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CATCH AND EFFORT FOR CANADIAN ATLANTIC BLUEFIN TUNA (THUNNUS THYNNUS L.)

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SUMMARY

Canadian bluefin tuna landings in 1987 were up 15 percent from 1986 which was the lowest in over 20 years; a portion of the fishery was carried out by Canadian companies chartering Japanese longline vessels.

The Canadian inshore tuna log record data base from 1975 to 1987 has been updated and catch-per-unit-effort indices generated from the data. The effort data have been divided into two major time periods: that prior to 1981 and that including and after 1981 (1981 being the year of introduction of tended line gear). Both of these time periods provide strong catch-effort relationships for the province of Prince Edward Island and slightly poorer relationships for New Brunswick and the other provinces. All series indicate a drastic decline in abundance over the last five years in particular and the last ten years in general.

A second analysis of this data used a multiplicative model approach. The correlation coefficient of 0.71 indicates a reasonable fit. This analysis suggests a declining stock abundance of the large fish since 1976.

RESUME

En 1987, les débarquements canadiens de thon rouge ont dépassé de 15 % ceux de 1986, qui représentait le niveau le plus bas de ces 20 dernières années. Une partie de la pêcherie a été effectuée par des compagnies canadiennes louant des palangriers japonais.

La base de données des livres de bord de la pêche côtière canadienne correspondant à 1975-1987 a été mise à jour et les indices de la prise par unité d'effort provenaient de ces données. Les données de l'effort ont été divisés entre deux principales périodes de temps: - celle d'avant 1981 et celle de 1981 et postérieure (1981 étant l'année de l'introduction de la ligne à main (tended line). Ces deux périodes fournissent des relations de fortes prise - effort dans l'Ile Prince Edward et relations légèrement plus faibles dans le New Brunswick et les autres provinces. Toutes les séries indiquent une forte baisse de l'abondance surtout ces cinq dernières années, et d'une manière générale durant les 10 dernières années.

Une seconde analyse de ces données a utilisée une approche de modèle multiplicatif. Le coefficient de corrélation de 0.71 indique un ajustement raisonnable. Depuis 1976, cette analyse suggère une abondance du stock à la baisse des gros poissons.

RESUMEN

Los desembarques canadienses de atún rojo en 1987 ascendieron un 15% desde 1986, que fue el más bajo de 20 años, y parte de la pesquería se llevó a cabo por compañías de Canadá que alquilaron barcos palangreros de Japón.

Se actualizó la base de datos de registros de cuadernos de bitácora de túnidos en aguas costeras de Canadá, desde 1975 a 1987, así como los índices de captura por unidad de esfuerzo creados a partir de los datos. Los datos de esfuerzo se han dividido en dos períodos de tiempo principales: el anterior a 1981, y el que incluía 1981 y años posteriores (1981 fue el año de la introducción del arte "tended line" (barrilete)). Ambos períodos de tiempo dan una fuerte relación captura - esfuerzo para la provincia de Prince Edward Island, y una relación ligeramente inferior para New Brunswick y las otras provincias. Todas las series indican un drástico declive de la abundancia durante los últimos cinco años, en particular, y en los últimos 10 años en general.

En un segundo análisis de estos datos se aplicó un modelo multiplicativo. El coeficiente de correlación de 0.71 indica un ajuste razonable. Este análisis sugiere una abundancia decreciente del stock de peces grandes desde 1976.

INTRODUCTION

Atlantic bluefin tuna (Thunnus thynnus, L.) are harvested in Canadian waters by two countries utilizing four major gear types. Japan uses offshore pelagic longline and Canada uses three traditional gears: tended line, rod and reel, and trap net and recently has begun to investigate the use of offshore pelagic longline. The Canadian fishery exploits large bluefin tuna (ie. fish over 120 kg.) which migrate north for summer feeding. The fishery takes place on the continental shelf off Nova Scotia (N.S.) and Newfoundland and in the waters of the southern Gulf of St. Lawrence. Over the past five decades the fishery has developed and collapsed in various areas only to reappear in new areas, recently the waters around Prince Edward Island (P.E.I.) have supported much of the Canadian inshore fishery.

Over the last two decades important shifts in the gear mix have occurred. The major shifts have been through three phases, from a purse seine fishery off New England in the late 1960's and early 1970's to a successful commercial trap net fishery in the mid to late 1970's in St. Margaret's Bay, N.S.; to the present commercial tended line fishery in the southern Gulf of St. Lawrence. A rod and reel fishery along the coasts of Nova Scotia and Newfoundland in the 1950's and 1960's and in the 1970's and 1980's in the Gulf of St. Lawrence has persisted throughout this period. Canadian large fish landings have remained relatively constant over the past decade averaging about 400 tonnes per year (Table 1). The proportion of the total west Atlantic bluefin tuna landings by Canada has varied considerably over this time, the major catches have been made by Japan and the U.S.A.

CATCH

Canadian landings in 1987 were under strict quota control as in previous years. Options are available within the Canadian management system to re-allocate surplus local quota from regions of low catch to regions having more successful fisheries. The landings in 1986 were 97 fish weighing 41.3 tonnes from the traditional inshore fishery and 343 smaller fish weighing 32 tonnes caught by the pelagic offshore longline fishery (Table 2). In 1987 the landings have increased to 144 fish weighting 51.2 tonnes in the traditional fishery and 332 fish weighting 32.6 tonnes in the offshore pelagic longline fishery.

For 1988 (as of 19/Oct/88) landings are up considerably with 1521 fish weighting 404 tonnes. The largest landings came from two 'new' offshore areas being fished by inshore vessels (< 13m). The average weight of bluefin tuna in the 1987 P.E.I. catch was 449 kg approximately the same as that of 1986 (Fig. 1). The provisional estimate for the 1988 mean weight in the P.E.I. fishery is 406 kg, the third year of declining mean size in this fishery.

The distribution of landings since the early 1970's (Table 2) indicates that the overall distribution of bluefin tuna has changed. The areas presently sustaining the Canadian fishery are P.E.I. and St. Georges Bay (N.S.) in the southern Gulf of St. Lawrence.

The St. Margaret's Bay (N.S.) trap fishery and Newfoundland rod and reel fishery have all but collapsed in the last five to ten years. This drop in catch may be interpreted as an indication of a change in migratory patterns, possibly due to environmental conditions. The St. Margaret's Bay trap fishery failed in 1986, but did recover slightly in 1987 to land 47 fish. The 1988 trap fishery catch is slightly better with 54 fish landed this year.

In 1987 several experimental fisheries were started within the Canadian fishery. A limited number of inshore and offshore longline fisheries and additional trap fisheries in St. Georges Bay (Nova Scotia) were licenced. Results have not been encouraging due to the low overall abundance of large bluefin in these northern waters. These experimental fisheries have been extended to 1988.

CATCH PER UNIT EFFORT

Compulsory submission of log records has been a licence requirement since 1975. At that time measures were introduced to restrict fishing mortality in compliance with ICCAT advice. Log record coverage has varied over the years. The accuracy and/or representativeness of this coverage can not be ascertained.

To standardize the quality of the inshore log data selected for analysis, a minimum threshold level of reported log days was chosen. Clay (MS 1987) investigated two different threshold levels, 10 and 20 days. Little difference was observed between the two series and therefore ten days were chosen because some areas have had seasons of only 10 to 20 fishing days in recent years. The Catch Per Unit Effort (CPUE) used in this analysis was number of fish caught per day of fishing.

The analysis of the log books from P.E.I. and other provinces show two distinct CPUE trends. The data between 1975 and 1980 represents only rod and reel fishing operations - both sport and commercial fishermen - these data indicate a decline in CPUE over the time period. During the period 1981 to 1987 the CPUE of the rod and reel fishery has stabilized, although it still shows a downward trend. This index can not be assumed equivalent to the index prior to 1981, it must be assumed that only the more successful of the charter rod and reel fishermen have remained with this gear. Tended line gear was first introduced to the fishery in 1981 and by 1982 an estimated 86% of the tuna fishermen were using it. This second data set (1981 to 1986) shows a dramatic decline in the tended line CPUE.

These two CPUE indices both indicate a decline in abundance of giants in these northern waters. The mobile rod and reel fishery (pre 1981) shows a slower rate of decline than the passive by-catch tended line gear.

A multiple linear regression (MLinReg) was used to investigate the feasibility of using all the available data for a single index. The data were compiled as the natural log of the CPUE (number of fish per day of fishing) and a series of 'dummy variables' representing three category types. First category type is the 5 provinces, second is the 13 years, and the third is the two gears (Table 5). This provides 18 variables as input to the MLinReg, the results of which are presented in Table 6. The coefficient of variation is 0.71 and the residuals appear to be randomly distributed (Fig. 2). A multiplicative model (Gavaris, 1980) was run on these data (Table 7) providing a single standardized CPUE series. The standards of this model were chosen as P.E.I., 1975, rod and reel. This series indicates a decline in abundance since 1976, however this series has more noise than the unstandardized province by province series.

REFERENCES

Clay,D. (MS 1987) Catch rates in the Canadian Atlantic bluefin fishery. ICCAT Col.Vol.Sci.Pap. XXVIII:186-191.

Gavaris, S. (1980) Use of a multiplicative model to estimate catch rate and effort from commercial data. Can.J.Fish. Aquatic Sci.37:2272-2275.

TABLE 1. Landings of bluefin tuna from the the ICCAT area in thousands of tonnes.

YEAR	WEST ATLANTIC OCEAN						EAST ATLANT. & MEDIT.	TOTAL
	CANADA		U.S.A.	JAPAN	OTHER	TOTAL		
	small	large						
1970	1.2	0.5	3.8	0.1	0.3	5.7	10.4	16.1
1971	0.9	0.2	4.1	1.4	0.2	6.9	10.8	17.7
1972	0.3	0.2	3.1	0.3	0.1	4.1	11.3	15.4
1973	0.6	0.3	1.6	1.1	0.1	3.7	10.5	14.2
1974	0.1	0.7	3.7	0.9	0.2	5.6	18.0	23.6
1975	0.3	0.3	2.9	1.5	0.1	5.1	21.0	26.1
1976	0.3	0.5	1.9	2.9	0.3	5.9	22.5	28.4
1977	0.3	0.7	2.1	3.7	0.2	6.9	18.8	25.7
1978	0.2	0.4	1.9	3.1	0.2	5.8	14.8	20.6
1979	0.0	0.2	2.3	3.6	0.2	6.3	12.2	18.4
1980	0.0	0.4	1.5	3.9	0.1	5.9	13.1	19.1
1981	0.1	0.3	1.2	3.8	0.2	5.6	13.4	19.3
1982	0.0	0.3	0.7	0.3	0.2	1.4	21.7	23.2
1983	0.1	0.4	1.3	0.7	0.2	2.7	21.0	23.7
1984	0.0	0.3	1.2	0.7	0.1	2.4	24.8	27.2
1985	0.0	0.1	1.4	1.1	0.1	2.7	22.4	26.0
1986	0.0	0.1	1.0	0.6	0.2	1.9	17.2	19.1
1987	0.0	0.1	-	-	-	-	-	-
1988	0.0	0.4	-	-	-	-	-	-

1988 provisional nominal landings

TABLE 2. Landings of Atlantic bluefin tuna by numbers of fish from Canadian fisheries by province. The trap net fishery is from St. Margaret's Bay, Nova Scotia (N.S.); the N.S. catch is from the rest of the province. These statistics do not include the Canadian purse seine fishery off the New England coast.

YEAR::PROV	TRAP NET +	P.E.I.	N.B.	QUE.	N.S.	NFLD	TOTAL
1965	286	-	-	-	73	283	642
1966	306	-	-	-	30	388	724
1967	614	5	-	-	23	179	821
1968	356	13	-	-	53	<604>	<1026>
1969	680	31	-	-	12	<585>	<1308>
1970	458	99	-	-	15	418	990
1971	208	173(201)	-	-	9	76	466
1972	104	482	-	-	12	104(259)	702
1973	508	653	4	-	19	33	1217
1974	865	1048	93	6	22	30	2064
1975	452	343	148	6		33	982
1976	474	650	180	26		6	1336
1977	948	448	196	95	13	5	1705
1978	530	437	35	11	17	2	1032
1979	72	317	55	20	111	1	576
1980	129	389	118	90	50	1	777
1981	93	515	26	29	81	3	747
1982	157	392	53	43	61	7	713
1983	17	789	125	54	20	3	1008
1984	8	384	78	17	100	3	590
1985	27	221	47	11	20	4	330
1986	2	75	2	5	8	5	97
(offshore)	343	-	-	-	-	-	+343
1987	47	55	1	1	28	4	136
(offshore)	184	-	-	-	-	148	+332
1988*	54	152			998	119	1323
(offshore)	230	-	-	-	-	180	+410
AVERAGE	308	349	73	28	81	121	891
	252					164	

* provisional nominal landings
+ 1965 to 1972 includes small portion of incidental longline catches
- no fishery
blank no data
(xxx) fish caught but not necessarily landed (usually associated with tagging program).
<xxx> estimated values

TABLE 3. Landings of Atlantic bluefin tuna by weight (tonnes) from Canadian fisheries by province. The trap net fishery is from St. Margaret's Bay, Nova Scotia (N.S.); the N.S. catch is from the rest of the province. These statistics do not include the Canadian purse seine fishery off the New England coast.

YEAR::PROV	TRAP NET +	P.E.I.	N.B.	QUE.	N.S.	NFLD	TOTAL
1965	81	-	-	-	18.4	<75.7>	<175.1>
1966	87	-	-	-	7.2	<103.8>	<198>
1967	174	1.6	-	-	6.2	47.9	229.7
1968	101	4.2	-	-	13.8	161.6	280.6
1969	193	10.0	-	-	3.2	156.6	362.8
1970	130	33.3	-	-	6.2	111.6	281.1
1971	59	64.3	-	-	3.0	<20.3>	<146.6>
1972	29	155.7	-	-	<4.6>	<27.8>	<217.1>
1973	144.4	221.0	<1.5>	-	6.1	9.9	<382.9>
1974	255.7	355.0	33.8	1.9	<7.1>	8.8	<662.3>
1975	144.0	133.5	57.3	2.1		10.4	347.3
1976	172.1	256.9	71.8	10.5		1.8	513.1
1977	367.9	178.2	77.9	37.9	5.4	1.5	668.8
1978	221.3	180.0	14.7	4.9	8.1	0.6	429.6
1979	30.6	128.6	21.8	8.1	54.7	0.4	244.2
1980	46.6	155.0	47.3	36.1	20.6	0.3	305.9
1981	40.7	219.2	10.9	11.6	36.4	0.9	319.7
1982	68.3	157.9	21.1	16.1	25.8	2.3	291.5
1983	6.6	341.7	52.4	22.1	8.9	1.0	439.3
1984	2.7	174.5	33.3	7.3	45.4	1.1	264.2
1985	11.7	103.0	20.1	4.0	<3.4>	1.2	143.5
1986	<1.0>	33.1	1.0	1.9	2.7	1.7	41.4
(offshore)	32.0						+32.0
1987	16.9	24.6	0.3	0.3	6.3	1.3	49.9
(offshore)	17.2	-	-	-	-	15.4	+32.6
1988*	18	56			247	42	363
(offshore)	23	-	-	-	-	18	+41
AVERAGE	100	136	29	11	25	33	311
	24					17	

* provisional nominal landings
+ 1965 to 1972 includes small portion of incidental longline catches
- no fishery
blank no data
(xxx) fish caught but not necessarily landed (usually associated with tagging program).
<xxx> estimated values

Table 4. Four indices of bluefin tuna abundance from the west Atlantic expressed as fish caught per day. Rod and reel (R&R) and tended line (TL) are the only two gears utilized in these series. The rod and reel pre-1981 are not considered comparable to the rod and reel post 1981 - see text.

	P.E.I.		Nova Scotia		New Brunswick		Quebec	
Year	Rod & Reel	Tended Line	Rod & Reel	Tended Line	Rod & Reel	Tended Line	Rod & Reel	Tended Line
75	.09		.01		.20			
76	.125				.21			
77	.09		.01		.22		.18	
78	.09		.04		.06			
79	.07				.13			
80	.07		.06		.19			
81		.21	.05			.03		
82	.06	.19	.09	.05	.10	.07		.03
83	.08	.13	.01	.03	.29	.38	.04	.06
84	.03	.09	.15	.01	.12	.08		.04
85	.02	.05				.05		
86	.02	.05				.04		.03
87		.04				.04		

Table 5. Three category types and their associated categories used to run a general linear model for Canadian bluefin tuna using the traditional inshore data set from 1970 to 1987.
*

Category Type	Variable Number	PROVINCE	YEAR	GEAR
1		reference 1 - P.E.I.		
1	2	2 - Nova Scotia		
1	3	3 - New Brunswick		
1	4	4 - Newfoundland		
1	5	5 - Quebec		
2		reference	75 - 1975	
2	6		76 - 1976	
2	7		77 - 1977	
2	8		78 - 1978	
2	9		79 - 1979	
2	10		80 - 1980	
2	11		81 - 1981	
2	12		82 - 1982	
2	13		83 - 1983	
2	14		84 - 1984	
2	15		85 - 1985	
2	16		86 - 1986	
2	17		87 - 1987	
3		reference		1 - rod & reel
3	18			2 - tended line

* variable 1 is independent variable

Table 6. Output from multiple linear regression of catch and effort data from the Canadian bluefin tuna fishery. The reference variables and variable codes are listed in Table 5. The independent variable is the natural log of the CPUE in fish per day.

DEPENDENT VARIABLE = VAR_1

TERM	COEFFICIENT	STD. ERROR	t-STATISTIC	STD. COEFF	CONTR. R-SQ
INTERCEPT	-2.67891	0.456756	-5.865079	---	---
VAR_2	-1.021679	0.3004786	-3.400172	-.4725904	0.1551
VAR_3	0.3462485	0.2580508	1.341784	0.1818562	0.0242
VAR_4	-1.147166	0.4566148	-2.512327	-.3445	0.0847
VAR_5	-.5306969	0.3761903	-1.410714	-.1913234	0.0267
VAR_6	0.6862806	0.6842358	1.002989	0.1485602	0.0135
VAR_7	0.4555343	0.5740129	0.7935959	0.1367994	0.0085
VAR_8	0.11321	0.6065721	0.1866391	0.0297300	0.0005
VAR_9	-.2295441	0.6269506	-.366128	-.0602804	0.0018
VAR_10	0.53162	0.6065721	0.8764334	0.1396084	0.0103
VAR_11	0.3249213	0.6004268	0.5411506	0.0975756	0.0039
VAR_12	0.4465627	0.527723	0.8462068	0.1820641	0.0096
VAR_13	0.3659942	0.5179637	0.706602	0.1565749	0.0067
VAR_14	0.1196594	0.5356285	0.2233999	0.0461173	0.0007
VAR_15	-.700953	0.6405563	-1.094288	-.1840768	0.0161
VAR_16	-.5342944	0.6086642	-.8778149	-.1604514	0.0103
VAR_17	-.7095196	0.734677	-.9657572	-.1535908	0.0125
VAR_18	-.0203244	0.2743644	-.0740781	-.0114186	0.0001

	SUM SQ	DEG FR	MEAN SQ
DUE TO REGRESSION	20.70827	17	1.218134
ABOUT REGRESSION	20.4201	37	0.5518946
TOTAL	41.12837	54	0.7616365

R-SQUARED: 0.5035034 CORRECTED R-SQUARED: 0.2753833
F-TEST: 2.207186 STD ERROR OF REG: 0.7428961

Table 7. Analysis of variance and parameter estimation for catch rate standardization of Canadian bluefin tuna from 1979 to 1987 using a multiplicative model (Gavaris, 1980). See Table 5 for category types and codes.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... .710
MULTIPLE R SQUARED..... .504

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	4.281E0002	4.281E0002	
REGRESSION	17	2.071E0001	1.218E0000	2.207
TYPE 1	4	1.484E0001	3.710E0000	6.722
TYPE 2	12	7.453E0000	6.211E-001	1.125
TYPE 3	1	3.028E-003	3.028E-003	0.005
RESIDUALS	37	2.042E0001	5.519E-001	
TOTAL	55	4.693E0002		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	1	INTERCEPT	-2.679	0.457	55
2	75				
3	1				
1	2	1	-1.022	0.300	11
	3	2	0.346	0.259	16
	4	3	-1.147	0.457	4
	5	4	-0.531	0.376	6
2	76	5	0.686	0.684	2
	77	6	0.456	0.574	4
	78	7	0.113	0.607	3
	79	8	-0.230	0.627	3
	80	9	0.532	0.607	3
	81	10	0.325	0.600	4
	82	11	0.447	0.528	8
	83	12	0.366	0.518	9
	84	13	0.120	0.536	7
	85	14	-0.701	0.641	3
	86	15	-0.534	0.609	4
	87	16	-0.710	0.735	2
3	2	17	-0.020	0.274	21

Table 7. Continued from previous page.

PREDICTED CATCH RATE

STANDARDS USED VARIABLE NUMBERS: 1 1

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	S.E.	EFFORT
1975	982	0.452	0.082	0.036	11995
1976	1336	0.597	0.156	0.079	8578
1977	1705	0.368	0.132	0.053	12941
1978	1032	0.453	0.092	0.040	11256
1979	576	0.634	0.065	0.029	8909
1980	777	0.418	0.139	0.061	5577
1981	747	0.477	0.114	0.049	6560
1982	711	0.437	0.134	0.045	5301
1983	1008	0.417	0.124	0.040	8102
1984	590	0.303	0.096	0.034	6127
1985	330	0.352	0.040	0.018	8181
1986	97	0.330	0.048	0.020	2000
1987	136	0.081	0.037	0.021	3653

AVERAGE C.V. FOR THE MEAN: .426

Figure 1. Mean round weight (kg) of bluefin tuna landed in southern Gulf of St. Lawrence by the P.E.I. inshore fishery.

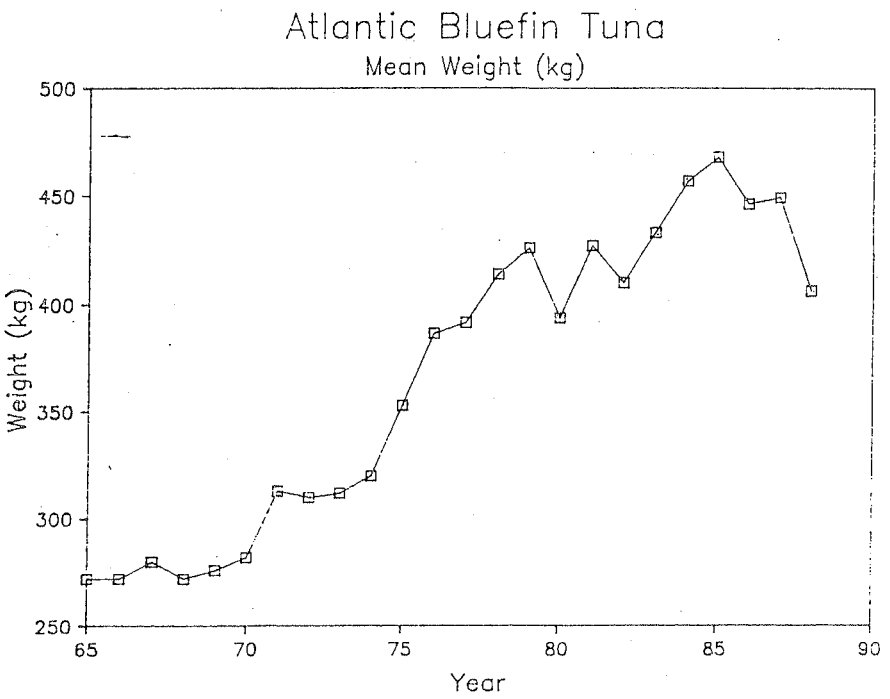

Figure 2. Residuals from multiple linear regression of catch and effort data from the Canadian bluefin tuna fishery. See Table 5 and 6 for model parameters.