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An Illustration of the By-Catch Problem in ICNAF Subarea 5 and Statistical Area 6

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INTRODUCTION

Fishery management based on individual species catch quotas faces difficulties whenever a significant proportion of the fishing mortality on a given species is generated as a by-catch in fisheries directed towards other species. Quotas are only effective in regulating fishing mortality of fleets which can control precisely their catches of each of the managed species. The initial haddock quota regulations (Subarea 5 and Division 4X) stated that the directed fishery should cease whenever the accumulated catch (directed catch plus by-catch) reported to ICNAF bi-weekly reached 80 percent of the quota, anticipating in advance that the catch after closure (a by-catch by definition) would be twenty percent of the quota. When the yellowtail flounder was added to the list of species under quota the closure procedures were changed. The Assessment Subcommittee first estimated the expected monthly by-catch after closure of directed fisheries. The decision to cease directed fishing was then made when the sum of the total catch reported to ICNAF on a bi-weekly basis plus the expected by-catch during the remainder of the year equalled the quota. With the introduction of national quota allocations in 1972 the procedure again changed requiring each country to close its directed fishery so that the sum of its directed catch and the estimated by-catches would not exceed its quota allocation.

This management procedure is adequate from a conservation standpoint when species are caught independently. When they are not, and the by-catch is relatively large, necessary restrictions are difficult to achieve by closures of the directed fishery. The goal of national quota allocation procedures is an equitable distribution of allowable catch among countries. Thus, the above requirements for successful management apply not only to the total quota but to the national quotas as well. When only a few species are under the quota and the by-catch of those fisheries is small, it may be possible to meet each quota by proper fleet management. However, in 1973, the situation in ICNAF Subarea 5 and Statistical Area 6 is such that all main fisheries are under national quotas and the by-catch in large. Under these circumstances it may not be possible to catch a species' entire quota which is set without regard for associated by-catch, and still achieve the desired objectives.

This paper analyzes the effect of by-catch on the realization of objectives using national quotas set for 1973.

MATERIALS AND METHODS

Data Base: Nominal landings and effort for designated main species (or species group) sought categories are submitted annually by all ICNAF associated countries fishing in Subarea 5 and Statistical Area 6. These data are published in Table 4 of the ICNAF Statistical Bulletin Series. From this series the 1971 records (ICNAF Statistical Bulletin, 1972) were selected as the data base from which the proportions of by-catch and directed catch were derived for use in subsequent simulations. The nominal landings were equated to catches and no attempt was made to estimate and include the removals due to discards.

Several different procedures were used to estimate the total allowable catches in 1973 in order to allow simulation of actual catches. 1973 ICNAF national quota allocations for member countries in Subarea 5 and Statistical Area 6 were used for cod, redfish, silver hake, flounder (other flounder plus yellowtail flounder quotas), herring, and mackerel. The global quota for haddock was apportioned between countries on the basis of the distribution of 1971 haddock catches. The total allowable catch of the category "other pelagic fish", was obtained by adding 12 tons to the mackerel quota based on ratio of the mackerel catch to total other pelagic catch in 1971. The 1971 nominal landings were used with species under quota for non-member countries and for member countries without a national quota. Finally, for unregulated species (other groundfish, and other fish), the 1971 national nominal landings were again chosen as the restraint. The term "quota" used for 1973 in this paper refers to the limitations described above.

Analytical Methods: Yearly landings for finfish only, excluding catches by fixed gear, were summarized over the "main species sought" categories in Table 4 of the ICNAF Statistical Bulletin excluding the menhaden, halibut, and those of the large pelagic fishes - tuna, billfish, and sharks (other than dogfish). In instances where no "main species sought" category was indicated, or where landings were attributed to a "mixed" fishery; the monthly landings were designated by "species sought" categories on a basis of simple plurality (Assessment Sub-Committee Report - ICNAF Summ. Doc. 73/1). The term "fishery" as used in this document refers to the vessels and associated catch in these main species sought categories. We also use the term "species" for both individual species and species groups. All reported landings were thus identified by two factors: species and fisheries. Such tabulations were prepared for all participating nations.

In order to estimate the effects of by-catch on 1973 catches, the following procedures were used, based on reported 1971 catches of each country. The catch of each species in a fishery was first expressed as a percentage of the total catch (column total) for that species for each country (CH percent in Appendix Tables 1-11). This computation shows the percentage of the total catch of a given species that was caught by the fishery for that species- the directed percent caught, as well as the percent of the total catch of that species in each of the other fisheries. These percentages were then used to distribute 1973 "quotas" for each species over all fisheries, to obtain an "estimated" catch for each country.

Secondly, within each fishery the catch of each species was expressed as a proportion (R) of the catch of the main species sought, again for each country separately (Appendix Tables 1 through 11). This computation shows the by-catch as a proportion of the main species sought in a given fishery. By applying these proportions to the estimated directed catch for each fishery as computed above, the "expected" by-catch of associated species was obtained for each fishery for each country.

Totals of the estimated and expected catches (Tables 1 and 2) were obtained by summing the appropriate values over all countries. The overall species by-catch ratios were then recomputed (Table 2). The difference between the "estimated" catches (Table 1) and the "expected" catches (Table 2) indicates fishery-species interactions that cause problem areas for harvesting operations (c.f. Special meeting of experts on effort limitation, ICNAF Summ. Doc. 73/5). In other words, the differences represent an effect which is not anticipated when setting regulations. Table 3 and Appendix Tables 12 through 19 give the differences between the estimated and expected catches. Where a negative difference exists, the quota would be exceeded.

Two other sets of simulations of 1973 patterns of catches were examined. In the first set, the entire 1973 quota for each species was assumed to be taken by its directed fishery. The associated by-catch within each fishery was then estimated using the proportions (R) given in Table 2. In the second set, quota restraints and simulated catches were analyzed using linear programming techniques.

Linear Programming: In this set of simulations, the summary by-catch ratios (R) were used to develop a series of linear equations, which when solved through a linear programming technique allowed the interaction terms to be reduced such that the total catch of all species could be maximized without exceeding the quotas.

The linear programming model is a decision model for which the effectiveness of an allocation scheme over several variables is measured by the maximum value of some linear function of those variables, when those variables are subject to linear constraints. The problem can be formulated as that of determining

$$X = (x_1, x_2, x_3 \ldots x_N) \tag{1}$$

in the model $$Z = \sum_{i=1}^{N} (c_i x_i) \tag{2}$$

such that the constraints $$\sum_{i=1}^{N} (a_{ij} x_i) \begin{matrix} < \\ (=) \\ > \end{matrix} b_j \quad j=1 \ldots M \tag{3}$$

$$x_i \geq 0 \qquad i=1 \ldots N \tag{4}$$

where a_{ij} and c_i are constants and Z is maximized with respect to the variables x_i. Since minimizing Z is equivalent to maximizing

$$\sum_{i=1}^{N} (-c_i x_i),$$

all optimization problems of the kind defined by equations (1)-(4) can be treated as maximization problems.

The linear programming model has a short history of application to fisheries problems. Recently, Rothschild, and Balsiger (1971) constructed such a model in order to allocate the catch of salmon among the days of the salmon run. In this application, the objective function to be maximized represented the total landings of the species. The constraints in the system included the cannery capacity for the species, and the adequate escapement of male and female fish.

Our analyses were concerned with maximizing a Z which would represent the total catch of all finfish in ICNAF Subarea 5 and Statistical Area 6. A computer program developed by the Honeywell Co., called LINPRO was used to determine solutions to equations (1)-(4) using the two-phase method (Hadley, 1963, pp. 149-173). The data which were entered in the equations are given in Table 2. Each entry in the fisheries-species 9 x 9 matrix can be written as

$$x_{ij} = x_{ii} * \frac{x_{ij}}{x_{ii}} = x_{ii} * a_{ij} \tag{7}$$

where x_{ij} is the catch of species j in fishery i; x_{ii} is the directed catch of species i; a_{ij} is the ratio (=R, Table 2) of the directed catch which is species j; i=1...9, the number of fisheries; j=1...9, the number of species caught.

Our base system, in the format of (1)-(4), can be written:

$$\sum_{i=1}^{9}(x_{ij}) = \sum_{i=1}^{9}(a_{ij}*x_{ii}) \lessgtr b_j, \quad j=1..9 \qquad (8)$$

where the objective function to be maximized is

$$Z = \sum_{i=1}^{9}\sum_{j=1}(x_{ij}) = \sum_{i=1}^{9}\sum_{j=1}(a_{ij}*x_{ii}) = \sum_{i=1}^{9}(x_{ii}\sum_{j=1}(a_{ij}))$$

$$= \sum_{i=1}^{9}(x_{ii}c_i), \qquad (9)$$

where $c_i = \sum_{j=1}^{9}(a_{ij})$.

Analagous to equation (1), the variables to be determined are $X=(x_{11},x_{22},\ldots x_{99})$, where x_{ii} is greater than or equal to 0.

The constraints b_j in (8) are the "quotas" allocated in 1973 for each of the 9 species. Variations on the system were easily handled, including the addition of minimum catches in individual cases x_{ij}. The solution of the system of equations gives for each species the directed catch, and the catch in all other fisheries, which satisfies the constraints.

RESULTS AND DISCUSSION

Maximum Extent of By-Catch Effect: The rationale behind the setting of species quotas is based on control of species directed fisheries. The amount of by-catch in our model is a function of the catch of the directed species. An estimate of the maximum effect of by-catch on species catches in an open-ended (no total limit) species-quota system can be obtained by assuming the 1973 "quotas" are completely taken in directed fisheries. This is the ideal situation from the standpoint of fishery control by quota regulations and is of course the maximum that could be taken without the directed fisheries exceeding their "quotas".

The by-catch associated with these catches is calculated using the (R) values from Table 2. The by-catch in this situation causes the total catch to exceed the total "quota" by about 50 percent (Table 4). All species are significantly overfished relative to the 1973 "quotas". Excesses are particularly high for haddock (328%), other groundfish (139%), other fish (107%), flounder (95%), cod (82%), and herring (58%). In all of the above species, the by-catch is greater than 50 percent of the directed catch. It is obvious from this illustration that since many of the "quotas" are equal to or greater than 1971 catches, fishery management in ICNAF in 1973 has to be concerned as much if not more with controlling the by-catch, as with the directed fishery itself.

Estimations of By-Catch in 1973 Based on 1971 Fishing Patterns: Table 3 gives the deviations between the estimated and expected by-catches in 1973, that will occur if the directed catch is the same proportion of the total catch as observed in 1971. There are significatnt deviations for some species in nearly every fishery. The silver hake fishery appears to cause the greatest amount of mortality on other species, with the by-catch in that fishery exceeding expected values for all species except other pelagics, and being particularly significant for haddock, flounder, other groundfish, and herring relative to their specific "quotas". The cod and flounder fisheries have a major impact on the haddock quota, while the other pelagic fishery impinges on flounder and herring quotas. The deviations for individual countries are presented in Appendix Tables 12-19.

This analysis clearly illustrates that the 1973 quota regulations dictate major changes in fishing practices if quotas are to be met. It is realized of course that the actual by-catch will fluctuate with changes in species density even under constant fishing pressures. However, in general, the relative mortalities generated would have a constant relationship to the units of effort expended.

The 1973 "quotas", as determined in this paper, include catches which are unallocated in the official 1973 regulations, but which in reality can be expected to occur. The effect of this can be ascertained by summing the deviations in Table 3 over fisheries for each species (column totals) and adding to these totals the difference between the 1973 "quota" used in this paper (refer to method section), and the actual legal quota (if any). This computation shows that for haddock (100%), flounder (22%), other groundfish (8%), herring (29%), and other fish (8%), quotas would be exceeded (by the percentages given in brackets), while for cod (20%), redfish (16%), silver hake (20%), and other pelagics (5%), catches would be under the quota by the percent indicated. This underachievement could result in the expansion of effort in the directed fisheries for these species, in order for countries to achieve their allotted legal quota, thus causing an accompanying increase in by-catch for those species already overharvested.

Linear Programming Solutions to By-Catch Problem: It is clear from Table 2 that by reducing certain directed fisheries and thus reducing by-catch, the problem of exceeding certain quotas could be mitigated; for example, reducing the directed catch of cod would lessen the total amount of haddock caught. There are, however, innumerable possible solutions to this general problem. For example, the herring quota could be met by adjusting the directed fisheries for herring, for other pelagic fishes, or for silver hake, in any one of several possible alternatives such as: eliminate the silver hake fishery, cut the mackerel fishery in half, and reduce the directed herring catch by 28 metric tons; or eliminate the other pelagic fishery, reduce the silver hake fishery by half, and cut back the directed herring fishery by 26 tons; and so on. Linear programming offers a rational approach to solving this problem.

One solution which maximizes total catch without allowing any species quota to be exceeded, although it does permit directed fisheries catch to go to zero, is given in Table 5. The resultant total catch of 1,068,000 MT is a reduction of 40,000 MT from the original total allowable catch (Table 1). However, the directed fisheries for cod and haddock are eliminated, and those for herring, other fish, and flounder are only 62, 52 and 38% of the original values (Table 1). These species groups are of primary interest to the coastal fisheries.

In order to obtain a solution that preserves some semblance of a directed fishery for the coastal state, additional minimum constraints (Table 6) were established for both the directed and total catches. These constraints were arbitrarily derived to serve as an example and do not fully meet the coastal fishery needs as reflected in previous years catches. Also, the directed fishery catches have been adjusted sufficiently below 1973 U.S. quotas to eliminate internal by-catch conflicts.

The solution to this second case is presented in Table 6. The total catch is now reduced by 190,000 MT, the directed fisery for haddock eliminated, and that for silver hake virtually eliminated. The directed fisheries for cod and herring are reduced substantially, and the total catches for cod, redfish, silver hake, flounder and other groundfish are lower than allocated for 1973. This indicates the gross inadequacy of regulation by species quotas alone, to achieve conservation goals or to provide for the needs of the coastal fleet.

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Table 1. Simulation of 1973 "estimated" catch based on 1971 fishing patterns summed over countries considering national allocations, but considering each species independently distributed over fisheries. Values in MT x^{10-3}.

			SPECIES CAUGHT									
			Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic*	Other fish	Total
SPECIES SOUGHT	Cod	EstCh	15.7	1.5	.4	1.3	1.0	2.0	-	.1	.1	22.1
	Haddock	EstCh	7.7	2.1	.9	.1	2.1	2.9	-	-	-	15.8
	Redfish	EstCh	1.7	.1	18.4	.9	.5	1.0	-	-	-	22.6
	Silver hake	EstCh	3.1	.4	1.2	99.3	3.4	14.2	8.5	15.7	10.5	156.3
	Flounder	EstCh	10.2	1.4	3.1	6.6	36.5	5.8	.3	4.1	.4	68.4
	Other groundfish	EstCh	2.3	.3	.3	10.0	2.9	28.4	3.0	4.3	3.8	55.3
	Herring	EstCh	1.4	.2	1.6	16.0	1.0	4.9	158.0	34.2	12.8	230.1
	Other pelagic	EstCh	.5	-	3.6	12.3	1.6	10.0	21.3	398.9	36.4	484.6
	Other fish	EstCh	.1	-	-	10.0	.7	11.0	1.4	4.8	24.9	52.9
	Total	EstCh	42.7	6.0	29.5	156.5	49.7	80.2	192.5	462.1	88.9	1108.1
	"Quota" (1973)**		45.0	6.	30.	170.	51.	80.	175.	462.	89.	1108.

*97.5% mackerel

**Estimated catch differs from quota when unallocated portion of quota differs from appropriate 1971 catch.

Table 2. Simulation of 1973 "expected" catch based on 1971 fishing patterns summed over countries considering national allocations, but considering each species independently distributed over fisheries. Catch values in M.T. $X10^{-3}$ and expressed as a ratio (R) of by-catch to main species sought within fisheries. See text for explanation.

		SPECIES CAUGHT									
		Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish	Total
Cod	ExpCh	15.7	3.0	.4	.4	1.3	2.6	-	-	.1	23.6
	R	1.000	.191	.025	.025	.083	.166	-	-	.006	
Haddock	ExpCh	2.9	2.1	.3	-	.9	1.4		-		7.6
	R	1.381	1.000	.143	-	.429	.667		-		
Redfish	ExpCh	1.3	.5	18.4	.3	.7	1.5	.1	-	-	22.8
	R	.071	.027	1.000	.016	.038	.082	.005	-	-	
Silver hake	ExpCh	5.1	2.2	2.7	99.3	11.6	20.9	21.9	15.4	12.3	191.4
	R	.051	.022	.027	1.000	.117	.210	.221	.155	.124	
Flounder	ExpCh	8.6	3.2	2.2	1.9	36.5	6.4	.4	.5	.4	60.1
	R	.236	.088	.060	.052	1.000	.175	.011	.014	.011	
Other groundfish	ExpCh	1.5	.5	.1	6.6	3.1	28.4	3.4	3.0	3.8	50.4
	R	.053	.018	.004	.232	.109	1.000	.120	.106	.134	
Herring	ExpCh	.6	.2	.8	5.7	1.0	3.8	158.0	17.8	8.6	196.5
	R	.004	.001	.005	.036	.006	.024	1.000	.113	.054	
Other pelagic	ExpCh	.2	.3	.4	13.8	5.5	11.3	39.1	398.9	45.8	515.3
	R	.001	.001	.001	.035	.014	.028	.098	1.000	.115	
Other fish	ExpCh	.1	-	-	8.8	1.4	9.9	2.5	3.6	24.9	51.2
	R	.004	-	-	.353	.056	.398	.100	.145	1.000	
Total	ExpCh	36.0	12.0	25.3	136.8	62.0	86.2	225.4	439.2	95.9	1118.9
Quota(1973)		45.0	6.0	30.0	170.0	51.0	80.0	175.0	462.0	88.3	1107.4

SPECIES SOUGHT

*(97.5% mackerel)

Table 3. Differences between estimated 1973 catch and expected 1973 by-catch. Values in MT $x10^{-3}$.

SPECIES SOUGHT	SPECIES CAUGHT: Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic*	Other fish
Cod	-	-1.5	0.0	0.9	-0.3	-0.6	0.0	0.1	0.0
Haddock	4.8	-	0.6	0.1	1.2	1.5	0.0	0.0	0.0
Redfish	0.4	-0.4	-	0.6	-0.2	-0.5	0.1	0.0	0.0
Silver hake	-2.0	-1.8	-1.5	-	-8.2	-6.7	+13.4	0.3	-1.8
Flounder	1.6	-1.8	0.9	4.7	-	-0.6	-0.1	3.6	0.0
Other groundfish	0.8	-0.2	0.2	3.4	-0.2	-	-0.4	1.3	0.0
Herring	0.8	0.0	0.8	10.3	0.0	1.1	-	16.4	4.2
Other pelagic	0.3	-0.3	3.2	-1.5	-3.9	-1.3	-17.8	-	-9.4
Other fish	0.0	0.0	0.0	1.2	-0.7	1.1	-1.1	1.2	-
Total	6.7	-6.0	4.2	19.7	-12.3	-6.0	-32.7	22.9	-7.0

*97.5% mackerel

Table 4. Simulated 1973 catches assuming "quotas" are taken in the respective main species sought fisheries. Simulation based on 1971 fishing patterns. Values in MT X 10^{-3}. See text for explanation.

SPECIES SOUGHT	SPECIES CAUGHT: Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish	Total
Cod	45.0	8.6	1.1	1.1	3.7	7.5	<.1	<.1	.3	67.3
Haddock	8.3	6.0	.9	<.1	2.6	4.0	-	<.1	-	21.8
Redfish	2.1	.8	30.0	.5	1.1	2.5	.2	<.1	<.1	37.2
Silver hake	8.7	3.7	4.6	170.0	19.9	35.7	37.6	26.4	21.1	327.7
Flounder	12.0	4.5	3.1	2.7	51.0	8.9	.6	.7	.6	84.1
Other groundfish	4.2	1.4	.3	18.6	8.7	80.0	9.6	8.5	10.7	142.0
Herring	.7	.2	.9	6.3	1.1	4.2	175.0	19.8	9.5	217.7
Other pelagic	.5	.5	.5	16.2	6.5	12.9	45.3	462.0	53.1	597.5
Other fish	.4	<.1	<.1	31.4	5.0	35.4	8.9	12.9	89.0	183.0
Total	81.9	25.7	41.4	246.8	99.6	191.1	277.2	530.3	184.0	1678.0
Quota	45.	6.	30.	170.	51.	80.	175.	462.	89.	1108.

Table 5. Linear Programming Simulation of 1973 Catches Maximizing Total Catch. Values in MT X 10^{-3}.

Species sought	Total allowable catch constraint	Directed catch	Total catch
Cod	45	0	14
Haddock	6	0	6
Redfish	30	24	30
Silver hake	170	140	170
Flounder	51	14	42
Other groundfish	80	27	80
Herring	175	98	175
Other Pelagic	462	424	462
Other Fish	89	13	89
Total	1108		1068

Table 6. Linear programming simulation of 1973 catches maximizing total catch considering nation allocations and preserving portion to the United States directed fishery. Values in MT X 10^{-3}.

Species Sought	Total Allowable Catch Constraint	Directed Catch	Total Catch
COD	45	8	19
HADDOCK	6	0	6
REDFISH	30	19	22
SILVER HAKE	170	3	40
FLOUNDER	51	33	46
OTHER GROUNDFISH	80	23.5	59
HERRING	175	125	175
OTHER PELAGIC	462	440.5	462
OTHER FISH	89	27	89
TOTAL	1108		918

Addtl. constraints for Coastal State fisheries

	Directed	Total
Cod	$\geq$ 8	= 19.4
Haddock	$\geq$ 0	= 5.0
Redfish	$\geq$ 19	= 22.0
Silver hake	$\geq$ 3	= 9.0
Flounder	$\geq$ 33	= 38.7
Other groundfish	$\geq$ 9	= 19.4
Herring	$\geq$ 23	= 25.1
Other pelagic	$\geq$ 9	= 10.0
Other fish	$\geq$ 3	= 4.5

Appendix Table 1. 1971 nominal landings for Canada (ICNAF Subarea 5 and Statistical Area 6) - expressed as percentages of species catch distribution over fisheries (CH Percent) and Ratios of by-catch to main species sought within fisheries (CH Ratio). See text for explanation.

SPECIES SOUGHT		SPECIES CAUGHT								
		Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish
Cod	CH Ratio (R)	1.000	.352	.020	.000	.060	.196	.000	.000	.000
	CH Percent	64.41	40.49	14.50	.00	55.35	13.11	.00	.00	.00
Haddock	CH Ratio (R)	.582	1.000	.115	.000	.063	.219	.000	.000	.000
	CH Percent	12.95	39.67	29.00	.00	20.00	5.06	.00	.00	.00
Redfish	CH Ratio (R)	.318	.218	1.000	.000	.091	.282	.000	.000	.000
	CH Percent	1.14	1.40	40.89	.00	4.65	1.05	.00	.00	.00
Other groundfish	CH Ratio (R)	.276	.133	.018	.000	.018	1.000	.000	.000	.000
	CH Percent	21.49	18.44	15.61	.00	20.00	80.78	.00	.00	.00
Herring	CH Ratio (R)	.000	.000	.000	.000	.000	.000	1.000	.000	.000
	CH Percent	.00	.00	.00	.00	.00	.00	100.00	.00	.00
Other Fish	CH Ratio (R)	.000	.000	.000	.000	.000	.000	.000	1.000	.000
	CH Percent	.00	.00	.00	.00	.00	.00	.00	100.00	.00

Appendix Table 2. 1971 nominal landings for Federal Republic of Germany (ICNAF Subarea 5 and Statistical area 6) - expressed as percentages of species catch distribution over fisheries (CH Percent) and Ratios of by-catch to main species sought within fisheries (CH Ratio). See text for explanation.

			SPECIES CAUGHT								
			Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish
SPECIES	Herring	CH Ratio(R)	.000	.000	.000	.000	.000	.011	1.000	.022	.000
		CH Percent	100.00	100.00	.00	.00	.00	100.00	100.00	43.02	100.00
CAUGHT	Other Pelagic	CH Ratio(R)	.000	.000	.000	.000	.000	.000	.000	1.000	.000
		CH Percent	.00	.00	.00	.00	.00	.00	.00	56.98	.00

Appendix Table 3. 1971 nominal landings for Japan (ICNAF Subarea 5 and Statistical Area 6) - expressed as percentages of species catch distribution over fisheries (CH Percent) and Ratios of by-catch to main species sought within fisheries (CH Ratio). See text for explanation.

			SPECIES CAUGHT								
			Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish
SPECIES	Herring	CH Ratio(R)	.003	.004	.001	.002	.001	.018	1.000	.000	.007
		CH Percent	87.50	100.00	50.00	10.53	25.00	2.90	99.67	.03	.34
CAUGHT	Other Pelagic	CH Ratio(R)	.000	.000	.000	.005	.002	.080	.002	1.000	.010
		CH Percent	.00	.00	.00	44.74	75.00	19.61	.29	97.59	.73
	Other Fish	CH Ratio(R)	.000	.000	.000	.003	.000	.235	.000	.018	1.000
		CH Percent	12.50	.00	50.00	44.74	.00	77.49	.04	2.39	98.93

Appendix Table 4. 1971 nominal landings for Poland (ICNAF Subarea 5 and Statistical Area 6) - expressed as percentages of species catch distribution over fisheries (CH Percent) and Ratios of by-catch to main species sought within fisheries (CH Ratio). See text for explanation.

SPECIES SOUGHT		SPECIES CAUGHT: Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish
Herring	CH Ratio (R)	.002	.000	.000	.000	.000	.002	1.000	.222	.107
	CH Percent	53.52	100.00	9.20	14.19	.00	41.36	85.38	14.93	43.80
Other Pelagic	CH Ratio (R)	.001	.000	.001	.001	.000	.002	.132	1.000	.104
	CH Percent	46.48	.00	90.80	85.81	100.00	55.93	14.27	84.93	53.80
Other Fish	CH Ratio (R)	.000	.000	.000	.000	.000	.018	.708	.355	1.000
	CH Percent	.00	.00	.00	.00	.00	2.71	.35	.14	2.40

Appendix Table 5. 1971 nominal landings for Romania (ICNAF Subarea 5 and Statistical Area 6) - expressed as percentages of species catch distribution over fisheries (CH Percent) and Ratios of by-catch to main species sought within fisheries (CH Ratio). See text for explanation.

SPECIES SOUGHT		SPECIES CAUGHT: Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish
Silver hake	CH Ratio(R)	.000	.000	.000	1.000	.069	.000	.000	.000	.000
	CH Percent	.00	.00	.00	6.71	.38	.00	.00	.00	.00
Herring	CH Ratio(R)	.000	.321	.000	.000	.437	.020	1.000	.553	1.088
	CH Percent	.00	71.11	.00	.00	41.68	41.67	55.57	6.10	26.09
Other pelagic	CH Ratio(R)	.001	.015	.000	.095	.071	.003	.094	1.000	.362
	CH Percent	100.00	28.89	.00	93.29	57.93	58.33	44.43	93.90	73.91

Appendix Table 6. 1971 nominal landings for Spain (ICNAF Subarea 5 and Statistical Area 6) - expressed as percentages of species catch distribution over fisheries (CH Percent) and Ratios of by-catch to main species sought within fisheries (CH Ratio). See text for explanation.

SPECIES SOUGHT		SPECIES CAUGHT								
		Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish
Cod	CH Ratio(R)	1.000	.175	.000	.000	.000	.024	.000	.000	.000
	CH Percent	100.00	100.00	.00	.00	.00	100.00	.00	.00	.00

Appendix Table 7. 1971 nominal landings for U.S.S.R. (ICNAF Subarea 5 and Statistical Area 6) - expressed as percentages of species catch distribution over fisheries (CH Percent) and Ratios of by-catch to main species sought within fisheries (CH Ratio). See text for explanation.

			SPECIES CAUGHT								
			Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish
SPECIES SOUGHT	Silver hake	CH Ratio (R)	.013	.005	.003	1.000	.039	.209	.177	.218	.173
		CH Percent	58.82	81.02	5.24	67.36	29.73	27.64	12.98	9.97	24.91
	Other groundfish	CH Ratio (R)	.003	.000	.000	.356	.058	1.000	.051	.142	.178
		CH Percent	3.39	.27	.00	5.70	10.39	31.43	.89	1.54	6.09
	Herring	CH Ratio (R)	.006	.000	.012	.120	.006	.037	1.000	.153	.056
		CH Percent	25.67	2.41	18.50	7.14	3.90	4.28	64.81	6.17	7.18
	Other pelagic	CH Ratio (R)	.001	.000	.025	.089	.031	.066	.147	1.000	.117
		CH Percent	10.71	4.01	76.25	10.50	40.48	15.20	18.85	80.01	29.56
	Other fish	CH Ratio (R)	.001	.003	.000	.617	.092	.725	.150	.225	1.000
		CH Percent	1.42	12.30	.00	9.31	15.50	21.45	2.47	2.31	32.26

Appendix Table 8. 1971 nominal landings for USA (ICNAF Subarea 5 and Statistical Area 6) - expressed as percentages of species catch distribution over fisheries (CH Percent) and Ratios of by-catch to main species sought within fisheries (CH Ratio). See text for explanation.

SPECIES SOUGHT		SPECIES CAUGHT								
		Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish
Cod	CH Ratio(R)	1.000	.132	.043	.060	.146	.259	.003	.002	.010
	CH Percent	24.70	8.61	1.46	2.50	1.93	7.21	.06	.39	1.17
Haddock	CH Ratio(R)	1.492	1.000	.143	.007	.489	.740	.000	.001	.000
	CH Percent	24.86	44.00	3.32	.19	4.35	13.90	.00	.10	.00
Redfish	CH Ratio(R)	.073	.025	1.000	.018	.036	.083	.005	.000	.001
	CH Percent	3.91	3.58	74.55	1.67	1.03	5.00	.17	.03	.13
Silver hake	CH Ratio(R)	.140	.062	.082	1.000	.295	.219	.312	.006	.011
	CH Percent	4.89	5.71	3.97	58.86	5.49	8.58	7.86	1.60	1.88
Flounder	CH Ratio(R)	.235	.089	.061	.051	1.000	.176	.010	.014	.012
	CH Percent	35.18	35.08	12.65	12.89	79.94	29.72	1.07	15.29	8.41
Other groundfish	CH Ratio(R)	.155	.032	.018	.149	.377	1.000	.048	.018	.075
	CH Percent	4.35	2.37	.69	7.05	5.64	31.56	.97	3.59	10.09
Herring	CH Ratio(R)	.014	.002	.019	.078	.022	.028	1.000	.008	.002
	CH Percent	1.78	.63	3.32	16.46	1.43	3.94	89.67	7.48	.91
Other pelagic	CH Ratio(R)	.005	.000	.000	.020	.011	.003	.029	1.000	.011
	CH Percent	.05	.00	.00	.32	.06	.03	.20	68.11	.49
Other fish	CH Ratio (R)	.019	.001	.001	.002	.017	.003	.000	.030	1.000
	CH Percent	.30	.04	.03	.05	.14	.05	.00	3.40	76.93

Appendix Table 9. 1971 nominal landings for German Democratic Republic (ICNAF Subarea 5 and Statistical Area 6) - expressed as percentages of species catch distribution over fisheries (CH Percent) and Ratios of by-catch to main species sought within fisheries (CH Ratio). See text for explanation.

			SPECIES CAUGHT								
			Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish
SPECIES SOUGHT	Other groundfish	CH Ratio (R)	.000	.000	.000	.000	.000	1.000	.474	.015	.005
		CH Percent	.00	.00	100.00	.00	.00	67.16	10.90	.10	.24
	Herring	CH Ratio (R)	.000	.000	.000	.000	.000	.086	1.000	.140	.067
		CH Percent	.00	.00	.00	.00	.00	18.20	72.63	3.05	10.20
	Other pelagic	CH Ratio (R)	.000	.000	.000	.000	.000	.016	.050	1.000	.108
		CH Percent	.00	.00	.00	.00	.00	14.64	16.02	96.67	73.15
	Other fish	CH Ratio (R)	.000	.000	.000	.000	.000	.000	.057	.077	1.000
		CH Percent	.00	.00	.00	.00	.00	.00	.44	.18	16.40

Appendix Table 10. 1971 nominal landings for Bulgaria (ICNAF Subarea 5 and Statistical Area 6) - expressed as percentages of species catch distribution over fisheries (CH Percent) and Ratios of by-catch to main species sought within fisheries (CH Ratio). See text for explanation.

			SPECIES CAUGHT								
SPECIES SOUGHT			Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish
Silver hake	CH Ratio (R)		.007	.010	.000	1.000	.023	.027	.752	.523	.299
	CH Percent		20.00	100.00	.00	14.80	2.73	.29	4.92	.55	1.33
Other groundfish	CH Ratio (R)		.000	.000	.000	.579	.033	1.000	.075	.761	.791
	CH Percent		.00	.00	.00	29.34	13.28	37.13	1.67	2.72	12.09
Herring	CH Ratio (R)		.002	.000	.004	.048	.002	.044	1.000	.057	.178
	CH Percent		60.00	.00	86.67	8.29	3.13	5.61	76.75	.70	9.31
Other pelagic	CH Ratio (R)		.000	.000	.000	.026	.005	.052	.026	1.000	.174
	CH Percent		20.00	.00	13.33	35.75	49.61	51.40	15.71	95.66	71.06
Other fish	CH Ratio (R)		.000	.000	.000	.575	.193	.370	.104	.261	1.000
	CH Percent		.00	.00	.00	11.82	31.25	5.57	.94	.38	6.20

Appendix Table 11. 1971 nominal landings for Cuba (ICNAF Subarea 5 and Statistical Area 6) - expressed as percentages of species catch distribution over fisheries (CH Percent) and Ratios of by-catch to main species sought within fisheries (CH Ratio). See text for explanation.

			SPECIES CAUGHT								
SPECIES SOUGHT			Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish
Other fish	CH Ratio (R)		.000	.000	.000	.358	.000	.000	.000	.196	1.000
	CH Percent		.00	.00	.00	100.00	.00	.00	.00	100.00	100.00

Appendix Table 12. Differences between estimated 1973 Canada catches and their expected 1973 by-catch. Values in MT X 10^{-3}.

SPECIES SOUGHT	SPECIES CAUGHT: Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish
Cod	0.0	-0.6	-0.1		-0.1	-0.1			
Haddock	0.3	0.0	0.1		0.1	0.1			
Redfish	-0.1	0.0	0.0		0.0	-0.1			
Silver hake									
Flounder									
Other groundfish	0.3	-0.1	0.1		0.0	0.0			
Herring							0.0		
Other pelagic								0.0	
Other fish									
Total	0.5	-0.7	0.1	0.0	0.0	-0.1	0.0	0.0	

Appendix Table 13. Differences between estimated 1973 Federal Republic of Germany catches and their expected 1973 by-catch. Values in MT X 10^{-3}.

SPECIES SOUGHT	SPECIES CAUGHT: Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish
Cod									
Haddock									
Redfish									
Silver hake									
Flounder									
Other groundfish									
Herring	0.0	0.0				0.2	0.0	0.8	0.0
Other pelagic								0.0	
Other fish									
Total	0.0	0.0				0.2	0.0	0.8	0.0

Appendix Table 14. Differences between estimated 1973 Poland catches and their expected 1973 by-catch. Values in MT X 10^{-3}.

SPECIES SOUGHT	SPECIES CAUGHT: Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish
Cod									
Haddock									
Redfish									
Silver hake									
Flounder									
Other groundfish									
Herring	0.1					0.0	0.0	10.0	3,6
Other pelagic	0.1		0.0	0.0		0.0	-7.5	0.0	-1.6
Other fish						0.0	-0.3	-0.1	0.0
Total	0.2		0.0	0.0		0.0	-7.8	9.9	2.0

Appendix Table 15. Differences between estimated 1973 Romania catches and their expected 1973 by-catch. Values in MT X 10^{-3}.

SPECIES SOUGHT	SPECIES CAUGHT								
	Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish
Cod									
Haddock									
Redfish									
Silver hake				0.0	0.0				
Flounder									
Other groundfish									
Herring		-0.1			-0.1	0.0	0.0	0.8	-0.3
Other pelagic	0.0	-0.3		-1.4	-1.0	-0.1	-1.2	0.0	-5.2
Other fish									
Total	0.0	-0.4		-1.4	-1.1	-0.1	-1.2	0.8	-5.5

Appendix Table 16. Differences between estimated 1973 Spain catches and their expected 1973 by-catch. Values in MT X 10^{-3}.

SPECIES SOUGHT	SPECIES CAUGHT								
	Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish
Cod	0.0	-0.3				0.0			
Haddock									
Redfish									
Silver hake									
Flounder									
Other groundfish									
Herring									
Other pelagic									
Other fish									
Total	0.0	-0.3				0.0			

Appendix Table 17. Differences between estimated 1973 USSR catches and their expected 1973 by-catch. Values in MT X 10^{-3}.

SPECIES SOUGHT	SPECIES CAUGHT: Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish
Cod									
Haddock									
Redfish									
Silver hake	0.8	-0.1	0.0	0.0	-1.8	-1.8	-5.9	-0.2	-1.6
Flounder									
Other groundfish	0.1	0.0		0.7	-0.5	0.0	-0.3	0.3	0.0
Herring	0.5	0.0	0.4	3.6	-0.1	0.7	0.0	4.3	1.3
Other pelagic	0.2	0.0	0.4	0.2	-2.5	-0.9	-8.3	0.0	-1.7
Other fish	0.0	0.0	0.0	1.2	-0.7	0.0	-0.8	0.4	0.0
Total	1.6	-0.1	0.8	5.7	-5.6	-2.0	-15.3	4.8	-2.0

Appendix Table 18. Differences between estimated 1973 USA catches and their expected 1973 by-catch. Values in MT X 10^{-3}.

SPECIES SOUGHT	SPECIES CAUGHT								
	Cod	Haddock	Redfish	Silver hake	Flounder	Other groundfish	Herring	Other pelagic	Other fish
Cod	0.0	-0.6	0.1	0.9	-0.2	-0.5	0.0	0.1	0.0
Haddock	4.5	0.0	0.5	0.1	1.1	1.4		0.0	
Redfish	-0.2	-0.4	0.0	0.6	-0.2	-0.5	-0.1	0.0	0.0
Silver hake	-2.8	-1.7	-1.5	0.0	-6.4	-4.9	-7.5	0.2	-0.2
Flounder	1.6	-1.8	0.9	4.7	0.0	-0.6	-0.1	3.5	0.0
Other groundfish	0.4	-0.1	0.1	2.7	0.3	0.0	-0.1	0.8	0.0
Herring	0.2	0.1	0.4	6.7	0.2	0.2	0.0	1.8	0.0
Other pelagic	0.0			-0.2	-0.2	-0.1	-0.4	0.0	0.0
Other fish	0.0	0.0	0.0	0.0	0.0	0.0		0.8	0.0
Total	3.7	-4.5	0.5	15.5	-5.4	-5.0	-8.2	7.2	-0.2