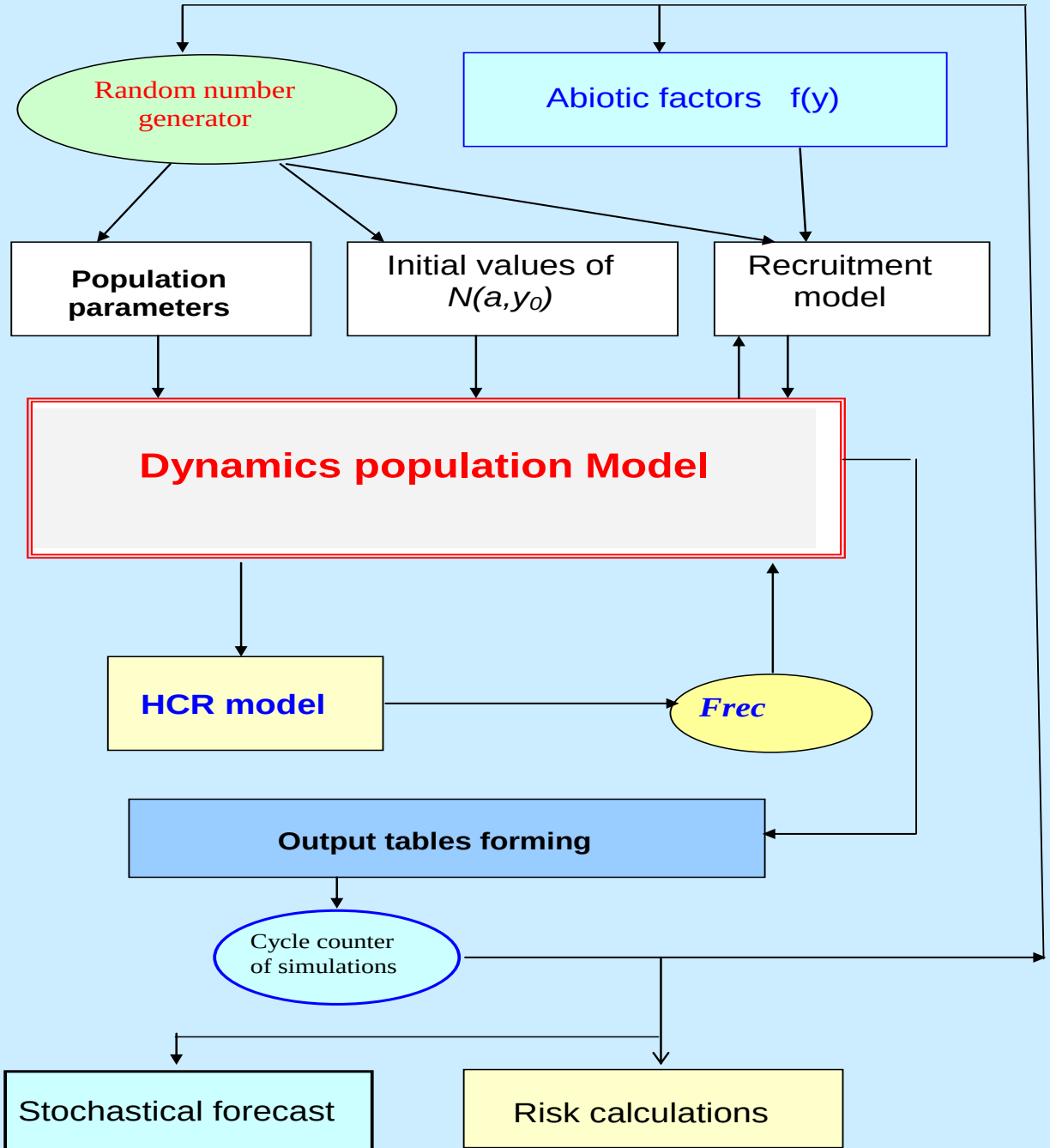
The 12- th Russian-Norwegian Symposium
Ecosystem dynamics and optimal long term harvest
in the Barents sea fisheries

# The simulation of Norwegian spring spawning herring dynamics to evaluate various variants of the harvest control rule

*T. Bulgakova*

***Russian Federal Research Institute of Fisheries and Oceanography (VNIRO)***


Random number generator
Abiotic factors f(y)
Population parameters
Initial values of $N(a,y_0)$
Recruitment model
Dynamics population Model
HCR model
Frec
Output tables forming
Cycle counter of simulations
Stochastical forecast
Risk calculations

- Input information was taken from WG NPBW–2005 and
- ISVPA output obtained in 2005
- Retrospective period is taken as 1980-2004, ages 2-16.

Input data :

N(a, 1980), conventional M(a), Rec(2, y), Wca(a,y), Wstock(a,y) and S(a,y)= F(a,y) */ (*F(5-14;y) , where F(5-14) was weighted on N(a,y))

# Harvest control rules investigated

1. *F(5-14)* values by year are const

and equal to 0.125, 0.15, 0.2, 0.3 or 0.5;

2. a single *step rule:*

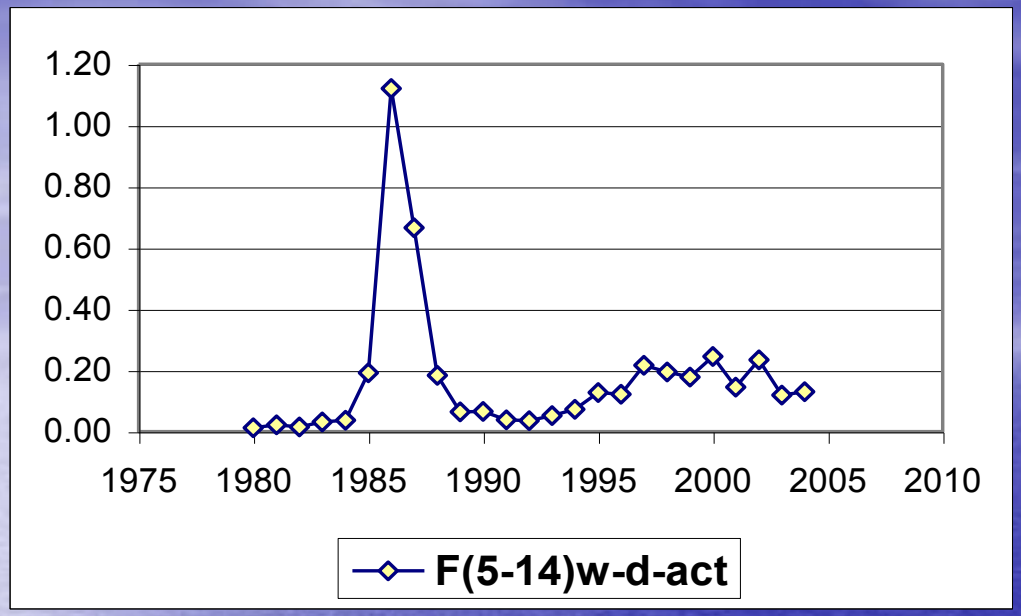
F(5-14) = 0, if SSB< 2500 000 t, else F(5-14)= 0.15

3. a double *step rule:*

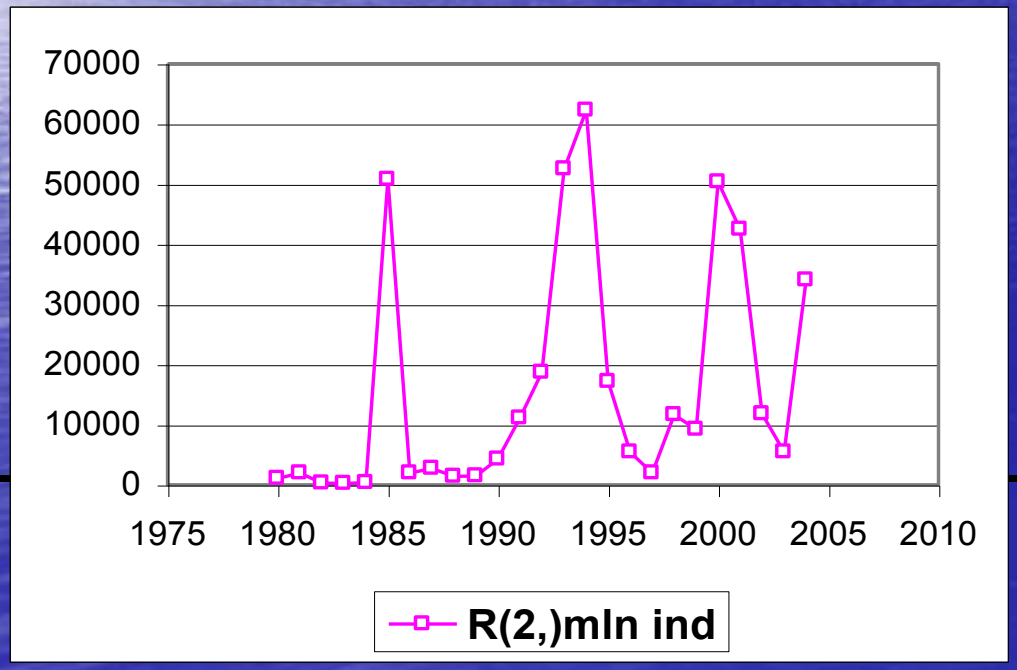
if SSB< 2500 000 t, F(5-14) = 0, else:

if SSB >5000 000 t, F(5-14) = F2, else F(5-14) =F1

F1=0.125 or 0.15;  F2=0.15 or 0.2

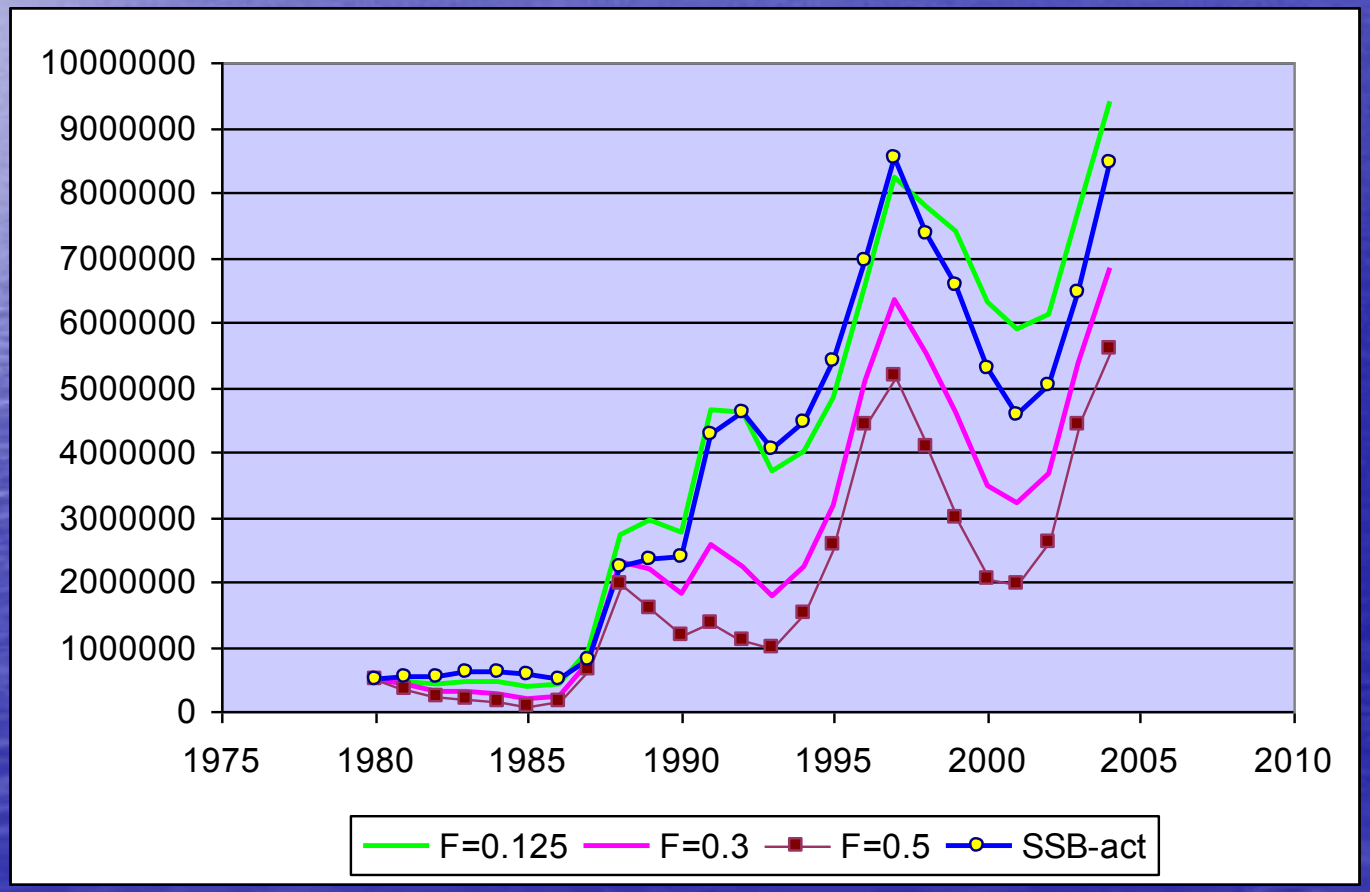



Actual F(5-14) weighted by numbers




Actual recruitment dynamics $*10^6$ ind.

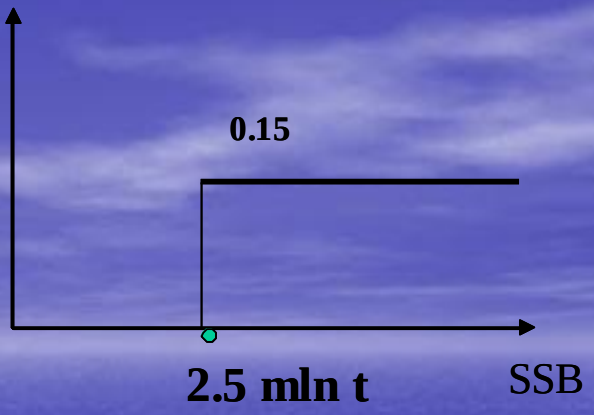
# Determinate version. SSB(y) from runs with HCR F-const (0.125,0.3 and 0.5) and actual SSB

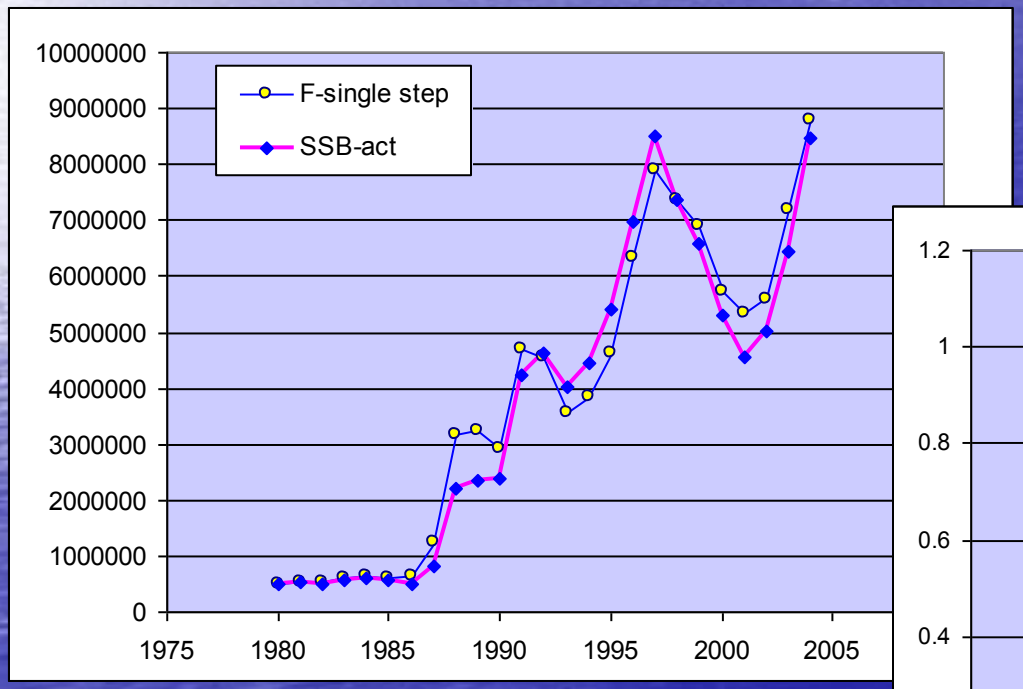


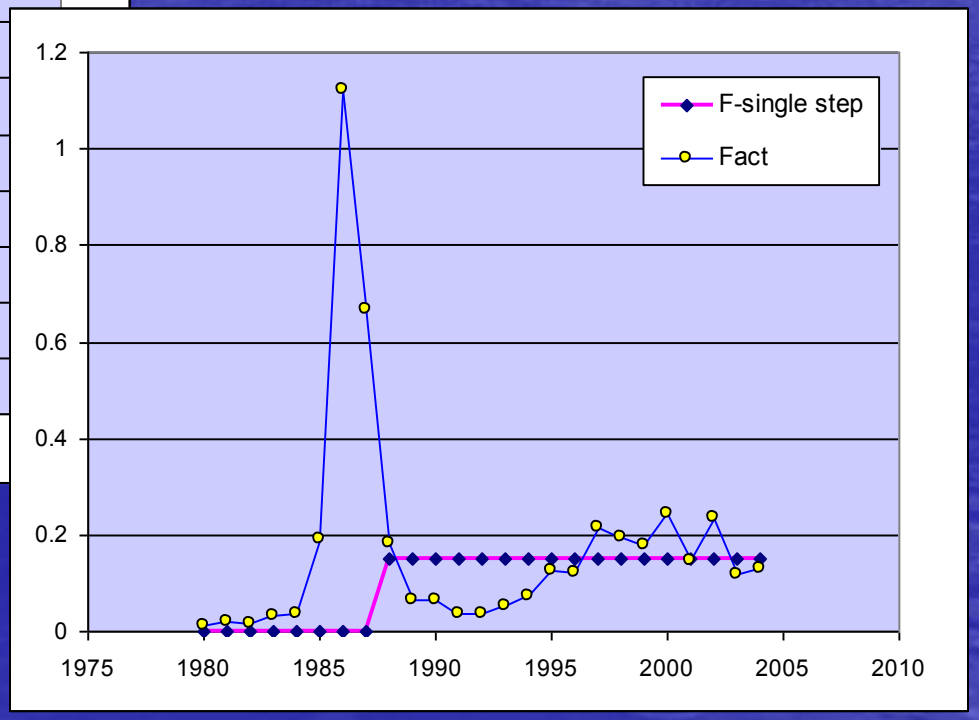
# Determinate model:

# actual SSB(y) and F(y)

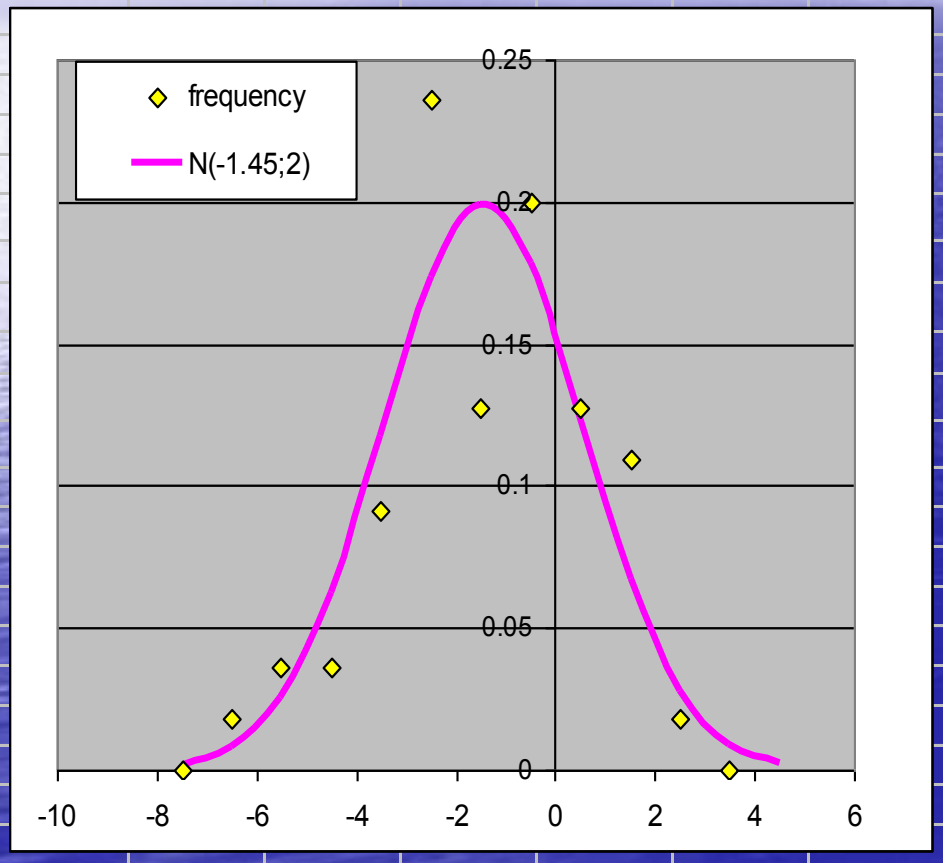
# and if HCR is single step



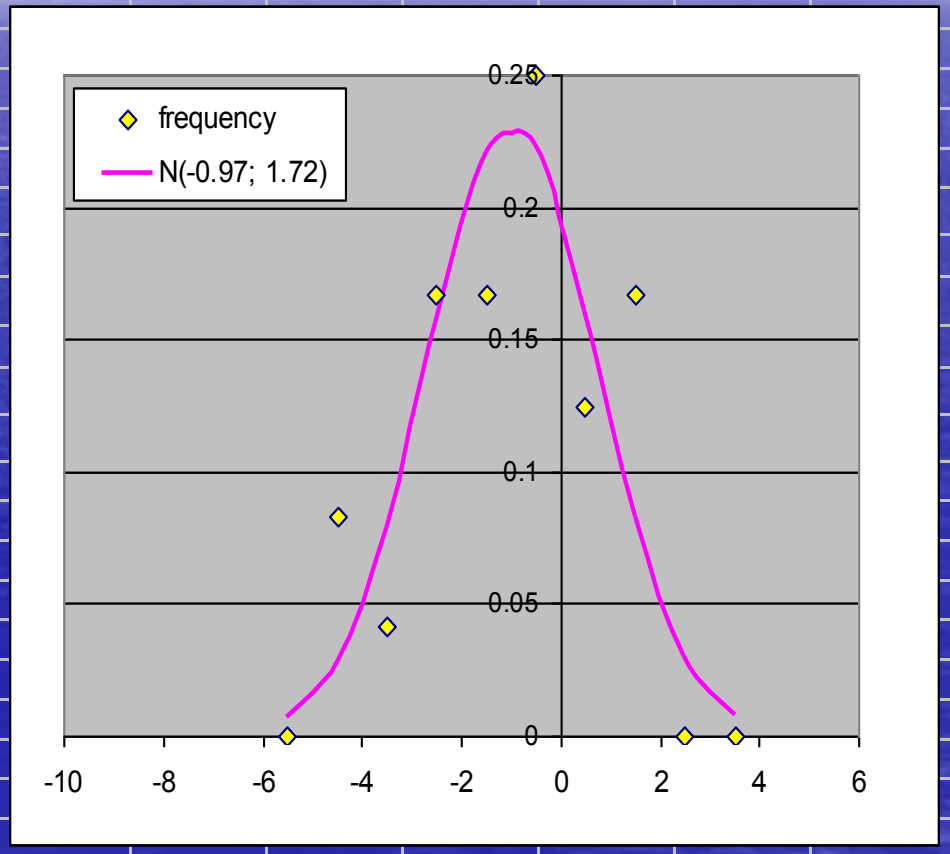



# Frequency distribution and theoretical normal distribution of LN(R/Raver) for two year-class intervals




1950-2003




1980-2003

# Models R(SSB)

- **The Ricker' model:**

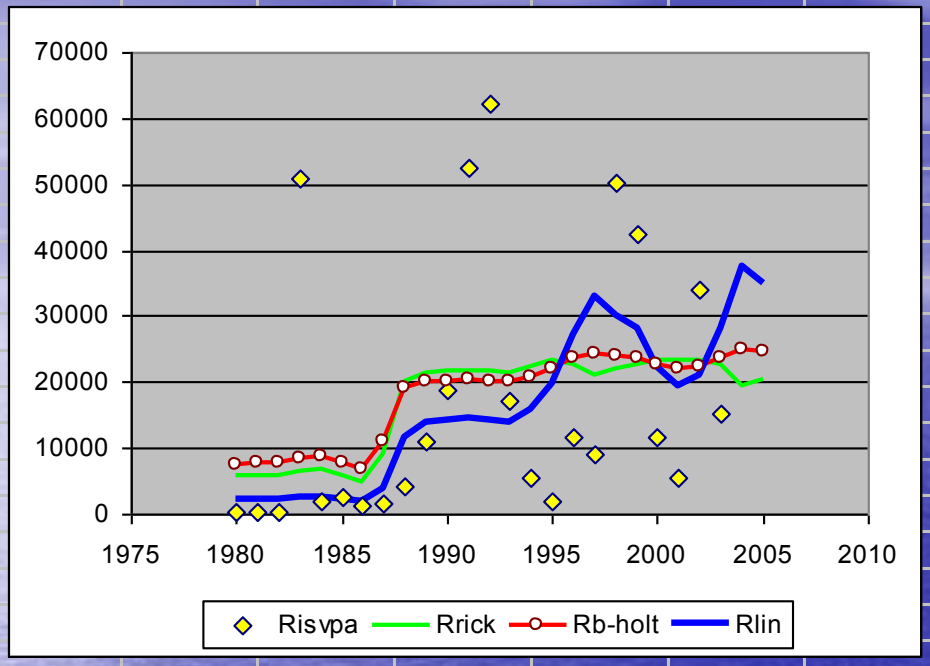
  ***R(2,y) = α*SSB(y-2)*EXP(- β*SSB(y-2)),***

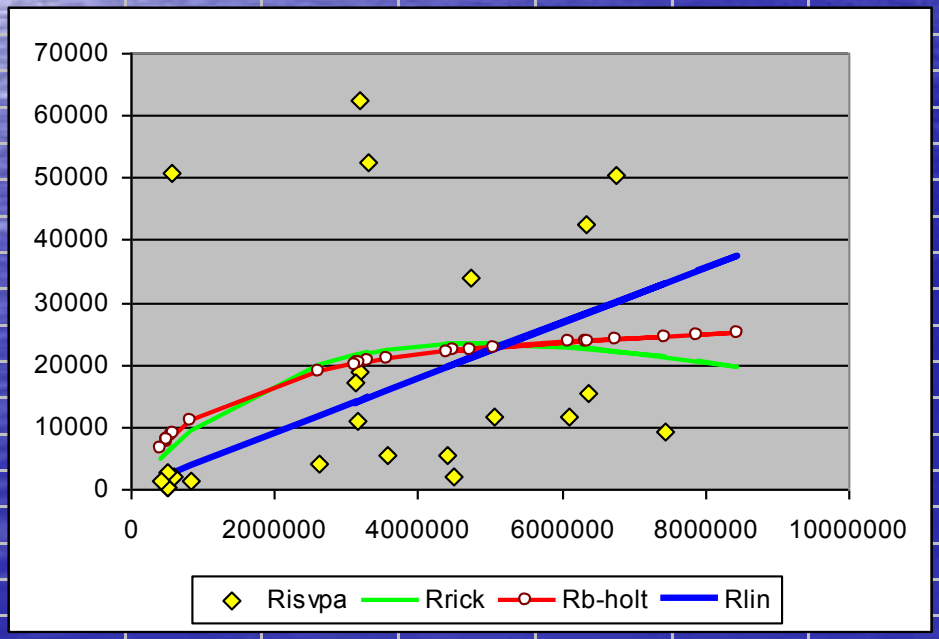
  **parameters *α* and *β* are constant**

- **Beverton and Holt' model**

$$R(2,y) = \frac{aSSB(y-2)}{1+bSSB(y-2)}$$

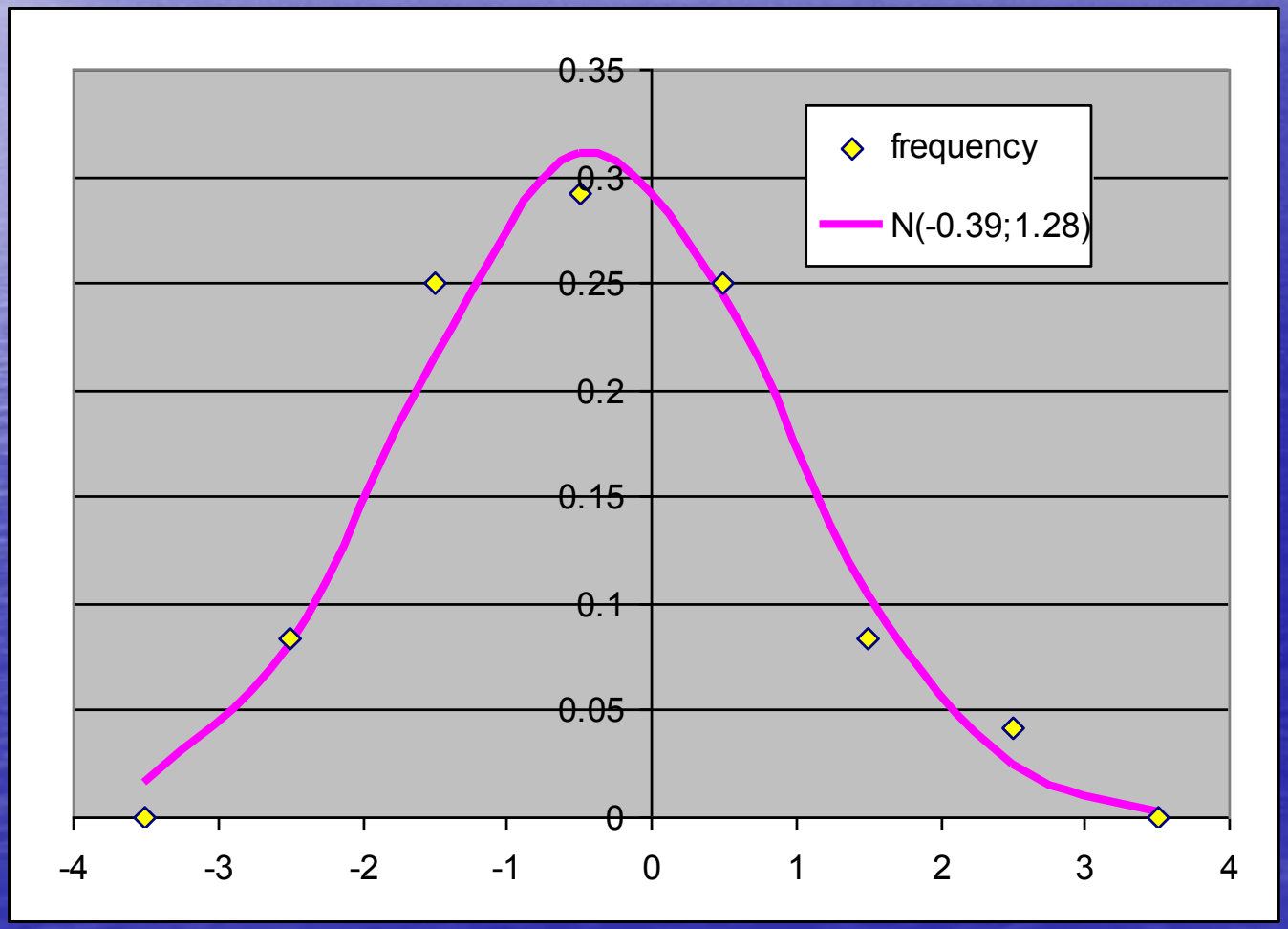
- **Linear function *R(2,y) =k SSB(y-2)*.**



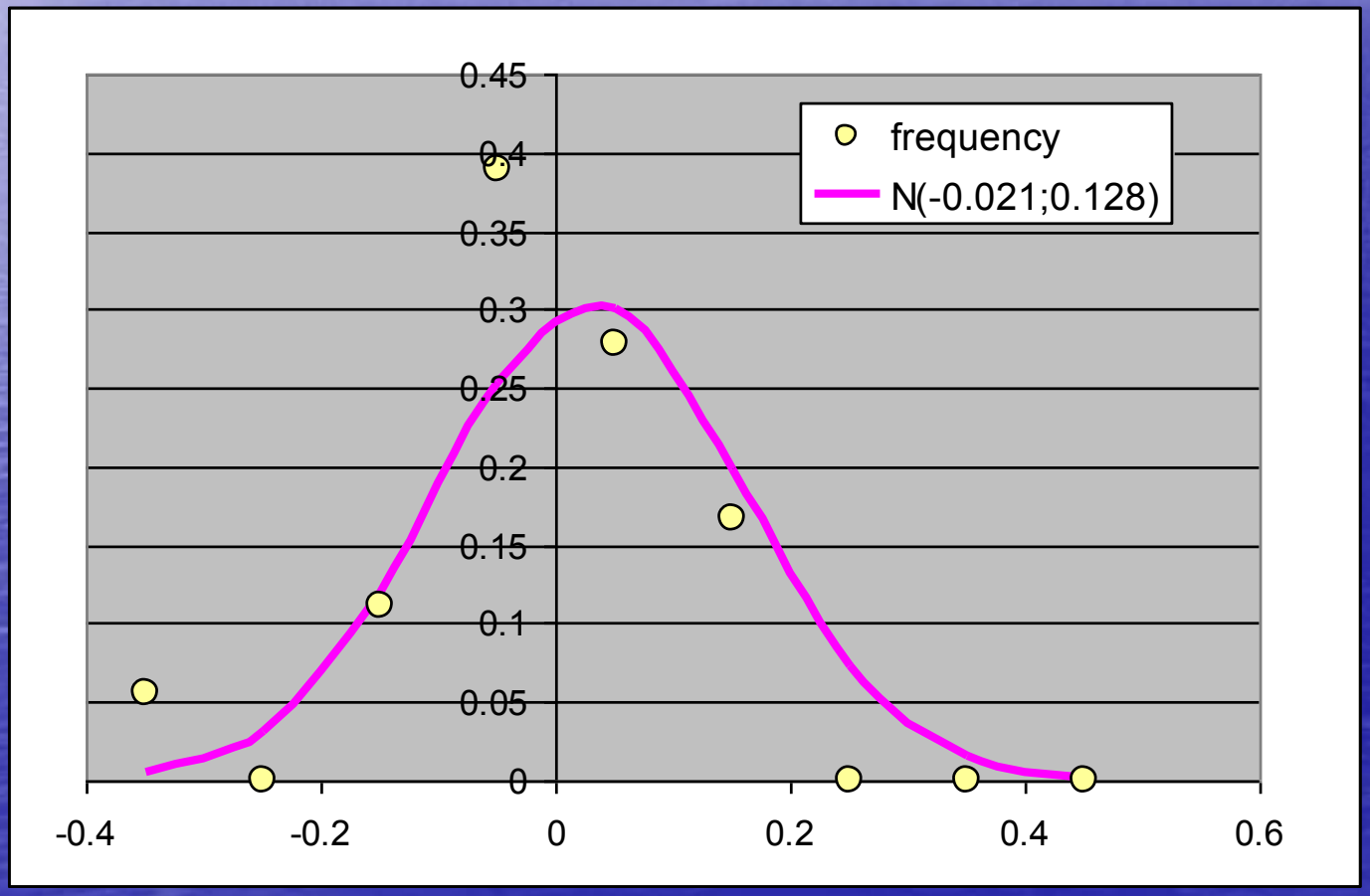




Three models Recruitment-SSB for 1980-2003 year-classes

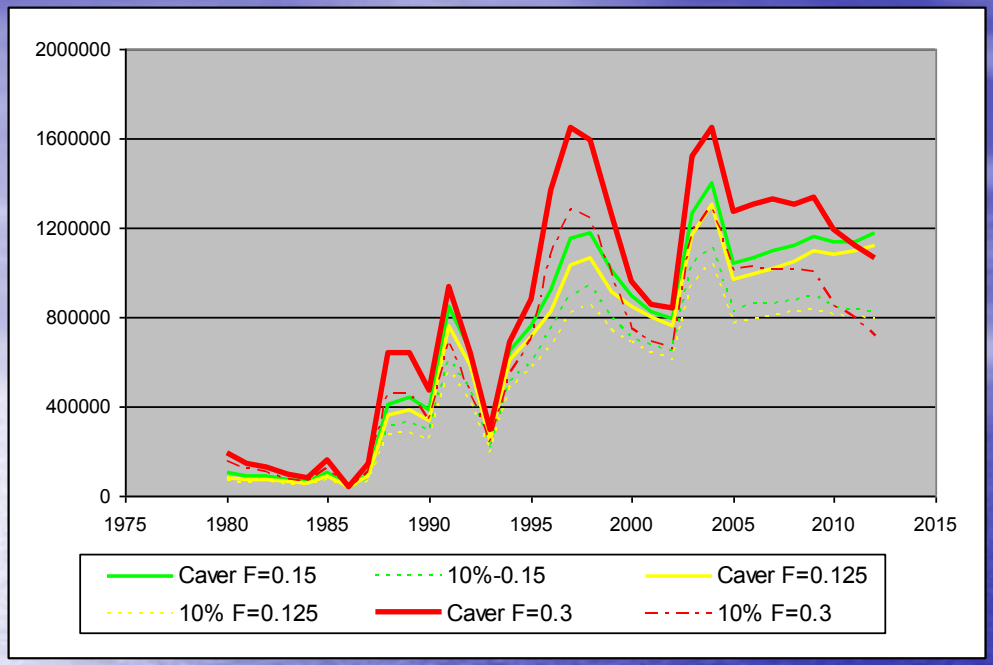
# Frequency distribution and theoretical normal distribution of LN(R/Rlinear) for y-classes 1980-2003



# Frequency distribution and theoretical normal distributionof LN(C/TAC) for 1988-2006

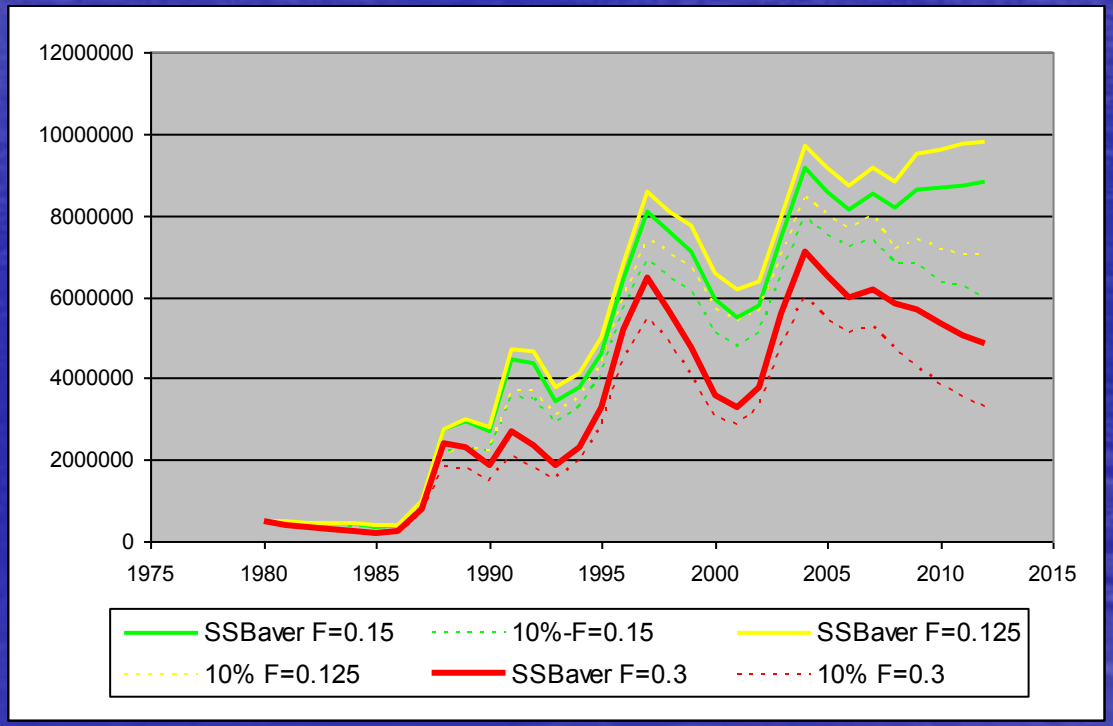


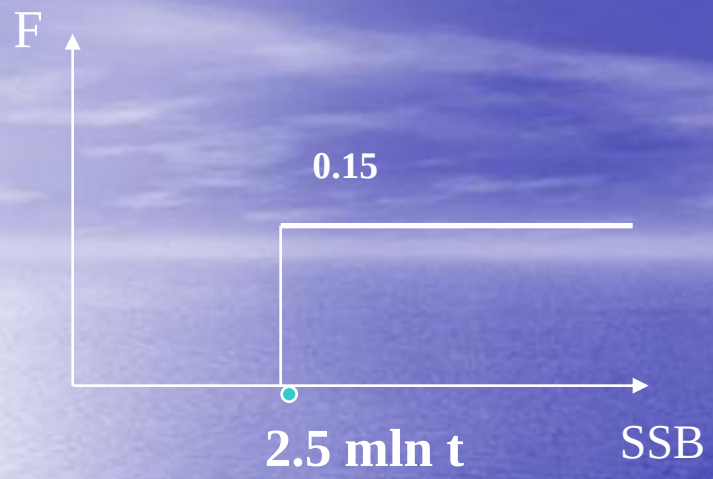
# Recruitment in predicted years obtained by different methods

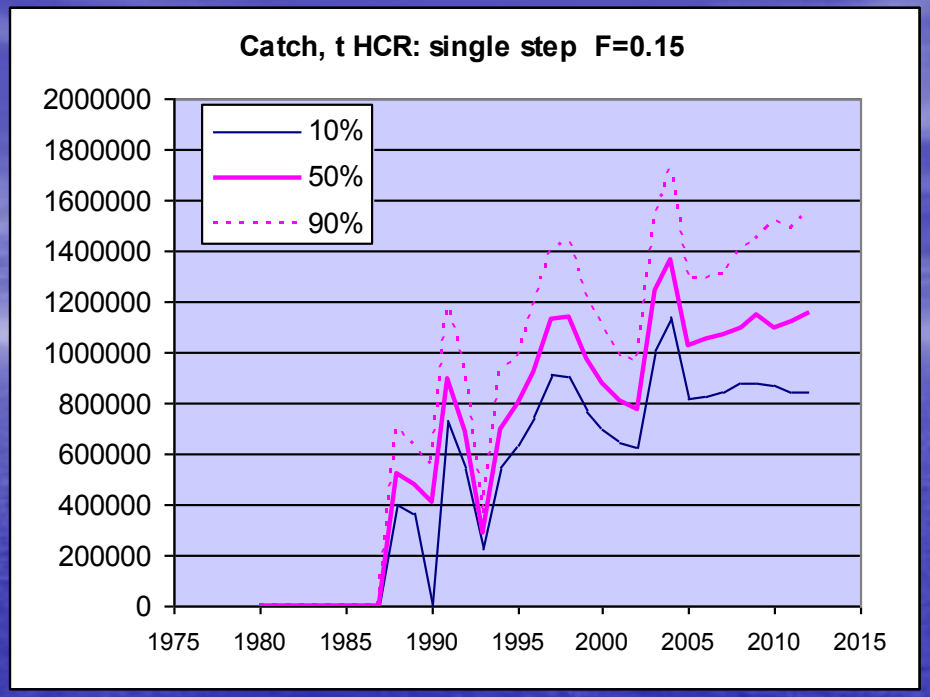


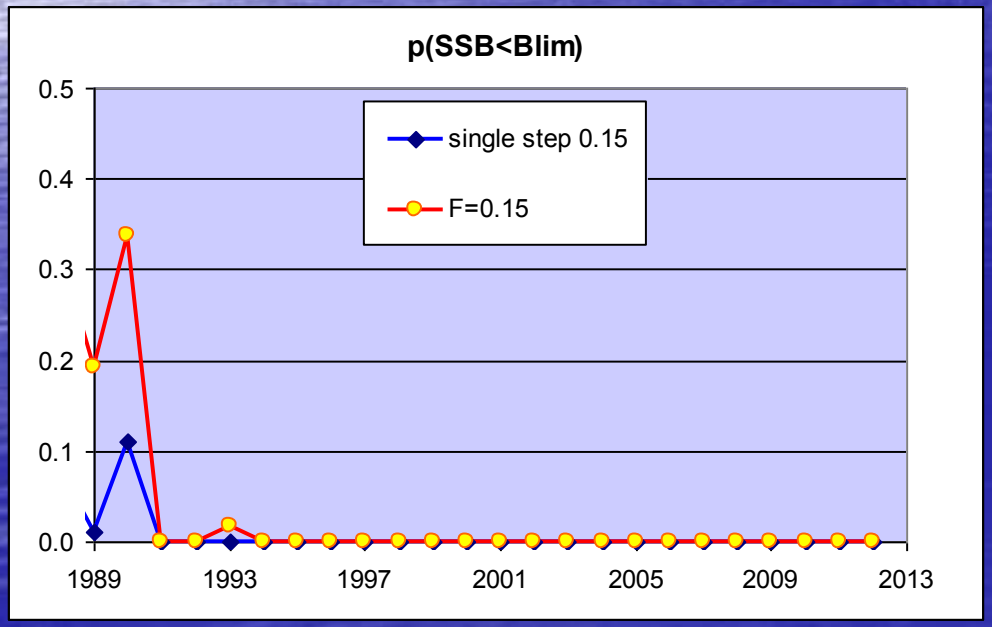

Catch –average and 10-procentile **HCR is F=const** 0.125, 0.15 and 0.30

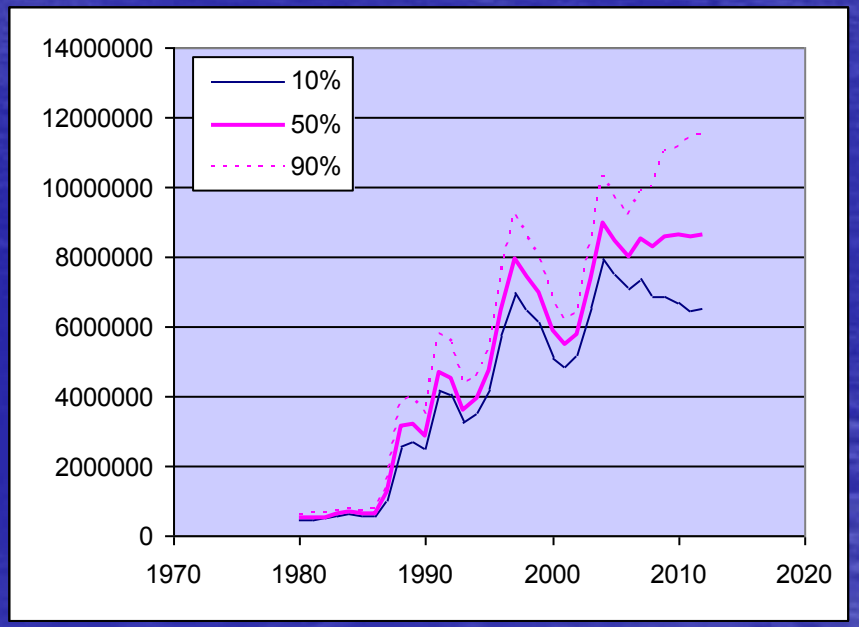
SSB –average and 10-procentile **HCR is F=const** 0.125, 0.15 and 0.30



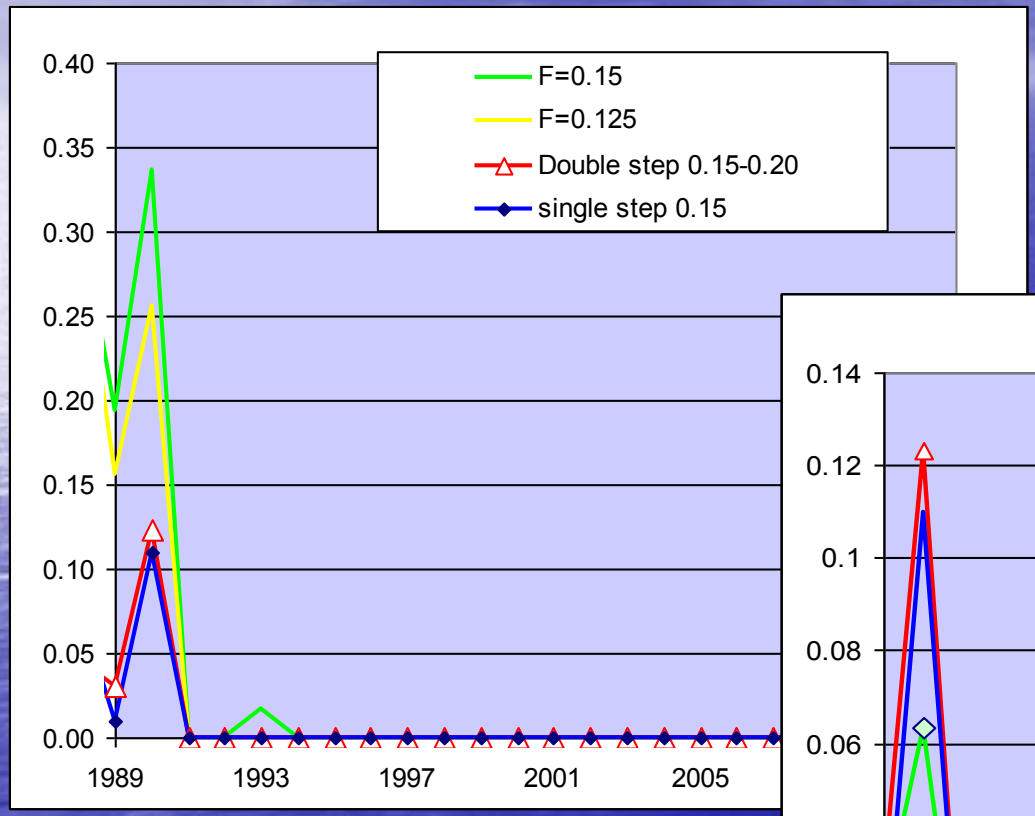

F
0.15
2.5 mln t
SSB

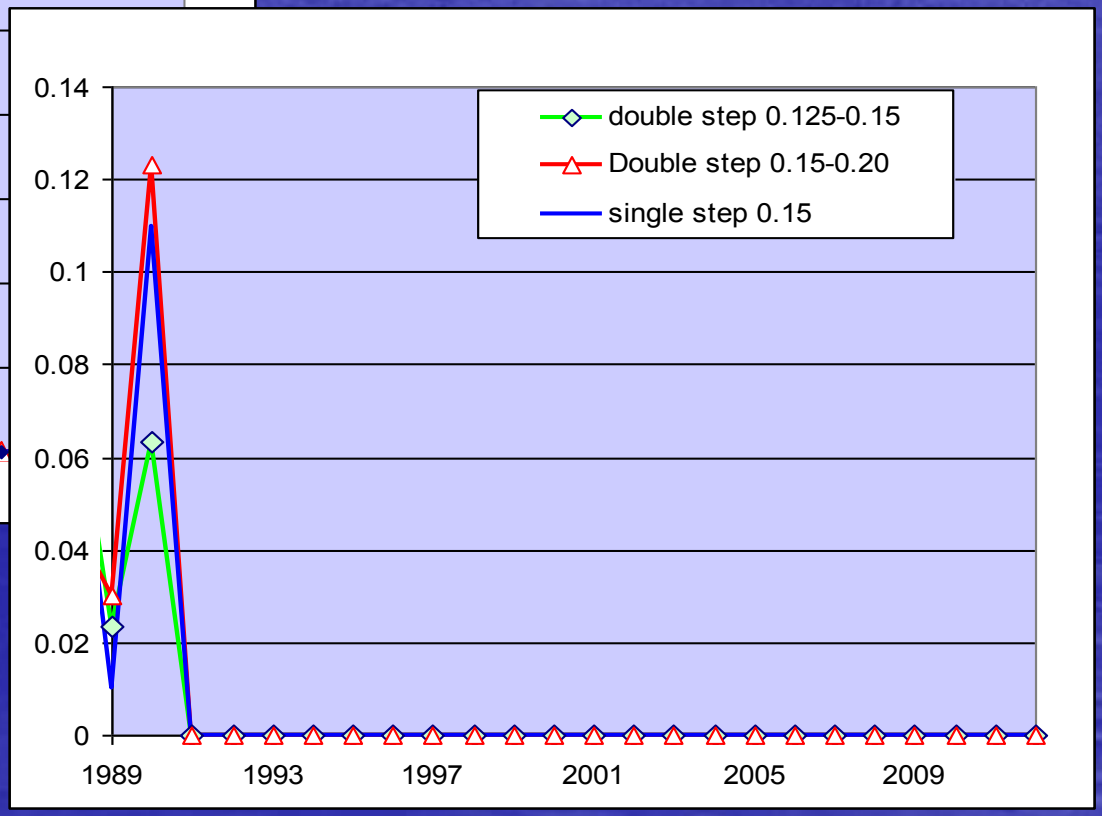

Catch, t HCR: single step F=0.15
2000000
1800000
1600000
1400000
1200000
1000000
800000
600000
400000
200000
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
10%
50%
90%

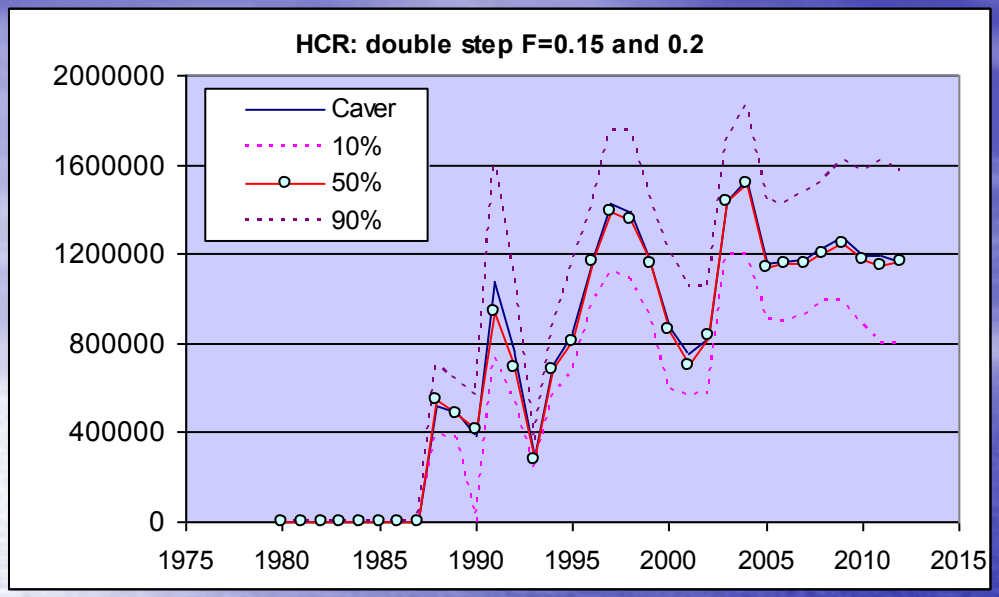

p(SSB<Blim)
0.5
0.4
0.3
0.2
0.1
0.0
1989
1993
1997
2001
2005
2009
2013
single step 0.15
F=0.15


14000000
12000000
10000000
8000000
6000000
4000000
2000000
0
1970
1980
1990
2000
2010
2020
10%
50%
90%

# Risk probability since 1989 for 5 HCR variants

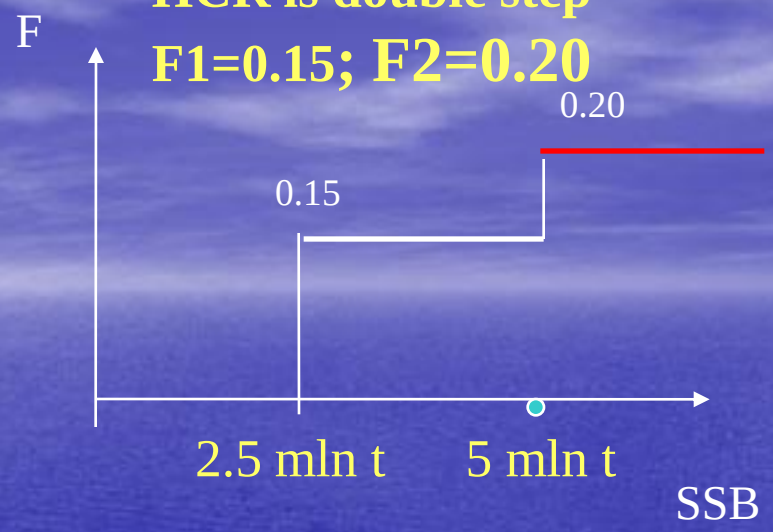




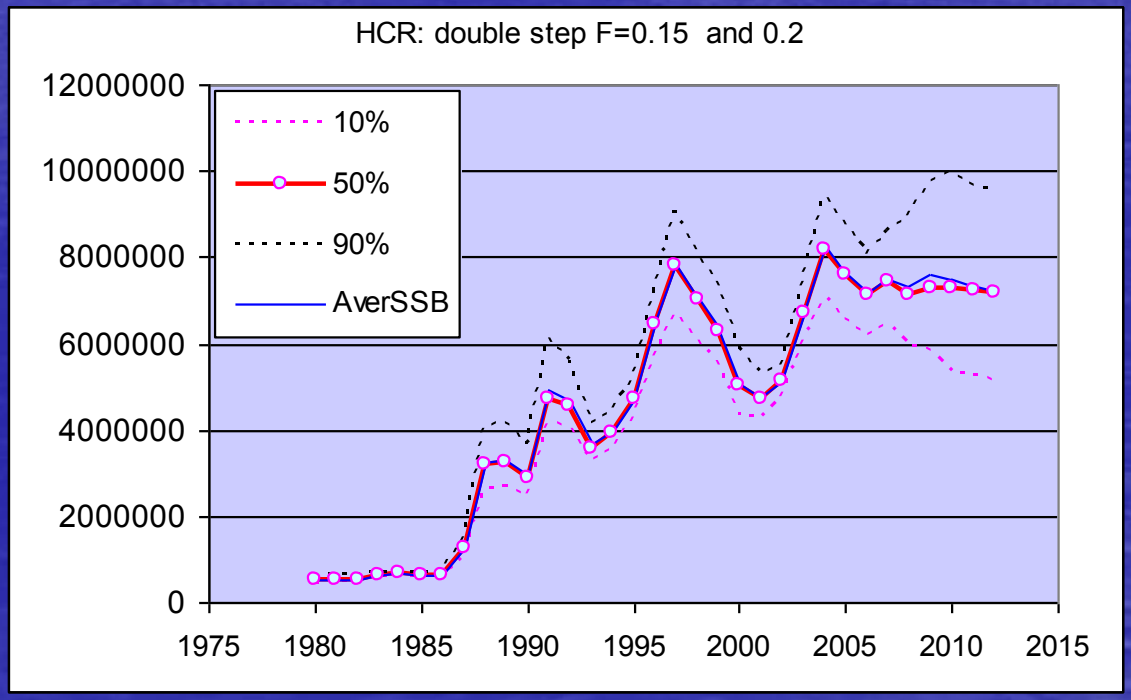

**HCR is double step**

**F1=0.15; F2=0.20**




Catch dynamics

**SSB dynamics**



## *Conclusions*

Each HCR was incorporated since 1980.

**Determinate model runs** : the increasing Fbar up to 0.15-0.20 is not dangerous for stock status and allows increasing catch=TAC .

**Stochastic model runs** :

- On year interval after the stock reconstruction the maximal risk fell at 1990 for all model runs and risk probability this year depends on the HCR set:

  if Fbar=const=0.30 risk = 0.95.

  If Fbar=0.15 the risk = 0.34.

  Double step ($F_1$=0.15, $F_2$=0.20)- risk =0.12

- Using of step function decreases the risk of SSB and allows to support catch in prognostic years on the level of 1200 000 tons.
- Risk was estimated relative to value Blim=2500000 t set by WGPBW and there is no confidence in correctness of chosen value for herring- this level is not historical minimum: in 21 years from 56 (in 37%) SSB<Blim !
- Functions R(SSB) describes a little part of R variability, it is not enough for actual population dynamics modeling. For the further development of the simulation model it is desirable to find out main environmental factors influencing on the recruitment forming.

Thank you !