RELATIONS BETWEEN RECRUITMENT INDICES AND OCCURENCE IN COD STOMACHS OF PRE-RECRUITS OF COD AND HADDOCK IN THE BARENTS SEA

by

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ABSTRACT

The predation by North-East Arctic cod on pre-recruits of cod and haddock is reviewed based on data from the joint PINRO-IMR stomach content data base. It is investigated how the abundance indices from surveys of pre-recruits are correlated with the occurrence in cod stomachs of pre-recruits of these species.

Estimates of the consumption of cod and haddock by cod based on a new model for the stomach evacuation rate of cod are also given.

INTRODUCTION

An important part of stock assessment and management advice is to predict the strength of year classes not yet recruited to the fishery. Such predictions are now mainly based on survey indices. However, the natural mortality on pre-recruits is large and variable. This may cause large errors in the predictions, as observed for North-East Arctic cod in the mid-late 80's (Anon. 1986, 1989).

After the post-larvae stage, predation is probably the main cause of natural mortality on pre-recruits. Estimates of the predation mortality on these age groups may thus improve the precision of the prognosis.

In the Barents Sea, North-East Arctic cod is one of the main predators on pre-recruits of a number of commercially important species (cod, haddock, capelin, herring, redfish, shrimp). Since 1984 a rather extensive stomach sampling program has been carried out in this area (Mehl and Yaragina 1992).

Based on these data we will investigate how the abundance indices of pre-recruits are correlated to the occurrence in cod stomachs of pre-recruits of cod and haddock. We then discuss whether cod stomach content data can be used when assessing the recruitment of these

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species. Finally estimates of the consumption of cod and haddock by cod are given based on a new model of the gastric evacuation rate of cod.

MATERIAL AND METHODS

Cod stomach data from the period 1984 to 1992 have been retrieved from the joint IMR-PINRO stomach content data base (Mehl and Yaragina 1992). The data used were collected during main fish abundance surveys in the periods 1 January to 31 March and 15 August to 15 October. Only predators (cod) ≥ 30 cm have been included in the analysis.

The total number of cod and haddock of different 5 cm length groups found in all the stomachs in each period and year were calculated. Prey of unidentified size were omitted. The number of prey in each 5 cm length group was converted to number by age group using age length keys from Norwegian surveys.

The number of prey in each age group found per stomach in the first period are compared to Norwegian acoustic and bottom trawl indices from the same period for the corresponding age groups (Mehl and Nakken 1994). In addition, the VPA-estimates of the year class as 3 year old fish (Anon. 1994a) have been included in the comparison.

For the second period, logarithmic indices from the International 0-group surveys (Anon. 1994b) and Russian acoustic and bottom trawl indices from late autumn surveys (Anon. 1994a) have been used in the comparison.

It was also attempted to include a time series of the number of prey by age in the analysis of recruitment indices performed when assessing the cod and haddock stocks (Anon. 1994a).

The stomach content data can also be used to calculate the amount of pre-recruits of cod and haddock eaten by cod (Mehl 1989, Bogstad and Mehl 1992, Bogstad *et al.* 1994). An updated version of the model for the stomach evacuation rate of cod developed by dos Santos and Jobling (1992) is now available (dos Santos and Jobling 1995). We apply this model to calculate the consumption of cod and haddock by cod using mainly the same approach as in Bogstad and Mehl (1992). The number at age of cod is taken from Anon. 1994a, and it is assumed that the cod spawning stock is outside the Barents Sea for three months during the first half of the year. The new evacuation rate model is given by

$$S_t = S_0 2^{-t/(\alpha_i S_0^{\beta} e^{-\gamma T} B^{-\delta})}$$

where
t: time in hours
S_t: Stomach content at time t (in g)
T: temperature (°C)
B: body weight in g,
S_0: Initial meal size (in g)
The values of the constants are: β=0.52
δ=0.26
γ=0.13
α_i is a prey-specific parameter indicating the half-life of prey i.

Table 1. Number of different age groups of cod found in stomachs of cod ≥ 30 cm in the Barents Sea 1 January - 31 March 1984 - 1992.

	Age group			No. stomachs sampled
	1	2	3	
1984	5	1	0	704
1985	1	1	0	1100
1986	6	11	2	1158
1987	3	1	1	705
1988	0	0	0	1615
1989	9	0	0	2057
1990	33	0	0	1574
1991	4	2	0	2939
1992	9	4	0	1030

Table 2. Number of different age groups of haddock found in stomachs of cod ≥ 30 cm in the Barents Sea 1 January - 31 March 1984 - 1992.

	Age group			No. stomachs sampled
	1	2	3	
1984	11	1	0	704
1985	9	1	0	1100
1986	7	4	2	1158
1987	2	0	0	705
1988	1	3	0	1615
1989	6	1	0	2057
1990	7	2	0	1574
1991	25	1	0	2939
1992	30	4	0	1030

Table 3. Number of different age groups of cod found in stomachs of cod ≥ 30 cm in the Barents Sea and Svalbard area 15 August - 15 October 1984 - 1992.

	Age group				No. stomachs sampled
	0	1	2	3	
1984	0	5	1	0	1114
1985	14	7	0	0	660
1986	5	4	7	1	1225
1987	33	4	2	0	2178
1988	12	3	0	0	1333
1989	63	3	0	0	1233
1990	4	4	2	0	2856
1991	10	9	0	0	818
1992	25	14	2	0	956

Table 4. Number of different age groups of haddock found in stomachs of cod ≥ 30 cm in the Barents Sea and Svalbard area 15 August-15 October 1984 - 1992.

	Age group				No. stomachs sampled
	0	1	2	3	
1984	5	7	0	0	1114
1985	4	17	0	0	660
1986	5	4	1	0	1225
1987	0	0	0	0	2178
1988	0	0	0	0	1333
1989	1	1	0	0	1233
1990	2	5	1	0	2856
1991	1	3	1	0	818
1992	0	4	3	0	956

If one assumes that over a period of days or weeks the fish reaches a steady-state, i.e. the amount ingested equals the amount evacuated, then the consumption of prey i is given by

$$C_i = \ln 2 \exp(\gamma T) B^{\delta} S_i / (\alpha_i S_0^{\beta})$$

The meal size S_0 is normally not known for stomachs sampled in the field, but has in this case been approximated by the total observed stomach content, S_i. The validity of this approximation is discussed by dos Santos and Jobling (1995), found that this approximation overestimates the consumption somewhat. In Bogstad and Mehl (1992) the meal size was set to twice the measured stomach content. Which value of the meal size that should be used and the feeding pattern of cod in general is discussed in Tjelmeland and Alvarez (1994).

The consumption model then becomes:

$$C_i = \ln 2 \exp(\gamma T) B^{\delta} S_i / (\alpha_i S^{\beta})$$

The species-specific constant (half-value) α_i for haddock is 84, and this value is also used for cod as prey. We have used the same age-length keys as mentioned above, and converted the consumption in weight of each length group to consumption in numbers by age group.

RESULTS

Table 1-4 present the number of cod and haddock found in the cod stomachs in the two periods. The total number of stomachs analysed is also given. In the first period the main part of the prey (both cod and haddock) were 1-group, with some occurrence of 2-group and almost none 3-group. In the second period it was on average found three times as many 0-group cod as 1-group in the stomachs and fewer older cod than in the first period. Of haddock it was however found about twice as many 1-group as 0-group, but fewer 2-group and none 3-group.

Figure 1 and 2 show plots of the frequency of occurrence of 1-group of cod and haddock respectively in cod stomachs analysed (multiplied by 100) against the Norwegian bottom trawl and acoustic abundance indices and VPA-estimates (of the year class at age 3) for the first period in 1984-1992. For 1-group cod (Figure 1) the development of the number in the stomachs show the same trend as most of the indices in most of the years. One exception is 1991 when the number in the stomachs is very low while both the bottom trawl index and the VPA-estimate show an increasing trend. The picture for haddock (Figure 2) is similar: decrease and increase in the number of 1-group in the stomachs normally coincide with decrease and increase in the abundance indices. The number of 2-group cod and haddock in the stomachs is very low (in many years zero), and plots of this compared to other indices are not included.

Figures 3-6 show the number of 0 and 1 group of cod and haddock found per cod stomach in the second period, plotted against the Russian bottom trawl (multiplied by 10) and acoustic abundance estimate and the 0-group index (multiplied by 100). The number of 1-group haddock in the stomachs in the autumn (Figure 6) seems to be correlated with the other survey indices in the autumn, while the number of 1-group cod and 0-group cod and haddock in the stomachs does not seem to show the same trend as the survey indices.

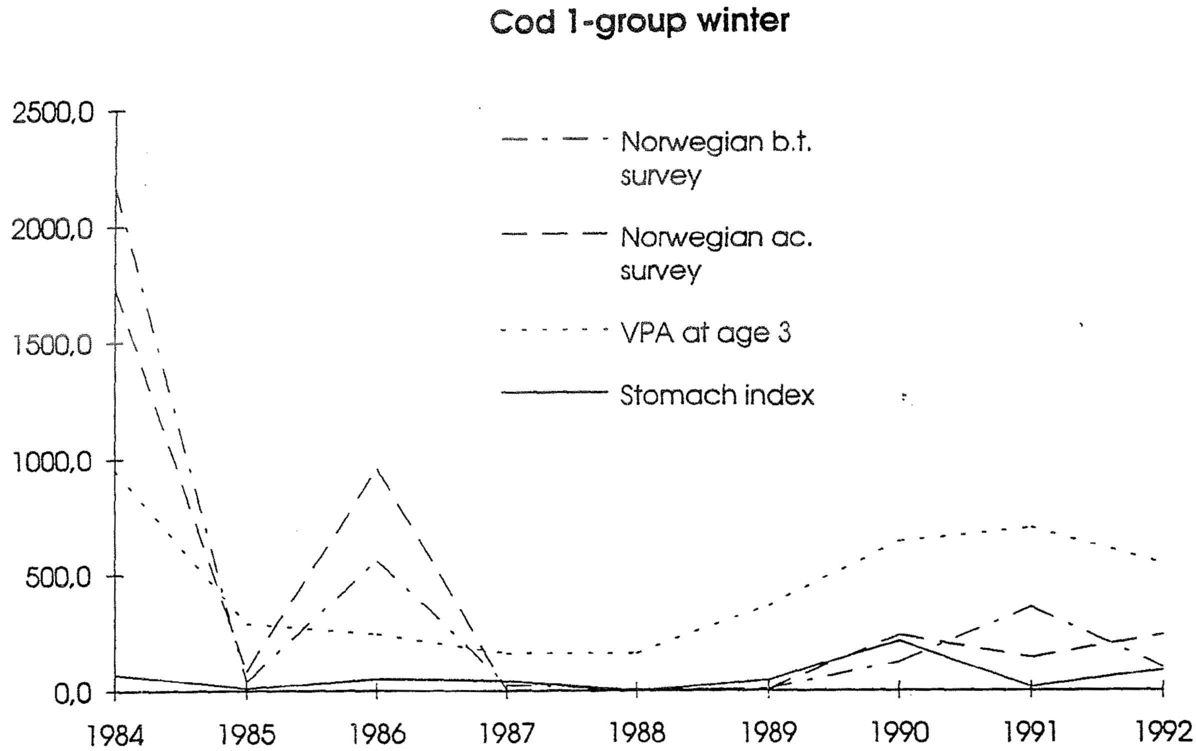

Figure 1. Frequency of occurence of 1-group cod in cod stomachs (scaled) compared to Norwegian survey indices and VPA-estimates of cod in the first period of 1984-1992.

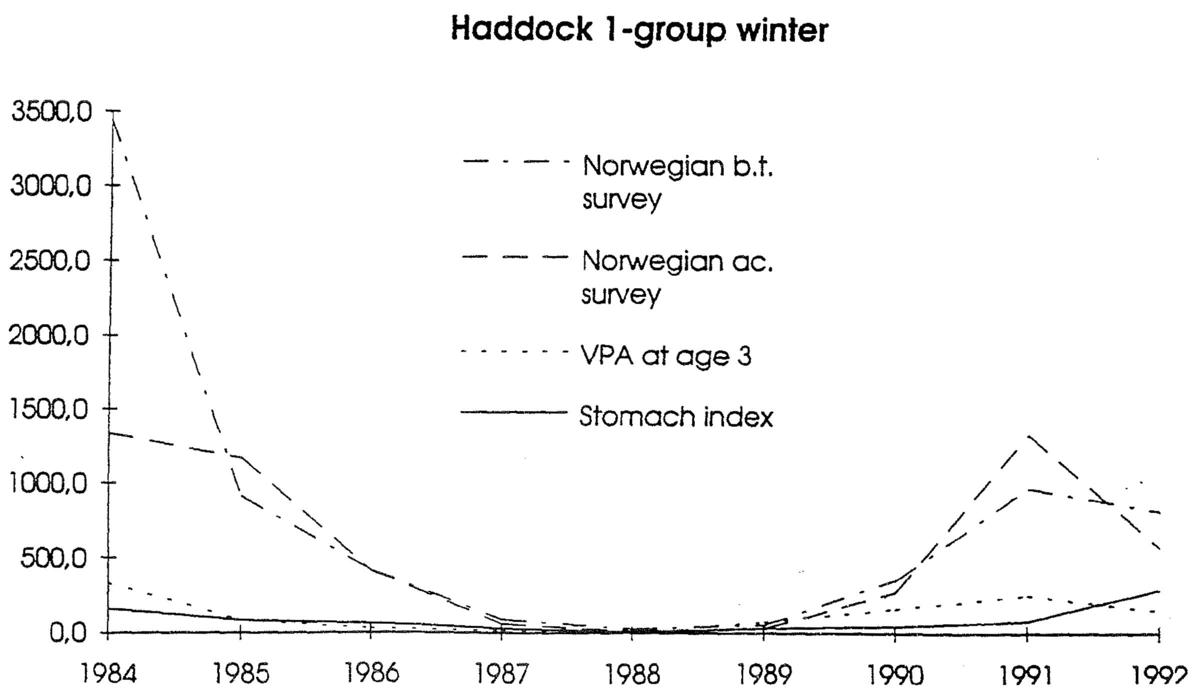

Figure 2. Frequency of occurence of 1-group haddock in cod stomachs (scaled) compared to Norwegian survey indices and VPA-estimates of haddock in the first period of 1984-1992.

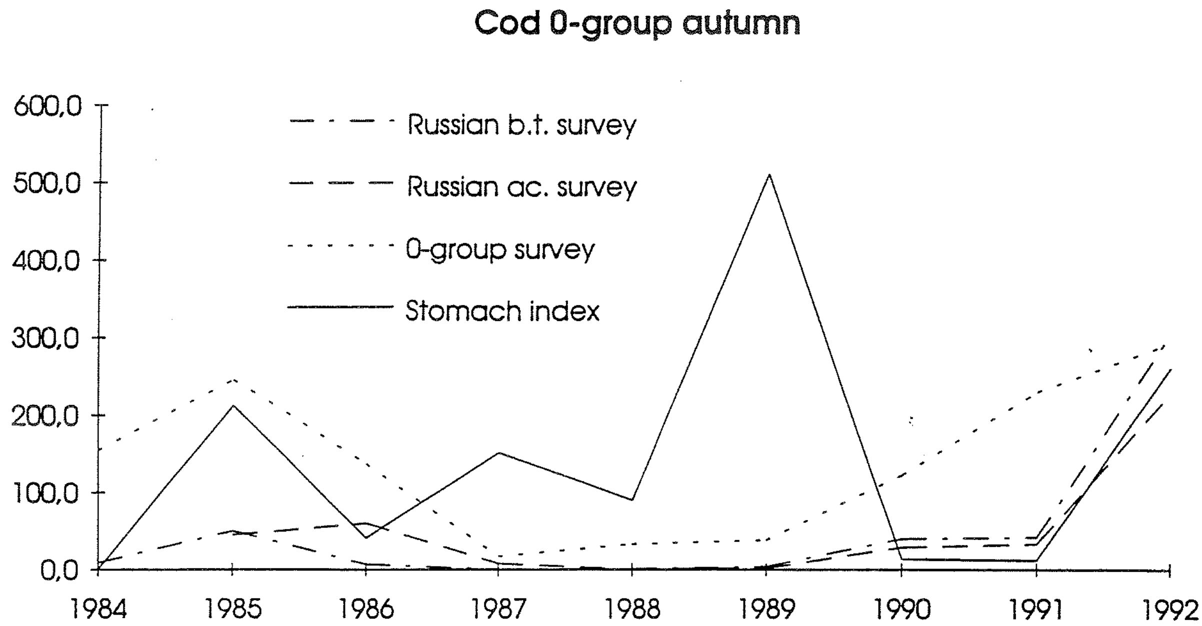

Figure 3. Frequency of occurence of 0-group cod in cod stomachs (scaled) compared to survey indices of cod in the second period of 1984-1992.

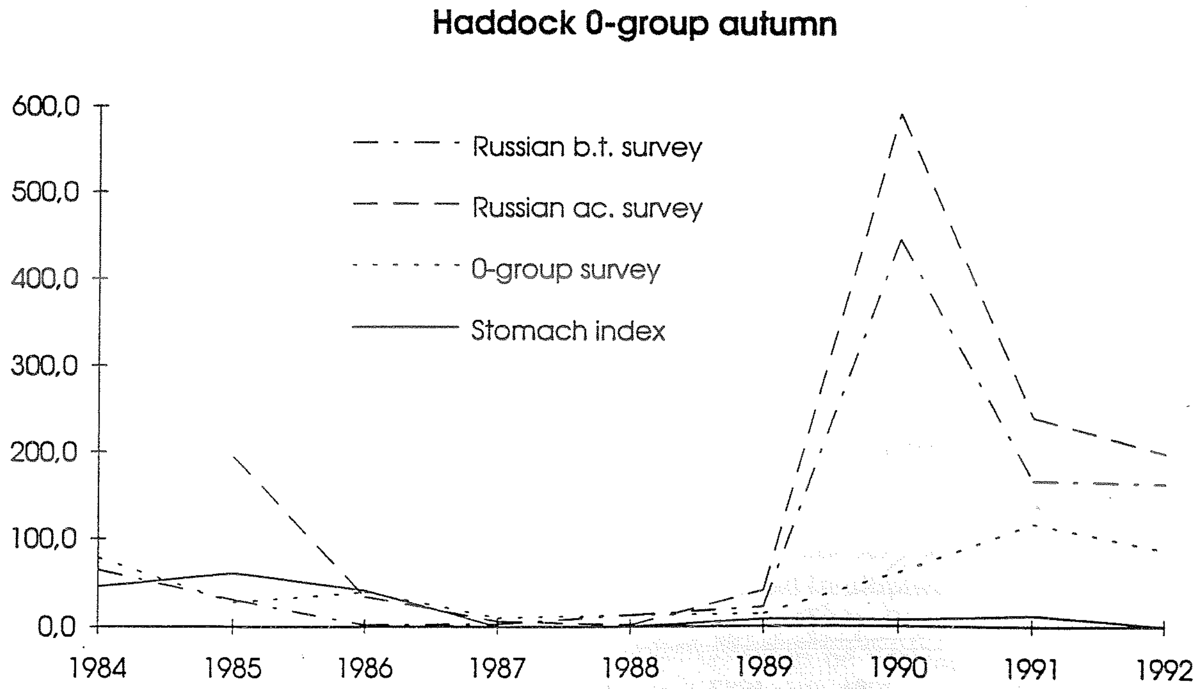

Figure 4. Frequency of occurence of 0-group haddock in cod stomachs (scaled) compared to survey indices of haddock in the second period of 1984-1992.

It was also attempted to include the number of 0, 1- and 2- group cod and haddock in the cod stomachs in the analysis of recruitment indices performed using the ICES computer program RCRTINX2 when assessing these two stocks. The number of 0, 1-and 2-group of each species in winter (not 0-group) and in autumn were included as an extra time series, with zero values set to an arbitrarily low value (1.0) in order to avoid problems when taking logarithms. The input data to the RCRTINX2 analysis are given in Appendix I (cod) and Appendix II (haddock). The analyses were carried out in the same way as done by the Arctic Fisheries Working Group at its last meeting (Anon. 1994a), updated by new survey indices. Some of the survey indices have been recalculated due to changes in gear and acoustic target strength (Mehl and Nakken 1994). The results of the analysis with and without the stomach indices included, are given in Table 5 (cod) and 6 (haddock). The difference in the predicted recruitment is small, as one would expect given the large number of indices already included (16 for cod, 10 for haddock). In general, including the stomach content data as indices lower the estimates of recruiting year classes slightly. However, the correlation coefficients (R^2) for these indices indicate a reasonable correlation (> 0.35 in the last year with data) only for 1-group haddock (both autumn and winter survey) and 1-group cod (winter survey). The number of 2-group found in the stomachs is so low, and zero in many years, that little correlation could be expected.

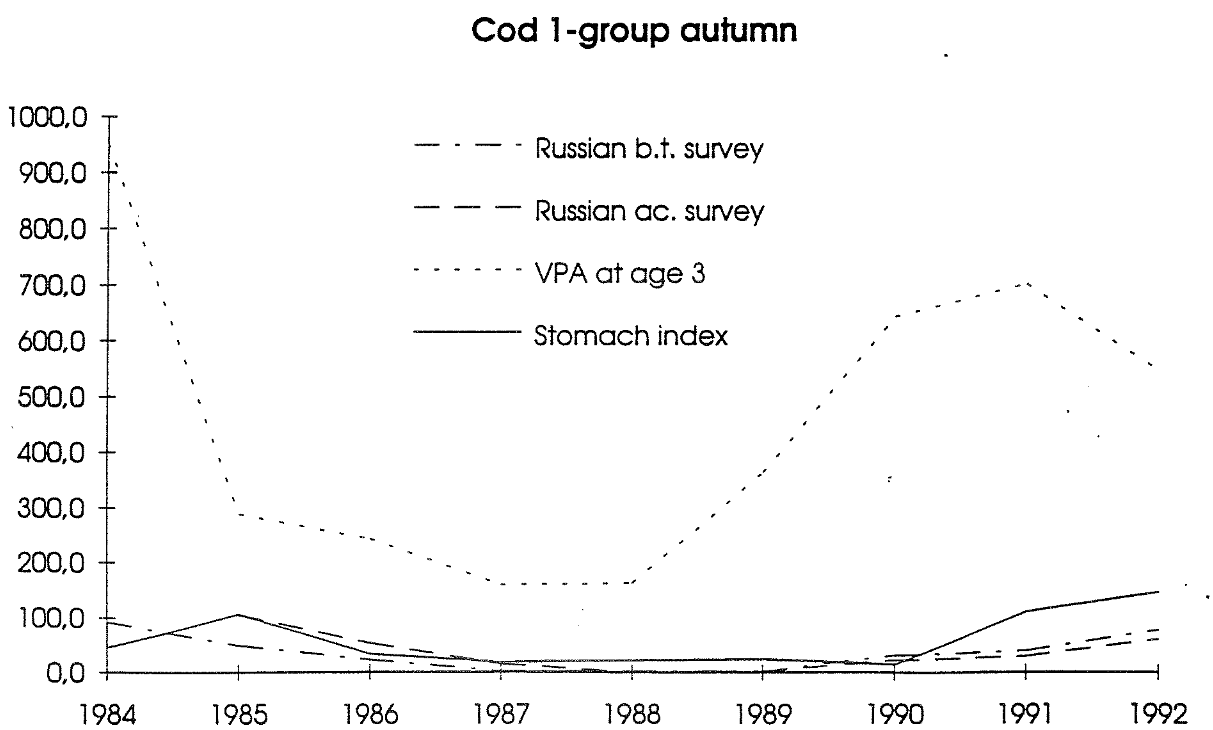

Figure 5. Frequency of occurence of 1-group cod in cod stomachs (scaled) compared to Russian survey indices and VPA-estimates of cod in the second period of 1984-1992.

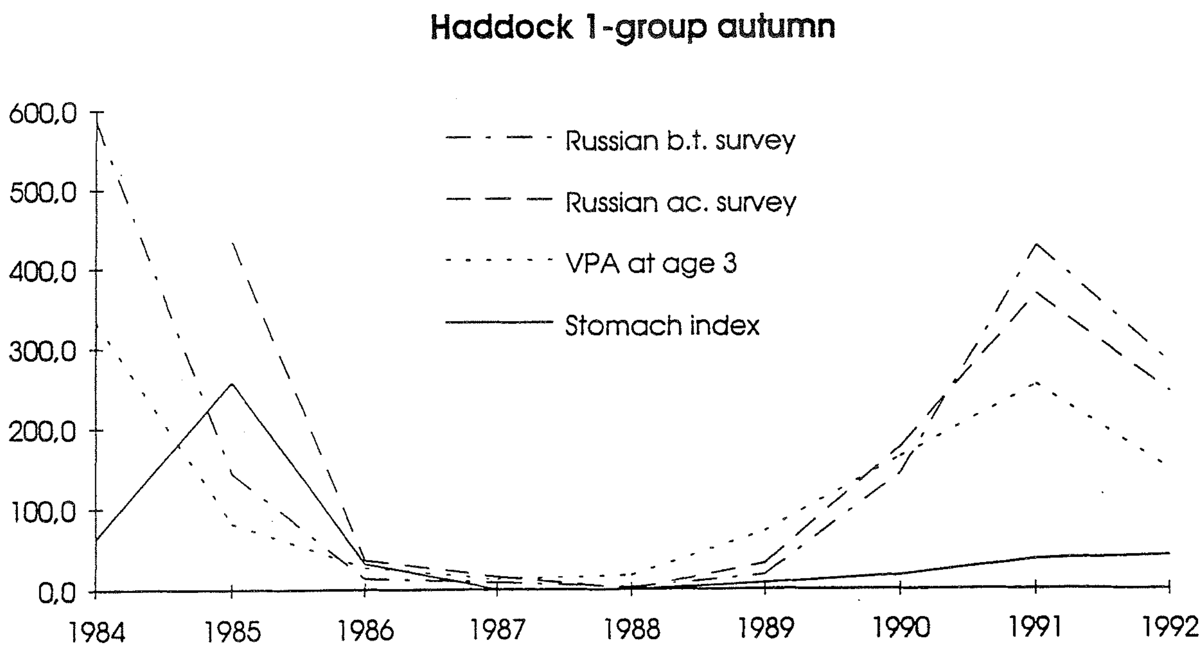

Figure 6. Frequency of occurence of 1-group haddock in cod stomachs (scaled) compared to Russian survey indices and VPA-estimates of haddock in the second period of 1984-1992.

Table 5.

RCRTINX2 analysis of survey data on cod recruitment, with and without abundance in cod stomachs included as indices

Analysis by RCRTINX2 of data from file cod-arctic:rcbb NORTHEAST ARCTIC COD : recruits as 3 year-olds (inc. data for ages 0,1,2 & 3)

Data for 21 surveys over 37 years
REGRESSION TYPE = C TAPERED TIME WEIGHTING APPLIED POWER = 3 OVER 20 YEARS PRIOR WEIGHTING NOT APPLIED FINAL ESTIMATES SHRUNK TOWARDS MEAN ESTIMATES WITH S.E.'S GREATER THAN THAT OF MEAN + INCLUDED MINIMUM S.E. FOR ANY SURVEY TAKEN AS .20 MINIMUM OF 3 POINTS USED FOR REGRESSION

Year-class = 1990

Survey/ Series	Index Value	Slope	Inter- cept	Rsquare	No. Pts	Predicted Value	Sigma	Standard Error	Weight
R-1-1	1.9459	2.306	3.556	.1772	20	8.0436	1.40529	1.60885	.01031
R-2B-1	.6931	2.314	3.072	.1484	20	4.6762	1.56216	1.65244	.00977
R-1-2	1.6094	1.039	4.428	.5856	20	6.1010	.54863	.57677	.08020
R-2B-2	1.6094	1.832	3.625	.2237	20	6.5733	1.21512	1.28766	.01609
R-1-3	3.2958	.686	4.488	.7704	33	6.7485	.35602	.40308	.16421
R-2B-3	4.2905	1.213	3.434	.3156	33	8.6360	.96043	1.25934	.01682
INTOGP	4.8203	2.502	-4.141	.0580	24	7.9211	2.62830	2.81834	.00336
N-BST1	5.8797	.460	4.062	.3262	10	6.7690	.94028	1.03334	.02499
N-BST2	6.1804	.604	3.050	.3831	11	6.7804	.83429	.92165	.03141
N-BST3	5.7519	.672	2.724	.6629	12	6.5884	.46816	.52028	.09856
N-SVT1	4.7622	.629	3.399	.3439	8	6.3917	.96036	1.03814	.02476
N-SVT2	4.8752	.568	3.641	.4700	9	6.4094	.69267	.74940	.04751
N-SVT3									
N-BSA1	4.9488	.362	4.501	.4158	9	6.2918	.80359	.86581	.03559
N-BSA2	6.2285	.528	3.573	.5140	11	6.8624	.63931	.72549	.05069
N-BSA3	5.7137	.575	3.339	.8530	12	6.6229	.27251	.30947	.27858
ST-W-1	2.6810	.685	3.421	.4125	7	5.2566	.87798	.95778	.02908
ST-W-2	3.6839	1.539	2.711	.0939	8	8.3798	2.15994	2.50974	.00424
ST-A-0	2.7081	1.041	1.154	.0704	6	3.9745	2.16168	2.47029	.00437
ST-A-1	4.7095	11.410	-33.326	.0081	7	20.4106	8.13099	10.93833	.00022
ST-A-2	3.0865	-6.238	16.295	.0070	8	-2.9574	8.26752	9.52040	.00029
MEAN						5.6966	.62207	.62207	.06894

Recruitment estimates, stomach content data included in analysis.

Year-class		Weighted Average Prediction	Internal Standard Error	External Standard Error	Virtual Population Analysis		Ext.SE/ Int.SE
1988	5.34	209.26	.14	.09	5.90	364.00	.67
1989	6.02	410.06	.15	.11	6.47	643.00	.73
1990	6.52	676.50	.16	.14			.85
1991	6.41	608.46	.16	.14			.84
1992	6.31	552.21	.29	.38			1.30
1993	6.37	584.90	.44	.34			.76

Recruitment estimates, stomach content data NOT included in analysis.

Year-class		Weighted Average Prediction	Internal Standard Error	External Standard Error	Virtual Population Analysis		Ext.SE/ Int.SE
1988	5.36	212.09	.14	.10	5.90	364.00	.72
1989	6.03	415.47	.15	.09	6.47	643.00	.64
1990	6.56	704.92	.17	.12			.75
1991	6.42	612.54	.17	.13			.79
1992	6.30	547.26	.29	.40			1.37
1993	6.37	584.90	.44	.34			.76

Table 6.

RCRTINX2 analysis of survey data on haddock recruitment, with and without abundance in cod stomachs included as indices.

Analysis by RCRTINX2 of data from file haddock-arctic:rcrt NORTHEAST ARCTIC HADDOCK : recruits as 3 year-olds (inc. data for ages 0,1,2 & 3

Data for 15 surveys over 37 years
REGRESSION TYPE = P TAPERED TIME WEIGHTING APPLIED POWER = 3 OVER 20 YEARS
PRIOR WEIGHTING NOT APPLIED FINAL ESTIMATES NOT SHRUNK TOWARDS MEAN
ESTIMATES WITH S.E.'S GREATER THAN THAT OF MEAN + INCLUDED MINIMUM S.E. FOR ANY SURVEY TAKEN AS .20 MINIMUM OF 3 POINTS USED FOR REGRESSION

Year-class = 1990

Survey/ Series	Index Value	Slope	Inter- cept	Rsquare	No. Pts	Predicted Value	Sigma	Standard Error	Weight
R-T-1	4.4067	.915	2.278	.7206	32	6.3088	.80208	.99970	.05891
R-T-2	4.2195	.812	2.288	.8043	32	5.7154	.67125	.77695	.09753
R-T-3	5.1591	.733	2.163	.7605	31	5.9419	.72081	.86181	.07927
INTOGP	4.0775	.978	.530	.3248	24	4.5181	1.24693	1.36409	.03164
N-BST1	6.8855	.479	1.489	.6557	9	4.7859	.93236	1.02695	.05583
N-BST2	7.0646	.637	1.261	.8244	10	5.7605	.66424	.78900	.09458
N-BST3	6.2683	.753	.995	.8824	11	5.7137	.54633	.64064	.14345
N-BSA1	7.2041	.430	1.763	.4849	8	4.8614	1.10727	1.30581	.03453
N-BSA2	6.4816	.656	1.536	.8078	10	5.7859	.69490	.82940	.08559
N-BSA3	6.4216	.785	1.230	.9133	11	6.2680	.46911	.57819	.17611
ST-W-1	4.4555	.765	1.196	.4165	6	4.6027	1.08499	1.22473	.03925
ST-W-2	3.6839	.395	3.289	.0821	7	4.7442	1.36131	1.66311	.02129
ST-A-0	2.0794	-.171	4.135	.0836	5	3.7802	1.15693	1.28050	.03591
ST-A-1	3.6297	.394	2.937	.3727	6	4.3671	1.12496	1.23818	.03840
ST-A-2	3.4782	.470	3.741	.0491	7	5.3768	1.38556	2.76514	.00770
MEAN						3.6683	1.44021	1.44021	.00000

Recruitment estimates, stomach content data included in analysis

1Year-class		Weighted Average Prediction	Internal Standard Error	External Standard Error	Virtual Population Analysis		Ext.SE/ Int.SE
1988	3.62	37.31	.17	.14	5.11	165.00	.82
1989	4.70	109.53	.22	.16			.73
1990	5.57	261.96	.24	.18			.74
1991	5.21	183.99	.24	.13			.53
1992	4.59	98.29	.34	.14			.42
1993	4.31	74.56	.57	.08			.14

Recruitment estimates, stomach content data NOT included in analysis.

Year-class		Weighted Average Prediction	Internal Standard Error	External Standard Error	Virtual Population Analysis		Ext.SE/ Int.SE
1988	3.63	37.53	.17	.17	5.11	165.00	.98
1989	4.79	120.78	.24	.20			.82
1990	5.76	318.38	.26	.16			.61
1991	5.30	200.30	.26	.10			.39
1992	4.62	101.63	.35	.15			.42
1993	4.31	74.56	.57	.08			.14

The results of the consumption calculations are given in Table 7 (cod) and 8 (haddock). Compared to the old consumption model, the new model gives a higher consumption by smaller fish relative to the consumption by larger fish. In addition, the temperature model used have been changed. Also, the evacuation rate for haddock has now been determined experimentally, while in Bogstad and Mehl (1992) the evacuation rate for haddock and cod was set equal to the evacuation rate of herring, which now is found to be slightly slower (α=88 vs. 84 for haddock). Compared with the calculated consumption of cod by cod using the model by dos Santos and Jobling (1992), which is presented in Bogstad *et al.* (1994), this new model gives somewhat higher consumption estimates. If the meal size had been set to twice the measured stomach content, however, as was done by Bogstad and Mehl (1992) the consumption would have been lower.

The very high consumption calculated of cod 0-group in 1992 should also be noted. Until 1990, the main part of the stomach samples in the period 15 August-15 October were taken during the second half of the survey, while in later years the main part of the samples were collected during the first half of the period. The bottom settling of the 0-group starts in this period. One should keep in mind that the consumption calculations in Tables 7-8 are based on data from throughout the year, while the data in Tables 1-4 are from two short periods (although the main part of the data are collected during these two periods).

Table 7. Consumption of cod by cod (numbers in millions) in the Barents Sea by prey age.

Year	Prey age group				Total consumption	
	0	1	2	3	numbers	tonnes
1984	-	546.2	59.7	1.3	607.2	31873
1985	1180.6	331.5	205.6	8.9	1713.6	49900
1986	66.4	666.2	438.1	273.6	1444.3	128904
1987	902.7	256.8	422.9	22.1	1604.5	36914
1988	43.4	617.7	35.4	+	696.2	13327
1989	1250.8	242.3	0.6	-	1493.7	10832
1990	-	163.5	44.0	-	207.5	28784
1991	139.7	231.3	88.0	55.9	514.9	42627
1992	7095.9	1315.9	204.2	0.1	8616.1	77594

Table 8. Consumption of haddock by cod (numbers in millions) in the Barents Sea by prey age.

Year	Prey age group				Total consumption	
	0	1	2	3	numbers	tonnes
1984	1915.8	1347.6	23.4	0.1	3286.9	59638
1985	1879.6	1557.7	7.6	-	3444.9	57221
1986	142.1	663.9	637.1	150.1	1593.2	160285
1987	-	1064.0	-	-	1064.0	5852
1988	-	21.5	1.0	18.9	41.4	4183
1989	32.6	349.2	3.0	-	384.8	15819
1990	49.2	224.6	67.5	5.3	346.6	24521
1991	-	598.2	22.9	-	621.2	26436
1992	803.3	2086.2	267.6	35.8	3192.9	181218

CONCLUSIONS

The number of 1 group cod and haddock found in cod stomachs may give some indication on the strength of the year class at that stage. The number of prey in cod stomachs is an indication both on the abundance of prey and the number removed. When calculating the consumption by cod of cod and haddock, the predation by cod on pre-recruits of cod and haddock is found to be of the same order of magnitude as the strength of a year-class at age 3. The predation by cod is thus an important factor in regulating the year class strength of cod and haddock, and one should try to model this, as has been attempted for cod cannibalism by Skagen *et al.* (1990), Bogstad *et al.* (1994) and Korzhev and Tretyak (1992).

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Appendix I. Input data to the RCRTINX2 analysis for cod.

NORTHEAST ARCTIC COD: recruits as 3 year-olds (inc. data for ages 0, 1, 2 & 3)

21,37, 2 (No. of surveys, No. of years, VPA Column No.)

1957	800	-11	-11	-11	-11	12	16	-11	-11	-11	-11	-11	-11	-11	-11	-11	11	-11	-11	-11	-11	-11
1958	929	-11	-11	-11	-11	16	24	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1959	736	-11	-11	-11	-11	18	14	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1960	478	-11	-11	-11	-11	9	19	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1961	342	-11	-11	-11	-11	2	2	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1962	776	-11	-11	-11	-11	7	4	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1963	1598	-11	-11	-11	-11	21	120	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1964	1306	-11	-11	-11	-11	49	45	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1965	171	-11	-11	-11	-11	1	1	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1966	113	-11	-11	-11	-11	2	1	002	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1967	199	-11	-11	-11	-11	1	1	004	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1968	409	-11	-11	-11	-11	7	1	002	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1969	1027	-11	-11	-11	-11	11	6	025	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1970	1837	23	64	60	42	70	85	251	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1971	530	7	9	6	3	37	24	077	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1972	629	5	4	34	15	54	17	052	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1973	621	16	5	15	2	70	5	148	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1974	351	1	1	4	1	6	1	029	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1975	646	60	1	44	1	93	4	090	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1976	201	1	1	1	1	4	1	013	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1977	142	1	1	2	1	2	1	049	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1978	160	1	2	1	1	1	3	022	-11	-11	17.2	-11	-11	-11	-11	-11	34	-11	-11	-11	-11	-11
1979	159	1	1	1	1	1	8	040	-11	31.9	30.6	-11	-11	-11	-11	61	40	-11	-11	-11	-11	-11
1980	171	1	1	1	1	1	8	013	3.5	2.7	23.2	-11	-11	10.7	4	4	11	-11	-11	-11	-11	-11
1981	398	1	1	1	1	4	4	010	0.6	17.7	122.0	-11	26.8	7.3	2	14	42	-11	-11	-11	-11	-11
1982	499	1	8	8	13	8	10	059	259.0	366.0	162.0	145.0	113.0	99.1	-11	175	209	-11	14,2	-11	-11	8,9
1983	952	4	9	11	7	45	41	169	2170.0	647.0	679.0	499.0	452.0	297.0	1735	696	602	71.0	9,1	-11	44,9	1,0
1984	288	1	1	2	8	7	15	155	39.0	403.0	233.0	239.0	181.0	141.0	84	503	81	9,1	95,0	1,0	106,1	57,1
1985	243	3	10	2	3	4	6	246	562.0	387.0	180.0	40.9	108.0	33.2	958	53	54	51,8	14,2	2121	32,7	9,2
1986	159	1	2	1	1	2	5	137	25.3	63.5	37.9	41.5	16.6	15.4	2	22	18	42,6	1,0	40,8	18,4	1,0
1987	161	1	1	1	1	1	1	017	3.8	12.7	25.8	3.1	2.7	8.6	1	7	16	1,0	1,0	151.5	22,5	1,0
1988	363	1	1	1	1	7	1	033	7.1	48.9	37.0	3.6	9.4	25.3	5	40	62	43,8	1,0	90,0	24,3	7,0
1989	642	1	1	4	1	7	10	038	122.0	213.0	170.4	70.1	101.0	105.0	235	227	202	209.7	6,8	510,9	14,0	1,0
1990	-11	6	1	4	4	26	72	123	356.7	482.2	313.8	116.0	130.0	-11	140	506	302	13,6	38,8	14,0	110,0	20,9
1991	-11	3	6	3	15	8	24	230	99.7	304.8	293.4	91,8	-11	-11	237	354	349	87,4	-11	12,2	146,4	-11
1992	-11	10	60	1	6	-11	-11	294	423.0	410.0	-11	-11	-11	-11	927	565	-11	-11	-11	261,5	-11	-11
1993	-11	2	5	-11	-11	-11	-11	209	632.4	-11	-11	-11	-11	-11	787	-11	-11	-11	-11	-11	-11	-11

R-1-1 Russian Botom tral survey, area I, age 1
R-2B-1 Russian " " " " IIb, age
R-1-2 Russian " " " " I, age 2
R-2B-2 Russian " " " " IIb, age 2
R-1-3 Russian " " " " I, age 3
R-2B-3 Russian " " " " IIb, age 3
INTOGP International 0-group survey
N-BST1 Norwegian Barents Sea, Bottom trawl survey, age 1
N-BST2 Norwegian " " " " " age 2
N-BST3 Norwegian " " " " " age 3
N-SVT1 Norwegian Svalbardarea " " " age 1
N-SVT2 Norwegian " " " " " age 2
N-SVT3 Norwegian " " " " " age 3
N-BSA1 Norwegian Barents Sea Acoustic survey age 1
N-BSA2 Norwegian " " " " age 2
N-BSA3 Norwegian " " " " age 3
ST-W-1 Number of age 1 cod in cod stomachs , winter
ST-W-2 " 2 , winter
ST-A-0 " 0 , autumn
ST-A-1 " 1 , autumn
ST-A-2 " 2 , autumn

Appendix II. Input data to the RCRTINX2 analysis for haddock

NORTHEAST ARCTIC HADDOCK : recruits as 3 year-olds (inc. data for ages 0,1,2 & 3)
15,37,2 (No. of surveys, No. of years, VPA Column No.)

1957	246	38	9	14	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1958	1092	2	4	5	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1959	44	7	14	33	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1960	277	30	40	72	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1961	323	32	50	34	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1962	101	5	3	4	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1963	242	16	9	12	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1964	293	11	12	15	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1965	20	0,3	0,3	0,3	001	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1966	17	0,3	0,3	0,3	001	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1967	166	3	13	8	008	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1968	97	0,3	0,3	3	000,3	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1969	1028	31	69	120	029	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1970	272	10	33	31	064	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1971	54	3	3	9	026	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1972	49	2	9	3	016	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1973	57	13	8	5	026	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1974	115	15	35	14	051	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1975	172	163	96	59	060	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1976	135	6	13	4	038	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1977	19	1	1	0,3	033	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11	-11
1978	6	0,3	0,3	0,3	012	-11	-11	2,6	-11	-11	5	-11	-11	-11	-11	-11
1979	8	036	0,3	0,3	020	-11	7,0	2,0	-11	-11	2	-11	-11	-11	-11	-11
1980	5	036	0,3	-11	015	2,0	1,4	3,1	4	2	2	-11	-11	-11	-11	-11
1981	8	036	0,3	8	003	2,5	5,7	16,9	4	3	7	-11	-11	-11	-11	-11
1982	257	23	59	63	038	1780,0	592,0	436,0	-11	199	284	-11	14,2	-11	-11	1,0
1983	333	40	79	239	062	3450,0	1180,0	385,0	1334	788	474	156,3	9,1	-11	62,8	1,0
1984	82	9	19	18	078	911,0	312,0	187,0	1168	276	60	81,8	34,5	44,9	257,6	8,2
1985	28	5	2	3	027	416,0	78,2	30,3	413	20	7	60,4	1,0	60,6	32,7	1,0
1986	13	1	1	1	039	86,1	15,0	10,1	58	3	6	28,4	18,6	40,8	1,0	1,0
1987	18	1	1	4	010	28,6	6,0	4,8	10	4	4	6,2	4,9	1,0	1,0	1,0
1988	164	2	3	21	013	51,7	49,2	90,4	29	36	61	29,2	12,7	1,0	8,1	3,5
1989	-11	3	25	30	014	356,0	404,7	351,1	273	247	129	44,5	3,4	8,1	17,5	12,2
1990	-11	81	67	173	058	977,0	1168,8	526,6	1344	652	614	85,1	38,8	7,0	36,7	31,4
1991	-11	17	44	69	117	821,9	468,0	316,8	580	537	257	291,3	-11	12,2	41,8	-11
1992	-11	20	8	-11	087	431,9	156,5	-11	832	182	-11	-11	-11	1,0	-11	-11
1993	-11	6	-11	-11	064	369,9	-11	-11	538	-11	-11	-11	-11	-11	-11	-11

R-T-1
R-T-2
R-T-3
INTOGP
N-BST1
N-BST2
N-BST3
N-BSA1
N-BSA2
N-BSA3
ST-W-1
ST-W-2
ST-A-0
ST-A-1
ST-A-2