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Catch and effort trends for the finfish resources of the Scotian Shelf and an estimate of the maximum sustainable yield of groundfish

by

R.G. Halliday
and
W.G. Doubleday
Environment Canada
Fisheries and Marine Service
Biological Station
St. Andrews, N. B.
Canada

INTRODUCTION

This document describes changes in nominal catches, fishing effort, and catch rates in Scotian Shelf fisheries (ICNAF Div. 4VWX) from 1954-73, but primarily from 1963-73. Attention is directed toward groundfish resources, and a simple general production model is applied to obtain a rough estimate of maximum sustainable yield for the groundfish resources as a whole, with the exception of silver hake.

Groundfish are defined liberally as all species other than silver hake, herring and mackerel, large pelagic species, and "inshore" species i.e. eels, salmon, smelt, sturgeons, trouts, tomcod, alewife, shad and bass. This leaves, in addition to the "traditional" groundfish species - cod, haddock, redfish and flatfish, a variety of species which are normally caught in the offshore trawl fisheries. Silver hake, although a groundfish species, is treated separately because of the very large catches involved. Hence the term "groundfish" as used below, solely for convenience, excludes silver hake.

NOMINAL CATCHES

Groundfish catches from the Scotian Shelf were about 165,000 metric tons in 1954, the first year for which comprehensive statistics can be separated out in ICNAF Statistical Bulletins for the Scotian Shelf (Fig. 1). Other species catches in Subarea 4 cannot be allocated to the Scotian Shelf and Gulf of St. Lawrence until 1961. It is likely that total catch of all species from the Scotian Shelf was in the order of 200,000 tons in 1954. By 1961, total catches were 291,500 tons (Table 1). (All statistics quoted here exclude large pelagic species and the small quantities of menhaden, butterfish and saury reported from Subarea 4.) From 1961, catches increased fairly steadily to 773,000 tons by 1973.

Groundfish catches reached a maximum of 322,000 tons in 1966 and have averaged 266,000 tons since. Catches in 1973 were 278,000 tons. Increasing total catches were maintained by expanded silver hake catches in 1963-64, then by increased herring catches from 1964 to 1969, and finally by a second large increase in silver hake catches from 1969 to 1973.

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Among groundfish, cod has been the most important single species in terms of volume (Table 1, Fig. 2). Cod landings averaged about 72,000 tons in 1954-58, then steadily increased to 131,700 tons by 1968. Subsequently, landings have been lower, averaging 109,800 tons in 1969-73. In the 1950's and early 1960's, haddock was the next most important species. Landings varied between 40,000 tons and 50,000 tons in 1954-63, but increased rapidly to 84,000 tons by 1965, then gradually declined to 17,500 tons by 1973. Flatfish landings increased from about 12,000 tons in 1961 to 56,500 tons in 1968, but averaged about 30,000 tons in 1969-73. In most recent years, redfish landings increased substantially to 60,000 tons in 1971 but declined to 40,000 tons by 1973, and pollock landings increased from 12,000 tons in 1971 to 30,000 tons in 1973. These increases, and increases in landings of less popular species have sustained landings at the average of 266,000 tons.

CATCH RATES

Catch rates (metric tons per day fished) of all major tonnage classes of Canadian (Maritimes) vessels fishing groundfish have declined gradually from 1964-65 to 1971 with apparent slight increases in most classes in 1972 and 1973 (Fig. 3). Separating major gear types within tonnage classes for vessels over 150 gross tons indicates, however, that this recent increase is largely a result of a change to midwater trawling for groundfish by a small proportion of vessels. The following catch rates (metric tons per day fished) were attained in 1971-73:

Year	151-500 gross tons		501-900 gross tons	
	Otter trawlers	Midwater trawlers	Otter trawlers	Midwater trawlers
1971	7.70	–	9.48	48.62
1972	8.39	30.21	10.30	36.27
1973	8.00	29.59	10.06	26.42

Catch rates of 501-900 gross ton midwater trawlers declined by 46% between 1971 and 1973. (Catch rates of vessels under 150 gross tons have not been examined in detail.)

Catch rates of 501-900 gross ton otter trawlers declined from 19.48 metric tons/day fished (m.t./d.f.) in 1965 when this class of vessel first entered the fishery to 10.06 m.t./d.f. in 1973 (Fig. 4, Table 2).

Catch rates of 151-500 gross ton otter trawlers were above 10.00 m.t./d.f. between 1954 and 1965, the highest catch rate of 13.02 m.t./d.f. being attained in 1956. Despite substantial vessel and gear improvements and the entry of a number of stern trawlers to this tonnage class, catch rates have gradually declined to 8.00 m.t./d.f. in 1973.

Species composition of catches (Fig. 5) of 151-500 g.t. otter trawlers (in terms of k.g. caught/hour fished which shows similar overall trends to m.t./d.f.) in 1965-73 is very similar to the composition of total international catches in those years (c.f. Fig. 2). These vessels do not fish for silver hake, herring or other pelagic species, or shellfish, but do fish for all of the major groundfish species.

Cod catch rates declined from 303 k.g./hr. in 1965 to 159 k.g./hr. in 1973, haddock from 190 k.g./hr. in 1966 to 69 k.g./hr. in 1973, flounders from 152 k.g./hr. in 1967 to 78 k.g./hr. in 1973. Redfish catch rates increased from 24 k.g./hr. in 1965 to 228 k.g./hr. in 1971, but declined to 155 k.g./hr. in 1973.

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Catch rates of "others", predominantly pollock, declined from
212 k.g./hr. in 1965 to 51 k.g./hr. in 1971, then increased to
168 k.g./hr. in 1973. Thus, there has been a succession of species
forming important components of the catches as more desirable
species declined in abundance, but this has not sustained overall
catch rates which declined from 846 k.g./hr. in 1965 to 630 k.g./
hr. in 1973.

Relatively few country x tonnage class x gear combinations
have consistently fished the Scotian Shelf in the period 1963-
73. Catch rates of those which did are summarised in Table 2
and Fig. 6. Catch rates of Canada (N) otter trawlers of 151-500
g.t. declined from 13.71 m.t./d.f. in 1965 to 10.13 m.t./d.f. in
1973, and of 501-900 g.t. otter trawlers from 19.23 m.t./d.f. in 1966
to 12.24 m.t./d.f. in 1973. French (M) otter trawlers of 901-
1800 g.t. had a catch rate of 32.47 m.t./d.f. in 1964, but only
18.80 m.t./d.f. in 1973. Spanish 151-500 g.t. pair trawlers
increased their catch rate to 22.35 m.t./d.f. in 1968 but catch
rates declined each year thereafter to 12.15 m.t./d.f. in 1973.
Spanish 901-1800 g.t. otter trawlers catch rates declined between
1964 and 1968, increased substantially in 1969, then declined to
1972. USA 151-500 g.t. otter trawlers suffered declining catch
rates between 1966 and 1969, but returned to the 1966 level by
1972, declining slightly in 1973. All of these vessel classes
have fished "traditional" groundfish species. Declines in French
and Spanish catch rates largely reflect declining cod abundance.
Recent increases in USA catch rates reflect the importance of red-
fish which increased in abundance in the early 1970's.

Catch rates of over 1800 g.t. USSR trawlers are unique among
these data sets in having highest catch rates in most recent years,
the highest (44.31 m.t./d.f.) occurring in 1973. USSR nominal
catches (Fig. 7), which were predominantly by this vessel class,
have been dominated by silver hake and recent increases in catch
rates reflect high silver hake abundance. High abundance of
traditional groundfish, particularly haddock, produced the 1965
peak in catch rates. Very low silver hake abundance in 1967 was
not reflected by low catch rates but by division of effort from
the area.

EFFORT

Canada, Spain, USSR, and USA have consistently exerted
substantial effort on the Scotian Shelf, although USA effort dropped
below 1,000 fishing days after 1967. The full record of effort
is too voluminous to produce here – that for 1973 is included
as an example (Table 3).

As discussed above, Canada (M) otter trawlers of 151-
500 gross tons has been the most consistent effort class, exert-
ing a high volume of effort throughout the recorded data series
from 1954 to 1973. They have also fished all the major ground-
fish species throughout this period. The vessels involved have
changed, with substantial improvements in gear and design in-
cluding introduction of some stern trawlers to this class. These
changes will have tended to minimise the observed decline in
catch rates over the time period.

This vessel class has been chosen to investigate total
effort trends in the groundfish fisheries, estimates of total
groundfish effort being obtained by dividing total catch by
Canada (M) 151-500 g.t. otter trawler catch per effort. This
indicates that effort increased fairly steadily from 1957 to
1966 (Fig. 2). In 1955-57, about 15,000 days were fished, effort
increasing, with small fluctuations to 33,200 days by 1966.
Effort fluctuated more widely since 1966 between about 27,000
and 41,000 days with an average close to the 1966 level. The
1973 level was 34,800 days.

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MAXIMUM SUSTAINABLE YIELD OF GROUNDFISH

The maximum sustainable yield and current status of
Scotian Shelf groundfish resources were examined by application of
the Schaefer production model to catch rates of Canada (M) 151-
500 g.t otter trawlers and the standardised effort derived from
them (Table 4).

Examination of catch per effort (C/E) in relation
to time indicated a downward trend with decreasing variance.
A regression line of log C/E against year has the form:

Log C/E = 1.594 - 0.0095 YEAR (r = -0.83)

A plot of residuals revealed positive correlations in successive
residuals. Therefore, a first order autoregressive model was
considered. The resulting equation is, for year t:

Log C/E(t) = 1.0624 + 0.3807 log 46(t-1)-0.00707t

(r = -0.89)

These regressions, taken together, indicate that a consistent
decline in C/E began in 1954 so that the population fished was
never in equilibrium from 1954 to 1973. Therefore, the
equilibrium C/E must be less than that suggested by these data.

Gulland's (1968) method, plotting C/E against effort
averaged over a number of preceding years, was used to correct
for the non-equilibrium conditions in the fishery. The correlation
between C/E and effort increases with increases in the averaging
period for effort up to three years (r = -0.88), declines with
four years, but again increases progressively up to seven years
(r = -0.92). It is unlikely that the time lag in population
response to fishing is greater than seven years. Thus, longer
averaging periods were not considered.

The regression line of C/E on three year running averages
of effort and the resultant equilibrium catch curve are illustrated
in fig. 8. This implies that maximum equilibrium catch is 280,000
m.t. attained with an effort of 37,500 days. Effort exceeded this
level only in 1971 (fig. 9). The seven year averaging period
gives an estimated MSY of 253,000 m.t. attained with an effort of
32,500 days, a level exceeded in the four years 1966, 1968, 1971
and 1973.

As noted above, substantial increases in efficiency
of this vessel class have occurred in the 1954-73 period due to
increases in the size and power of vessels, gear and navigational
and acoustic equipment improvements, and improvements in vessel
design including introduction of some stern trawlers to the class.
To allow for these changes, a steady rate of increase in efficiency
was introduced into the model. Running averages of effort were
varied from three to seven years and increases in efficiency varied
from one to five percent per year. The highest correlation between
C/E and effort was obtained using five year running averages
and four percent increase in efficiency (r = -0.97). This suggests
that the MSY is 255,000 m.t. (fig. 10) and that effort exceeded
that required to obtain this catch level in 1966 and from 1968
to 1973 inclusive.

Walter (MS 1975) proposed an alternative method to
that of Gulland to correct for non-equilibrium in the fishery.
Following Walter, a first approximation to the relationship of
C/E and effort was obtained by plotting C/E in year t+1 against
effort in year t. An adjustment for efficiency increase of four
percent per year also gave the best fit in this analysis. The
least squares regression line

C/E = 11.64 - 0.000120 Effort (r= -0.92)

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suggests an MSY of 282,000 m.t. at an effort approximately equal
to the 1965 value. Effort in 1966 and in 1968-72 substantially
exceeded this level.

An attempt to obtain a second approximation using Walter's
method of plotting $\Delta U/U$ versus $11.64 - U - 0.000120f$ (where
$U = C/E$ and f = effort) did not yield a significant regression,
hence little reliance could be placed on corrected C/E values.
Continuing the calculation, despite this, yielded a second approx-
imation to the MSY of about 230,000 m.t.

CONCLUSIONS

Application of the Schaefer production model to catch
and effort data for the Scotian Shelf groundfish resources (ex-
cluding silver hake) from 1954 to 1973 indicates that their MSY
is unlikely to be greater than 280,000 m.t. and could be as low
as 250,000 m.t. Recent levels of effort are at least sufficiently
high to attain this yield, but could in fact be 40% to 50% above
this level.

Groundfish species catch quotas for Scotian Shelf
stocks set for 1975 sum to 242,000 tons. This assumes that
50% (25,000 tons) of the Div. 4T-4Vn (spring) cod quota and about
70% (40,000 tons) of the Div. 4VWX + SA5 pollock quota are taken
on the Scotian Shelf, i.e. that the proportions remain the same
as in 1972 and 1973. Additional catches will be taken of un-
regulated species stocks, catches of which averaged 58,000 tons
in the four year period 1970-73. Thus, if all catch quotas are
taken in 1975, and if non-regulated species catches are at recent
levels, total catch would be 300,000 tons.

Preliminary 1974 data on catch rates of Canadian
otter trawlers show a decline of 10% over those of 1973 i.e for
151-500 g.t. vessels to 7.29 m.t./day from 8.00 m.t./day, and
for 501-900 g.t. vessels to 9.01 m.t./day from 10.06 m.t./day.
These are the lowest catch rates on record, indicating that
population abundance continues to decline.

Some increase in vessel efficiency has certainly
occurred and the time lag in population response to fishing can
be expected to be greater than three years (if the primary response
is through the recruitment mechanism) since the primary species -
cod, haddock, redfish and flounders - do not mature until age 4
or older. Thus, it is likely that the MSY is substantially below
280,000 m.t., and that recent levels of effort have resulted in
over-exploitation. This is substantiated by the fact that average
catches of 278,000 m.t. over the last 10 years have resulted in
continuing stock decline.

Catch quota regulations in force in 1974 and 1975 are
not sufficient to prevent continuing stock decline. The reduction
in effective effort below the 1973 level required to obtain
MSY could be as much as 50%. If the results of the Schaeffer
model using five year running averages of effort and four percent
efficiency increase are accepted, the reduction in effort required
from the 1973 level is 37%.

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Table 1. Nominal catches from the Scotian Shelf by major species and species groups, 1961-73

Section A

Year	Cod	Haddock	Redfish	Flatfish	Pollock	R & W Hake	Cusk	Wolf Fish	Argentine	Skates	Angler	Other "Bottom" Fish	Sub-total
1961	98,498	45,253	31,484	12,255	29,352	3,428	3,295	1,566	—	112	—	1,024	226,267
62	104,357	42,764	36,735	14,231	32,961	2,572	3,695	1,391	—	111	—	5,079	243,896
63	113,288	49,929	38,759	16,007	30,471	2,622	1,900	1,014	8,127	99	—	25,561	287,777
64	118,625	58,811	22,906	20,175	32,245	5,692	4,367	1,152	4,943	1,271	96	8,446	278,729
1965	126,457	84,087	19,578	30,283	27,729	10,026	4,634	96	5,611	166	—	8,021	316,688
66	125,545	65,723	40,836	36,122	24,476	4,196	4,997	130	14,983	51	696	4,227	321,982
67	101,321	48,101	18,259	26,020	14,787	2,147	4,630	1,003	4,271	77	8	2,569	223,193
68	131,682	45,668	13,627	56,506	17,623	2,103	3,154	1,655	2,675	6,290	2,428	4,629	288,040
69	98,980	41,566	22,993	34,194	15,221	3,814	2,735	1,595	5,354	4,505	3,295	12,935	247,187
1970	118,433	27,415	31,579	20,479	11,795	4,246	3,216	103	4,553	3,910	2,123	11,531	239,383
71	105,318	30,918	62,381	38,054	12,072	6,806	4,585	1,995	6,715	17,666	13,506	14,314	314,333
72	118,834	18,187	50,300	26,535	20,206	7,243	5,300	1,405	5,868	5,265	2,879	9,688	271,710
1973	107,605	17,494	40,173	31,482	30,100	7,526	5,650	1,277	1,444	7,573	10,291	17,666	278,281

Section B

Year	Section A Subtotal	Silver hake	Herring	Mackerel	"Inshore" species	Total Finfish[1]
1961	226,267	2	60,675	2,482	2,074	291,500
62	243,896	8,854	79,116	4,438	2,053	338,357
63	287,777	123,028	69,209	3,336	1,738	485,088
64	278,729	81,147	95,010	4,728	1,444	461,058
1965	316,688	50,022	131,274	6,762	864	505,610
66	321,982	10,323	192,037	7,397	1,345	533,084
67	223,193	2,483	191,928	7,986	1,340	426,930
68	288,040	3,547	250,320	15,312	1,680	558,899
69	247,187	46,564	301,218	14,545	947	610,461
1970	239,383	169,045	245,645	14,256	1,052	669,381
71	314,333	128,657	164,398	16,936	7,702	632,026
72	271,710	114,048	192,046	13,045	5,524	596,373
1973	278,281	298,621	164,923	25,703	5,353	772,881

[1]Excluding large pelagics and small quantities of menhaden, butterfish and saury.

Table 2. Catch rates (metric tons per day fished) for major vessel categories fishing the Scotian Shelf, 1963-73. Parentheses indicate values based on very small amounts of effort.

Year	Canada (M)		Canada (N)		Fra (M)	Spain		USSR	USA
	151-500OT	501-900OT	151-500OT	501-900OT	901-1800OT	151-500PT	901-1800OT	>1800OT	151-500OT
1963	10.19	-	12.13	-	25.00	15.49	30.36	36.45	14.66
1964	10.95	-	12.49	-	32.47	16.66	34.67	35.54	13.03
1965	10.40	19.48	13.71	15.45	28.88	19.16	20.64	40.60	14.83
1966	9.71	14.41	12.86	19.23	32.11	17.01	(5.00)	33.41	21.83
1967	8.28	10.69	12.70	15.27	30.33	14.83	18.42	33.65	11.98
1968	8.34	11.84	12.69	15.92	(16.22)	22.35	16.04	39.41	12.32
1969	8.23	11.63	12.18	13.88	(29.75)	17.64	36.24	42.59	8.03
1970	7.68	11.38	10.58	13.22	24.97	17.39	31.74	41.06	9.30
1971	7.70	9.48	11.18	11.96	20.60	15.04	22.75	36.40	15.23
1972	8.39	10.30	11.25	15.61	18.21	13.37	13.81	37.32	22.07
1973	8.00	10.06	10.13	12.24	18.80	12.15	16.12	44.31	19.89

Table 3. Effort and nominal catch by country, vessel tonnage class and major gear type - Scotian Shelf, 1973.

Division	Country	Tonnage Class	Gear	DG	DF	HF	Total catch	Gfsh. catch	% effort for Total catch	% effort for Gfsh. catch
4Vn	Canada(M)	501-900	OT	-	392	4881	4173	4173	100	100
			MWT	-	78	1094	1052	1052	100	100
		151-500	OT	-	855	10625	6922	6922	100	100
			MWT	-	78	1018	2599	2474	95	100
			PS	-	-	-	17268	0	0	-
		51-150	OT	-	71	982	301	301	100	100
			DS+SS	-	428	3323	1174	1174	100	100
			PS	-	-	-	401	0	0	-
			LL	-	15	121	47	47	100	100
			GN	-	142	1970	428	428	100	100
	Canada(N)	501-900	OT	-	100	1434	1410	1410	100	100
			MWT	-	21	316	391	391	100	100
		151-500	OT	-	330	4229	2965	2965	100	100
			MWT	-	25	392	465	465	100	100
			PS	-	-	-	3783	0	0	-
		51-150	OT	-	7	77	22	22	100	100
			PS	-	-	-	439	0	0	-
	Denmark(F)	NK	NK	-	-	-	1088	1088	0	0
	France(M)	901-1800	OT	-	452	-	8689	8679	100	100
	France(SP)	151-500	OT	-	61	963	386	386	100	100
	FRG	>1800	OT	-	2	31	89	89	100	100
			MWT	-	7	85	558	0	100	-
	Portugal	>1800	OT	-	69	874	756	756	100	100
		901-1800	OT	-	197	2359	2049	2049	100	100
			GN	-	2	48	1	1	100	100
			DV	-	7	337	121	121	100	100
		501-900	DV	-	7	443	68	68	100	100
	Spain	901-1800	OT	66	53	769	731	731	100	100
			PT	55	39	403	839	839	100	100
		501-900	PT	64	49	627	1652	1652	100	100
		151-500	PT	103	85	960	955	955	100	100
	USA	151-500	MWT	-	3	-	7	7	100	100

Table 3. (continued)

Division	Country	Tonnage Class	Gear	DG	DF	HF	Total catch	Gfsh. catch	% effort for Total catch	% effort for Gfsh. catch
4Vs	Canada (M)	501-900	OT	–	213	2711	2219	2219	100	100
			MWT	–	8	128	187	187	100	100
		151-500	OT	–	735	9268	6680	6680	100	100
			MWT	–	21	317	524	524	100	100
			LL	–	77	(645)	64	64	100	100
		51-150	OT	–	26	333	126	126	100	100
			DS	–	58	509	264	264	100	100
			LL	–	163	(1194)	223	223	100	100
	Canada (N)	501-900	OT	–	261	3669	2988	2988	100	100
			MWT	–	18	264	361	361	100	100
		151-500	OT	–	197	2435	2369	2369	100	100
			MWT	–	4	24	43	43	100	100
	Denmark (F)	NK	NK	–	–	–	1936	1936	0	0
	France (M)	901-1800	OT	–	21	–	325	325	100	100
	France (SP)	151-500	OT	–	58	851	382	382	100	100
	FRG	>1800	MWT	–	4	41	360	0	100	–
		901-1800	MWT	–	4	65	315	0	100	–
	Japan	>1800	OT	–	–	1362	2606	2497	100	100
		901-1800	OT	–	–	227	197	173	100	100
	Poland	>1800	OT	–	8	7	71	71	100	100
		901-1800	OT	–	70	480	1649	400	100	100
	Portugal	>1800	OT	–	44	656	591	591	100	100
		901-1800	OT	–	20	113	258	258	100	100
	Spain	901-1800	OT	46	45	650	849	849	100	100
			PT	76	56	623	833	833	100	100
		501-900	PT	500	363	4875	6795	6795	100	100
		151-500	PT	734	541	6708	5605	5605	100	100
	USSR	>1800	OT	614	460	6808	18592	17701	100	100
		501-900	OT	72	42	557	336	330	100	100
	USA	151-500	OT	–	17	–	391	391	100	100

Table 3. (continued)

Division	Country	Tonnage Class	Gear	DG	DF	HF	Total catch	Gfsh. catch	% effort for Total catch	% effort for Gfsh. catch
4W	Canada(M)	501-900	OT	–	512	6992	5240	5240	100	100
			MWT	–	17	223	523	416	78	98
		151-500	OT	–	1211	14873	10023	10023	100	100
			MWT	–	3	28	254	20	8	100
			PS	–	–	–	4143	0	0	–
			LL	–	37	(379)	162	162	100	100
		51-150	OT	–	4	45	22	22	100	100
			MWT	–	–	–	542	11	0	0
			DS+SS	–	299	1705	734	734	100	100
			LL	–	546	(4645)	1706	1706	100	100
	Canada(N)	501-900	OT	–	4	53	69	69	100	100
			MWT	–	5	76	193	193	100	100
		151-500	OT	–	18	226	185	185	100	100
			PS	–	–	–	502	0	0	–
	Denmark(F)	NK	NK	–	–	–	1236	1236	0	0
	France(M)	901-1800	OT	–	33	–	500	500	100	100
	France(SP)	151-500	OT	–	1	15	2	2	100	100
	Japan	>1800	OT	–	–	107	86	58	100	100
		901-1800	OT	–	–	23	24	5	100	100
	Portugal	>1800	OT	–	6	82	87	87	100	100
	Spain	901-1800	PT	87	55	753	591	591	100	100
		501-900	PT	412	343	4552	7670	7670	100	100
		151-500	PT	1088	850	11684	11624	11624	100	100
	USSR	>1800	OT	9583	7573	104164	34327	309153	100	100
		501-900	OT	185	148	1817	1437	826	100	100
	USA	151-500	OT	–	225	–	5074	5074	100	100
			MWT	–	3	–	14	14	100	100
			LL	–	8	–	19	0	100	–
		51-150	OT	–	5	–	35	35	100	100

Table 3. (continued)

Division	Country	Tonnage Class	Gear	DG	DF	HF	Total catch	Gfsh. catch	% effort for Total catch	% effort for Gfsh. catch
4X	Canada (M)	501-900	OT	–	578	8274	5423	5422	100	100
		151-500	OT	–	1613	21318	11707	11707	100	100
			PS	–	–	–	13379	0	0	–
			LL	–	52	(534)	228	228	100	100
		51-150	OT	–	1960	17287	9141	9141	100	100
			MWT	–	–	–	25	0	0	–
			SH.T.	–	–	–	16	2	0	0
			SS	–	162	1035	315	315	100	100
			PS	–	–	–	24681	0	0	–
			LL	–	1108	(10925)	4229	4229	100	100
	Denmark (F)	NK	NK	–	–	–	254	254	0	0
	FRG	>1800	OT	–	3	41	39	39	100	100
			MWT	–	3	43	124	0	100	!
		901-1800	MWT	–	3	24	114	0	100	–
	Japan	>1800	OT	–	–	1527	1989	1106	100	100
		901-1800	OT	–	–	88	43	11	100	100
	Poland	901-1800	OT	–	2	12	63	63	100	100
	Spain	901-1800	PT	7	6	81	120	120	100	100
		501-900	PT	47	37	521	1108	1108	100	100
		151-500	PT	67	56	614	428	428	100	100
	USSR	>1800	OT	1751	1300	16822	51666	38059	100	100
		501-900	OT	39	15	173	118	102	100	100
		151-500	PS	349	246	–	4444	0	100	–
			PS	217	175	–	3177	0	100	–
	USA	151-500	OT	–	339	–	6202	6202	100	100
			MWT	–	1	–	10	10	100	100
			LL	–	40	–	37	0	100	–
		51-150	OT	–	39	–	354	354	100	100

Table 3. (continued)

Division	Country	Tonnage Class	Gear	DG	DF	HF	Total catch	Gfsh. catch	% effort for Total catch	% effort for Gfsh. catch
4VWX	Canada (M)	501-900	OT	-	1695	22858	17055	17054	100	100
			MWT	-	103	1445	1762	1655	93	100
		151-500	OT	-	4414	56084	35332	35332	100	100
			MWT	-	102	1363	3377	3018	89	100
			PS	-	-	-	34790	0	0	-
			LL	-	166	(1558)	454	454	100	100
		51-150	OT	-	2061	18647	9590	9590	100	100
			MWT	-	-	-	567	11	0	0
			DD+SS	-	947	6572	2487	2487	100	100
			Sh.T.	-	-	-	16	2	0	0
			PS	-	-	-	25082	0	0	-
			LL	-	1832	(16885)	6205	6205	100	100
		0-50	GN	-	142	1970	428	428	100	100
			Misc.	-	-	-	129655	52828	0	0
	Canada (N)	501-900	OT	-	365	5156	4467	4467	100	100
			MWT	-	44	656	945	945	100	100
		151-500	OT	-	545	6890	5519	5519	100	100
			MWT	-	29	416	508	508	100	100
			PS	-	-	-	4285	0	0	-
		51-150	OT	-	7	77	22	22	100	100
			PS	-	-	-	439	0	0	-
		26-50	LL	-	2	48	10	10	100	100
	Denmark (F)	NK	NK	-	-	-	4514	4514	0	0
	France (M)	901-1800	OT	-	506	-	9514	9504	100	100
	France (SP)	151-500	OT	-	120	1829	770	770	100	100
	FRG	>1800	OT	-	5	72	128	128	100	100
		901-1800	MWT	-	14	169	1042	0	100	-
			MWT	-	7	89	429	0	100	-
	Japan	>1800	OT	-	-	2996	4681	3661	100	100
		901-1800	OT	-	-	338	264	189	100	100
	Poland	>1800	OT	-	8	57	71	71	100	100
		901-1800	OT	-	72	492	1712	463	100	100

Table 3. (continued)

Division	Country	Tonnage Class	Gear	DG	DF	HF	Total catch	Gfsh. catch	% effort for Total catch	% effort for Gfsh. catch
4VWX continued	Portugal	>1800	OT	–	119	1612	1434	1434	100	100
		901-1800	OT	–	217	2472	2307	2307	100	100
			GN	–	2	48	1	1	100	100
			DV	–	7	337	121	121	100	100
		501-900	DV	–	7	443	68	68	100	100
	Spain	901-1800	OT	112	98	1419	1580	1580	100	100
			PT	225	156	1860	2383	2383	100	100
		501-900	PT	1023	792	10575	17225	17225	100	100
		151-500	PT	1992	1532	19966	18612	18612	100	100
	USSR	>1800	OT	11948	9333	127794	413530	364913	100	100
		501-900	OT	296	205	2547	1891	1258	100	100
			PS	349	246	–	4444	0	100	–
		151-500	PS	217	175	–	3177	0	100	–
	USA	151-500	OT	–	581	–	11667	11667	100	100
			MWT	–	7	–	31	31	100	100
			LL	–	48	–	56	0	100	–
		51-150	OT	–	44	–	389	389	100	100
		0-50	Misc.	–	11	–	24	7	100	100

Table 4.   Catch rates of Canadian otter trawlers of 151-500 g.t.,
             1954-73, and estimated total effort for groundfish (ex-
             cluding silver hake) on the Scotian Shelf.

Year	m.t/day fished	Effort (days)	Year	m.t./day fished	Effort (days)
1954	10.22	16,134	1964	10.95	25,455
55	10.54	14,973	65	10.40	30,451
56	13.02	15,123	66	9.71	33,160
57	11.47	15,475	67	8.28	26,957
58	10.32	19,001	68	8.37	34,413
59	10.53	21,393	69	8.23	30,035
60	10.56	21,767	1970	7.68	31,170
61	11.98	18,887	71	7.70	40,822
62	10.91	22,355	72	8.39	32,385
63	10.19	28,241	73	8.00	34,785
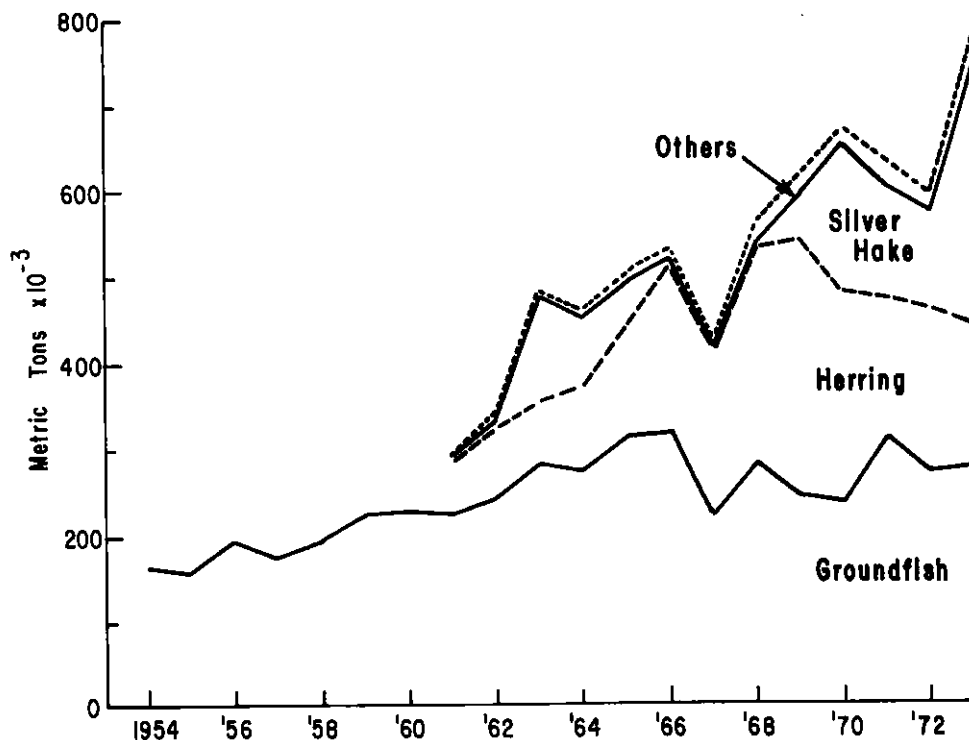
Fig. 1.   Nominal catches of finfish by species or species group from the Scotian
          Shelf (ICNAF Div. 4VWX) 1954-73, excluding large pelagic species.
          ("Others" includes mackerel and inshore and diadramous species i.e.
          eels, salmon, smelt, sturgeons, trouts, tomcod, alewife, shad, bass,
          and also includes capelin.)
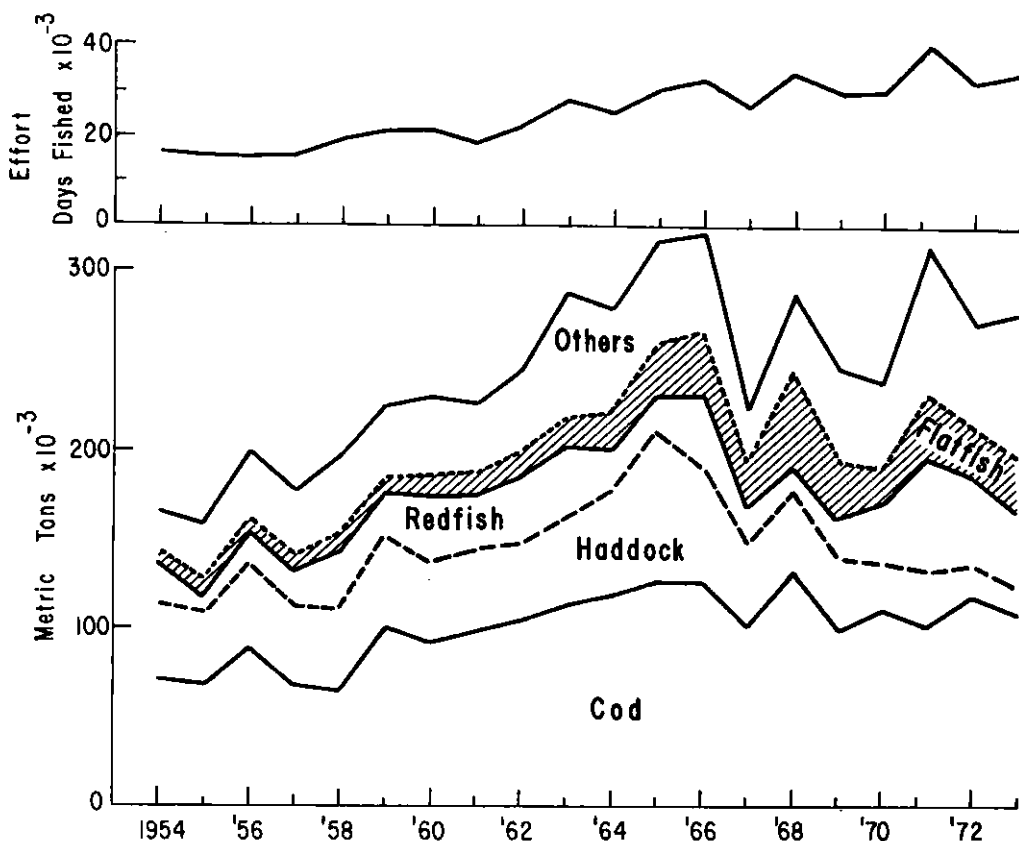
Fig. 2. Nominal catches of groundfish excluding silver hake by species from the
Scotian Shelf (Div. 4VWX) 1954-73, and total fishing effort for ground-
fish in Canada (M) 151-500 gross ton otter trawler units.
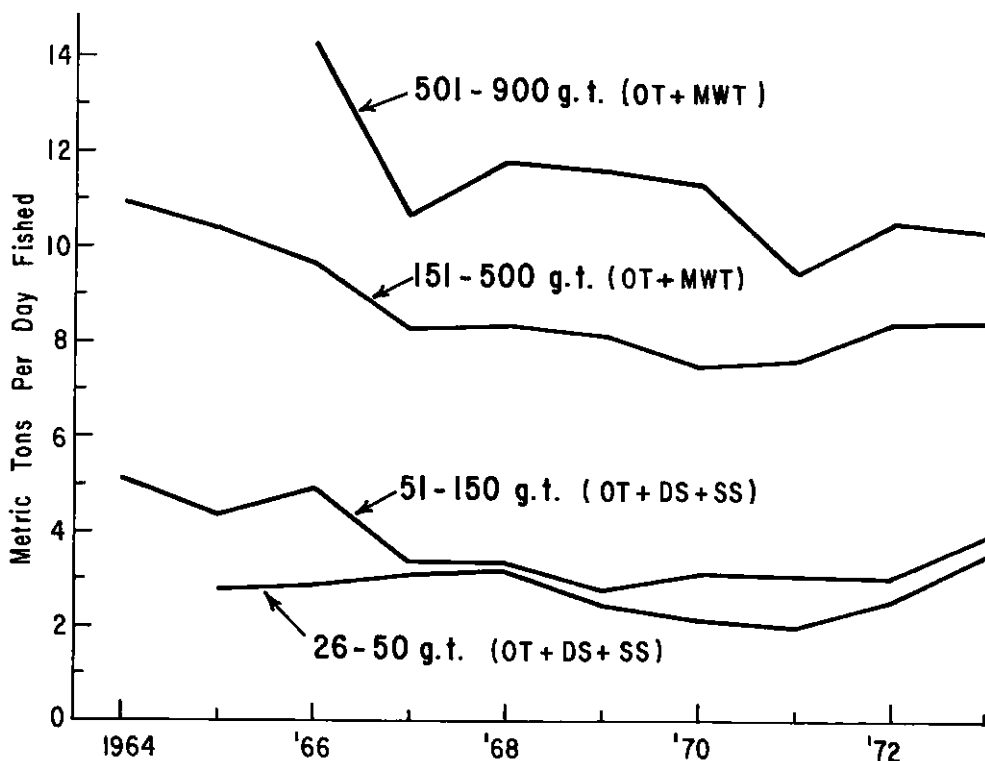
Fig. 3. Catch rates of all species (metric tons per day fished) by Canada (M)
vessels on the Scotian Shelf (Div. 4VWX) 1964-73, by tonnage class.
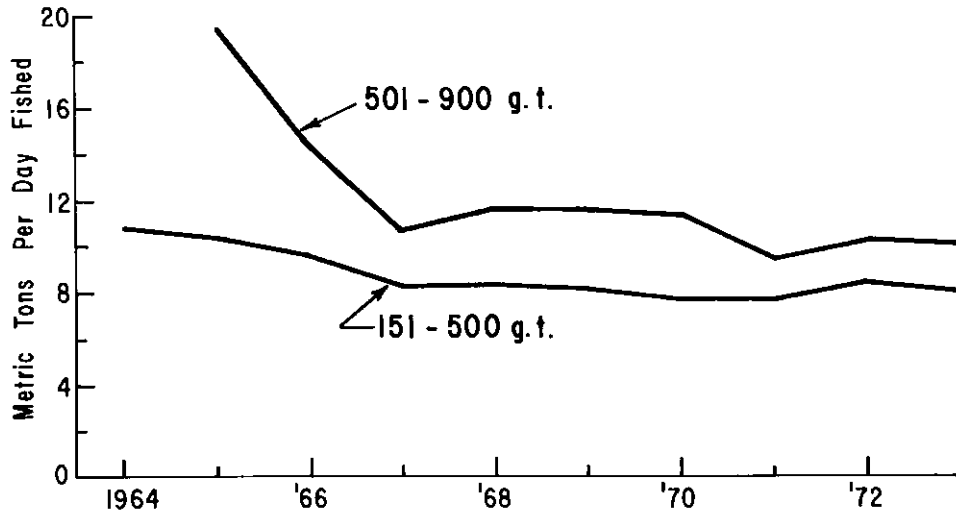(O.T. = otter trawl, MWT = midwater trawl, SS = Scottish seine,
DS = Danish seine.)

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Fig. 4. Catch rates of all species (metric tons per day fished) by Canada (M)
bottom otter trawlers of 151-500 gross tons and 501-900 gross tons on
the Scotian Shelf (Div. 4VWX) 1964-73.
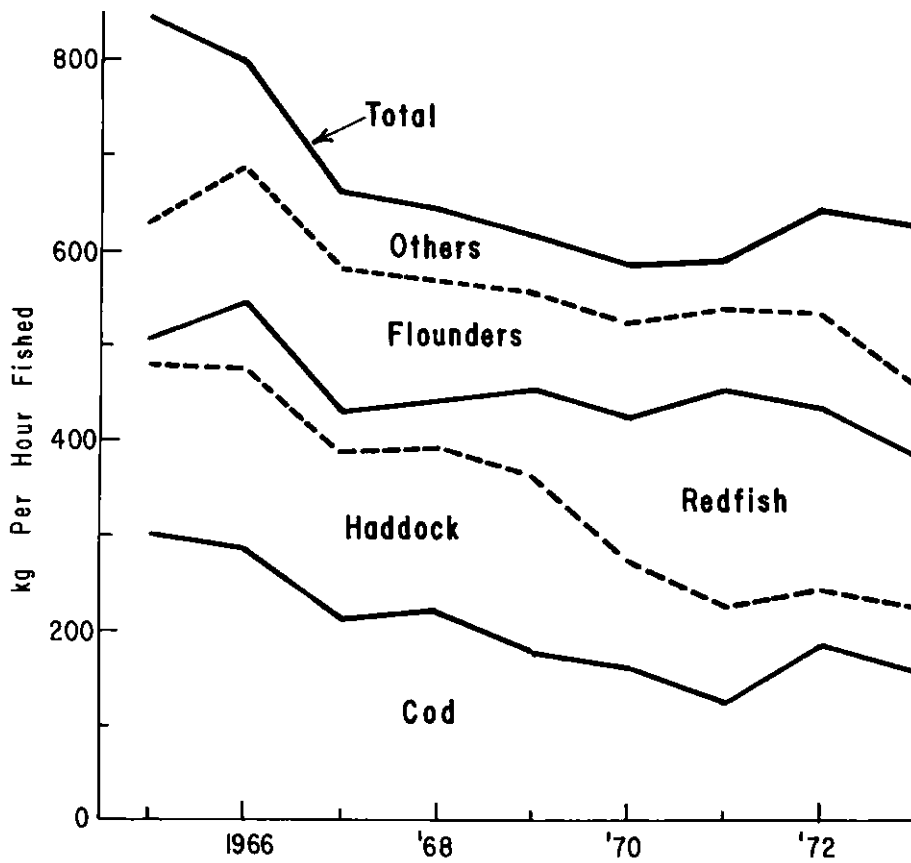
Fig. 5. Catch rates by species (kg. per hour fished) of Canada (M) bottom otter
trawlers of 151-500 gross tons on the Scotian Shelf (Div. 4VWX) 1965-73.
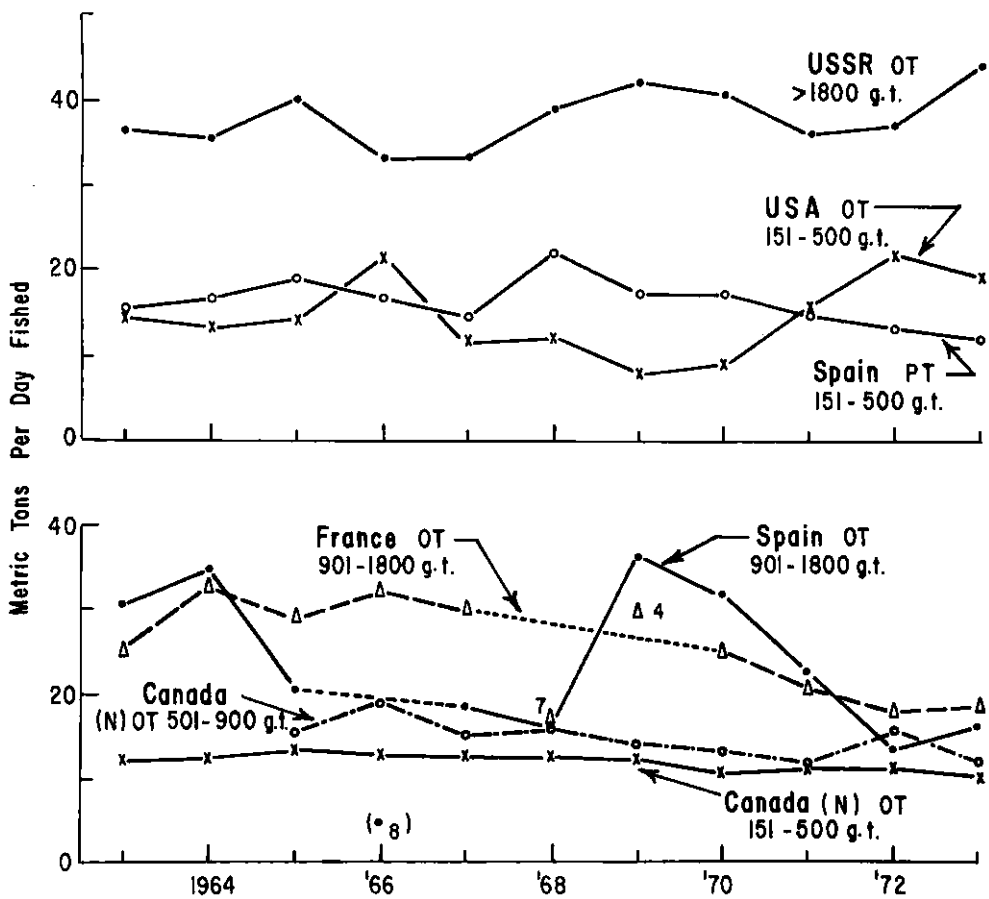
Fig. 6. Catch rates of all species (metric tons per day fished) for important
Country x gear x tonnage categories fishing the Scotian Shelf (Div.
4VWX) 1963–73. (OT = otter trawl, PT = pair trawl.)
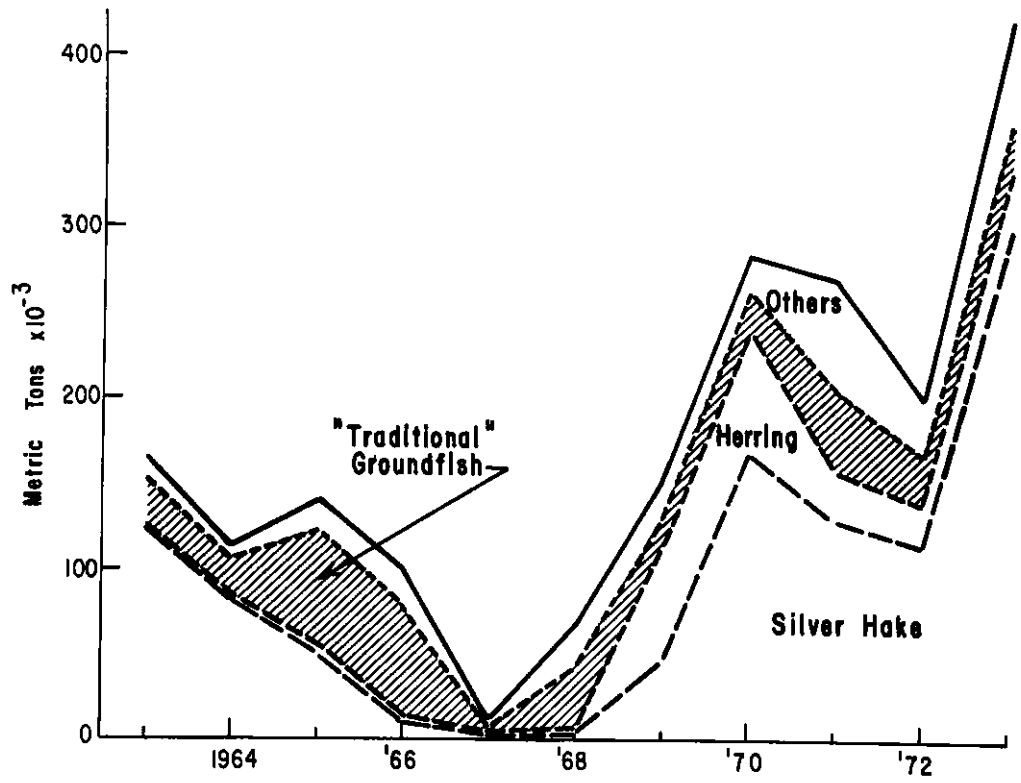
Fig. 7. USSR nominal catches of finfish from the Scotian Shelf (Div. 4VWX) 1963–
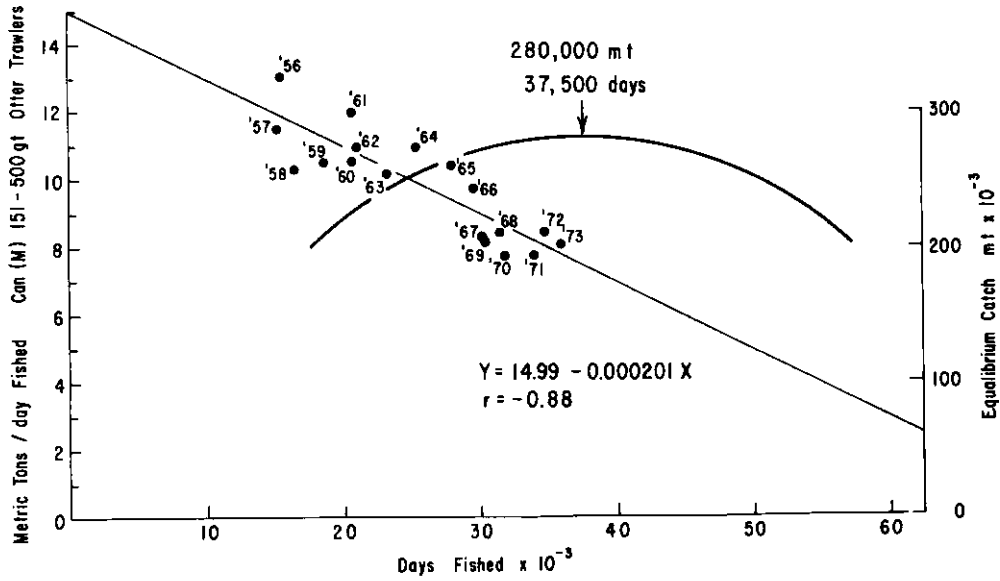73. ("Traditional groundfish" = cod, haddock, redfish and flatfish.)

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Fig. 8. Regression of catch rates on (3 year running average of) effort and
resultant equilibrium yield curve for groundfish (excluding silver hake)
on the Scotian Shelf (Div. 4VWX). (Standardised days fished calculated
by dividing total catch by catch per day (metric tons) of Canada (M)
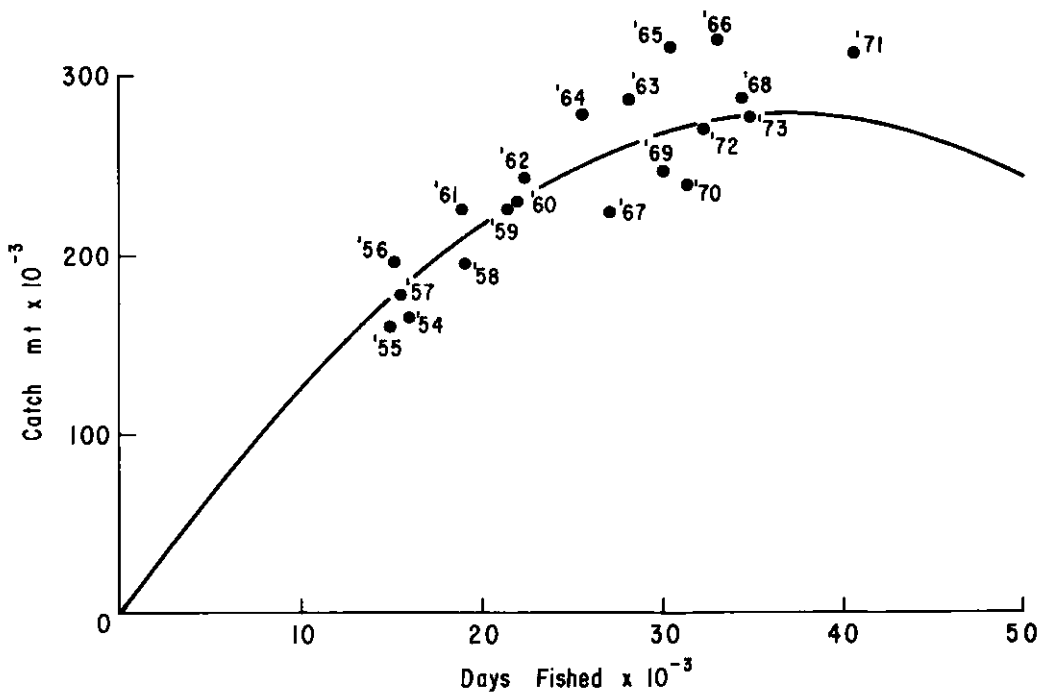151-500 gross ton otter trawlers.)

Fig. 9. Plot of catches against effort for groundfish (excluding silver hake) on
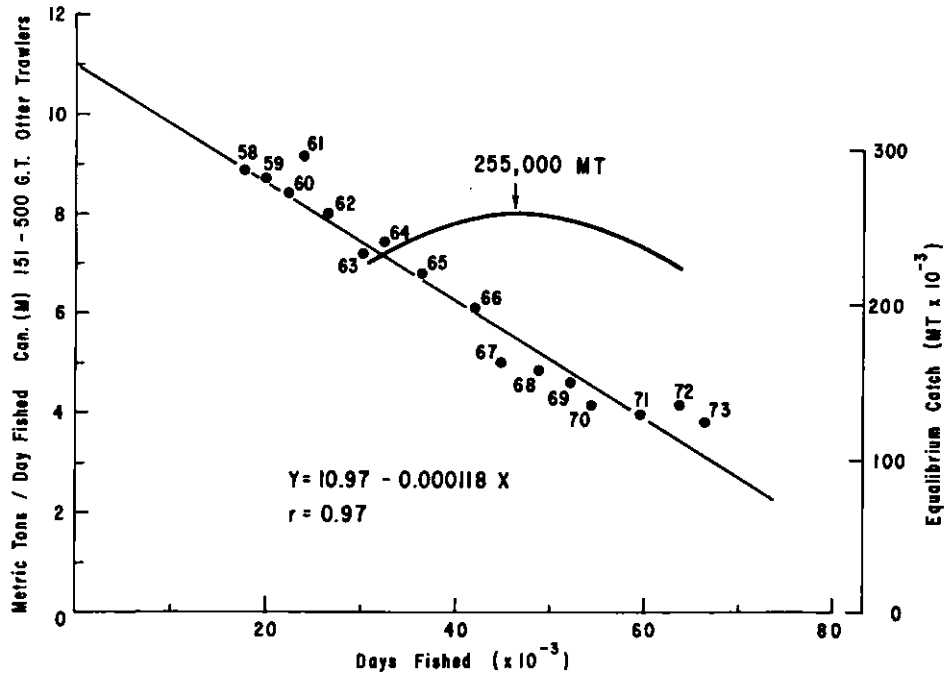the Scotian Shelf (Div. 4VWX), 1954-73, and equilibrium yield curve from
Fig. 8.

Fig. 10. Regression of catch rates on effort and resultant equilibrium yield curve
for groundfish (excluding silver hake) on the Scotian Shelf (Div. 4VWX).
A five year running average of effort is used and the data are corrected
for a constant increase in efficiency of 4% per year.