68-06

FISHERY RESOURCES OF THE NORTH ATLANTIC AREA

by

ROBERT L. EDWARDS

Reprinted from *The Future of the Fishing Industry in the United States,*
University of Washington Publications in Fisheries, New Series, Volume IV, 1968.

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The North Atlantic area differs from all the others considered here today in that it is already intensively exploited. Nonetheless no one will disagree that it can yield even more, perhaps double the present landings. Further, no one will disagree that to double present landings there must be radical improvements in capture technology, new markets and possibly even a different economic basis for our fisheries. It is our purpose today to delineate the size and nature of the resource as clearly as possible so that others may suggest the appropriate course of action to strengthen the industry.

The American fishery industry never really exploited all the available resources off the Northwest Atlantic coast. That the area could produce very much more was dramatically demonstrated when the USSR began to take an interest in the herring and silver hake stocks in the early 1960's. As a result of Soviet activity alone, the landings from the Gulf of Maine (ICNAF Subarea 5) were more than doubled in a period of five years (Fig. 1). This traditionally American fishing area now plays host to the vessels of many countries and our contribution to the total catch has dropped from 98% or better to barely 32%.

This increased exploitation has had its direct effects. Some of our fisheries are virtually out of business, others are barely maintaining themselves. Some products are now so scarce that the consumer is paying record prices, even luxury prices, for products that once even the humblest could enjoy occasionally. The scientific evidence is clear cut. The overall abundance of those species taken with an otter trawl has dropped 40% in four years. In Table 1 are some comparative catch/tow data obtained during the fall groundfish surveys in the New England area carried out by the Bureau's Laboratory in Woods Hole. Four species are listed separately because they are especially interesting.

Haddock abundance has dropped over 60%. In this case there has been serious overfishing. This species has been regulated (by establishing a minimum mesh size) for maximum yield since 1953. Mesh regulation is premised upon the maintenance of a reasonable stable amount of effort. The fishing fleets of the Soviet Union, and to a lesser degree those of Canada, increased the total fishing mortality on haddock by a factor of about 3 times over a period of two years with the result that almost no one can economically fish for haddock at this time. To add to our grief there have been no substantial year classes recruited to the population since 1963.

Red hake abundance has dropped to about one-fourth its 1964 level. In this case as well the Soviet fishery appears to be the principal cause of the decline. Unlike the haddock however, the red hake does not appear to be seriously overfished. Rather the Soviet fishery is taking all the available surplus before the spring inshore migration and as a result the American industrial fishery based on this species is in dire straits. Silver hake abundance is down moderately. This species normally has wide variations in year class strength and while the data on hand show the effects of fishing, the stocks appear to be in reasonably good shape.

The yellowtail flounder is fished only by Americans at the moment. This species tends to be cyclic in its abundance and there is evidence that colder water temperatures

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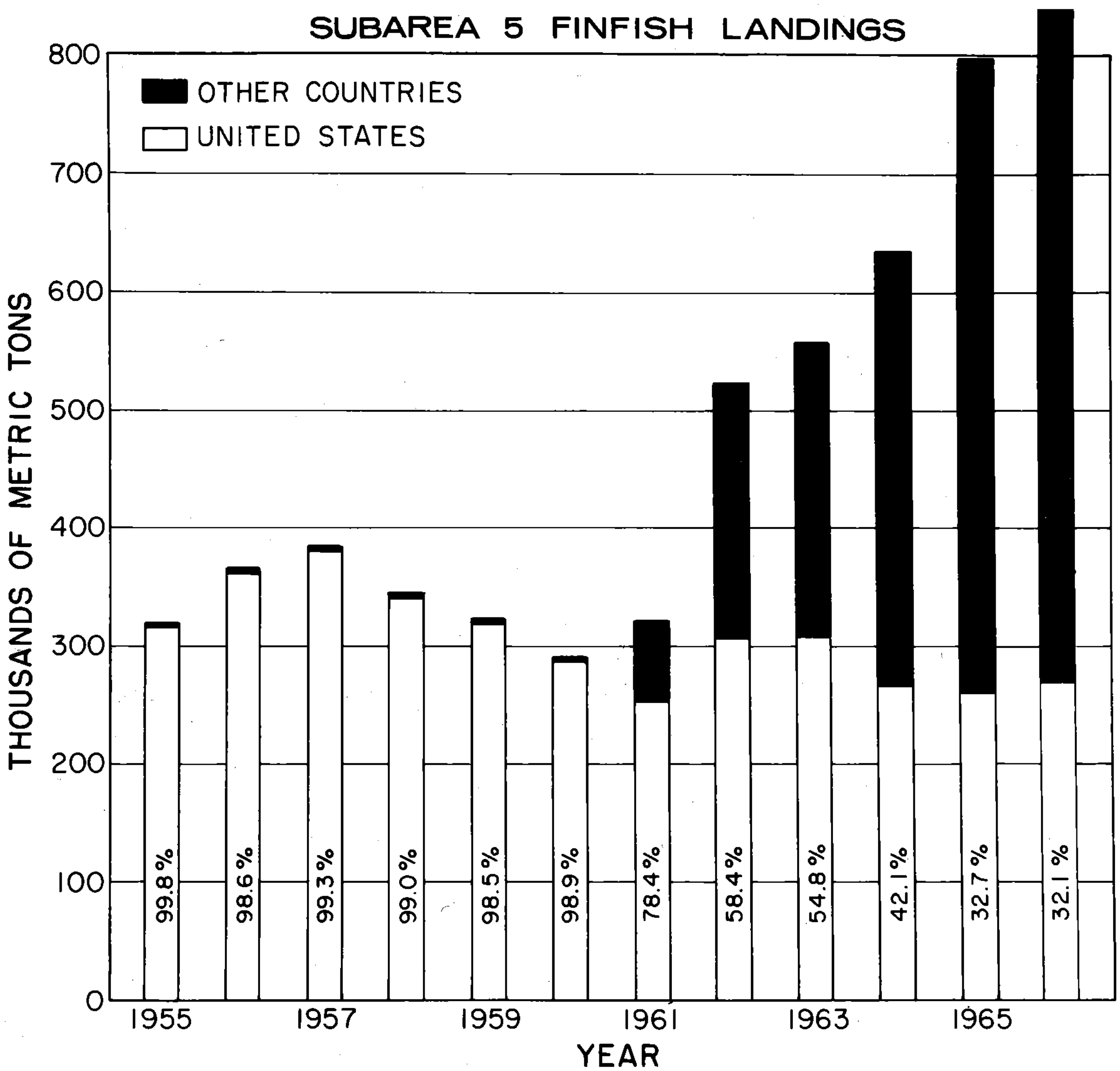

Figure 1.—The total landings of finfish from Subarea 5 (ICNAF) and the percentage taken by the United States.

Table 1. Catch/tow, in pounds, for various species for the years 1964-1967. Data obtained during fall groundfish survey cruises of the *Albatross IV* carried out by the Woods Hole Biological Laboratory of the Bureau of Commercial Fisheries.

Catch/tow	1964	1965	1966	1967
Haddock	73.5	59.8	34.0	28.2
Silver hake	9.2	11.5	7.7	5.6
Red hake	4.9	4.2	2.6	1.4
Yellowtail	10.3	6.8	4.6	8.9
All others	193.5	162.0	171.7	144.2
Total	291.4	244.3	219.6	188.3

enhance the success of yellowtail recruitment. At the present time the New England area is going through a period of unusually low water temperatures and the yellowtail population is, relatively speaking, at a high level.

As mentioned above, overall abundance since 1964 has dropped about 40%. The combined abundance of the 4 species listed separately has dropped about 50% and the abundance of the remaining species (more than 50) has dropped about 25%.

In two recent papers, Graham (1967 and 1968) has presented a detailed account of the recent trends in the landings of Northwest Atlantic fisheries. In these papers he has fully documented the impact of foreign fleets on our traditional resources as well as some we seldom, if ever, exploited. In almost every instance the picture is the classic one of a rapid increase in landings followed by a sharp decline and, in some cases, apparent stabilization at a new low level. He concluded one paper (1967) with the following summary statement:

"Our conclusion at the moment is that the Northwest Atlantic on the whole is in a heavily exploited state and that we cannot expect any substantial increases from the area in the future. The yields of some species such as redfish and herring can probably be increased, but the total of all species is not likely to rise more than 10 or 20% under the most intensive exploitation and diversification of catch . . ."

In his papers Graham only concerned himself with those species that were the principal objects of a fishery.

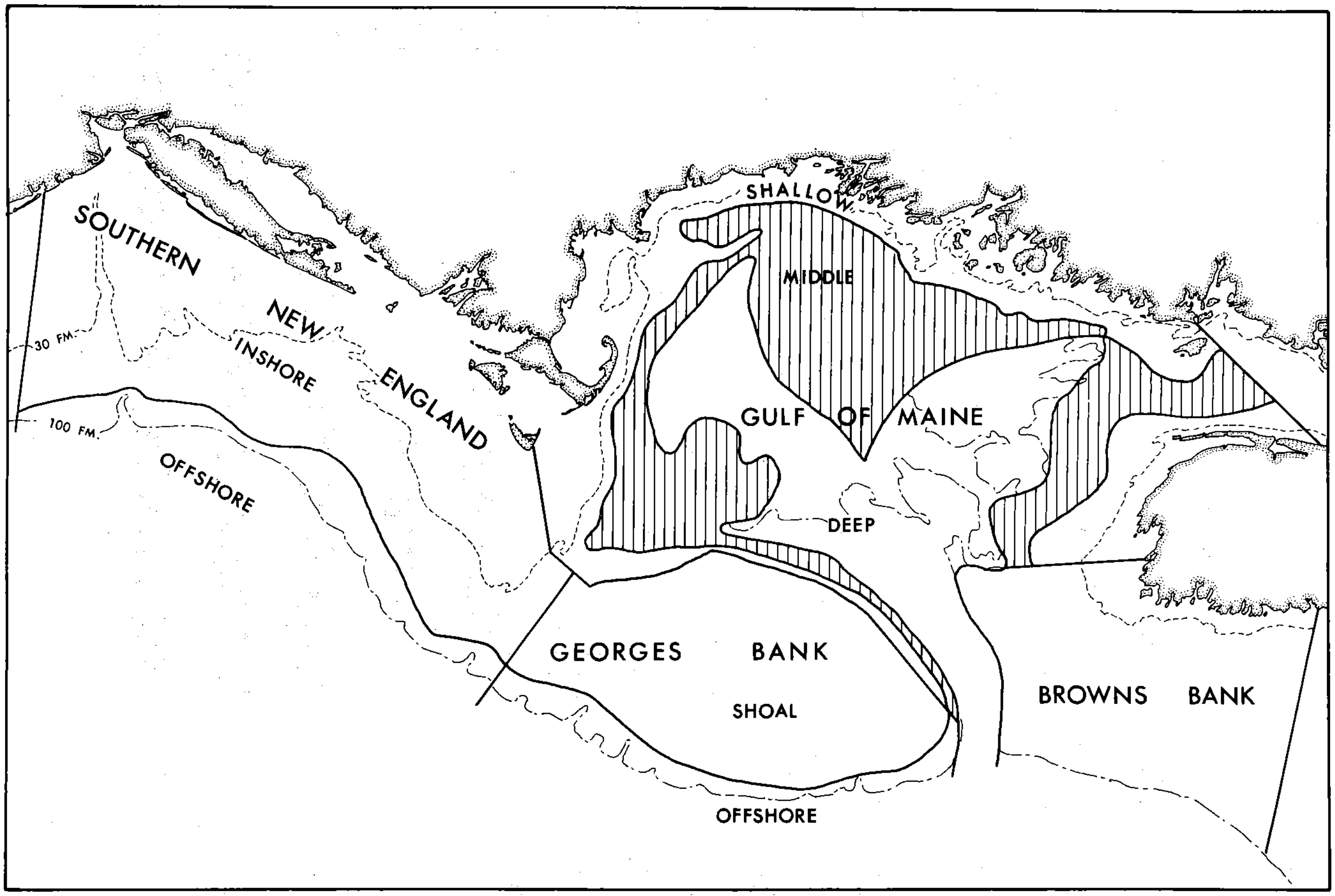

Figure 2.—The Woods Hole survey cruise area and the zones discussed in the text.

Table 2. Percent by weight contribution of various species to industrial landings, 1957 and 1958. Only those species contributing significantly are listed. The average catch/tow during this period was 3,000 pounds per hour. Data from Edwards, 1958 and Edwards and Lawday, 1960.

	Southern New England	Western Gulf of Maine
Red hake	44.2	46.5
Silver hake*	18.3	25.4
Little skate	6.1	0.2
Eel pout	5.6	2.4
Goosefish	5.3	2.8
Big skate	5.1	0.6
Spiny dogfish	4.0	1.6
Longhorn sculpin	1.4	0.9
Butterfish*	1.3	0.2
Sea robin	1.1	+
Barndoor skate	0.9	+
Yellowtail flounder*	0.8	0.4
Alewife	0.7	5.1
Sea herring	0.1	1.3
Haddock*	+	3.1
Cod*	+	2.8
American plaice*	—	1.7
	95+%	95+%

* Depending upon individual size and market condition, these species were also sold for food on the fresh fish market.

What about those that are not exploited? We must bear in mind that few species occupy so unique a physical niche in the ocean that others are not taken at the same time, albeit not so efficiently. The present fisheries are using midwater as well as bottom gear with the result that the entire water column is being swept to some degree. The unwanted species, and there are many, are either discarded or used for the production of fish meal and flour. Landings statistics may seriously underestimate the impact of fisheries on resources, neglecting as they do any estimate of discard.

To some extent records exist for some areas from which all fish caught were landed. Prior to the development of the Peruvian anchovy fishery New England had a healthy fish meal industry of its own. (Edwards, 1958, and Edwards and Lux, 1958). It was most successful, particularly in the southern New England region, because 1) it was based on an abundant supply of red and silver hake, and 2) it was not specialized—that is food fishes were usually sold separately and their abundance as much as the abundance of the industrial species determined the grounds fished.

Since everything taken in the net was saved, estimates of the relative abundance of all species taken by the otter trawl could be calculated and were. It was quite apparent that while there were many species involved, other fisheries were already exploiting most of those with higher biomasses or with a high market demand, and that the

Table 3. Average catch/tow, in pounds, for each zone.

	Southern New England		Georges Bank		Gulf of Maine			Browns
	Inshore	Offshore	Shoal	Offshore	Shallow	Middle	Deep	Bank
Alewife	6.65	.69	4.41	.02	.62	1.40	.07	—
American Plaice	.10	.02	.98	.23	8.20	15.72	5.86	3.81
Argentine	—	—	—	—	—	.01	4.53	1.34
Barndoor	2.35	1.50	4.98	5.03	2.49	1.23	4.51	1.27
Big Skate	10.82	.05	24.92	1.04	14.48	.94	1.02	.61
Blackback	8.01	—	4.99	.01	11.44	.55	.09	.13
Butterfish	9.64	2.08	2.39	.02	.41	—	—	—
Cod	5.26	.10	25.76	2.97	40.89	20.24	14.66	47.50
Eel Pout	19.20	.06	14.36	3.43	5.81	.47	—	—
Fourspot	2.91	3.13	.89	3.17	.01	—	—	—
Greysole	.76	.15	.34	.58	2.95	7.72	1.92	.66
Goosefish	5.93	8.50	4.80	9.88	6.77	7.39	10.34	5.49
Haddock	11.21	.41	195.11	67.04	112.82	68.10	53.46	53.93
Little Skate	14.17	.03	23.15	2.57	7.70	.15	.34	2.49
Longhorn Sculpin	9.45	.01	8.10	1.25	3.00	.68	.09	.45
Ocean Perch	—	—	.01	1.86	9.26	38.12	62.64	22.83
Pollock	.31	.04	1.25	1.52	8.50	15.19	11.92	13.08
Red Hake	10.84	19.56	6.04	23.88	2.91	4.71	2.76	.20
Sand Flounder	2.44	—	1.39	—	.19	—	—	—
Scup	1.51	—	.07	—	—	—	—	—
Sea Herring	1.20	.02	3.54	4.02	9.00	2.48	.28	.38
Sea Raven	.37	—	3.14	1.50	3.90	.71	.03	.56
Silver Hake	11.38	14.97	4.38	14.40	15.41	8.79	21.42	1.67
Spiny Dogfish	144.79	82.04	5.94	1.21	50.26	21.10	30.66	.23
Thorny Skate	—	—	1.21	1.50	13.57	24.35	17.00	4.36
White Hake	1.11	4.79	.38	4.32	9.77	10.39	14.18	.82
Yellowtail	25.18	.02	17.52	1.54	6.82	.09	.03	.91
All Others	6.00	14.65	5.67	6.23	7.12	6.23	7.88	13.37
Total	311.59	152.82	365.72	159.22	354.30	256.76	265.69	176.09

rest, even in combination, did not represent any vast untapped resource. The exceptions were the red hake, spiny dogfish, two species of skates and the sea herring.

The percentage contribution by weight of various species in 1957 and 1958 for the two principal industrial fishery areas are given in Table 2. The number of species involved in this fishery totalled more than sixty in each area but less than a dozen contributed more than 95% to the total. Of all the species available only one was actively avoided, the spiny dogfish.

The abundance of spiny dogfish is underestimated by these data as is that of any widely ranging pelagic species. Since this fishery stayed in the inshore area the data are of little value in estimating the abundance of fishes living in water deeper than 30 fathoms. Additional comparable data are not available for recent years.

Had the Canadians, Soviets, and others fished species not of vital interest to our own industry, clearly the resource situation would have been different today. They did not, except in the case of the Georges Bank sea herring. A practical fishery generally requires a reasonably large biomass as well as a market. Small populations can only be exploited economically if there are unique properties associated with the fishery such as an unusually high market value for the product or a highly predictable time during which the resource is easily harvested. The foreign fleets did the logical thing; they developed their fisheries around those resources with relatively high biomasses and which were acceptable as food by their nationals, or, as in the case of the Canadians, specialized on those resources that could be profitably exported.

A useful estimate of the total fish resources of the Continental Shelf off New England can be derived from the groundfish survey data obtained by the Bureau's Biological Laboratory at Woods Hole, Massachusetts. A series of 9 surveys were carried out during the period 1963 to 1966.[1] Included were three cruises each for the summer, fall and late winter seasons. Each survey covered the area shown in Figure 2. A stratified random station plan was developed for each cruise, and about 180 stations were occupied each time.

The net used for the groundfish surveys is a "36 Yankee" trawl with a 0.5 inch codend liner. The trawl has a spread on the bottom, depending upon many factors, of from 35 to 40 feet and a height at the middle of the head rope of about 7 feet. Since much of the survey area has a very rough bottom, rollers are used throughout.

The catch/tow data for these cruises has been averaged

[1] This particular series of cruises started in August, 1963 and was completed in February, 1966. This work is continuing and ultimately a defiinitive report will be made on the survey techniques developed and the data obtained.

for each of the eight zones indicated in Figure 2. Each of these zones represents many separate strata in the survey design that have been pooled for this analysis. In Table 3 the mean catch per tow in pounds is listed for the 27 most abundant species that in combination make up in excess of 95% of the total fish biomass.

Table 4. Area in square statute miles for each zone (estimated to nearest 1,000 square miles) and correction factor used to calculate first estimate of biomass (Area X 0.016^{-1}).

	Area X10^3	Correction Factor X10^6
Southern New England		
Inshore	31	1.92
Offshore	6	.37
Georges Bank		
Shoal	15	.93
Offshore	3	.19
Gulf of Maine		
Shallow	15	.93
Middle	21	1.30
Deep	9	.56
Southern Nova Scotia	10	.62

To get a first estimate of biomass it is necessary to adjust these data for the area of each zone. We have calculated that the net swept 0.016 square miles each tow. The standard tow duration is 30 minutes on the bottom at a speed of 3.5 knots. The net fishes somewhat longer than 30 minutes inasmuch as a stern trawler such as the R/V Albatross IV continues underway while setting and retrieving the net. There is considerable evidence that the net fishes, although very inefficiently, as it passes through the water column. Since it moves up and down through the water column quickly, the effect on the catch is considered to be minimal. However, the net reaches the bottom a substantial amount of time before the full scope of cable is played out and timing begins, and similarly leaves the bottom after the cable starts coming in. It is estimated that the additional time on bottom or very near it averages about eight minutes and that the distance normally covered is approximately 13,200 feet. Assuming a minimum effective spread of 35 feet for the net, on each tow 462,000 square feet (0.016 square miles) of bottom is sampled. The correction factor required to convert the catch/tow value to a first estimate of biomass is the number of square miles for the zone divided by 0.016 (or multiplied by 62.5). The area for each of the zones and the correction factors used to adjust the mean catch/tow data are given in Table 4.

The first estimates of biomass given in Table 5 are useful

Table 5. First estimates of biomass obtained by correcting catch/tow data for differences in the area of each zone. In millions of pounds.

	Southern New England		Georges Bank		Gulf of Maine			Browns
	Inshore	Offshore	Shoal	Offshore	Shallow	Middle	Deep	Bank
Alewife	12.77	.26	3.98	—	.58	1.82	.04	—
American Plaice	.19	—	.88	.04	7.63	20.44	3.28	2.36
Argentine	—	—	—	—	—	—	2.54	.83
Barndoor	4.51	.56	4.48	.96	2.32	1.60	2.53	.79
Big Skate	20.77	.02	22.43	.20	13.47	1.22	.57	.38
Blackback	15.38	—	4.49	—	10.64	.72	.05	.08
Butterfish	18.51	.77	2.15	—	.38	—	—	—
Cod	10.10	.04	23.19	.57	38.03	26.31	8.21	29.45
Eel Pout	36.86	.02	12.92	.65	5.40	.61	—	—
Fourspot	5.59	1.16	.80	.60	—	—	—	—
Greysole	1.46	.06	.31	.11	2.74	10.04	1.08	.41
Goosefish	11.39	3.15	4.32	1.88	6.30	9.61	5.79	3.40
Haddock	21.52	.15	175.60	12.74	104.92	88.53	29.94	33.44
Little Skate	27.21	.01	20.84	.49	7.16	.20	.19	1.54
Longhorn Sculpin	18.14	—	7.25	.24	2.79	.88	.05	.28
Ocean Perch	—	—	—	.35	8.61	49.56	35.08	14.15
Pollock	.60	.01	1.13	.29	7.91	19.75	6.68	8.11
Red Hake	20.81	7.24	5.44	4.54	2.71	6.12	1.55	.12
Sand Flounder	4.68	—	1.25	—	.17	—	—	—
Scup	2.90	—	.06	—	—	—	—	—
Sea Herring	2.30	—	3.19	.76	8.37	3.22	.16	.24
Sea Raven	.71	—	2.83	.29	3.63	.92	.02	.35
Silver Hake	21.85	5.54	3.94	2.74	14.33	11.43	12.00	1.04
Spiny Dogfish	278.00	30.35	5.33	.23	46.74	27.43	17.17	.14
Thorny Skate	—	—	1.09	.29	12.61	31.66	9.52	2.70
White Hake	2.13	1.77	.36	.82	9.09	13.57	7.94	.51
Yellowtail	48.35	—	15.77	.30	6.34	.12	.02	.56
All Others	11.51	5.42	4.88	1.18	6.63	8.10	4.42	8.29
Total	598.24	56.53	328.91	30.27	329.50	333.86	148.83	109.17

in a limited way. They are, at least, minimum estimates. They are also useful estimates for the purposes of planning fishing strategy using trawls similar to that used on the survey cruises. They are also amenable to further analysis for the purpose of estimating the standing crops of each species.

Before the data of Table 5 can be used to derive estimates of the standing crop, we must first estimate the effectiveness of the gear used as well as the bias resulting from not sampling the entire area occupied by any particular species.

The effectiveness of the gear is determined principally by the distribution of individuals of the species, here termed availability, and the ability of the fish to escape once they come in direct contact visually or otherwise, with the gear, here termed vulnerability. It is virtually impossible to get precise values for either availability or vulnerability. Among the factors demonstrated to change the effectiveness of a net by modifying the behavior of the fish are temperature, depth, time of day, season, amount of light and amount of harassment.

Coefficients of availability and vulnerability (Table 6) have been estimated for the 27 species for which data is given. They were derived after careful consideration of all of our knowledge concerning the behavior of these species. This knowledge is based on observations from research submarines, underwater television observations of fish and their reactions to trawls and the components of trawls, studies of echo sounder records, comparative gear studies and other data on behavior and distribution. Documentation of the process by which each coefficient was determined would require a paper many times the length of this one. A few examples will be discussed to illustrate the process of estimating these coefficients.

Table 6. Availability, vulnerability and areal/seasonal factors used to derive standing crop estimates from survey cruise data. Species listed in alphabetical order.

Species	Availability	Vulnerability	Areal/ Seasonal	Total Factor
Alewife	0.30	0.90	0.80	0.22
American dab	0.70	0.40	1.00	0.28
Argentine	0.60	0.03	1.00	0.018
Barndoor skate	1.00	0.10	1.00	0.10
Big skate	1.00	0.20	1.00	0.20
Blackback flounder	0.60	0.70	0.40	0.17
Butterfish	0.20	0.70	0.50	0.07
Cod	0.35	0.80	1.00	0.28
Eel pout	0.90	0.70	0.40	0.31
Fourspot flounder	0.70	0.70	1.00	0.49
Grey sole	0.70	0.70	1.00	0.49
Goosefish	0.90	0.40	0.90	0.32
Haddock	0.60	0.80	1.00	0.48
Little skate	1.00	0.15	1.00	0.15
Longhorned sculpin	0.70	0.60	1.00	0.42
Ocean perch	0.45	0.75	0.80	0.27
Pollock	0.15	0.50	1.00	0.075
Red hake	0.90	0.20	0.40	0.07
Sand flounder	0.90	0.25	0.40	0.09
Scup	0.20	0.30	0.30	0.045
Sea herring	0.017	0.90	0.65	0.01
Sea raven	1.00	0.90	1.00	0.90
Silver hake	0.20	0.25	0.70	0.035
Spiny dogfish	0.70	0.70	0.60	0.29
Thorny skate	1.00	0.10	1.00	0.10
White hake	0.95	0.90	0.60	0.51
Yellowtail flounder	0.80	0.70	0.70	0.39

During our joint US-USSR research at Woods Hole in the fall of 1967, we compared the catch rates of various species using the Yankee Trawl and the Soviet 27.1 Herring Trawl. Both trawls have a spread on the bottom of 35 to 40 feet. The Soviet trawl had 2 to 3 times the height of the Yankee. The Yankee was equipped with 18-inch rollers, the Soviet with a heavy foot rope only. The nets were used in accordance with a carefully developed statistical model that took into account area, direction of tow, time of day, depth, vessels and the two nets. Two quite different experiments were carried out with comparable results, and some of the results were startling.

Some of the data obtained are presented in Table 7 to illustrate the nature of the differences observed. Flounders generally were not caught in significantly greater numbers by the Soviet trawl, suggesting that rollers were not seriously biasing the Yankee trawl data. On the other hand the skate data indicated that the Yankee trawl greatly underestimated their abundance.

Underwater television observations show that skates tend to be herded ahead of the net and are not prone to get up off the bottom and be captured efficiently by a net with rollers. Flounders on the other hand tend to rise quickly and are accordingly far more vulnerable than skates.

None of the species of skates, in this region at least, distribute themselves in such a manner as to be missed by the net. They are all considered to be fully available to the gear (coefficient = 1.0). This is not true of the flounders. Some actively pursue their prey in the water column, especially the fluke and to a lesser degree the sand flounder. Many species bury in the bottom at sometime during the day or night. The blackback flounder apparently becomes very inactive at night when its catch rate drops to less than 50% of the daytime rate. Observations on its behavior are that it feeds actively during the day, at which time it is

Table 7. The relative efficiency of the Soviet 27.1 Herring Trawl vs. the "36 Yankee." These figures are approximate. More exacting values and their statistical significance will be presented at the 1968 ICNAF meeting.

	27.1 Herring Trawl — Catch in Pounds / 36 Yankee Trawl — Catch in Pounds
Blackback flounder	0.8
Butterfish	1.3
Eel pout	17.0
Fourspot flounder	1.3
Goosefish	2.7
Little skate	6.0
Longhorned sculpin	1.6
Red hake	4.7
Sand flounder	2.6
Silver hake	3.6
Spiny dogfish	No difference
Yellowtail flounder	1.2

EDITOR'S NOTE— Table 7, above, seeks to express on a ratio basis the relative effectiveness of the Soviet and the Yankee trawls as indicated by the catches of several principal species. Figures are the result of dividing the Soviet net's catch in pounds by the catch of the Yankee net in pounds for the same species. Where the ratio shown is above 1.0, the Soviet net made the heavier catch; where the number is below 1.0 the advantage was with the Yankee trawl.

quite available, and buries itself at night, becoming relatively unavailable. For all practical purposes it was caught with equal efficiency by either the Soviet or the Yankee trawl (see Table 7).

Flounders and skates differ sharply in their vulnerability coefficients. As mentioned before skates tend to stay very close to the bottom and as a result avoid capture when the net is equipped with rollers. The variations in vulnerability between species are great. Some species, like the barndoor, appear extraordinarily adept at avoiding capture, and others, like the big skate, relatively vulnerable. In general skates have low vulnerability coefficients. Flounders, without exception, seem to be quite vulnerable to the Yankee trawl with its rollers. Of the species listed in Table 7, the sand flounder appears to be the least vulnerable.

Our survey trawl is not an efficient piece of gear for sampling pelagic and quasi-pelagic species. It does sample many of the species of interest to us, however, and the necessary coefficients for correction of the data have been estimated. Fortunately most of these species have recognizable traces on echo sounder records and their availability coefficient can be estimated with considerable precision. Many of these species migrate diurnally and change their behavioural pattern seasonally, complicating the estimation of coefficients. With the exception of the sea herring, however, all those we are concerned with here go right to the bottom and are available to the gear in substantial numbers in certain seasons or at certain times of the day.

Coefficients for the sea herring were developed in a straight-forward manner. Bureau biologists at Boothbay Harbor Laboratory have carefully studied the diurnal migratory pattern of sea herring using echo sounder and trawl data. They have informed us that during clear days about 5% of the population is available to our survey net for a period of eight hours or less. The availability coefficient is accordingly estimated as 0.017 (0.05×0.33). Television observations of sea herring and comparative gear study data do not suggest that herring are particularly adept at escaping the trawl. A relatively high coefficient of vulnerability, 0.9, was therefore chosen.

It is also necessary to correct for the bias introduced because a particular species favors a physical niche not properly sampled by the survey cruise station pattern, or because a species leaves the survey area seasonally. A species that left the survey area entirely during one season but was contained entirely within the survey area for the other two seasons sampled would be given an areal coefficient of 0.67. Unfortunately none of our species behave this simply and the areal/seasonal coefficients were difficult to estimate and are admittedly quite subjective.

For those species which migrate in and out of the survey area and that do not favor parts of the area not properly surveyed, reasonable areal/seasonal coefficients can be derived by comparing the average changes in relative abundance associated with season. Obviously any future survey program planned for the purpose of estimating biomass would use only the data obtained during the optimal sampling season for any particular species.

To obtain estimates of the standing crop the total correction factor (last column in Table 6) is divided into the first estimate of biomass. These final estimates are given in Table 8. For convenience these estimates are listed in decreasing order of quantity in Table 9, with the available statistics on actual landings.

There are no particular surprises in these data. It would appear that the mean annual harvest was approximately one quarter of the standing crop of fish, or about 37 pounds/acre. In comparison with other productive grounds in the Northern Hemisphere this can be considered average (Graham and Edwards, 1962).

Table 8. First estimate of biomass (for all zones) and estimates of standing crops derived using correction factors.

	First Estimate of Biomass lbs $\times 10^6$	Total Correction Factor	Estimated Standing Crop lbs $\times 10^6$
Alewife	19.45	0.22	87.53
American plaice	34.82	0.28	125.35
Argentine	3.37	0.018	187.37
Barndoor	17.75	0.10	177.50
Big skate	59.06	0.20	295.30
Blackback	31.41	0.17	185.32
Butterfish	21.81	0.07	309.70
Cod	135.90	0.28	489.24
Eel pout	56.46	0.31	170.67
Fourspot	8.15	0.49	16.30
Greysole	16.21	0.49	32.42
Goosefish	45.84	0.32	142.10
Haddock	466.84	0.48	980.36
Little skate	57.64	0.15	386.19
Longhorn sculpin	29.63	0.42	71.11
Ocean perch	107.75	0.27	398.68
Pollock	44.48	0.075	596.03
Red hake	48.53	0.07	693.98
Sand flounder	6.10	0.09	30.50
Scup	2.96	0.045	65.71
Sea herring	18.24	0.01	1,824.00
Sea raven	8.75	0.90	9.63
Silver hake	72.87	0.035	2,084.08
Spiny dogfish	405.39	0.29	1,373.33
Thorny skate	57.87	0.10	578.78
White hake	36.19	0.51	72.38
Yellowtail	71.46	0.39	185.80
All Others	50.43	0.16	307.62
Total			11,876.90

The largest single unexploited resource is the spiny dogfish. When a good use has been found for this species it will obviously sustain a large fishery although not as large as might be expected from the size of its standing crop. The dogfish is highly vulnerable to existing gear and its reproductive potential relatively low. A sustained yield of about 30% of its standing crop would be near the maximum level of exploitation. We have available then an annual resource of approximately 400 million pounds of dogfish.

The skates as a group have a high standing crop, estimated at 1,438 million pounds. This would be a difficult resource block to harvest efficiently. They are relatively invulnerable to standard gear with rollers and unlike the dogfish, seldom, if ever, aggregate to any significant degree.

Of the food species listed, the percentage of standing crop landed has increased significantly in the last two years (1966 and 1967) for all but pollock, ocean perch, white hake, butterfish, greysole and goosefish. In every case but one, that of the ocean perch, effective fishing tactics need

Table 9. Estimated standing crops in decreasing order and average landings for the period 1963-1965. To nearest million pounds.

	Standing Crop	Average Annual Landings	Percentage of Landed Standing Crop
Silver hake	2,084	638	30.6
Sea herring	1,824	529	29.0
Spiny dogfish	1,373	+	
Haddock	980	337	34.4
Red hake	694	176	25.4
Pollock	596	54	9.1
Thorny skate	579		
Cod	489	156	31.9
Ocean perch	399	54	13.5
Little skate	386		
Butterfish	309	10	3.2
Big skate	295	+	
Argentine	187	9	4.8
Blackback	185	32	17.3
Yellowtail	185	93	50.3
Barndoor skate	178	+	
Eel pout	171	12	7.0
Goosefish	142	+	
American plaice	125	9	7.2
Alewife	87	42	48.3
White hake	72	7	9.7
Longhorned sculpin	71	+	
Sand flounder	68	+	
Scup	66	10	15.2
Greysole	32	4	12.5
Fourspot flounder	16	+	
Sea raven	10	+	
All Others	308	460[1]	
Totals	11,877	2,630	(Average) 22.1

[1] This poundage includes all species, especially those landed but not recorded separately by various food fisheries and the industrial fishery. Only a small part of this figure represents species not listed in table.

to be developed if we are to take advantage of these resource blocks. Pollock and butterfish are both semi-pelagic species and are best captured with mid-water trawl gear. White hake and greysole are both deeper water species that do not aggregate strongly. The goosefish is widely distributed over all types of bottoms and in all depths and is never strongly aggregated. The last three species can only be fully exploited directly if gear is developed that sweeps wide areas of the bottom, or if full advantage is taken of the catch that is incidental to other fisheries.

The ocean perch is a special case. While it has a market as a food species, marketing problems exist because it is heavily parasitized by the copepod *Sphyrion*.

There are some moderately large blocks, as for example the pollock and butterfish, that are not being exploited to any significant degree primarily because of the gear problem. The solution of the gear problem, one of developing proper, controllable mid-water gear creates opportunities for doing much more than harvesting pollock and butterfish. With such gear our fisherman could effectively compete with anyone for a significant share of the silver hake and sea herring as well as other pelagic and semi-pelagic species.

The survey cruise data includes data on resources other than finfish. Two of these, the squid *Loligo* and the lobster, are worth some comment.

Using the techniques discussed earlier, the standing crop of squid is estimated to be approximately 700 million pounds. Squid have a marked seasonal migratory pattern, generally well inshore in the summer at which time they are often strongly aggregated and offshore in the winter at which time they are generally dispersed. While they are moderately available and vulnerable during the day to otter trawls, an effective fishery would require mid-water gear.

The standing crop of lobster is estimated to be around 50 million pounds. The species is generally widely dispersed across the shelf and aggregates significantly only in the areas of submarine canyons in fairly deep water. The harvest problem presented is like that presented by skates. The resource seems quite large but it is widely dispersed.

South of the area covered by the survey cruises there are other finfish resources worthy of brief mention. They are the silver hake (two species), menhaden, round herring and the mackerel, all pelagic or quasi-pelagic species. With the exception of the round herring each of these resources is currently exploited to some degree. The results of one winter survey cruise in the region have been published (Edwards, et al., 1962). The Virginia Institute of Marine Science has carried out extensive fish resource surveys off the Virginia Capes during the past two years. The data will be published in the future and should prove helpful in specifiing more exactly the nature of the resource.

The round herring appears to be a resource of considerable magnitude. During the winter months large schools are encountered at the edge of the Continental Shelf. During the warmer months small schools may migrate as far north as the Bay of Fundy. Very large schools of round herring have been reported in the Hudson Canyon area and one such is said to have extended nearly 100 miles. Whether this was a gross exaggeration or not remains to be seen. In any event the available evidence suggests that the standing crop of round herring is very large in the area between the Carolinas and Cape Cod.

Once the object of a substantial fishery in New England waters even by today's standards, the mackerel has not been abundant in recent decades. It is at present becoming much more abundant. Whether this is merely a short term increase or not is not known. The species could conceivably become as abundant as it once was and again support a very large fishery. At the present time a small mackerel fishery, perhaps producing from 50 to 75 million pounds annually seems feasible.

There are some offshore pelagic resources and benthic resources that offer some further opportunities.

Mr. Keith A. Smith, Director of the Bureau's Exploratory Fishing and Gear Research Base at Gloucester, Mass., kindly provided the data contained in Table 10. There is a tuna resource of modest dimensions that is not being exploited at the present time, with the exception of the bluefin. The ocean quahog is a comparatively large and essentially unexploited resource in the middle Atlantic. The species is most abundant in deeper water and an efficient harvest technology does not exist for it. The northern shrimp resource is being exploited more each year and given a favorable reception at the market place will soon

Table 10. Estimated sustained production capabilities for various latent or largely unused fishery resources, in millions of pounds (Courtesy Keith A. Smith).

	Estimated Production Potential by Areas		
	ICNAF Subarea 5	Middle Atlantic	Total Estimated Annual Yield
FISHES			
Flyingfish	6.6	11.0	17.6
Grenadiers	40.0	11.0	51.0
Anchovies	6.6	15.0	21.6
Sand lance	6.6	2.2	8.8
Bluefin tuna	15.0	4.4	19.4
Yellowfin tuna	—	11.0	11.0
Skipjack	55.0	22.0	77.0
Little tuna & others	2.2	2.2	4.4
Swordfish	4.4	2.2	6.6
Sharks	77.0	66.0	143.0
Totals	213.4	147.0	360.4
INVERTEBRATES			
Northern shrimp	25.0	—	25.0
Red crabs & others	2.2	2.2	4.4
Ocean quahogs	11.0	114.0	125.0
Surf clams	5.0	85.0	90.0
Totals	43.2	201.2	244.4

reach the level suggested by Smith as near the maximum. On the surface at least none of these appears to be a very large resource and nearly all require substantial improvement in harvest technology if we are to take full advantage of them.

SUMMARY STATEMENTS AND CONCLUSIONS

1. The estimated biomass of finfish in the Continental Shelf area between the Hudson Canyon and the southern end of the Nova Scotian shelf is about 12 billion pounds or 168 pounds per acre.

2. During the three years 1963-1965, in excess of 2.6 billion pounds of finfish were landed annually from this area. This is an annual harvest rate of 37 pounds per acre, a relatively high figure for northern hemisphere fishing areas.

3. The standing crop has been decreasing rapidly in recent years. While the decrease is obviously greater in those species specifically fished for, the decrease is general.

4. The largest unexploited resource blocks are elasmobranchs, dogfish and skates, for which there is virtually no market demand in this country.

5. Utilization of those species caught incidentally and discarded would greatly increase our landings. The quantity discarded is unknown and can only be roughly estimated but it is clearly a very large amount, judging by industrial fishery and survey cruise data.

6. The greatest potential for increase at the moment appears to lie in those species best taken with mid-water gear. Improved harvest technology, especially the development of versatile mid-water trawls, would greatly increase the capability of the American fisherman both to compete for presently exploited resources (e.g. sea herring and silver hake) as well as to exploit species presently not heavily exploited (e.g. pollock and butterfish).

7. A highly organized, versatile and efficient fishery, paying due attention to the principles of good fishery management, should be able to extract from 4 to 5 billion pounds of finfish annually from the area covered by the groundfish survey. While such a fishery cannot be visualized at this time, the potential is there if we ever truly need it.

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