, least depth 42 fathoms, 23 miles W. by S. (magnetic) from Toke Point Light, Willapa Bay.
3. Yaquina Bank, 40 square miles, least depth 42 fathoms, 19 miles SSW. $\frac{1}{4}$ W. (magnetic) from Yaquina Head.
4. Heceta Bank, 300 square miles, least depth 41 fathoms, 35 miles SW. $\frac{1}{2}$ W. from Heceta Head.

In this work but few halibut were taken, several species of rock cod were found to be generally distributed, and flounders and cultus cod were abundant on all the banks.

During the summer of 1914 the United States Bureau of Fisheries conducted an investigation of the fishing grounds off the coast of Washington and Oregon. The greater part of this work was confined to the region between Heceta Bank and the Columbia River, although some time was given to the sections off Grays Harbor and Coos Bay. In all, 38 sets were made for halibut with varying success, resulting in the conclusion that if halibut were to be found off the Oregon coast in paying quantities, they would occur as a seasonal run when

^a Summary of the fishing investigations conducted in the North Pacific Ocean, by Richard Rathbun. Bulletin of the U. S. Fish Commission, vol. XII, 1892, p. 127-205.

they came inshore to feed. It was apparent that there were no banks of sufficient size nor of a character to hold the fish the year around.

As a result of these investigations, many vessels of the Seattle halibut fleet made trips to the Newport Bank and obtained excellent catches. During the period from May 10, 1914, to September 15 of the same year 853,300 pounds of halibut were caught.^a This total does not include several fares about which no definite information could be secured.

The following comparison of the yield of fish on the Newport and the Alaska Banks is taken from the report of the investigations of 1914:^b

In August, 1914, the average schooner trip (inclusive of mushy fish) from Oregon was 42,800 pounds, 3,000 pounds less than the average schooner fare landed at Seattle during the same month. Compared with the average trip for the same month of the previous year, the Oregon catch was about 100 pounds greater.

In September the average trip from the Newport Bank exceeded by over 15,000 pounds the average of all schooner trips landed in Seattle in September of either year. The average catch of sound fish alone from off Newport during this month compares favorably with the average Seattle fare including mushy fish, being 34,667 as against 38,343 pounds at Seattle in 1914, and 38,657 pounds in 1913. The Seattle averages are based on 38 trips in 1913 and 70 in 1914, whereas the Newport data include but 6 trips.

To all appearances, within the fishing area off Newport, halibut are as plentiful, at least in August, and especially in September, as on the various northern banks fished by the Seattle schooners. It may be said that with the great number of northward trips there is greater possibility for making poor ones; but a few of these would not materially reduce the Seattle average, based on so many trips, whereas a few from Newport would have reduced that average to an insignificant quantity.

Flounders, sole, red rockfish, black cod, and dogfish, although not marketed extensively, were found to be present on this part of the Pacific coast in considerable quantities.

The summarization of the results of the investigations of 1914 is quoted verbatim:^c

The investigation developed the existence of a nice run of halibut during a period of at least two months on a bank having an area of approximately 250 square miles, off Newport, Oreg. The run attained its maximum in August and September, but fish were present in June and July. A profitable fishery probably could be conducted at that time, and at certain places might possibly be engaged in as early as the latter part of April. Irrespective of the abundance of fish, however, the weather conditions and lack of shelter will restrict fishing to the period from April to September. In 1914 this run yielded commercial catches totaling over 850,000 pounds of halibut in 21 trips, for which \$23,646.25 was received by the fishermen. Average trips of 40,000 pounds were caught in four days or less, the fish averaging 27 pounds in weight.

^a Survey of the fishing grounds on the coasts of Washington and Oregon in 1914. Bureau of Fisheries Document no. 817, p. 29.

^b *Idem*, p. 23.

^c *Idem*, p. 27.

Mushy fish occur to the extent of 30 to 40 per cent of the total catch, but in view of certain returns from Alaska during the same year (1914) this proportion does not seem greater than on other Pacific coast grounds.

Halibut may be expected in limited quantities off Coos Bay, on a considerably smaller and less developed patch of bottom, and possibly off Grays Harbor at some season of the year, as a good piece of bottom was located in that vicinity, although not a halibut was caught thereon. With respect to halibut and halibut bottom, the section of the coast lying off Tillamook seems to be the least favorable.

On the other hand, throughout practically the entire reach of the Oregon coast, there seems to be an abundance of the smaller flatfishes, some of which are food fishes of great excellence. The red rock cod, and doubtless black cod, occur in great abundance. Dogfishes are so numerous at times as to be a nuisance.

Scallops apparently are to be found over a wide range of territory, and in some places probably form beds thickly enough populated to warrant fishing, though the depth in which they lie may militate against taking them commercially.

In conclusion, the harbor and market facilities, bait supplies, transportation, and cold storage are perhaps too limited and uncertain to enable any of the Oregon coast ports to become fishing centers of any great consequence under present conditions. The limitation of the fishing season by weather conditions is possibly the greatest handicap in competition with Seattle and its proximity to the vast, year-round Alaska fishery resources. No doubt the Newport Bank will provide a valuable addition to the available supply of halibut, and the greater part of the Oregon coastal region will furnish a future source of supply of flounders, sole, black cod, and red rockfish, which at present find but a limited market, if any.

THE INVESTIGATION OF 1915.

On July 6, 1915, the steamer *Albatross* left Sausalito, Cal., for Seattle to pick up the fishermen and to obtain necessary supplies and gear. On July 9 a series of soundings was made immediately west of the mouth of the Columbia River. These soundings disclosed the presence of a gully 150 fathoms deeper than the inclosing ridges, 12 miles long by 4 miles wide, extending westward from a point approximately 12 miles offshore. The northern ridge of this gully was definitely located, and although no good halibut bottom was found, there probably exist small areas along the edge of the ridge where halibut may be taken.

On July 20 operations were begun at a point west of Grays Harbor. The work was continued in a northerly direction to the edge of Flattery Bank, the soundings, with few exceptions, being confined to the edge of the continental shelf. The method of work was to run lines of soundings between the 70 or 80 fathom curve and a depth at which fishing would be impractical. These lines were run several miles apart. It was demonstrated that there are many small patches of good halibut bottom scattered through this region, no less than 14 being located on this trip. Owing to the small size of these areas of good bottom, they probably hold the fish for only a short time. Four fishing trials were made, the results of which are discussed elsewhere in this report.

Between August 9 and 19 a search was made for possible offshore banks. The first line of soundings began at the edge of the continental shelf west of Destruction Island and extended westward a distance of approximately 300 miles. Three other lines of soundings were run north of the first one, parallel with it and about 20 miles apart. Soundings were made to a depth of 500 fathoms at 5-mile intervals, and every fifth sounding was extended to the bottom. No bank was found which could be fished upon, but a submarine elevation was located whose summit lies at a depth of only 525 fathoms. This has been named "Gibson Bank," in honor of Mr. John Gibson, manager, Fishing Vessel Owners' Association of Seattle.

Between September 2 and 11 sounding operations were resumed along the 100-fathom line west of Grays Harbor, which work was extended southward as far as Cascade Head, the same methods being used as in the work in July. Very few patches of favorable bottom were found.

As the halibut fishermen have repeatedly expressed their willingness to make fishing trials, provided they knew the location, depth, character of the bottom, etc., of a bank, the work of this cruise was confined to determining the location of new or unknown banks rather than to the determination of the fishing value of any bank.

CHARACTER AND TOPOGRAPHY OF THE BOTTOM.

The region covered by this investigation is confined, for the most part, to a narrow strip lying along the edge of the continental shelf in the vicinity of the 100-fathom curve. This course was decided upon in view of the limited time at the disposal of the survey, and the probability that a coarse or rocky bottom would be found wherever a ridge or a rapid change in depth exists.

The data collected have been entered upon five Coast and Geodetic Survey charts which include the coast line from Cape Flattery to Coos Bay. The charts, as reproduced, are sections of the originals: Chart 1 is a section of Coast and Geodetic Survey chart No. U, including Cape Flattery. Chart 2, Cape Flattery to Grays Harbor, is a section of Coast and Geodetic Survey chart No. 6400; Chart 3, Willapa Bay to Cascade Head, is compiled from sections of Coast and Geodetic Survey charts No. 6000 and 6100; Chart 4, Cape Foulweather to Coos Bay, comprises section of Coast and Geodetic Survey charts No. 5900 and 6000.

The 100, 50, and 20 fathom contour lines have been corrected or extended to conform with the soundings made at this time. All depths over 30 fathoms are indicated, the center of the figure being the spot where the sounding was made. The character of the bottom is noted near the sounding at which it was obtained. Favorable

patches of good halibut bottom are located by dotted lines and numbered with Roman numerals. In Chart 3, Willapa Bay to Cascade Head, one reported halibut fishing ground which was not found by the *Albatross* is indicated by a different style of dotted lines.

In taking up the discussion of the character and topography of the bottom the region investigated during 1915 falls naturally into four sections and that investigated during 1914 into three, viz: (a) Flattery section, in which four lines of soundings were made from the edge of the continental shelf extending seaward 300 miles; (b) Grays Harbor section, reaching south from the edge of Flattery Bank to Grays Harbor; (c) Columbia River section, which takes in the area off the Columbia River and south to Tillamook Bay, where (d) Tillamook section begins; this runs south to Cascade Head; (e) Newport section; (f) Heceta Bank section; and (g) Coos Bay section. The last three were covered by the 1914 investigation.

Flattery section.—Extending 50 miles west of Cape Flattery, the continental shelf contains numerous outcroppings of rocky ledges and patches of pebbles and gravel. At the western edge the bottom, which drops to a depth of 1,000 fathoms in a distance of 25 miles, is composed largely of gray sand changing to green or gray mud as the depth increases. On the first line of soundings this green mud persists for over 100 miles, beyond which it is replaced by a brown ooze. On the other three lines the brown ooze is found inshore to the 1,000-fathom line. Only at one sounding was *Globigerina* ooze found, although the calcareous remains of Foraminifera were present in nearly every sample of the bottom. At one station the mud appeared nearly black, while at one other a sample of yellow mud was obtained.

Lying 279 miles west-southwest (S. 66° W. true) from Cape Flattery, Gibson Bank was discovered with a surrounding depth of over 1,500 fathoms. It was first located at a depth of 635 fathoms, and at an interval of 2 miles the minimum depth of 525 fathoms was obtained. Two miles farther the depth increased to 830 fathoms and after a run of 25 miles to 1,600 fathoms. A series of soundings were made around the 525-fathom depth with the result that no bottom was found at 700 fathoms. From all indications Gibson Bank is an isolated submarine peak with a summit less than 2 miles in diameter. The same brown ooze which predominates over this section outside the 1,000-fathom curve is found covering Gibson Bank. Specimens of Foraminifera (*Globigerina*) are present, but not in sufficient numbers to warrant characterizing the bottom as *Globigerina* ooze. The discovery of this bank adds strength to the rumors of shoal water lying off Cape Flattery and off Cape Scott, the northern

end of Vancouver Island, and it is possible that a bank or banks of greater or less extent exist off the northwest coast.

Grays Harbor section.—Good halibut bottom should be found in this region, although soundings at this time failed to indicate such a place. The following paragraph is taken from the report on the 1914 survey:^a

Off Grays Harbor the continental shelf, which here attains a width of 25 to 30 miles, is covered from shore outward to between the 40 and 50 fathom curves with fine gray sand, and beyond that line out into deep water is composed almost uniformly of green mud. An outcrop of shale was found on one sounding about 25 miles west of Point Chehalis. In the vicinity of Chehalis Bank, reported by Capt. Tanner, the soundings increased regularly in depth offshore, and showed nothing but green mud from the 46-fathom mark to a depth of 64 fathoms and doubtless beyond that. To the northward of this reported bank, and between 10 and 15 miles offshore, a patch of gravel bottom was found in 38 to 40 fathoms.

The patch of gravel mentioned in the latter part of the above extract was relocated during the present investigation and found to be at least 6 miles in diameter. Between this and the 100-fathom line the bottom was found to be composed of fine gray sand or of green mud.

An extensive ledge of hard and granular shale lies along the 100-fathom line 31 miles west of Point Chehalis. In the same locality an outcrop of hard, rocky shale covered the bottom at a sounding of 279 fathoms.

From 35 to 40 miles northwest of Point Chehalis the bottom is very irregular, dropping from 77 fathoms in depth to over 200 fathoms within a distance of a mile. The depths on a line of soundings at 1-mile intervals proved to be $\overline{200}$, 115, 110, $\overline{200}$, $\overline{200}$, and 77 fathoms.^b

With the exception of the spots tabulated below, the bottom was found to be composed mainly of green mud or of gray or black sand of varying degrees of coarseness. At one sounding, 37 miles northwest of Grays Harbor, a sample of fine white sand with a few black specks was obtained.

There were located in this section 14 patches of good or favorable halibut bottom. In fact, good bottom may be found everywhere along the 100-fathom line between the depths of 90 and 115 fathoms. Perhaps the most promising locality is at the northern limit of operations along the southeast ridge of the deep channel which separates Flattery Bank from the coast of Washington. The bottom here is of coarse gravel, rocks, and coarse sand. A tabulated list of the most favorable bottoms follows, with location and the character of the bottom:

^a Survey of the fishing grounds on the coasts of Washington and Oregon in 1914. Bureau of Fisheries document no. 817, p. 13.

^b The character $\overline{}$ means no bottom found at the depth indicated.

TABLE 1.—GOOD HALIBUT BOTTOMS IN GRAYS HARBOR SECTION.

No. ^a	Bearings.	Distance.	Character of bottom. ^b	Approximate area.
		<i>Miles.</i>		<i>Sq. miles.</i>
1	WSW. $\frac{1}{2}$ S. (S. 60° W.) from Umatilla Lightship.	21	G; crs bk S; crs and fine gy S; R; gn M.	18
2	SSW. (S. 22° W.) from Umatilla Lightship.	25	fine bk G; gn M; gran Shale.....	1
3	SSW. $\frac{1}{4}$ S. (S. 18° W.) from Umatilla Lightship.	31	G; fine bk S.....	1
4	S. by W. (S. 12° W.) from Umatilla Lightship.	37	G; bk S; Sh; gy S; gn M.....	16
5	S. $\frac{1}{4}$ W. (S. 4° W.) from Umatilla Lightship.	39	G; crs bk S.....	1
6	NW. by W. (N. 54° W.) from Grays Harbor Light.	37	crs bk S; gn M.....	1
7	WNW. (N. 65° W.) from Grays Harbor Light.	39	G; crs and fine gy and bk S.....	3
8	WNW. (N. 68° W.) from Grays Harbor Light.	35	G; Sh; fine gy S; gn M; crs and fine bk S.....	3
9	WNW. $\frac{1}{2}$ W. (N. 73° W.) from Grays Harbor Light.	37	G; crs bk S; fine gy S; gn Shale.....	1
10	WNW. $\frac{1}{4}$ W. (N. 75° W.) from Grays Harbor Light.	34	G; bl M; crs bk S; fine gy S.....	1
11	W. by N. (N. 80° W.) from Grays Harbor Light.	33	fine G; fine gy S.....	3
12	NW. (N. 46° W.) from Grays Harbor Light.	22	crs bk S.....	1
13	WNW. (N. 65° W.) from Grays Harbor Light.	16	crs G.....	40
14	W. by S. $\frac{1}{4}$ W. (S. 83° W.) from Grays Harbor Light.	31	G; crs bk S; fine gy S; gran Shale....	16

^a Numbers refer to areas on chart 2.^b Abbreviations descriptive of the bottom: G, gravel; crs, coarse; bk, black; S, sand; fine, fine; gy, gray; R, rock; gn, green; M, mud; gran, granular; Sh, shell; bl, blue.

Columbia River section.—This section includes the region from Willapa Bay to Tillamook Bay. Off Willapa Bay a uniform bottom of fine gray sand predominates out to the 100-fathom line, beyond which there are occasionally found small areas of coarse black sand, blue mud or shale, and in one instance granular shale. Granular shale appears as a pseudogravel, but the nodules can be easily pressed together in the hands.

Twelve miles west of Cape Disappointment is the eastern end of a long, narrow gully which extends to the westward approximately 12 miles and which is 3 to 4 miles wide and 150 fathoms deeper than the inclosing ridges. The floor of this gully is covered with green mud, while the continental shelf to the north and east is regularly composed of fine gray sand. From the Columbia River southward the gray sand is replaced by green mud with a trace of gray sand which can not be detected until the mud is washed away. Along the south ridge of this gully several successful catches of halibut have been made during the spring of this year. Soundings here showed an outcrop of shale. Trials upon the north ridge would probably show that region to be worth fishing upon a large scale. Five outcrops of shale were found in this area, along the 100-fathom line. In fact, each time a line of soundings crossed the 100-fathom curve, hard blue mud or shale was obtained.

In May, 1915, a halibut bank was reported as lying 16 miles nearly southwest from the Columbia River Lightship in 80 fathoms. That this is a small patch is probable, as soundings made in this locality failed to discover any good fishing ground.

The report of the 1914 investigation says of the area within the 60-fathom line:

On the fine gray sand within the 60-fathom curve, about 9 miles south of Tillamook Rock, a small patch of shale resembling hard mud was discovered, but an attempt to relocate it later proved unsuccessful. Between Cape Falcon and Tillamook Bay coarse gray sand was found on a single sounding, in 32 fathoms. From all indications it is doubtful if halibut will be found here in paying quantities, although it is the most promising bottom found off Tillamook. * * * The bottom throughout the Tillamook section seems to be generally unfavorable for halibut, though it supports a great many of the smaller flatfishes and other, at present, less marketable species.^a

The positions and character of bottom of the most favorable patches of bottom are tabulated below. It will be seen that they are all small.

TABLE 2.—GOOD HALIBUT BOTTOMS IN COLUMBIA RIVER SECTION.

No. ^a	Bearings.	Distance.	Character of bottom. ^b	Approximate area.
		<i>Miles.</i>		<i>Sq. miles.</i>
15	W. from Cape Shoalwater Light.....	32	gn M; Shale	1
16	S. by W. (S. 9° W.) from Cape Shoalwater Light.	24	hrd bl M	3
17	W. by N. $\frac{1}{2}$ W. (N. 85° W.) from Columbia Lightship.	12	bl Shale	2-4
18	SW. $\frac{1}{4}$ W. (S. 50° W.) from Columbia Lightship.	16	gn M	Reported.
19	WSW. (S. 70° W.) from Columbia Lightship.	17	bl M; fine G	1
20	WSW. $\frac{1}{4}$ W. (S. 73° W.) from Columbia Lightship.	22	bl M; gran Shale	1
21	SW. by W. (S. 58° W.) from Columbia Lightship.	21	bl M; gran Shale	1
22	W. (N. 88° W.) from Tillamook Rock Light.	25	G; gran Shale	1
23	W. by S. $\frac{3}{4}$ W. (S. 87° W.) from Tillamook Rock Light.	22	rky Shale	3
24	W. by S. $\frac{1}{4}$ W. (S. 82° W.) from Tillamook Rock Light.	23	bk S; gran Shale; rky G	2
25	W. by S. $\frac{1}{4}$ W. (S. 84° W.) from Tillamook Rock Light.	26	fine G	1
26	W. by S. (S. 78° W.) from Tillamook Rock Light.	28	gran Shale; bk S	4
27	SW. (S. 46° W.) from Tillamook Rock Light.	26	G	1
28	SW. $\frac{1}{4}$ S. (S. 40° W.) from Tillamook Rock Light.	9	Shale; hrd M	1
29	SW. by S. (S. 64° W.) from Tillamook Rock Light.	27	Shale; hrd M	2

^a Numbers refer to areas on chart 3.

^b Abbreviations descriptive of the bottom: G, gravel; gn, green; M, mud; hrd, hard; bl, blue; fine, fine; gran, granular; rky, rocky; S, sand; bk, black.

Tillamook section.—Along the edge of the continental shelf in the northern part of this section are found the Miocene shales which showed in numerous outcroppings in the Columbia River and Grays Harbor sections. The whole of this section and south to Cape Foul-

^a Survey of the fishing grounds on the coasts of Washington and Oregon in 1914. Bureau of Fisheries document no. 817, p. 14.

weather is barren of possible fishing grounds; only two spots were located. The continental shelf, 30 miles wide off Tillamook Head on the north narrows to 12 miles off Cape Kiwanda in the south and is covered throughout with green mud.

West of Tillamook Rock, 25 to 30 miles, was discovered an area of gravel, coarse sand, blue mud, and granular shale. A small patch of gravel bottom was located 22 miles west of the mouth of Nehalem River. Near Cascade Head there is a patch of fine gravel in 42 fathoms, near which, in 1914, a good scallop catch was made.

Newport section.—The Tillamook section marked the southern limit of the 1915 investigation, but for completeness a brief description of the Newport, Heceta Bank, and Coos Bay sections is taken from the report on the 1914 survey:

Between Yaquina and Alsea Bays and about 12 miles offshore, a ridge was discovered on which 30 fathoms was the minimum sounding made by the *Albatross*, although Capt. Carrol, until recently of the *Decorah*, reports that he made one sounding of 20 fathoms in this vicinity. This ridge is the outer wall of a submarine valley having, so far as sounded, an extreme depth of 47 fathoms, shoaling at its mouth to 42 fathoms and merging with the flat of the continental shelf at the 50-fathom curve. On both sides of the ridge, and principally at the upper end of the submarine valley formed by it, the late summer run of halibut, developed by this survey, was found. The bottom across the head of the valley and through the greater extent of its floor is of coarse gray sand, carrying a very rich growth of such organisms (sea anemones and pennatulids) as are typically found on good halibut bottom.

Over the ridge and principally on its northwestern and southern slopes is found what has been designated as broken bottom—composed of materials of a mixed character, shale, gravel, sand, and mud—in patches varying in size and composition, but all very rich in bottom-living organisms. On the western slope is a patch of coarse gray sand and another of gravel, apparently of considerable extent, though no great number of soundings were made there. On this patch a good lot of fish were taken.

Heceta Bank section.—Similar to the ridge off Newport, but larger and in somewhat deeper water, there is a large, roughly triangular plateau called Heceta Bank, between 25 and 30 miles offshore to the southwestward of Heceta Head. It is composed largely of shale too hard for good halibut bottom, while the submarine valley formed by it is too soft, having a bottom of soft green mud. Several patches each of broken bottom and black sand occur both on the flat of the bank and on the offshore slopes. The most promising broken bottom is in the vicinity of set xi, where a lot of fish were taken in the spring of the year (set i). Black sand is considered good black cod bottom and on one patch of it (set x) a fair catch was made.

Between Heceta Bank, Alsea Bay, and Heceta Head is a large area of fine gray sand which below Heceta Head is encroached upon by the green mud of the submarine valley formed by Heceta Bank. Off the mouth of the Siuslaw River is a small isolated patch of gravel surrounded by fine gray sand. The mud line trends in from the 70-fathom line toward the Umpqua River, where it reaches the 30-fathom curve less than $2\frac{1}{2}$ miles offshore. Another gravel patch about 7 miles below the Umpqua River lies within this mud area but 6 miles from shore, and south of this the mud recedes until it lies beyond the 70–80-fathom line 10 miles off Coos Bay.

Coos Bay section.—In a line between the Umpqua River and Coos Bay, three sets (xxvii, xxix, and xxx) were made on fine gray sand, which occurs everywhere in this region inshore of the mud. As developed by the above sets, this sand bottom

seems to carry a thin surface film of mud or else the line of demarcation between the two extends much nearer shore than has been shown either by the chart or by the soundings.

Southward of Coos Bay, extending well toward the Coquille River, is a comparatively extensive outcrop of shale, rich in bottom organisms, in which the soundings developed two areas of good halibut bottom, fine gravel. The soundings, together with the yield of set XXVIII, seem to indicate that more detailed examination might locate areas of so-called broken bottom, which is more productive of fish than shale alone.^a

DISCUSSION OF THE SETS.

On account of the fact that the fishermen of Seattle were willing and desirous of testing any new halibut ground if its location and character were given them, and because of the limited time available for the survey (two and one-half months), it was considered more practicable to make a small number of fishing trials and to spend all of the time in locating new banks. Consequently four practical fishermen were taken on the first trip and four trial sets were made. Two fishermen were taken on the second trip, but no halibut bank was discovered (the trip was offshore in deep water) and no sets were made. On the third trip no fishermen accompanied the vessel except the expert fishermen, who remained during the whole survey.

Arrangements were made to carry, in the ship's refrigerator, enough fresh frozen bait for one trip. Fresh salmon could not be obtained at a reasonable price at the time bait was purchased, but some excellent frozen herring were secured and a reserve supply of salt herring was carried. Fresh salmon has been found to be a better halibut bait than herring, the better results warranting the payment of a higher price.

An 8-line trawl, carrying about 250 hooks spaced 9 feet apart, was used in the same manner as is customary among the commercial fishermen. The sets were all double-banked and made with two skates of line. The trials each lasted an hour. While the set was being made the surface and bottom temperatures were taken; surface and bottom water samples secured; and tow net hauls made with nets of three sizes of mesh.^b

The results of the four fishing trials are shown in table 3 together with the locations of the sets. The bearings are given as a fisherman would give them.

Set I.—On July 21, SW. by W. $\frac{1}{2}$ W. (magnetic) 19.1 miles from Destruction Island, a bottom of gravel and coarse black sand was found in 88 fathoms. A set of one hour resulted in five halibut, weighing 22, 32, 44, 48, and 50 pounds, respectively, all being first-class fish. The 50-pound fish was a male and the rest females. A blue shark 83 inches long and weighing 64 pounds and one cultus cod 42 inches long were caught. Black cod were abundant (44 taken)

^a Survey of the fishing grounds on the coasts of Washington and Oregon in 1914. Bureau of Fisheries document no. 817, p. 14

^b No. 000 grit gauze; no. 12 and 20 bolting silk.

and red rock cod numerous, 29 being taken on the trawl. Dogfish and blue sharks occurred in moderate numbers.

Set II.—On July 21, W. by S. $\frac{1}{3}$ W. 21.8 miles from Destruction Island, a bottom of gravel, gray and black sand, shells, and green mud were found. The next day the spot was located and a trial made in 101 fathoms. Eight halibut were taken, two being males weighing 46 and 26 pounds. As in sets I and III the largest halibut proved to be males, although in the four sets 14 females and 4 males were taken. Black cod were exceptionally numerous and of a large size, 71 being caught, 1 of which weighed 36 pounds. In this set 20 dogfish and 19 blue sharks were secured. A small stone covered with worm casts, sponges, etc., was brought up on the trawl.

Set III.—Too late to make a set on July 23, a patch of good halibut bottom was found in 99 to 124 fathoms W. by S. $\frac{1}{2}$ W. 31 miles from Grays Harbor Light. On July 24 a set was made on the edge of this patch in 98 fathoms where the sounding lead showed as fine green sand. The offshore ends of the two trawls evidently fell on a gravel bottom, because both of them brought up small stones the size of ducks' eggs and covered with organic remains. But 2 halibut were obtained on this set, 1 on each trawl, weighing 22 and 24 pounds, respectively, the latter being a male. A number of other fish, 21 black cod (9 young), 7 blue sharks, 2 dogfish, 3 arrow-toothed halibut, and 1 flounder, were caught.

Set IV.—On July 22 good bottom of gravel and coarse sand, together with a little green mud, was found on the southern ridge of the deep channel which separates Flattery Bank from Capo Flattery. A set was made on this ridge on July 27, SW. by W. 20.7 miles from Umatilla Lightship. Three halibut were secured weighing 94, 55, and 30 pounds, all females. About 150 black cod weighing 40 to 50 pounds, 10 dogfish, and 8 blue sharks were caught. The black cod, according to the fishermen, were the largest and most numerous they had ever seen. Only one trawl could be hauled in; the other was bitten off at both ends by sharks as soon as the haul in was started. Many of the black cod were cut in two by the sharks, numbers of which continually swam around the ship at the surface of the water. From the number of birds ("black hags," gulls, etc.), whales, and sharks, the proximity of good feeding grounds was plainly evident.

TABLE 3.—LOCATIONS AND RESULTS OF HALIBUT FISHING TRIALS OFF THE COASTS OF WASHINGTON AND OREGON BY THE STEAMER "ALBATROSS," 1915.

Set No.	Position. (All bearings magnetic.)	Date.	Depth.	Character of bottom.
I	SW. by W. $\frac{1}{3}$ W. (magnetic) distant 19.1 miles from Destruction Island.	1915. July 21	<i>Fms.</i> 88	Gravel, coarse black sand.
II	W. by S. $\frac{1}{3}$ W. distant 21.8 miles from Destruction Island.	July 22	101	Gravel, green mud, fine-gray sand.
III	W. by S. $\frac{1}{3}$ W. distant 31 miles from Grays Harbor Light.	July 24	98	Fine green sand.
IV	SW. by W. distant 20.7 miles from Umatilla Lightship.	July 27	95	Gravel, fine and coarse gray sand.

TABLE 3.—LOCATIONS AND RESULTS OF HALIBUT FISHING TRIALS OFF THE COASTS OF WASHINGTON AND OREGON BY THE STEAMER "ALBATROSS," 1915—Continued.

Set No.	Number of skates of gear used.	Duration of set.	Bait.	Fish taken (catch).					
				Halibut (<i>Hippoglossus</i>).					
				Number taken.	Range of size.	Total weight.	Average weight.	First class (between 11 and 80 lbs.).	Average weight of first class.
I	2	1	Live herring, frozen.	5	Inches. 22-50	Pounds. 196	Pounds. 39.2	5	Pounds. 39.2
II	2	1	do.....	8	10-46	225	28.1	7	30.7
III	2	1	do.....	2	22-24	46	23.0	2	23.0
IV	2	1	do.....	3	30-94	179	59.7	3	59.7

Set No.	Fish taken (catch)—Continued.									Addenda.
	Dogfish (<i>Squalus sucklini</i>).	Blue shark (<i>Prionace glauca</i>).	Skates (<i>Raja binoculata</i>).	Rock salmon (<i>Sebastes paucispinis</i>).	Red rock cod (<i>Sebastes ruberrimus</i>).	Blackcod (<i>Anoplopoma fimbria</i>).	Cutlus cod (<i>Ophiodon elongatus</i>).	Sole (<i>Eopsetta jordani</i>).	Flounder (<i>Parichthys melanostictus</i>).	
I	7	6	.....	1	29	44	1	.....	.....	Double-banked set; 4 females, 1 male halibut; 1 blue shark 83 in. long, 64 lbs.; 1 cultus cod, 42 in. long.
II	20	19	1	1	1	71	1	1	.....	2 Double-banked set; 6 females, 2 males; 1 black cod, 36 lbs.; 1 small stone with worm casts, sponges, etc., attached.
III	2	7	.....	.....	.....	21	.....	.....	1	3 Double-banked set; 1 female, 1 male; a large sea anemone; 3 rocks, size of duck's egg, covered with organic remains.
IV	10	8	.....	.....	.....	150	.....	.....	.....	All females; many black cod exceptionally large (40-50 lbs.); many indications of a good halibut bank; birds dipping over water, many sharks, whales, etc., 1 line bit off at both ends by sharks and lost.

YIELD OF THE BANKS.

On July 25, while at anchor off Grays Harbor buoy, handlines were used for about an hour and a half and 150 hake (*Merluccius productus*), 2 dogfish, 1 rockfish (*Sebastes pinniger*), and 3 "sole" (*Eopsetta jordani*) were caught. The hake proved unpalatable, the flesh being watery and tasteless.

Food of the halibut.—Just over the edge of the continental shelf, where the water rapidly deepens, will be found many strips of gravel, rocky or broken bottom. It is on these patches that halibut are found. Many of the fishermen think that there is a seepage of fresh water which carries away the mud and fine sand and which attracts

the bait and the halibut themselves. On such a bottom will be found growing sea anemones, pennatulids, crabs, starfish, and other organisms which form part of the food of the halibut.

Mr. Thompson ^a says of the food of the halibut:

The food of the halibut is well known to exhibit great variety, but the data recently collected indicate that it differs widely on different banks and may be quite limited in any given locality. The range of food has been found to include crabs, sea-anemones, starfish, sand-lance (*Ammodytes personatus*), dogfish (*Squalus sucklii*), ratfish (*Chimara*) (*Hydrolagus*) (*collicii*), Cyclogasterids (of determined species), the arrow-toothed halibut (*Atherestes stomias*), octopi, gray cod (*Gadus macrocephalus*), salmon (*Oncorhynchus kisutch*), and even occasional red cod (*Sebastes*). It is here deserving of remark that the crabs and the gray cod form the vast bulk of the food on many banks, while on at least one the halibut used mainly the sand-lance. The crabs and sand-lance were eaten by halibut of small size generally in shallower line. Thus, in 90 fathoms off Middleton Island, of 130 stomachs, 59 per cent were empty, 39 per cent had gray cod, 2 per cent had crabs and the arrow-toothed halibut. * * * Usually but a single kind of food was found identifiable in a single stomach, although this was far from being a rule. A large quantity of the particular kind of food is usually found, indicating that the halibut has not moved so rapidly as to leave the type of bottom on which it was found before the food caught was digested. The presence of small worms serves to indicate the capacity the halibut has for picking up minute foods.

The problem of the mushy halibut is one that must be solved in the near future. As much as 50 per cent of the fish, when delivered at the market, have been found to be mushy and, hence, unsalable. At the time they are caught the affected fish can not be separated from the good fish, but after being on ice for some time the meat becomes soft and can easily be shaken from the bones.

There are two kinds of mushiness—milky halibut and white-meated halibut. In the former case (milky) the meat will become soft and falls away from the skin and bones. In the latter variety (white-meated) there will be found running through the white flesh what might be called lean meat. When culling fish a small gash is made in the tail whereby the condition of the meat is made apparent. Sometimes only part of the fish is mushy; the tail may be mushy and the body good, and again the reverse may be true. As to the cause of this condition of the halibut, nothing but theories has been advanced up to the present. The Bureau has the matter under investigation.

In addition to the halibut, black cod (*Anoplopoma fimbria*) was found to be abundant at all points between Grays Harbor and Flattery Bank. Near Flattery Bank exceptionally large ones occurred in great abundance. The survey of 1914 reported that, from all indications, black cod could be fished in the deep water just off the southern and western slopes of Heceta Bank. Fresh black cod is a good table fish and in some places it is considered a delicacy.

^a A preliminary report on the life history of the halibut. Report of the Commissioner of Fisheries for the Province of British Columbia, for the year ending December, 1914; also a Progress Report in the Canadian Fisherman for December, 1915.

The rock cods or rockfishes occur abundantly over the whole region surveyed in 1914 and 1915. The halibut fishermen do not take these fish, of which there are many species, but small local boats take and market them.

At San Francisco several companies carry on large fishing operations for flounders and sole, but farther north the interest lies with salmon, halibut, etc. While making dredge hauls for scallops during 1914, flounders were taken in great quantities and to all appearances were in greater abundance than off San Francisco Bay. This should prove a profitable industry if properly taken up.

During the latter part of June and the first half of May practically the whole of the Seattle fishing fleet were fishing off the Columbia River. It is reported that 2,000,000 pounds of halibut were taken at that place. From 50 to 60 boats could be seen at one time fishing on an area not over 2 miles square. Prince Rupert and Vancouver boats also visited this bank. As the percentage of mushy fish increased from a nominal percentage at first to 50 per cent of the catch, the fleet moved north to Hecate Strait and landed its fares at Prince Rupert.

But three schooners have fished south of Cape Flattery since that time: The *America* took 40,000 pounds, 50 per cent of which were mushy; the *Daisy* landed at Prince Rupert a fare of 20,000 pounds, the percentage of mushy fish was not reported; and the *Mary* took 5,000 pounds early in September, reporting that there were not nearly the number of fish on the Newport Bank as there were in 1914. The *Daisy* reported that there were "quite a few fish off Newport."

In the accompanying table a comparison is made of the amount of fish taken from the banks off the coasts of Washington and Oregon during the years 1914 and 1915. There are no records available for May, 1915, or October, November, and December, 1914.

TABLE 4.—QUANTITY AND VALUE OF HALIBUT CAUGHT BY THE COMMERCIAL FISHERMEN OFF THE COASTS OF WASHINGTON AND OREGON DURING THE SEASONS OF 1914 AND 1915.

Month.	1914			1915		
	Number of trips.	Catch.	Value.	Number of trips.	Catch.	Value.
		<i>Pounds.</i>			<i>Pounds.</i>	
May.....	2	18,200	\$683.00	(a)	(a)	(a)
June.....	1	22,800	684.00	63	1,620,000	\$85,511.50
July.....	5	119,500	5,098.75	4	13,000	937.50
August.....	6	186,800	6,925.50	2	5,200	285.50
September.....	7	271,000	10,255.00	6	38,000	2,037.00
October.....	(a)	(a)	(a)	1	1,930	135.10
November.....	(a)	(a)	(a)	0	.....	.....
December.....	(a)	(a)	(a)	1	5,000	375.00
Total.....	21	618,300	23,646.25	77	1,683,130	89,281.60

^a The returns for the months of October, November, and December, 1914, and May, 1915, are not available but they are probably small.

SUMMARY.

Along the edge of the continental shelf, in depths from 80 or 90 to 120 fathoms, good or favorable halibut bottom is found in many small patches. Between Grays Harbor and Flattery Bank these patches are more numerous than in the region south of the Columbia River. South of Tillamook Bay there are very few spots of good bottom. These patches do not hold the schools of fish for any length of time, and the largest of them can be cleared of halibut in a few trips by the fishing fleet.

In the region under consideration the schools of halibut appear to arrive at the banks from a westerly or northwesterly direction, and this, taken into consideration with the rumors of shoal water offshore, would seem to indicate the possible presence of banks farther out to sea than any now known. The discovery of Gibson Bank would seem to lend support to such a belief. It is desirable that a thorough survey be made.

Black cod occur in great numbers along the coast of Washington and should support a large fishery if a demand can be created for this species. Rock cod should also be marketed. Dogfish occur in large numbers and might be utilized as fertilizer. The smaller flatfishes, flounders, sole, sand dab, etc., are also found in great abundance.

EXPLANATION OF CHARTS.

The charts accompanying this report are sections of those issued by the Coast and Geodetic Survey, to which have been added all the soundings made by the steamer *Albatross* in the years 1914 and 1915. Near the figures representing the depths obtained, and near many of those contained in the original chart, have been entered the bottom characterizations for that locality. The positions of these soundings are accurate, as in most of the cases at the time of sounding land was in sight from which bearings could be secured. All doubtful figures have been discarded.

As little or no fishing is done inside the 30-fathom curve, the depths and bottom characterizations have been omitted from between that curve and the shore. The 10, 20, 30, 50, and 100 fathom contour lines are included after being changed to conform with the soundings made in this investigation. The lighthouses and other positions on shore from which bearings were taken have been indicated.

Areas of bottom favorable for halibut are inclosed by heavy dashes and numbered with Roman numerals. Tables 1 and 2 contain the information pertaining to these areas. The character— means that no bottom was found at the depth indicated. A table for abbreviations used is shown on each chart.

1. The first part of the paper
is devoted to a general
survey of the subject.
2. The second part
contains a detailed
account of the
experiments which
have been made
in connection with
the subject.

Wm. H. R. R. R.

Wm. H. R. R. R.

COAST OF WASHINGTON
CAPE FLATTERY
TO
GRAYS HARBOR

Scale of Nautical Miles

AREAS ENCLOSED BY HEAVY DASHES ARE PATCHES
OF BOTTOM FAVORABLE FOR HALIBUT.

Note.
Base map C & G.S. Chart No. 6400.

Abbreviations

- Cl ----- Clay
- Co ----- Coral
- G ----- Grovel
- M ----- Mud
- P ----- Pebbles
- S ----- Sand
- Sp ----- Specks
- Sh ----- Shale
- St ----- Stones
- For ----- Foraminifera

Abbreviations

- bk black
- bl blue
- brk broken
- crs coarse
- dk dark
- fine fine
- gn green
- gran granular
- gy gray
- hd hard
- rd red
- rk rocky
- wh white
- yl yellow

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