The 11th Russian-Norwegian Symposium
Ecosystem dynamics and optimal long term harvest in the Barents sea fisheries

The use of B_{pa} reference point when determining TAC for the north-east arctic cod (*Gadus morhua* L.): how valid is it?

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TAC establishment with B_{pa} needs answers next questions:

- **Do the species examined meet the rule: SSB ≥ B_{pa} = ensures strong R?** (*SSB – spawning stock biomass; B_{pa} – precautionary approach SSB; R – fishing recruitment*)

- **Are the search and application of B_{pa} justified in case of species with poor or statistically uncertain SSB →R relationship?**

Materials

- AFWG data of SSB and N_3 of NEAcod (1946-2005)
- Weights and the survival ratio for each age group

Methods

- Correlation between SSB and N_3
- Variance analysis – the share of the SSB effect on formation of recruitment against the background of other factors
- Check-up of survival effect of 3-5 age groups on the fishing stock

R e s u l t s

Correlative coefficient for 56 pairs of SSB – N_3 ($r = 0.23$) is statistically insignificant

Table 1. Estimation of the SSB role in forming of the cod recruitment (N_3) (data of one way variance analysis)

SSB groups	Correl. coef. by groups (r)	Generations in group (n)	Sum of devations' square			SSB role for N3 SSa/SSx100%	Average sums of		Fisher's calculat. criterion (Fc)	Fisher's standart criterion (Fs)
			between groups (SSa)	inside groups (SSe)	total (SS)		mSa	mSe		
< 600 > 600	0.13 -0.37	47 9	598553	7331635	7930188	*7.55*	598553.4	138332.7	4.32691*	4.02301
< 400 401-800 > 800	0.16 0.31 -0.17	39 13 4	361173	7569015	7930188	4.55	180586.6	145558.0	1.24065	3.17515
< 250 251-500 501-750 > 750	*0.44* 0.24 0.32 -0.17	23 20 9 4	343837	7586351	7930188	4.34	114612.3	148752.0	0.77049	2.78623
< 300 301-600 601-900 > 900	0.32 -0.03 -0.42 -0.73	26 21 6 3	665753	7264435	7930188	8.40	221917.5	142439.9	1.55797	2.78623
< 250 251-500 501-750 751-1000 > 1000	*0.44* 0.24 0.32 - -0.73	23 20 9 1 3	350802	7579386	7930188	4.42	87700.5	151587.7	0.57855	2.55718
< 200 201-400 401-600 601-800 801-1000 > 1000	*0.46* -0.29 -0.01 -0.35 - -0.73	16 23 8 5 1 3	1166624	6763564	7930188	14.71	233324.8	138031.9	1.69037	2.40438
Common	0.23	56								

Comments: SSa - factor mutability (for studied factor); SSe - variate mutability;
SS - total mutability; mSa - deviation of group averages of studied factor;
mSe - deviation of group averages of nonstudied factors; Fc = mSa/mSe; Fs for P=0.95;
blue figures are statistically significant;
* - Fc>Fs indicates the confidence of the effect of the factor considered

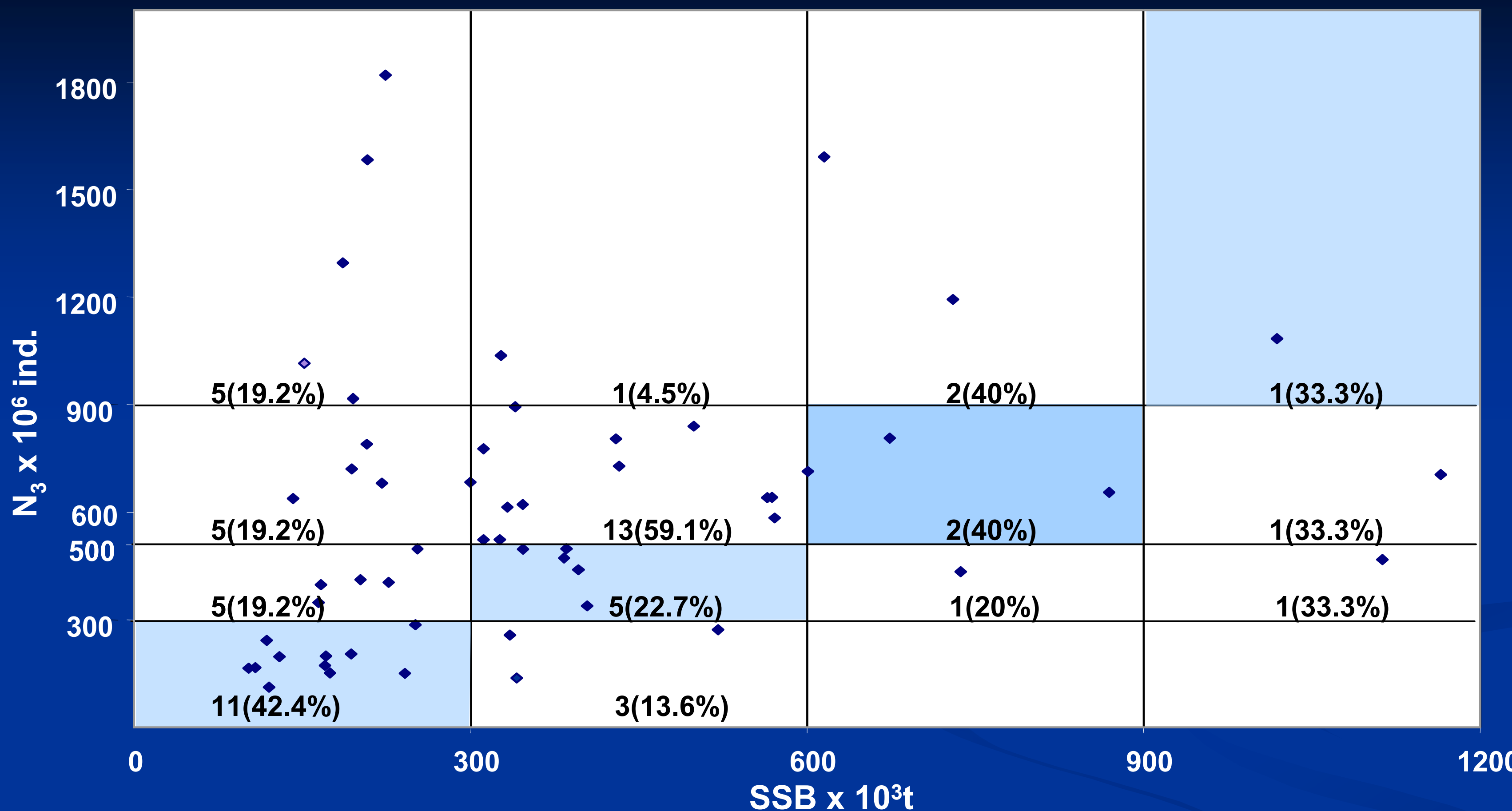

Fig. 1. Strength of the year-classes (N_3) born from different SSB levels. *Figures in the rectangles point quantity /percentage of the year-classes by N_3 groups in every SSB range. Shaded rectangles show the zone of correspondence among N_3 and SSB range.*

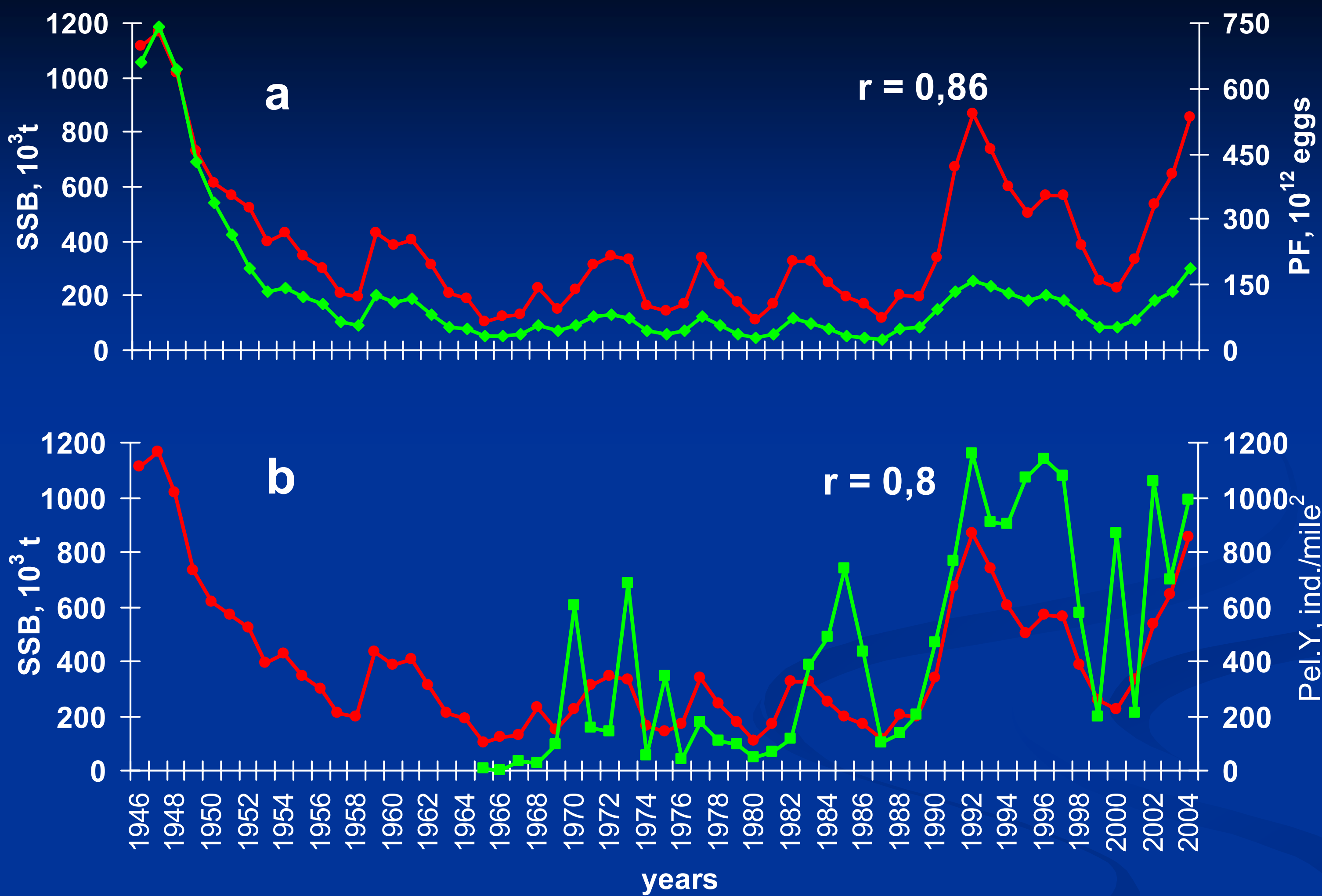

Fig.2. NEAcod. Spawning stock biomass (SSB), population fecandity (PF) and pelagic young (Pel.Y.) (-●- SSB; -♦- PF; -■- Pel.Y.)

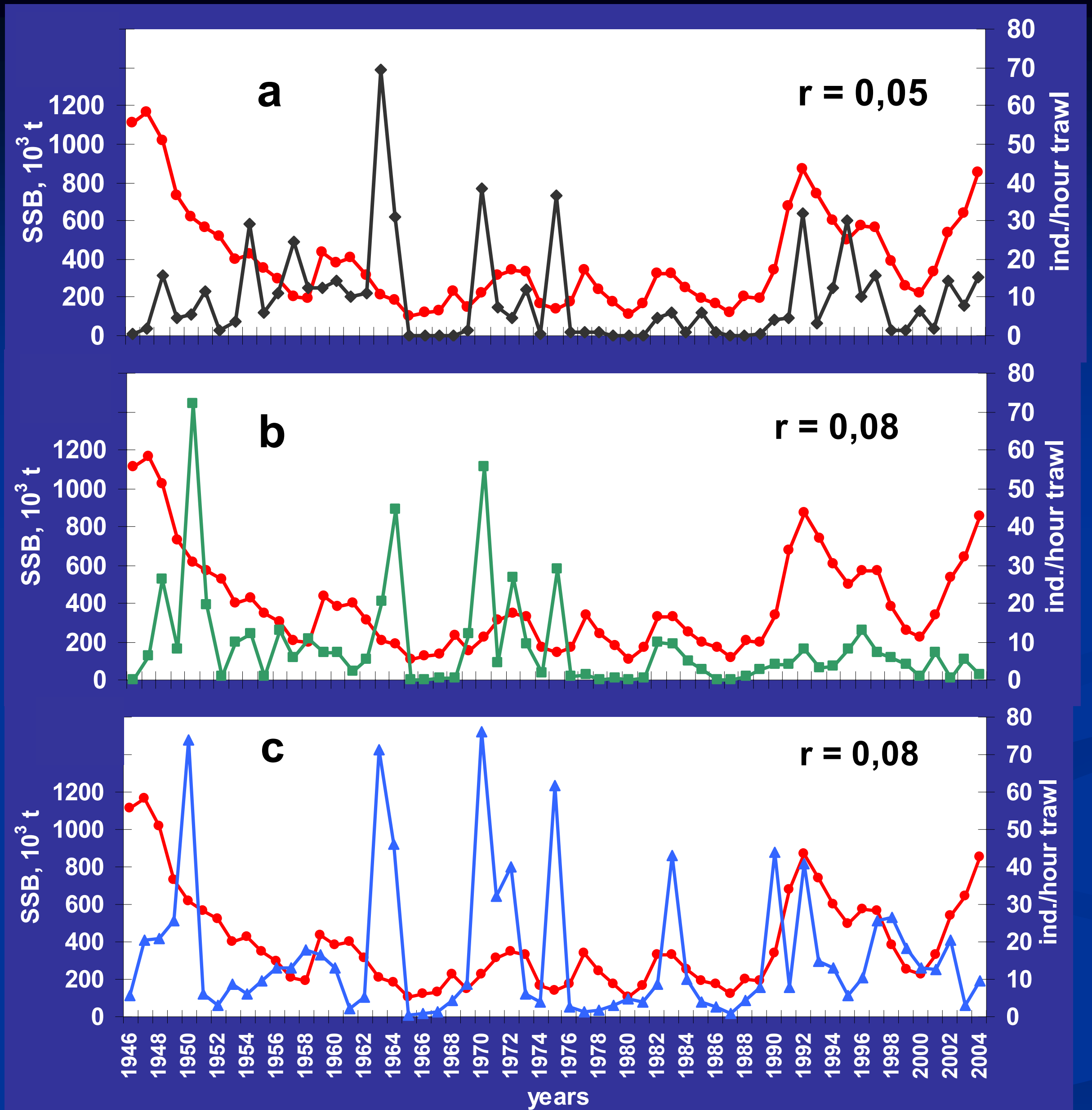

Fig.3. NEAcod. Spawning stock biomass and relative abundance of the benthonic young of age “0+”(-♦-); “1+”(-■-); “2+”(-▲-)

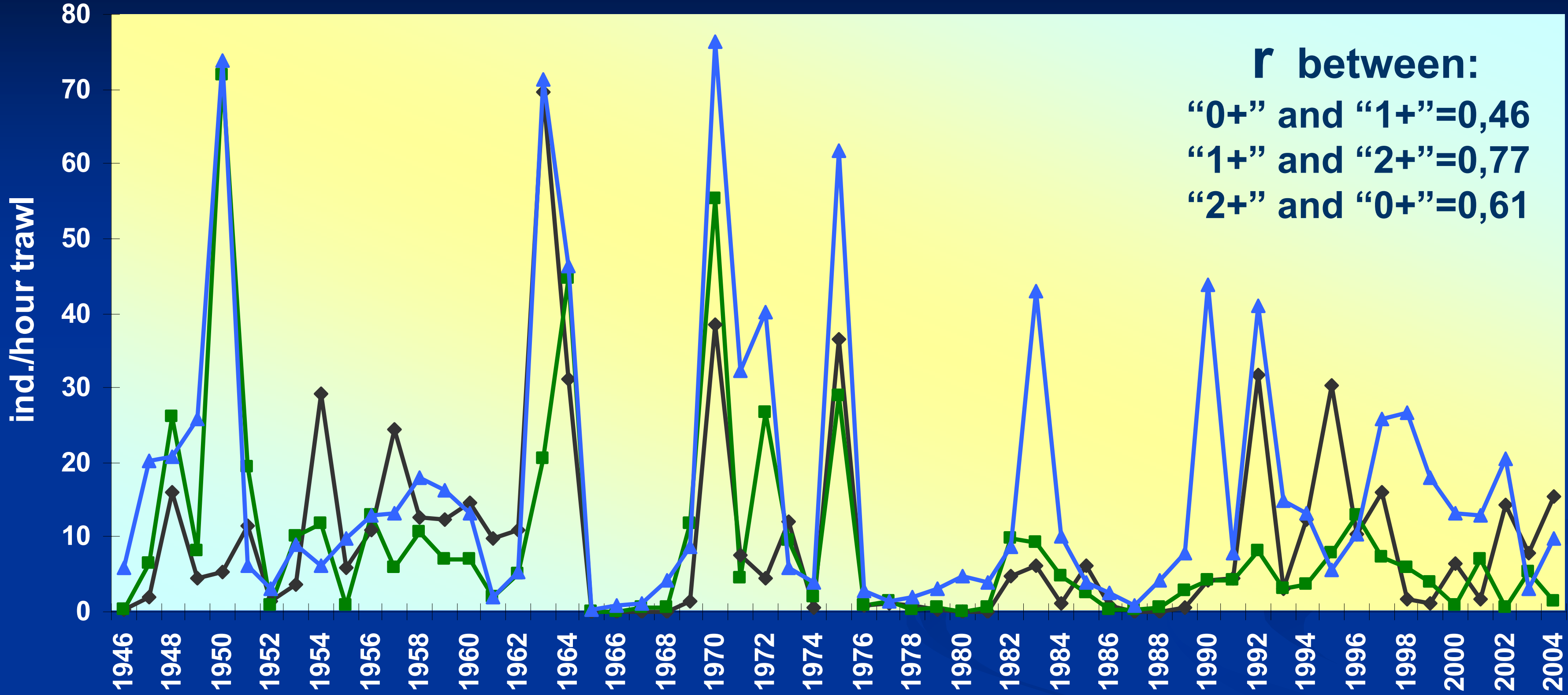

Fig.4. NEAcod. Relationship between relative abundance of the benthonic young at age "0+"(-◆-); "1+"(-■-); "2+"(-▲-)

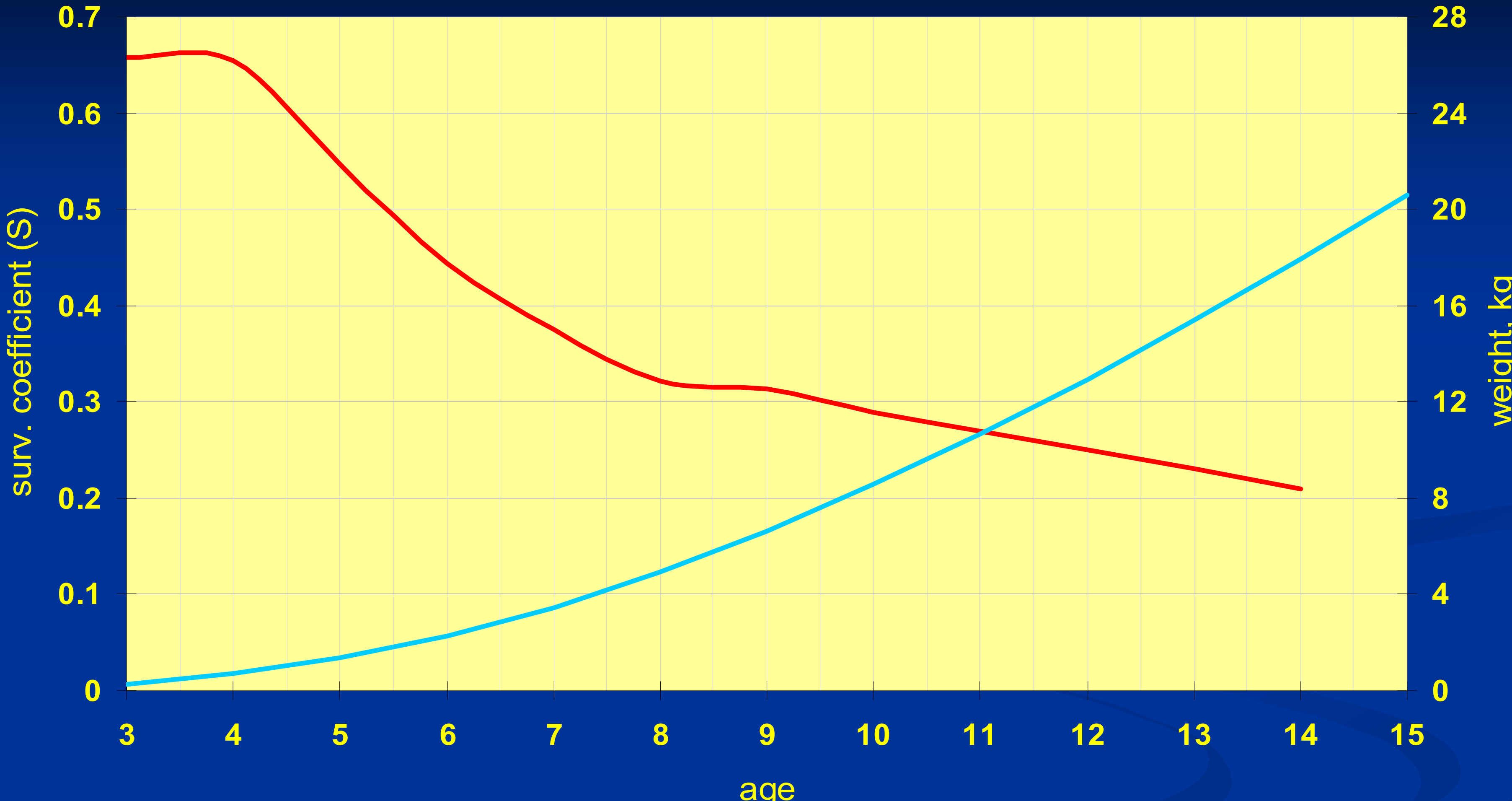

Fig.5. NEAcod. Survival coefficients (—) and weights (—) at age 3-15

Table 2. Change in the fishing stock biomass (FSB) at different survival levels in 3-5-age cod

Age	Weight, kg	S_1	$N_1 \cdot 10^3$ ind.	FSB_1 10^3t	S_2	$N_2 \cdot 10^3$ ind.	FSB_2 10^3t	S_3	$N_3 \cdot 10^3$ ind.	FSB_3 10^3t
3	0.27	0.657	500000	135000	0.700	500000	135000	0.800	500000	135000
4	0.69	0.655	328500	226665	0.700	350000	241500	0.800	400000	276000
5	1.35	0.547	215167	290475	0.600	245000	330750	0.700	320000	432000
6	2.28	0.443	117700	268356	0.443	147000	335160	0.443	224000	510720
7	3.47	0.375	52140	180926	0.375	65121	225970	0.375	99232	344335
8	4.93	0.321	19552	96391	0.321	24420	120391	0.321	37212	183455
9	6.63	0.314	6276	41610	0.314	7839	51973	0.314	11945	79195
10	8.55	0.289	1971	16852	0.289	2461	21041	0.289	3751	32071
11	10.67	0.270	569	6071	0.270	711	7586	0.270	1084	11566
12	12.96	0.250	154	1996	0.250	192	2488	0.250	293	3797
13	15.39	0.230	38	585	0.230	48	765	0.230	73	1123
14	17.95	0.210	9	161	0.210	11	197	0.210	17	305
15	20.59		2	41		2	41		3	62
Sums FSB_i				*1265*			*1473*			*2010*
Difference between sums: FSB_2-FSB_1=208000 t FSB_3-FSB_2=537000 t FSB_3-FSB_1=745000 t										

Discussion

- B_{pa}'s reputation as a biological reference point for fisheries management is unreasonably high
- As for cod, B_{pa} sustains only population fecundity and pelagic young abundance but it is not always true for N_3
- Starting from the formula $B_{pa} = B_{lim} \exp(1.645\ s)$ B_{pa} is rather a statistical than biological index

MAIN ELEMENTS OF TAC SETTING

Analysis of previous and current status of the stock:
assessment of fishing stocks (S),
relative interannual changes ($\Delta S\%$);
Influence of S on recruitment (R_s), growth (W_s), natural mortality (M_s)

Analysis of previous and current status of fisheries:
catches (C), relative interannual changes ($\Delta C\%$);
assessment of CPUE, F, correspondence of $\Delta C\%$ with $\Delta S\%$, influence of C on S

Forecast $S_{i+1} = S - C - M_s + R_s + W_s$,
where R_s prognosis is based on surveys of young fish and assessment of conditions of its survival on the stages from eggs to R_s; M_s includes cannibalism, discards, and other accountable losses of S

Assessment of $\Delta S_{i+1}\%$ ***based on $S - S_{i+1}$***

Choice of reasonable $\Delta C_{i+1}\%$
based on $\Delta S_{i+1}\%$, tendencies in S and CPUE assessments, and consideration of W_s and M_s trends

Setting of TAC_{i+1}
based on ΔS_i and chosen $\Delta C_{i+1}\%$

Conclusion

- Common use of the B_{pa} at TAC setting is not always reasonable
- B_{pa} estimation cannot be regarded as properly biologically based in the case of species with R dependent on survival conditions for pre-fishery young to a greater extend than SSB
- It would be reasonable to check the SSB effect on the R formation prior to determining B_{pa} and using it for TAC setting


...and are you sure the key to TAC was lost just here?
- Most likely there. But here is lighter place...
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