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RECOMMENDATIONS AS TO MINIMUM MARKET SIZE FOR GEORGES BANK HADDOCK AND MINIMUM MESH SIZE FOR OTTER TRAWLS CATCHING SUCH FISH[1]

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In previous reports (Herrington 1935, 1936, 1941; Walford and Schuck 1947 at Atlantic States Marine Fisheries Commission meeting) it has been concluded that preventing the destruction of baby haddock on the New England banks would result in a substantial increase in the total poundage produced by any year class and would also increase the spawning stock of this fishery. It has also been concluded that a larger mesh size in otter trawls would, in large part, prevent the catching of baby haddock. Inasmuch as otter trawls of a certain size mesh are not perfectly selective, and inasmuch as any mesh size that is likely to be adopted is still capable of taking many baby haddock, at times in large numbers, it has been agreed that a minimum legal size of haddock to be landed should be adopted in addition to a minimum mesh size. The minimum mesh size will prevent the catch of most small haddock and the minimum legal size of fish will discourage efforts and remove the incentive to concentrate in places and at times where some baby scrod could still be caught in spite of the larger mesh.

The most feasible method of preventing the destruction of baby haddock thus would consist of a two-fold measure:

a. A strictly enforced legal minimum market size of haddock.
b. The use of larger mesh in all offshore otter trawls, except those fishing for redfish, whiting and red hake.

To determine a satisfactory combination of minimum mesh size and minimum legal fish size for haddock requires considerable study. The problem appears to be reduced logically to three parts:

I What sizes of Georges Bank haddock should be protected?

II What mesh size will normally result in a reasonable protection of these sizes?

III What sizes should the industry be allowed to land: i. e., what legal size and what amount of tolerance would be most satisfactory?

This subject will be considered according to three problems.

1/ Presented in summary form by Dr. L. A. Walford at the annual meeting of the Atlantic Coast Fishery Commission, July 18, 1947, New York.

PART I. WHAT SIZES OF GEORGES BANK HADDOCK SHOULD BE PROTECTED?

In regard to the size to which baby haddock on Georges Bank should be protected, it is possible to compute the benefits, in terms of poundages available and value in dollars to the fishery, of leaving 1-year-old baby scrod on the Bank to the ages of 2, 3, 4, 5, and 6 years. The figures shown in Table 1 are for revised growth-rate determinations. They assume an initial stock of 50,000,000 1-year-old haddock and a 10 percent natural mortality of haddock annually. The values in dollars are based on the 1945 values to the fishermen at the ports of Boston, Gloucester, Portland, and New Bedford of:

3.14 cents a pound for round scrod haddock (1- and 2-year olds)
7.33 cents a pound for round scrod haddock (3-year-olds)
7.91 cents a pound for large haddock (4-, 5-, and 6-year olds)

Table 1.--Data showing the benefits of leaving 1-year-old baby scrod haddock on Georges Bank to the ages of two, three, four, five and six years.

Age	Average length	Average weight	Quantity of fish		Value of fish	Annual increase in value
			By number	By weight		
years	inches	pounds		pounds	dollars	percent
1	7.6	0.16	50,000,000	9,500,000	298,300	--
2	13.0	0.80	45,000,000	42,300,000	1,328,220	345
3	16.6	1.56	40,500,000	63,180,000	4,631,094	249
4	20.2	2.66	36,450,000	96,957,000	7,669,299	66
5	21.7	3.34	32,805,000	109,568,700	8,666,884	13
6	23.3	4.10	29,524,500	121,050,450	9,575,091	10

Considering the total and percentage increase in value, it can be seen that the protection of baby scrod from 1 to 2 years of age may result in an increase of 345 percent; protection from 2 to 3 years of age may result in an increase of 249 percent; and protection from 3 to 4 years of age may result in an increase of 66 percent. There appears to be good reason to protect baby haddock until the end of their third year, but relatively little advantage to protect them until the end of their fourth year.

Although the cull of haddock, as recognized by the New England Fish Exchange, lists scrod (the smallest recognized category of haddock) as from 1-1/2 to 2-1/2 pounds (gutted weight), at the present time numbers of baby haddock as small as 1/2 pound are landed.

If 1/2-pound (round weight) baby scrod were protected until they had reached a weight of 1.56 pounds (age 3 years) the result would be about 63,180,000 pounds of scrod at the value of 7.33 cents a pound, rather than about 24 million pounds of low-priced (3.14 cents a pound) round scrod, or an overall increase of about 39,180,000 pounds or about $3,900,000. This would be an increase of 515 percent in value.

It appears efficient to protect haddock until they have attained an average weight of 1.5 pounds, which corresponds to a length of about 16-1/2 inches or 42 centimeters (fork length). This size is usually attained by the average Georges Bank haddock at the completion of its third year of life, which occurs in the spring (March). Such protection would, in addition to producing a much greater poundage from any year class, result in many more of the year class spawning at least once (most Georges Bank haddock spawn at the end of their third year).

It should be realized that, although the average length of fish at the end of the third year of life is about 16-1/2 inches, many of the fastest growing fish will attain 16-1/2 inches before the completion of the third year, and thus be available. This partial availability of 3-year-olds will also vary between years, as there is some difference in the growth rate to the end of the third year in different years.

PART II. WHAT MESH SIZE WILL NORMALLY RESULT IN A REASONABLE PROTECTION OF THESE SIZES?

The second main problem is to decide what mesh size will best serve to protect the majority of haddock of 1-1/2 pounds (gutted weight) and under and still capture most of the haddock 1-1/2 pounds and larger.

If the selection of various sized fish by mesh of various sizes in otter trawls were sufficiently precise, then it would be possible to select the mesh size that would release 100 percent of all fish less than 1-1/2 pounds and retain 100 percent of all fish of 1-1/2 pounds and larger. Unfortunately, net selection is not as precise as this, i.e., the mesh size which will release 100 percent of all fish below 1-1/2 pounds will also release a considerable number of fish of 1-1/2 pounds and larger; and a mesh size that will retain 100 percent of all 1-1/2 pound fish will capture a considerable number of under-sized fish, also. (1-1/2 pound haddock average 42 centimeters or 16-1/2 inches in length).

There are some data available on the effect of various sizes of mesh in cod-ends of otter trawls upon the size of fish captured or released (Herrington 1935). The rest of this part consists of a study and summary of data presented in this publication.

The available data were confounded by several factors such as differences between measurements of new and used mesh, and between measurements representing inside knots and between knot centers. Corrections were made for these factors and all measurements of mesh size, where possible, were expressed in terms of inside knots after use. The effect of the various mesh sizes on the size of fish captured (of those entering the net) was expressed as follows:

X = stretched mesh inside knots after use, in inches
Q_1 = the size of fish in centimeters of which 25 percent of those entering the net are retained
Mdn = the size of fish in centimeters of which 50 percent of those entering the net are retained
Q_3 = the size of fish in centimeters of which 75 percent of those entering the net are retained

The tabulation of these original data is as follows:

Mesh size	Q_1	Mdn	Q_3
1.5 In.	13.2 cm.	14.7 cm.	16.3 cm.
2.0	15.3	15.3	16.8
2.3	17.3	19.1	20.4
2.8	18.7	20.8	22.3
2.5	21.5	23.7	26.0
2.0	23.1	25.0	26.7
3.0	25.0	26.9	29.0
3.8	35.7	38.4	41.6
4.1	38.8	42.6	46.6
4.1	39.0	41.6	44.1
4.7	39.0	43.0	48.0
4.1	38.7	42.3	45.8
3.9	38.7	42.0	46.0

For the purposes of estimating, for any mesh size, the sizes of fish that would be captured or released, regression lines for the relationship between

(X) and Q_1, between
" " Mdn, and between
" " Q_3

were computed by the method of least squares. The resultant equations are as follows:

$$Q_1 = -2.20 + 9.62X$$
$$Mdn = -2.69 + 10.55X$$
$$Q_3 = -3.22 + 11.55X$$

Solving for a wide range of mesh sizes (X), that appear to be usable from the viewpoint of conserving small haddock, i.e., meshes of 3-3/4, 3-7/8, 4, 4-1/8, 4-1/4, 4-3/8, 4-1/2, 4-5/8, 4-3/4, and 4-7/8 inches, the following values are obtained.

Mesh size X	Q_1	Mdn	Q_3
3-3/4" or 3.75"	33.9 cm.	36.9 cm.	40.1 cm.
3-7/8 " 3.88	35.1	38.2	41.6
4 " 4.00	36.3	39.5	43.0
4-1/8 " 4.13	37.5	40.9	44.5
4-1/4 " 4.25	38.7	42.2	45.9
4-3/8 " 4.38	39.9	43.5	47.4
4-1/2 " 4.50	41.1	44.8	48.8
4-5/8 " 4.63	42.3	46.2	50.3
4-3/4 " 4.75	43.5	47.4	51.6
4-7/8 " 4.88	44.8	48.8	53.1

With Q_1, Mdn, and Q_3, it is possible, knowing the general shape of the selection curves, to estimate the complete selection curve for any given mesh size, i.e, the percent of fish of any particular size entering the net that are captured. Thus, for the 4-5/8-inch mesh, in addition to the value of 25 percent capture for 42.3 cm. fish, 50 percent for fish of 46.2 cm., and 75 percent for fish of 50.3 cm., it is calculated that about 5 percent of fish of 38 cm., 10 percent of 39 cm. fish, and 15 percent of 40 cm. fish would be captured.

Considering only the meshes of 4-1/2, 4-5/8, and 4-3/4 inches, it is estimated that approximately the following sizes of fish would be captured (percent of fish of that size that enter the net).

Percent caught	Mesh size 4-1/2"	4-5/8"	4-3/4"
0	35 cm.	36 cm.	37 cm.
5	37	38	39
10	38	39	40
15	39	40	42
20	40	42	43
25	41	42	44
30	42	43	44
40	43	45	46
50	45	46	47
60	47	48	49
70	48	50	51
80	49	51	52
90	51	52	53
100	54	55	57

In Part I it was concluded that most fish below 42 centimeters (age 3 years) should be protected. Although a good rate of growth to the end of the 4th year also exists, it does not seem desirable to protect them to this late age due to the fact that the fishing intensity is not high enough to ensure that all fish would be caught at that age. More accurate data for the effect of the Georges Bank fishery on the rate of removals of haddock will be available shortly, but at this time it appears unlikely that too many fish over 3 years old should be protected.

With the present state of knowledge, a minimum stretched mesh inside knots (after use rather than as purchased or constructed) of 4-5/8 inches is thought to represent a reasonable compromise, although either 4-1/2 or 4-3/4 inches would also accomplish somewhat similar results. The great majority of fish under 42 cm. (85 percent of the 40 cm., 90 percent of the 39 cm., and 95 percent of the 38 cm. fish) should be released through a 4-5/8-inch mesh under average trawling conditions, and on the other hand, excessive numbers of large fish should not be released with this mesh. About 30 percent of the 43 cm. fish, 50 percent of the 46 cm. fish, 70 percent of the 50 cm. fish, and 90 percent of the 52 cm. fish that enter the net should on the average be retained. Thus, only occasionally will fish over 4 years be released.

It should be borne in mind that considerable variations from these values may be experienced due to various conditions.

This measurement represents a minimum mesh "as fished" and not "as constructed" or "as purchased." In general, the netting purchased will have to be larger than 4-5/8 inches. The exact size "as purchased" is variable, due to variation in size of twine, type of twine, original tightness of the knots, etc.

More study would be desirable on the amount of shrinkage of variously constructed mesh and cod ends in order to advise the industry what should be bought in order to conform with the minimum of 4-5/8 inches, but from Herrington there are some data on shrinkage from new to used mesh. The average shrinkage for 4-5-inch mesh new 3-thread 1100 and 1200 twine double was 0.5 inches; that for 4-3/4-inch 4-thread 750 twine single was 0.3 inches; that for 5-inch 4-thread 750 and 900 twine double was over 0.6 inches.

The minimum mesh is also "inside knots" and not "between knot centers." Limited data on used nets indicate that "between knot centers" averaged larger than "inside knots" by about the following amounts:

For 3 and 4-thread, 1100 and 1200 twine double	-	0.57 inches
For 4-thread 750 twine single	-	0.56 inches
For 4-thread 750 twine double	-	0.78 inches

The use of double or single twine would be permitted. The minimum mesh would be for the complete trawl with the exception of the lower belly, cod-end belly, and 3 feet of the rear end of the cod-end top, in which parts regular mesh as small as 3-1/4 inches could be used. The use of large mesh in these parts was found by Herrington to result in too many tear-ups. The large mesh on top of the cod end is adequate for the release of the fish.

PART III. WHAT SIZES OF HADDOCK SHOULD IT BE LEGAL TO LAND?

If a minimum mesh size of 4-5/8 inches were in use, some haddock smaller than 16-1/2 inches would still be taken, due to the fact that the size of mesh in trawls is not perfectly selective as to size of fish released.

The small percentage of small haddock that would be caught in normal operation could be greatly increased by definite efforts of fishermen to do so. Some of the them probably would make such efforts, if a market was available for the sale of small haddock, as it is at present.

A minimum market size is thus necessary to remove both the market for such sized fish, and the incentive to catch them.

It is felt that the market size should be such that almost all of the small haddock that would normally be caught with no special efforts in that direction should be utilized. All data at present indicate that fish brought onto the deck do not survive if released. Thus, to utilize any small normally caught haddock it should be legal to land them.

If the minimum market size were set at 16-1/2 inches, some tolerance would have to be allowed, i.e., it should be permissible to land a certain number of fish under 16-1/2 inches, probably a proportion of the total number in the catch.

Unfortunately, the abundance of young haddock fluctuates considerably. Thus, the proportion of these young fish in the total catch also varies. Assuming a legal length of 16-1/2 inches, Herrington's studies showed that in the large-meshed trawls he used, about 9.3 percent of the total catch by numbers were under this size. If we assume this is a normal average, then in a net of 4-5/8 inches inside knots in use (slightly larger than Herrington's nets), a reasonable tolerance for haddock below 42 centimeters would be about 5 percent of the total number of haddock caught.

Slightly different legal lengths and amounts of tolerance might be more suitable. Any regulations that are adopted concerning minimum market size, and also minimum mesh size, should however allow for modifications after observations are made as to how the regulations are working, to ensure that full advantage is taken of trends of the fishery (such as abundance or scarcity of young) varying growth rates and changes in the mode of fishing, net construction, etc.

For actual regulations it is probably more precise to specify the minimum legal length rather than the minimum legal weight, inasmuch as the gutted weight can be made to vary considerably through various degrees of gutting completeness. It is therefore recommended that at least 95 percent of the catches of haddock be over 16-1/2 inches, fork length. Fork length is the length of the fish from the tip of the snout to the center of the fork of the tail.

General Considerations

Although we have no data as to whether these regulations would be a conservation measure for Nova Scotian haddock or not, it might be necessary in order to simplify enforcement, to include haddock caught on these banks, as well as Georges, under the regulations.

Exactly how to regulate catches of small trawlers and trawlers fishing part time for redfish, whiting, and red hake, is a subject which also will require some study.

A SUMMARY OF SOME BIOLOGICAL DATA ON MAJOR SPECIES OF FISH OTHER THAN HADDOCK CAUGHT IN OTTER TRAWLS ON GEORGES BANK

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Of the species other than haddock that are taken in otter trawls on Georges Bank, there are several that may be considered as of major importance. The total 4-port (Boston, Gloucester, New Bedford, Portland) landings in 1945 for various species, taken in large and medium sized otter trawlers on Georges Bank were as follows:

Species	Landings in pounds	Percent of total of all species
Haddock	62,794,693	55.4
Cod	17,125,881	15.1
Rosefish	13,435,595	11.8
Flounders	11,547,098	10.2
Pollock	4,786,331	4.2
Hake	1,999,898	1.8
Whiting	639,926	0.6

In regard to possible recommendations of desirable minimum legal sizes for species other than haddock caught in numbers in large-meshed otter trawlers on Georges Bank, the important species are principally cod, pollock, and hake, and possibly yellowtail flounder.

Published biological data on these species are limited. Following the meeting of the Atlantic States Marine Fisheries Commission on May 2, 1947, we began to assemble what little published or unpublished data were available and to obtain original observations on growth rate and length-weight where it was lacking, and where it was feasible.

Growth

Published material on growth that was found consisted of some data by Newfoundland, Canadian, and American workers on cod, hake, and pollock in North American waters. Growth rate of the yellowtail flounder on Georges Bank was furnished by the Flounder Investigation of the U.S. Fish and Wildlife Service (Royce and Buller). Data supplementing the published data on cod and pollock were obtained by the Haddock Investigation and Mr. Arnold, by the collection of scales of these species at the Boston Fish Pier and their reading. Due to the difficulties of reading hake scales, no time was spent on the growth of this species at this time..

Length-weight

Yellowtail data were supplied by the Flounder Investigation, and data for cod, pollock, hake, were obtained by the Haddock Investigation at the Boston Fish Pier.

Abundance

At present there are some data on the catch per day of cod and hake for Boston trawlers, which fish principally for haddock. The limitations of these data as indicative of abundance of secondary species such as cod and hake must thus be realized. The average yearly figures on catch per day in pounds in these species for the years 1932 to 1946 for Georges Bank, medium depth, have been computed as follows:

Year	Cod	Hake
1932	5359	118
1933	5433	130
1934	4611	128
1935	5158	94
1936	6630	159
1937	6629	203
1938	5008	146
1939	3702	136
1940	5256	80
1941	4959	91
1942	4576	122
1943	5990	150
1944	5932	117
1945	6360	141
1946	4921	158

The information for determining the size to which each of these species should be protected by the establishment of minimum size limits might be considered to be data on growth rate and the age at maturity. Utilizing what limited data were available at the time of writing, the analysis consisted of a similar system as with the haddock, i.e., the tabulation of the average size and average weight at various ages and, assuming a 10 percent natural mortality, the calculation of the poundages and value resulting, based on an assumed initial stock of 50 million fish. The 10 percent natural mortality was used for the lack of a better figure, but is probably too high in the case of cod, possibly too high for pollock. Values of the stock were computed in terms of the prices paid to fishermen in 1945 at Boston, Gloucester, New Bedford, and Portland. These data are shown in the following tables:

1.	Pollock	-	Bay of Fundy	-	Canadians
2.	Pollock	-	Georges Bank	-	USFWS
3.	Cod	-	Bay of Fundy	-	Canadians
4.	Cod	-	Georges Area	-	Schroeder
5.	Cod	-	Georges & Browns	-	USFWS
5a.	Cod	-	Newfoundland	-	Thompson
6.	Hake	-	Bay of Fundy	-	Canadians
7.	Yellowtail	-	Georges	-	USFWS

POLLOCK

Table 1.--Pollock (Contr. Can. Biol.), 1917-1918, Bay of Fundy

Age	Average length in inches	Average weight in pounds	Stock on hand in numbers	Total weight in pounds	Average value in cents	Total value in dollars	Value increase in dollars	Percent yearly increase in value
1	5.9	.11	50,000,000	5,500,000	5.58	306,900	-	-
2	12.4	.76	45,000,000	34,200,000	5.58	1,908,360	1,601,460	521.8
3	-	-	-	-	-	-	-	-
4	22.6	3.7	36,450,000	134,865,000	5.58	7,525,467	5,617,107	294.3
5	24.9	4.8	32,805,000	157,464,000	5.58	8,786,491	1,261,024	16.8
6	26.8	5.9	29,524,500	174,194,550	5.58	9,720,056	933,565	10.6

Table 2.--Pollock (U. S. F. W. S. Age Analysis) Georges Bank

Age	No. aged	Average length in inches	Average weight in pounds	Stock on hand in numbers	Total weight in pounds	Average value in cents	Total value in dollars	Value increase in dollars	Percent yearly increase in value
1	102	6.7	.15	50,000,000	7,500,000	5.58	418,500	-	-
2	83	12.2	.72	45,000,000	32,400,000	5.58	1,807,920	1,389,420	332.0
3	83	17.0	1.7	40,500,000	68,850,000	5.58	3,841,830	2,033,910	112.5
4	68	21.2	3.2	36,450,000	116,640,000	5.58	6,508,512	2,666,682	69.4
5	53	24.7	4.8	32,805,000	157,464,000	5.58	8,786,491	2,277,979	35.0
6	36	27.9	6.7	29,524,500	197,814,150	5.58	11,038,030	2,251,539	25.6
7	14	30.3	8.3	26,572,050	220,548,015	5.58	12,306,579	1,268,549	11.5
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Growth rate The growth of the Georges Bank pollock, table 2, while not more rapid than haddock during the early years of life, maintains itself longer than does haddock with the result that the total poundage and total value of the resource does not fall off as much as haddock in the later years of life. On this basis, it would appear possible that pollock should be protected to a somewhat larger average size and older age than haddock.

No information was found on the age at maturity.

Present market size (N.E. Fish Exchange).

Scrod 1-1/2 to 4 pounds. Very few fish less than 1-1/2 pounds are marketed.

Table 3.--Cod (Woodhouse, Contr. Can. Biol.,1914-1915) Bay of Fundy

Age	Average length in inches	Average weight in pounds	Stock on hand in numbers	Total weight in pounds	Average value in cents	Total value in dollars	Value increase in dollars	Percent yearly increase in value
1	5.7	.06	50,000,000	3,000,000	6.10	183,000	-	-
2	14.1	.90	45,000,000	40,500,000	6.10	2,470,500	2,287,500	1250.0
3	19.6	2.3	40,500,000	93,150,000	6.10	5,682,150	3,211,650	130.0
4	25.6	5.0	36,450,000	182,250,000	6.93	12,629,925	6,947,775	122.3
5	32.3	9.8	32,805,000	321,489,000	6.93	22,279,188	9,649,263	76.4
6	35.4	13.0	29,524,500	383,818,500	7.44	28,556,096	6,276,908	28.2
7	39.0	17.7	26,572,050	470,325,285	7.44	34,992,201	6,436,105	22.5

Table 4.--Cod (Schroeder) Georges Area

Age	Average length in inches	Average weight in pounds	Stock on hand in numbers	Total weight in pounds	Average value in cents	Total value in dollars	Value increase in dollars	Percent yearly increase in value
1	6.7	.10	50,000,000	5,000,000	6.10	305,000	-	-
2	15.1	1.06	45,000,000	47,700,000	6.10	2,909,700	2,604,700	854.0
3	20.8	2.66	40,500,000	107,730,000	6.10	6,571,530	3,661,830	125.8
4	24.8	4.6	36,450,000	167,670,000	6.93	11,619,531	5,048,001	76.8
5	27.7	6.3	32,805,000	206,671,500	6.93	14,322,335	2,702,804	23.3
6	31.1	9.0	29.524,500	265,720,500	6.93	18,414,431	4,092,096	28.6
7	33.6	10.9	26,572,050	289,635,345	7.44	21,548,870	3,134,439	17.0
8	36.1	13.5	23,914,836	322,850,286	7.44	24,020,061	2,471,191	11.5

Table 5.--Cod (U. S. F. W. S. Age Analysis, 1935) Browns and Georges

Age	No. aged	Average length in inches	Average weight in pounds	Stock on hand in numbers	Total weight in pounds	Average value in cents	Total value in dollars	Value increase in dollars	Percent yearly increase in value
1	259	5.4	.05	50,000,000	2,500,000	6.10	152,500	--	--
2	132	13.3	.72	45,000,000	32,400,000	6.10	1,976,400	1,823,900	1196.0
3	54	18.9	2.10	40,500,000	85,050,000	6.10	5,188,050	3,211,650	162.5
4	24	23.1	3.75	36,450,000	136,687,500	6.93	9,472,444	4,284,394	82.6
5	7	27.8	6.50	32,805,000	213,232,500	6.93	14,777,012	5,304,568	56.0
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Growth rate Studies made by the Service showed the growth rate of Browns and Georges Bank to be very similar. It seems to indicate a more complete mixing of the fish between Georges and the Nova Scotian Banks than is the case for haddock, which show a definite difference in growth rate between these areas. The data for these two banks were thus combined. These data, up to the age of five years, show no signs of a diminished growth rate in older fish and the data in table 4 (Schroeder-Georges Area) and table 5a (Newfoundland) bears out the conclusion that the cod is a relatively long-lived and steadily growing fish.

In this light it appears desirable that cod should, in order to obtain a/ nearly maximum poundage and value, be protected for a considerably longer span of years than haddock.

Table 5a.--Cod (Thompson) Newfoundland

Age	Average length in inches	Average weight in pounds
3	10.2	.33
4	14.5	.92
5	17.5	1.62
6	20.5	2.4
7	23.6	3.9
8	26.2	5.6
9	28.5	6.7
10	31.3	9.0
11	34.6	12.2
12	38.1	15.9
13	40.6	19.0
14	42.9	22.9

The only data that were found on the age of maturity of North American cod are for the Newfoundland Banks (Thompson) as follows:

Age	Percent mature
4	2
5	8
6	30
7	52
8	74
9	97
10	99
11	100

In contrast to haddock, most of which are mature on Georges at the end of 3 years, it is apparent that cod are much later maturing.

Present market size (N. E. Fish Exchange) Scrod 1-1/2 to 2-1/2 pounds. Very few fish less than 1-1/2 pounds are marketed.

Hake

Table 6.--Red hake (Crogie, 1916) (3-year olds)

Age	No. aged	Average length in inches	Average weight in pounds	Stock on hand in numbers	Total weight in pounds	Average value in cents	Total value in dollars	Value increase in dollars	Percent yearly increase in value
1	?	8.1	.21	50,000,000	10,500,000	5.37	563,850	--	--
2	?	13.5	.90	45,000,000	40,500,000	5.37	2,174,850	1,611,000	285.7
3	?	17.2	1.80	40,500,000	72,900,000	5.37	3,914,730	1,739,880	80.0

81

The very limited data available on growth rate do not indicate a diminishing growth rate up to the completion of the 3rd year.

No data on age at maturity found.

Present market size (N. E. Fish Exchange)

Snappers 1-1/2 pounds.

Yellowtail

Table 7.--Yellowtail (U. S. F. W. S. Age Analysis) Area XXII Q

Age	No. aged	Average length in inches	Average weight in pounds	Stock on hand in numbers	Total weight in pounds	Average value in cents	Total value in dollars	Total increase in dollars	Percent yearly increase in value
1	?	1.29	.0002	50,000,000	10,000	5.69	569	--	--
2	?	11.74	.50	45,000,000	22,500,000	5.69	1,280,250	1,279,681	2150.0
3	?	13.39	.80	40,500,000	32,400,000	5,69	1,843,560	563,310	44.0
4	?	14,79	1.10	36,450,000	40,095,000	5,69	2,281,405	437,845	23.7
5	?	16.08	1.45	32,805,000	47,567,250	5.69	2,706,577	425,172	18.6
6	?	17.67	2.00	29,524,500	59,049,000	5.69	3,359,888	653,311	24.1

375

Growth data indicate an extremely small size at the age of 1 year followed by rather uniform increments in the following years.

Present market size (N. E. Fish Exchange)

1 pound. At present many fish as small as 1/2 pound are landed.

Data assembled to help answer some questions of the Committee of New England which refer to the New England haddock. assembled by H.A. Schuck

The major United States fisheries off New England depend upon groundfish (species which live on or near the bottom, most of which are taken by otter trawl gear). Taken together, the groundfisheries far outrank the pelagic species, of which mackerel is the most important in this area.

Haddock is the mainstay of the United States otter trawl fishery and is the most valuable of all the Northeastern United States fisheries.

Haddock are landed in the States of Maine, Massachusetts, Rhode Island, Connecticut, and New York. The major ports are Boston, New Bedford and Gloucester. Substantial landings also are made in the Cape Cod area, at Portland, Rockland, and at New York City.

At peak production in 1929 the haddock resource yielded nearly 260 million pounds. The average catch since then, owing to reduced abundance brought on by intensive fishing, has been about 150 million pounds a year, worth about 12 million dollars (to fishermen) at recent prices.

The haddock of the northwest Atlantic make up a complex of populations, of which at least three main groups are recognized, inhabiting, respectively, the New England banks, the Nova Scotian banks, and the Newfoundland banks. The fish vary between groups as to growth rate, spawning time, migratory habits, and fluctuations in size of stock.

Only the haddock populations off New England and Nova Scotia are important to the United States fishermen. In the average year since 1931, 66.8 percent of the haddock landed at the principal ports have been caught from the New England banks, 33.1 percent from the Nova Scotian banks, and only .1 percent from areas farther to the north and east.

The Fish and Wildlife Service has carried on studies of the haddock resource for several years, chiefly on the important Georges Bank. Here the catch increased to a high of 223 million pounds in 1929, and then declined to a low of 50 million pounds in 1934. Since then the landings have averaged 94 million pounds and never have exceeded 122 million pounds.

Two causes of the reduced catches are known. First, the number of young haddock surviving to enter the fishery has fluctuated--sometimes the landings of two year old haddock have been as much as 38 times those of the poorest year. The causes of this varying production of young are not yet known. Second, the young rapidly growing haddock have been wasted in great numbers, either by being thrown overboard at sea, or by being landed at too small sizes.

At the present state of our investigation we are not convinced that the stocks have been harmfully depleted but we are convinced that the fishery is an unnecessarily wasteful one, and that production could be increased by protection of the young.

We have investigated the various methods of preventing the waste of small haddock and have concluded that the most effective method would be to enlarge the mesh size of the otter trawls which are used to catch haddock.

The following details refer, unless otherwise stated, to the Georges Bank haddock fishery only. For United States fishermen this is the most important haddock area, and only United States fishermen fish this area. This information is arranged according to numbers of the subjects in the outline of "The Committee of New England" on Natural Resources - Fisheries.

Estimates of growth rate

2b. For Georges Bank haddock the growth rate can be derived from the approximate sizes at the end of various completed years of life:

Complete years of life	Average length in inches	Average gutted weight in pounds
1	7.7	.18
2	13.7	.96
3	17.6	1.96
4	19.9	2.70
5	21.5	3.32
6	22.8	3.98

Trend of catches on the various banks

2c. There has not been any trend toward the U.S. haddock fleet to fish farther and farther from port over the past years as evidenced by the following table showing (for each year) the percentage of the total landings that were taken from each of 6 large areas.

Percent haddock landed at principle New England ports

Year	New England	So. Nova Scotia	Cent. Nova Scotia	No. Nova Scotia	Gulf of St. Lawrence	Newfound-land	Total
1931	71.0	21.9	7.1	0.0	- - -	0.0	100.0
1932	75.9	16.0	8.1	0.0	- - -	0.0	100.0
1933	63.8	19.8	16.3	- - -	0.1	0.0	100.0
1934	34.5	12.3	47.1	5.8	0.1	0.2	100.0
1935	42.2	12.5	41.1	4.2	0.0	- - -	100.0
1936	54.6	14.0	27.4	4.0	0.0	0.0	100.0
1937	63.8	12.7	19.7	3.6	0.0	0.2	100.0
1938	61.7	18.3	18.4	1.5	- - -	0.1	100.0
1939	70.7	15.2	10.9	2.9	- - -	0.3	100.0
1940	73.8	11.9	9.8	4.5	- - -	0.0	100.0
1941	79.0	6.7	9.3	5.0	- - -	- - -	100.0
1942	88.1	8.3	2.6	1.0	- - -	- - -	100.0
1943	90.6	4.5	3.8	1.1	- - -	- - -	100.0
1944	72.4	11.2	15.1	1.3	- - -	- - -	100.0
1945	43.9	18.2	31.9	6.0	- - -	- - -	100.0
1946	75.6	7.0	14.8	2.6	- - -	0.0	100.0
1947	75.8	11.6	11.5	1.1	- - -	0.0	100.0
1948	70.1	13.4	12.8	2.4	- - -	1.3	100.0
1949	77.7	15.5	5.7	1.1	- - -	- - -	100.0
Average	66.9	13.3	17.1	2.6	0.0	0.1	100.0

The total landings from Georges Bank have been as follows:

Year	Total catch Millions of pounds
1917	27
1918	48
1919	76
1920	79
1921	58
1922	60
1923	64
1924	71
1925	80
1926	99
1927	143
1928	191
1929	223
1930	184
1931	115
1932	105
1933	82
1934	50
1935	79
1936	84
1937	95
1938	92
1939	105
1940	93
1941	122
1942	107
1943	90
1944	96
1945	78
1946	104
1947	105
1948	94
1949	82
1950	1/ 81

1/ Partially estimated.

Determine trend of size of fish caught

(2) (f) The average weight of all haddock landed in each of 20 years were as follows:

Year	
1931	2.94
1932	2.67
1933	2.64
1934	2.58
1935	2.45
1936	2.37
1937	2.61
1938	2.44
1939	2.38
1940	2.65
1941	2.38
1942	2.37
1943	2.39
1944	2.90
1945	2.95
1946	2.78
1947	2.52
1948	2.27
1949	2.24
1950	1.85

Thus, aside from 1950 (for which year the average weight was unusually low) there is no definite trend toward the landing of smaller haddock over this 20 year span.

Determine amount of fish thrown away and type

2 (g) Estimates by years -- Numbers of fish discarded on Georges Bank only.

1947	—	33 million
1948	—	15 million
1949	—	12 million
1950	—	15 million

Reason -- The small meshes used in otter trawlers catch large numbers of small sized haddock -- too small sized to be readily marketable -- and these fish are discarded at sea. We feel that most of those discarded are killed by the process.

Determine and analyze catch per trip

2 Catch per day available, rather than per trip -- and for a standard group of the large trawlers, fishing out of Boston only.

These figures are:

Year	Average yearly catch per day
1917	25,825
1918	32,950
1919	34,975
1920	36,575
1921	32,475
1922	24,475
1923	18,375
1924	23,150
1925	32,250
1926	41,275
1927	43,790
1928	34,520
1929	22,402
1930	11,545
1931	8,880
1932	11,572
1933	9,708
1934	10,308
1935	12,275
1936	13,500
1937	11,650
1938	11,733
1939	13,040
1940	12,836
1941	16,615
1942	18,682
1943	18,343
1944	16,973
1945	16,000
1946	14,264
1947	12,800
1948	12,123
1949	11,444
1950	14,549

Are there any natural causes for scarcity?

3a. No natural causes for scarcity of haddock are as yet known.

More details regarding the haddock resource and its research concerning its biological productivity have been published, and some of these details are available in the attached set of reprints.

October 9, 1951 Howard A. Schuck

Encl: 2 sets of 6 reprints each

Mr. Graham

Senior Biologist, Pacific Oceanic Fishery Invs., February 20, 1952
P. O. Box 3830, Honolulu, T. H.
In Charge, North Atlantic Haddock Investigation

Predicted haddock catch

I realize that you have been anxious, throughout the year, about how closely the actual landings of haddock were approximating that which we predicted last March.

Throughout the year we have made three-month, six-month preliminary evaluations, but now that the 1951 haddock year is over, it is possible to evaluate the complete year, which is more appropriate.

This evaluation is preliminary as the final figures of 1951 landings will not be available for some time, and thus for the last few months of 1951 (haddock year, not calendar, including January 1952) preliminary estimates of landings for major ports only are used as a basis of evaluation. Such comparisons are made for like quantities of 1950, however, so should be very close to reality.

The records on effort for 1951 show a 9 percent increase in days fished over 1950. With an increased effort of this amount, the prediction was that landings would increase from the 1950 level of 79.8 million pounds to 92.7 million pounds. Our best figures on 1951 landings show that actually 90.2 million pounds were landed, an error of only 2.5 million pounds, or 2.7 percent.

Or we might say the landings came to 97.3 percent of the predicted.

I am greatly pleased with this order of accuracy, of course, and believe that you will be also.

We are busy now trying to get the computations finished for the 1952 prediction. I figure them to come out in Atlantic Fisherman, Commercial Fisheries Review, or similar publications.

The report on the development of the method logically should be a Fishery Bulletin with you as senior author, me as junior, but I can see no possibility of even getting to work on it in the near future. Could you find time to work it over?

As to the authorship of the popular note on the 1952 prediction, do you have any feelings on that? I have a vague feeling that some might consider that protracted use of the method, as opposed to development of the method, should be the business of those who are at present engaged in the area and the work, but I have not talked with anyone about it.

Sorry I haven't given you the results of the prediction sooner, but have been very busy.

Best regards to Mary and the boys.

Howard A. Schuck

Through: Dr. Graham

HAS:vr

1

The Basis for a Mesh Regulation in the New England Haddock Fishery

1. The Problem of Depletion

Tables of Total Landings
" " Large + Small
" " Catch per day
" " Effort (days fished per year).
Stabilizing

2. The Problem of Waste (discarded fish)

Trimming.

Exploitation not always decreasing.

3. Practical approach

Ignores economic factors

4. Selection of mesh.