UALG

Where do the magic numbers come from?

The signal in the input data

The assessment model in mathematical terms

$$s_a = \begin{cases} e^{\frac{-(a-a_{full})^2}{\sigma_L}} & \text{for } a \le a_{full} \\ e^{\frac{-(a-a_{full})^2}{\sigma R}} & \text{for } a > a_{full} \end{cases}$$

$$F_{ay} = s_a F_y$$

$$N_{a,y} = \begin{cases} R_{a,y} & a = 1 \quad \text{or } y = 1 \\ N_{a-1,y-1} e^{-(F_{a-1,y-1} + M_{a-1,y-1})} & 1 < a < a_{plus} \\ N_{a-1,y-1} e^{-(F_{a-1,y-1} + M_{a-1,y-1})} + N_{a,y-1} e^{-(F_{a,y-1} + M_{a,y-1})} & a = a_{plus} = 11 \end{cases}$$

$$\hat{C}_{ay} = \frac{F_{a,y}}{F_{a,y} + M_{ay}} \left(1 - e^{-(F_{a,y} + M_{ay})}\right) N_{ay}$$

$$\hat{U}_{ay} = q_a N_{ay}$$

$$\min SSE = \lambda_C \sum_y \sum_a \omega_a \left(\ln C_{ay} - \ln \hat{C}_{ay}\right)^2 + \lambda_U \sum_y \sum_a \rho_a \left(\ln U_{ay} - \ln \hat{U}_{ay}\right)^2$$

Another way of putting it:

- We have:
  - Relative measures of stock abundance (Uay)
  - Absolute measures of removals from the stock (Cay)

- We want:
  - Absolute numbers of the stock (Nay)
  - Removals relative to stock abundance (Fay)

- But where does the model pick up the information on Nay and Fay from the measurements?

Signals in the catch data: The absolute value

- The catch data are the only data that contain any absolute information (millions of fish caught)
  - Thus the absolute numbers in the stock (Nay) must come from the catches

- But accuracy hinges on:
  - That the natural mortality is reasonable close to reality
  - That the catch data do not deviate too much from what is actually removed from the fisheries

- However:
  - The advice may be fair, if the deviations are consistent in time

Signals in the catch data: The total mortality 1

- The stock equation is:

$$N_{a+1,y+1} = N_{a,y} e^{-Z_{a,y}}$$

- Taking a logarithm gives

$$\ln\left(N_{a+1,y+1}\right) = \ln\left(N_{a,y}\right) - Z_{a,y}$$

$$Z_{a,y} = \ln\left(N_{a,y}\right) - \ln\left(N_{a+1,y+1}\right)$$

$$Z_t = \ln\left(\frac{N_{a,y}}{N_{a+1,y+1}}\right)$$

- Thus, we do not need an absolute estimate of abundance, only the relative abundance of each from one age group to the next

Signals in the catch data: The total mortality 2

- The math:

$$CPUE_{a,y} = q_a N_{a,y} = \frac{C_{a,y}}{E_{a,y}}$$

If we assume: $E_{a,y} = E_{a+1,y+1}$ and $q_{a,y} = q_{a+1,y+1}$

$$Z_{a,y} = \ln\left(\frac{N_{a,y}}{N_{a+1,y+1}}\right)$$

$$= \ln\left(\frac{C_{ay} \big/ \left(E_{ay} q_{ay}\right)}{C_{a+1,y+1} \big/ \left(E_{a+1,y+1} q_{a+1,y+1}\right)}\right)$$

$$= \ln\left(\frac{C_{a,y}}{C_{a+1,y+1}}\right)$$

- If there has been no change in effort over time or in catchability by age/size one can use the log ratio of the number of fish caught at each stage to estimate the total mortality.

- This derivation show that if we have some measurement of catches by age (or length) we can estimate Z.

- E: Effort
- q: Catchability

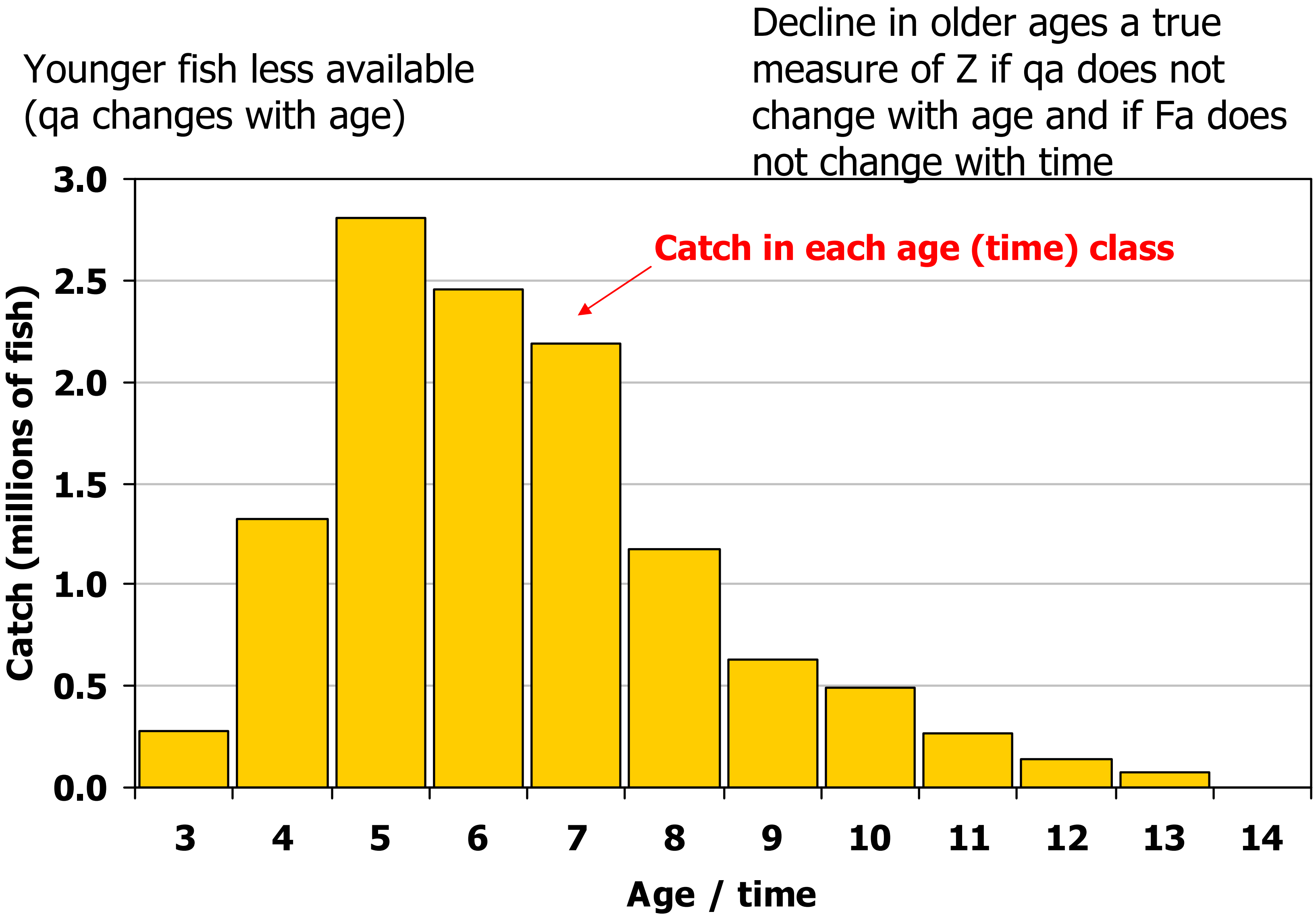
Another way of putting it:

- If we assume that F=qE we can show that:

$$\ln\left(\frac{C_{a,y}}{C_{a+1,y+1}}\right) \sim averageZ + \ln\left(\frac{F_{a,y}}{F_{a+1,y+1}}\right)$$

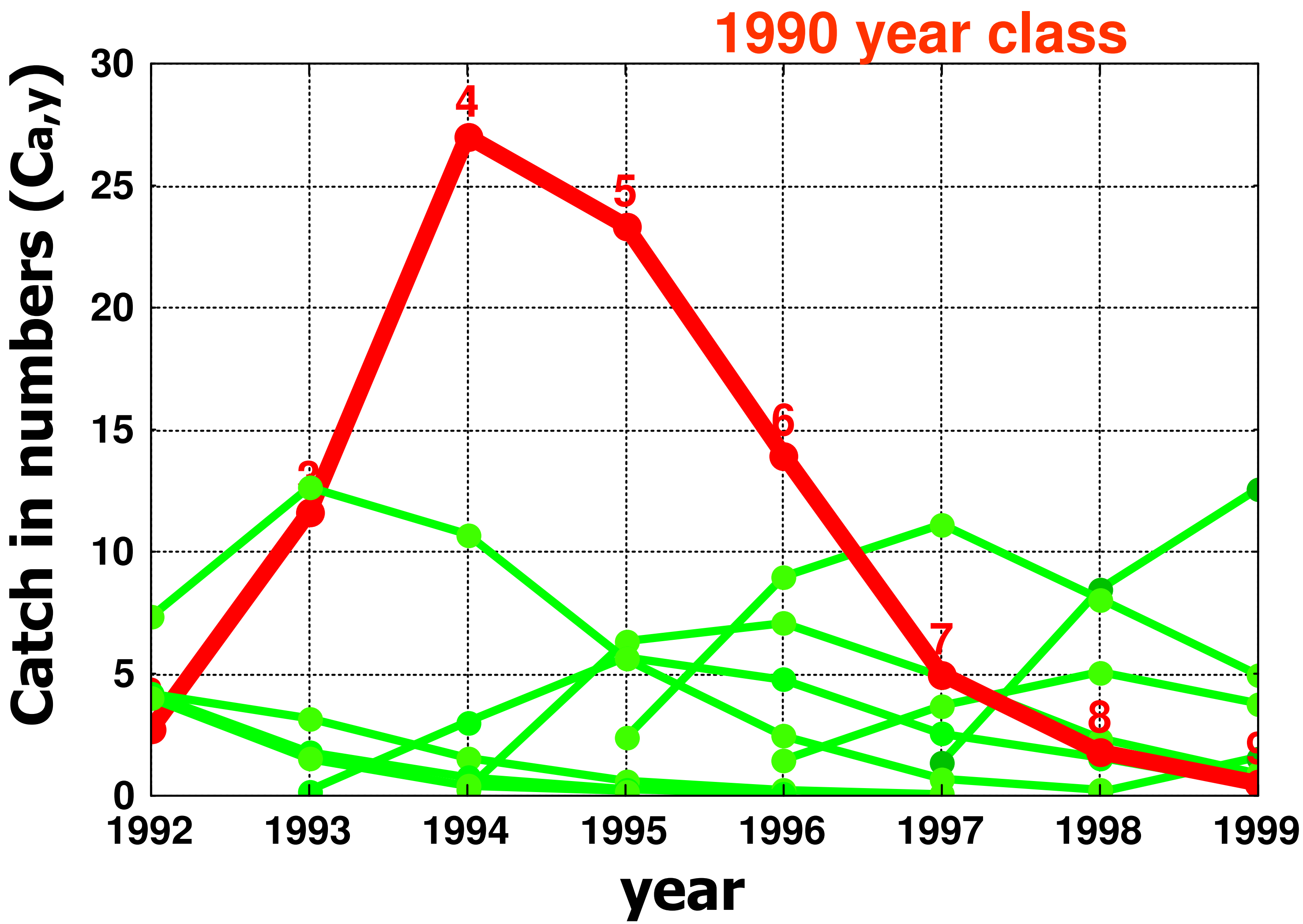
- Thus, the log catch ratio:
  - Contains the whole mortality information and nothing else
  - Can give us some ideas about the order of the total mortalities, but is modified by changes in fishing mortalities

The catch development of ONE cohort

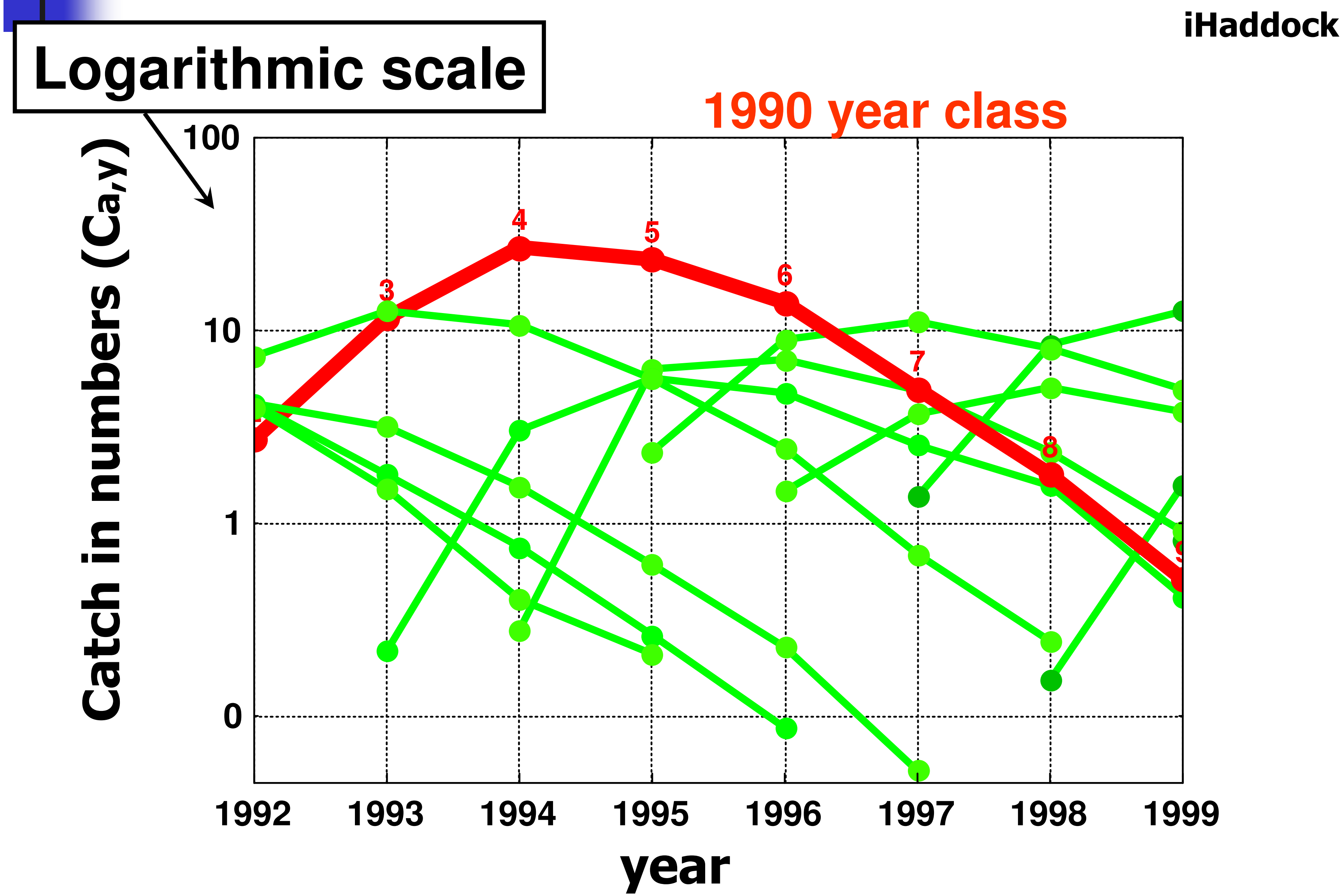


Total mortality signal of older fish: Part 1

iHaddock

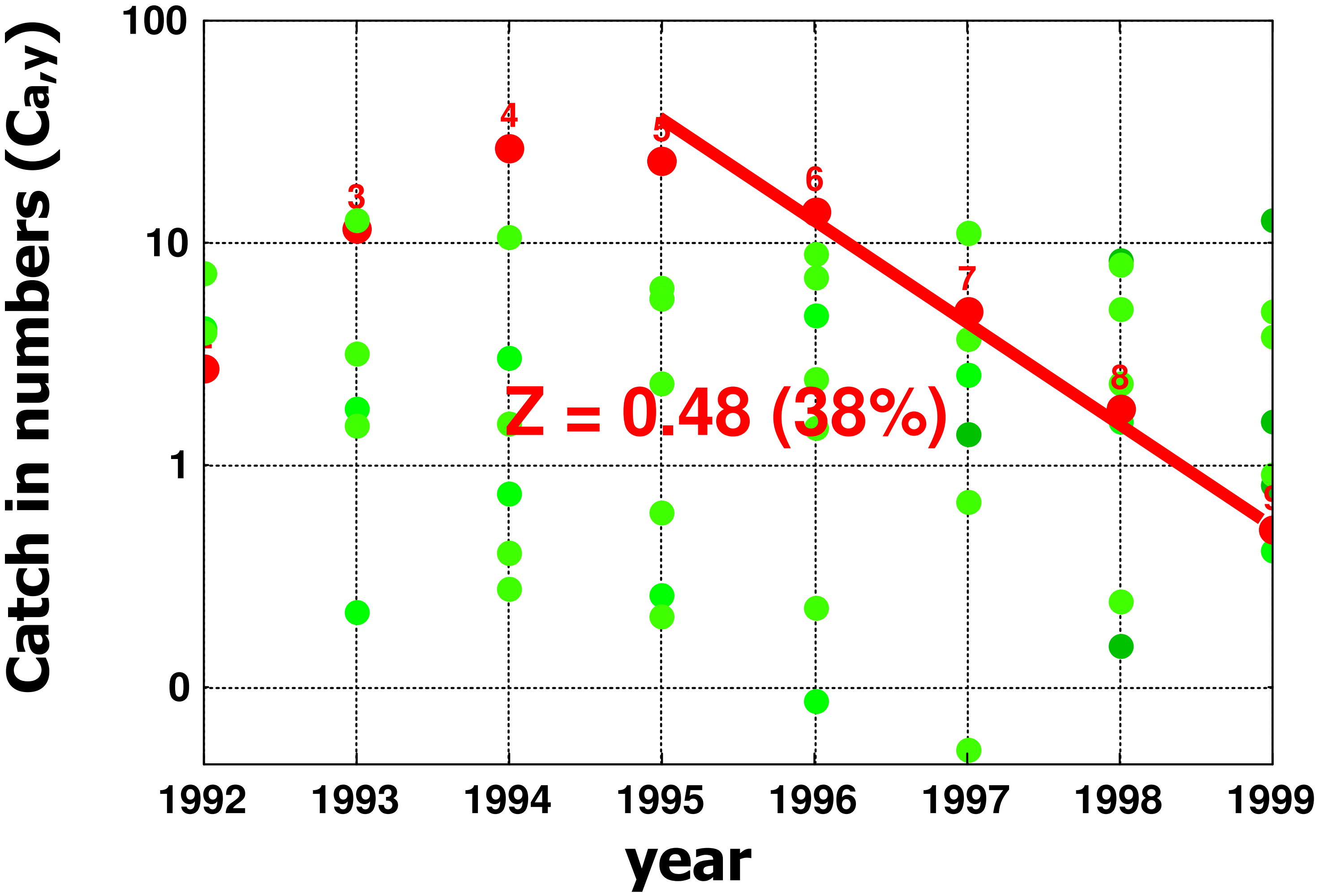


Total mortality signal of older fish: Part 2



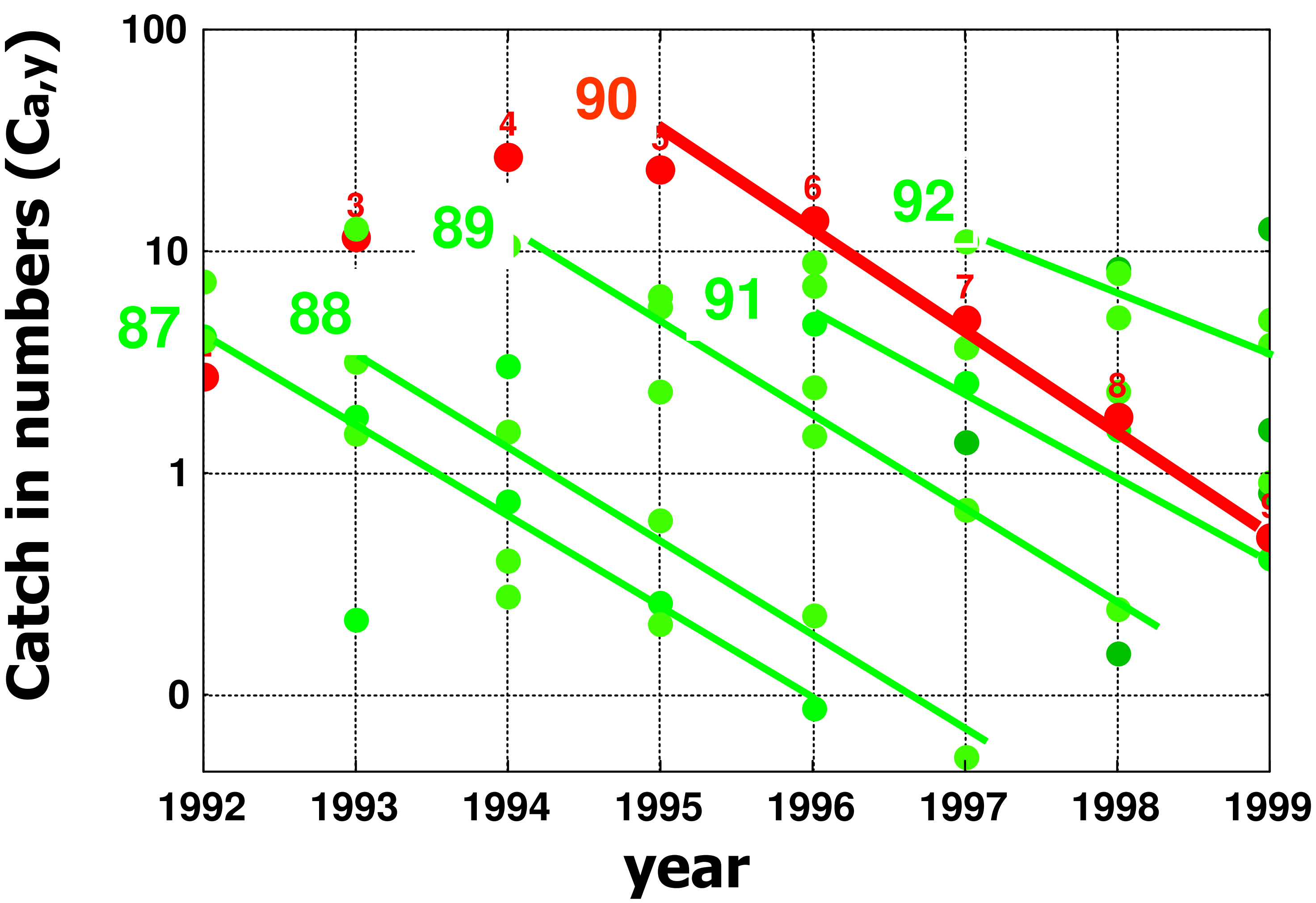
Total mortality signal of older fish: Part 3

iHaddock



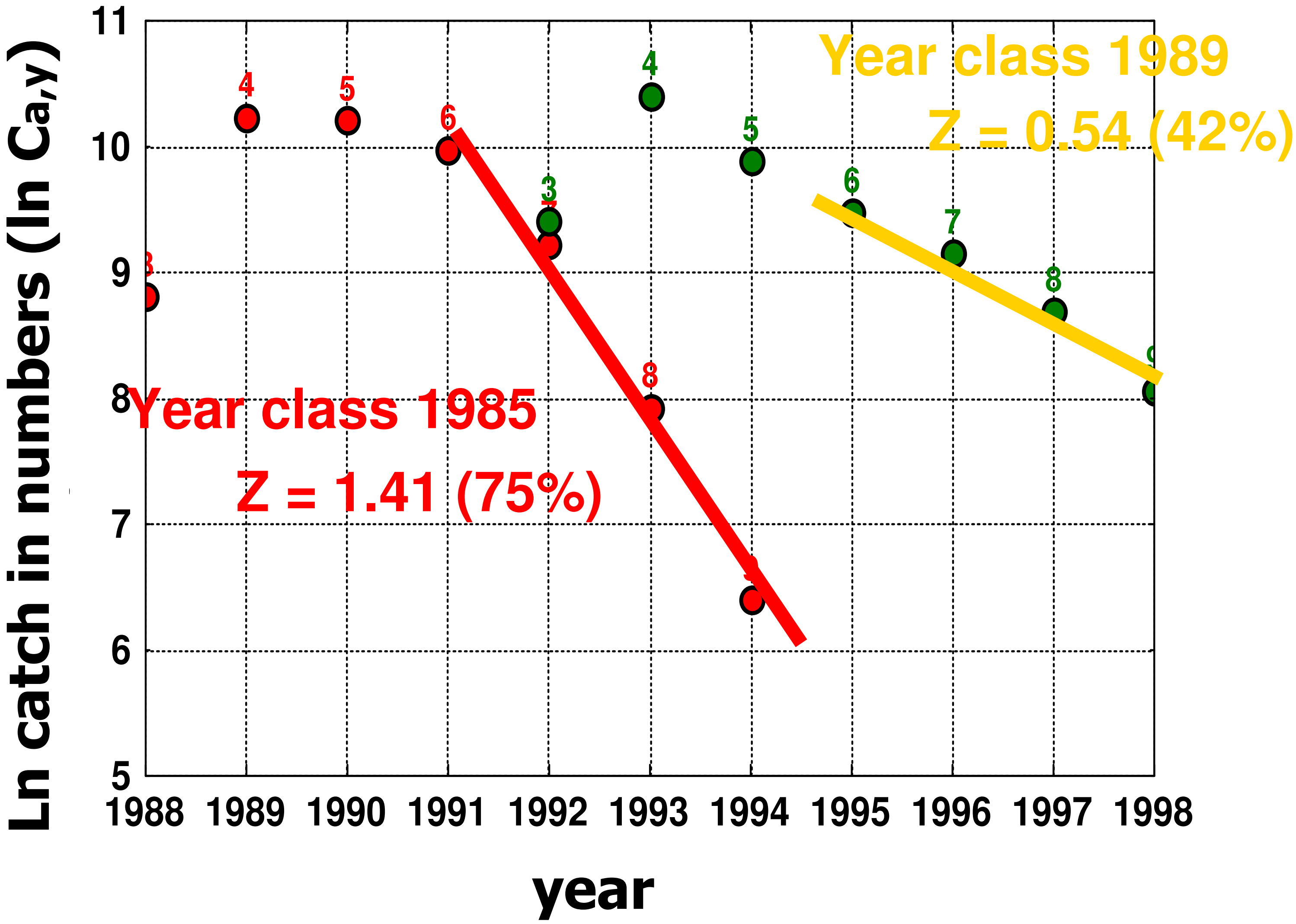
Total mortality signal of older fish: Part 4

iHaddock

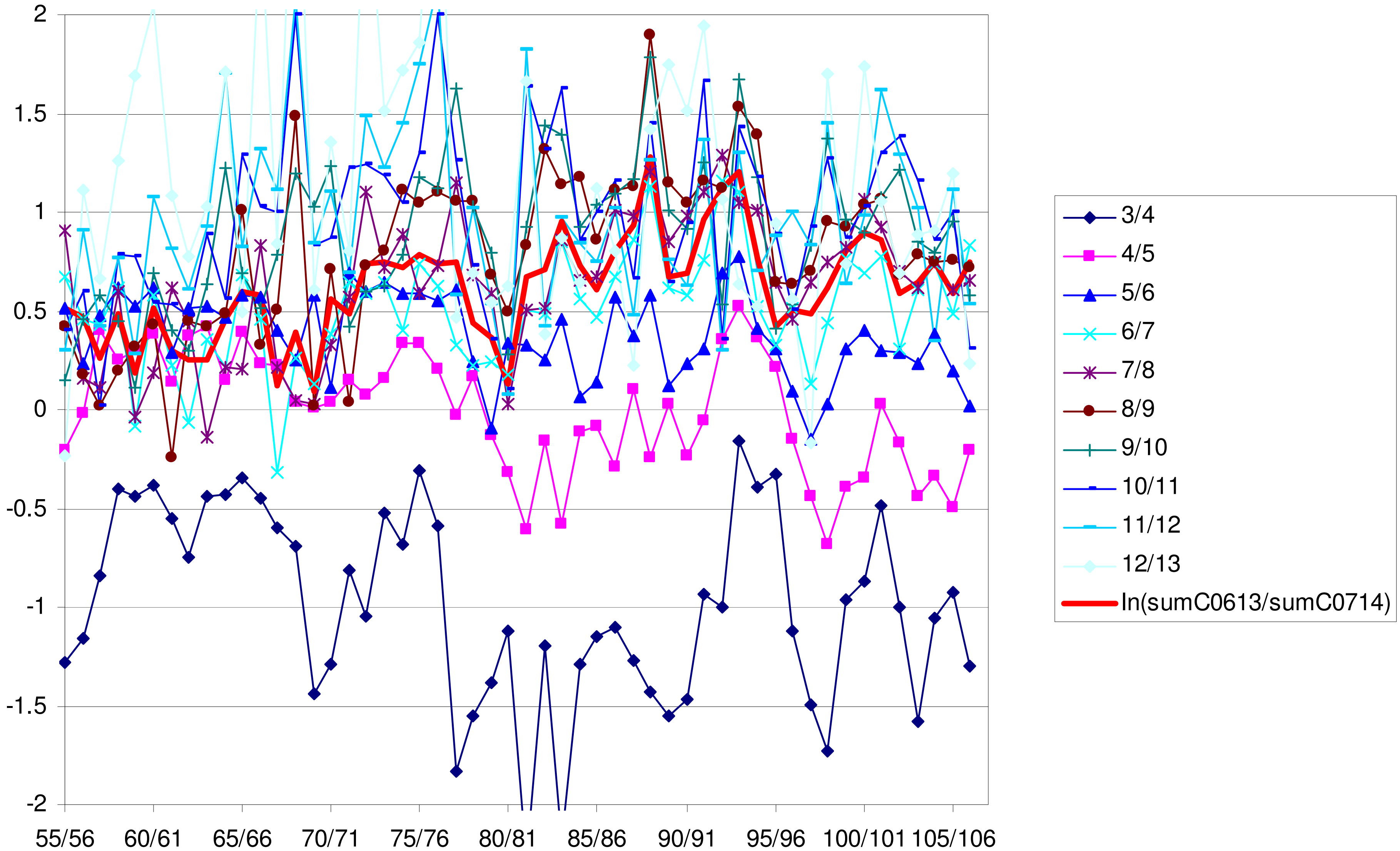


iCod: Estimates of total mortality (Z)

Z = F + M



iCod: Log catch ratios by each age group



Signals in the survey data

- The survey data:
  - Are in most cases only relative indices, i.e.

$$U_{a,y} = q_a N_{a,y}$$

  - Since q is in those cases unknown and is a parameter normally estimated in the model, the absolute numbers in the stock (Nay) must come from the catches

- But accuracy in the estimates of q thus hinges on:
  - That the natural mortality is reasonable close to reality
  - That the catch data do not deviate too much from what is actually removed from the fisheries
  - That the survey design is unbiased with regards to Nay

Signals in the survey data: The total mortality 1

- The stock equation is:

$$N_{a+1,y+1} = N_{a,y} e^{-Z_{a,y}}$$

- Taking a logarithm gives

$$\ln\left(N_{a+1,y+1}\right) = \ln\left(N_{a,y}\right) - Z_{a,y}$$

$$Z_{a,y} = \ln\left(N_{a,y}\right) - \ln\left(N_{a+1,y+1}\right)$$

$$Z_t = \ln\left(\frac{N_{a,y}}{N_{a+1,y+1}}\right)$$

- Thus, we do not need an absolute estimate of abundance, only the relative abundance of each from one age group to the next

Signals in the survey data: The total mortality

- The math:

$$U_{ay} = q_a N_{a,y}$$

If we assume: $q_a = q_{a+1}$

$$Z_{a,y} = \ln\left(\frac{N_{a,y}}{N_{a+1,y+1}}\right)$$

$$= \ln\left(\frac{U_{ay}/q_a}{U_{a+1,y+1}/q_{a+1}}\right)$$

$$= \ln\left(\frac{U_{a,y}}{U_{a+1,y+1}}\right)$$

- If q is the same for certain age/size one can use the log ratio of the survey indices caught at each stage to estimate the total mortality.
- This derivation show that if we have some measurement of indices of abundance by age we can estimate Z.
- q: Catchability

UALG

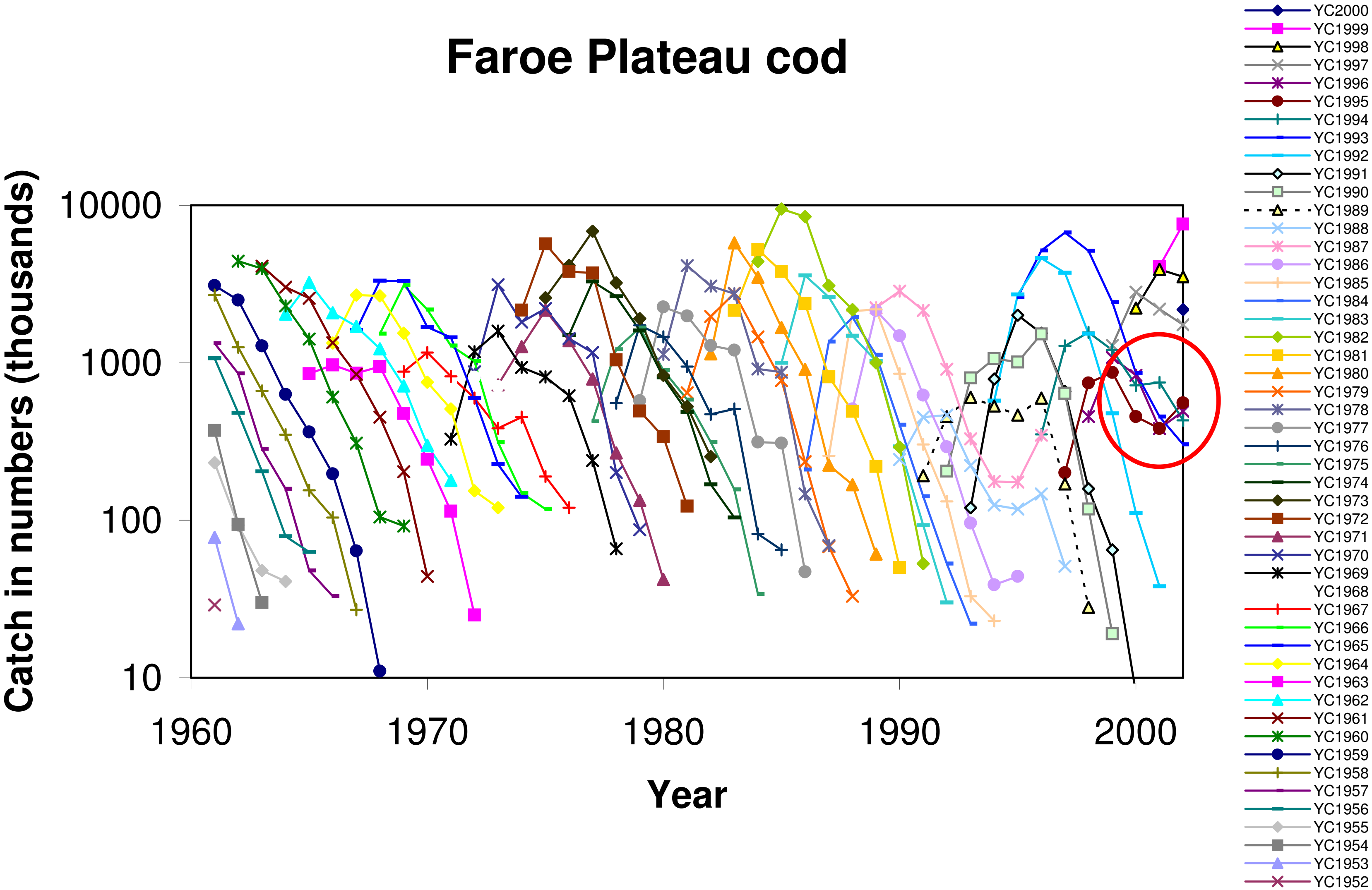
Analysis of input data: More examples

Faroe cod: Catch at age

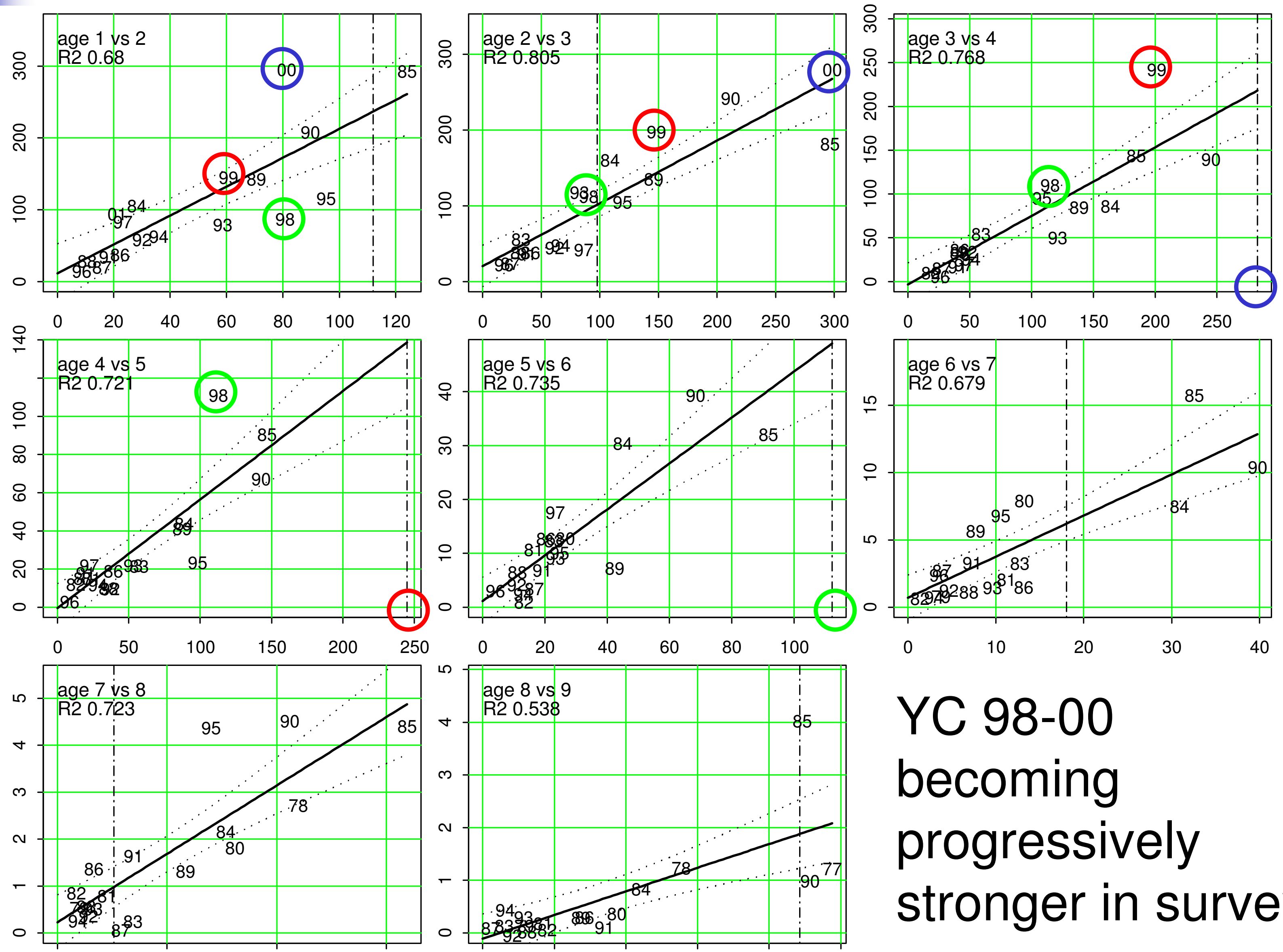
C matrix

AGE	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
2	120	573	2615	351	200	455	1288	2230	4082	2171
3	802	788	2716	5164	1278	745	1080	2812	3923	7605
4	603	1062	2008	4608	6710	1558	869	834	2192	3521
5	222	532	1012	1542	3731	5140	1204	455	383	1745
6	329	125	465	1526	657	1529	2420	**719**	**382**	491
7	96	176	118	596	639	159	477	863	**750**	**556**
8	33	39	175	147	170	118	65	111	455	431
9	22	23	44	347	51	28	19	8	38	303

Faroe cod: Catch at age

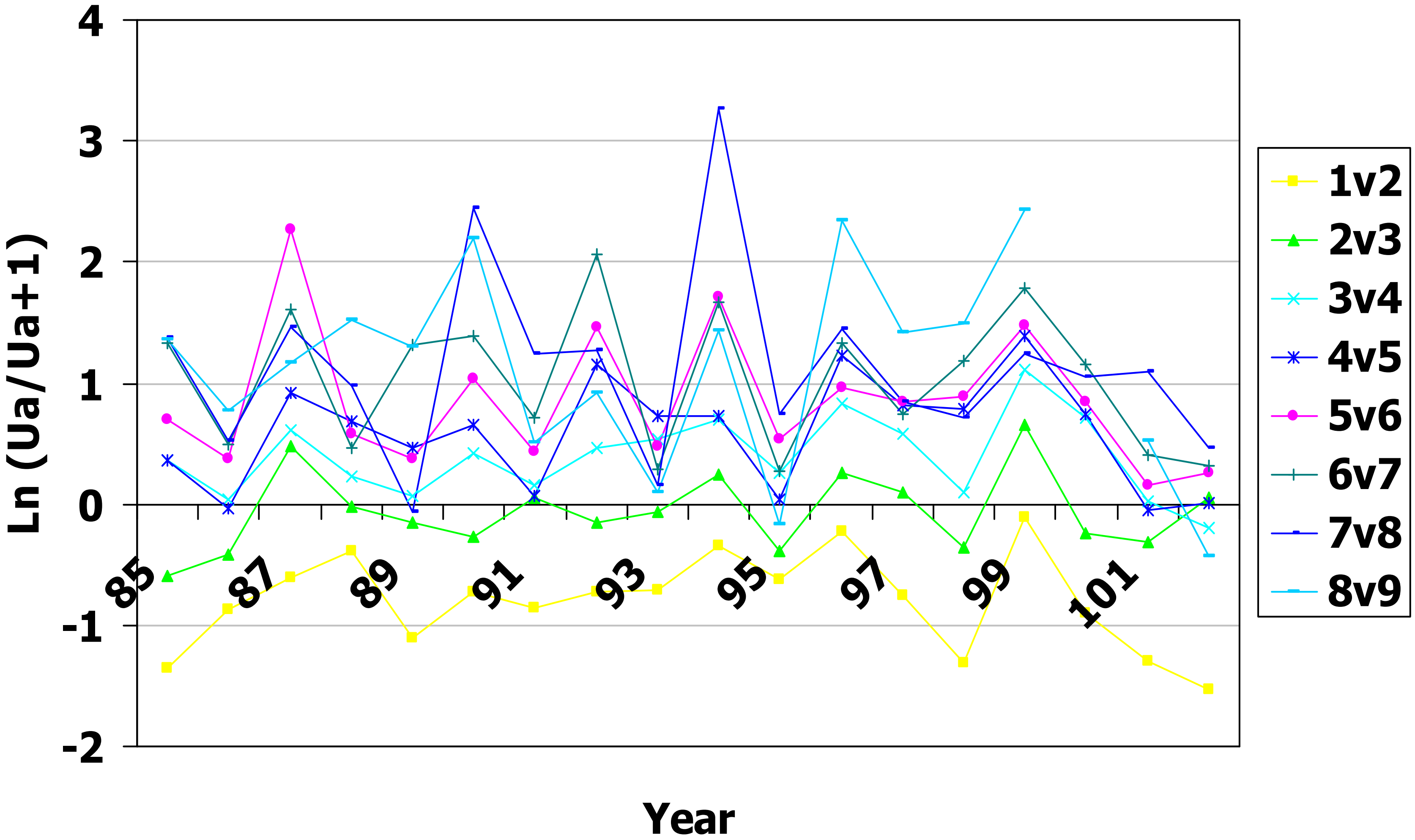


Icelandic survey: Haddock (age 1-9)

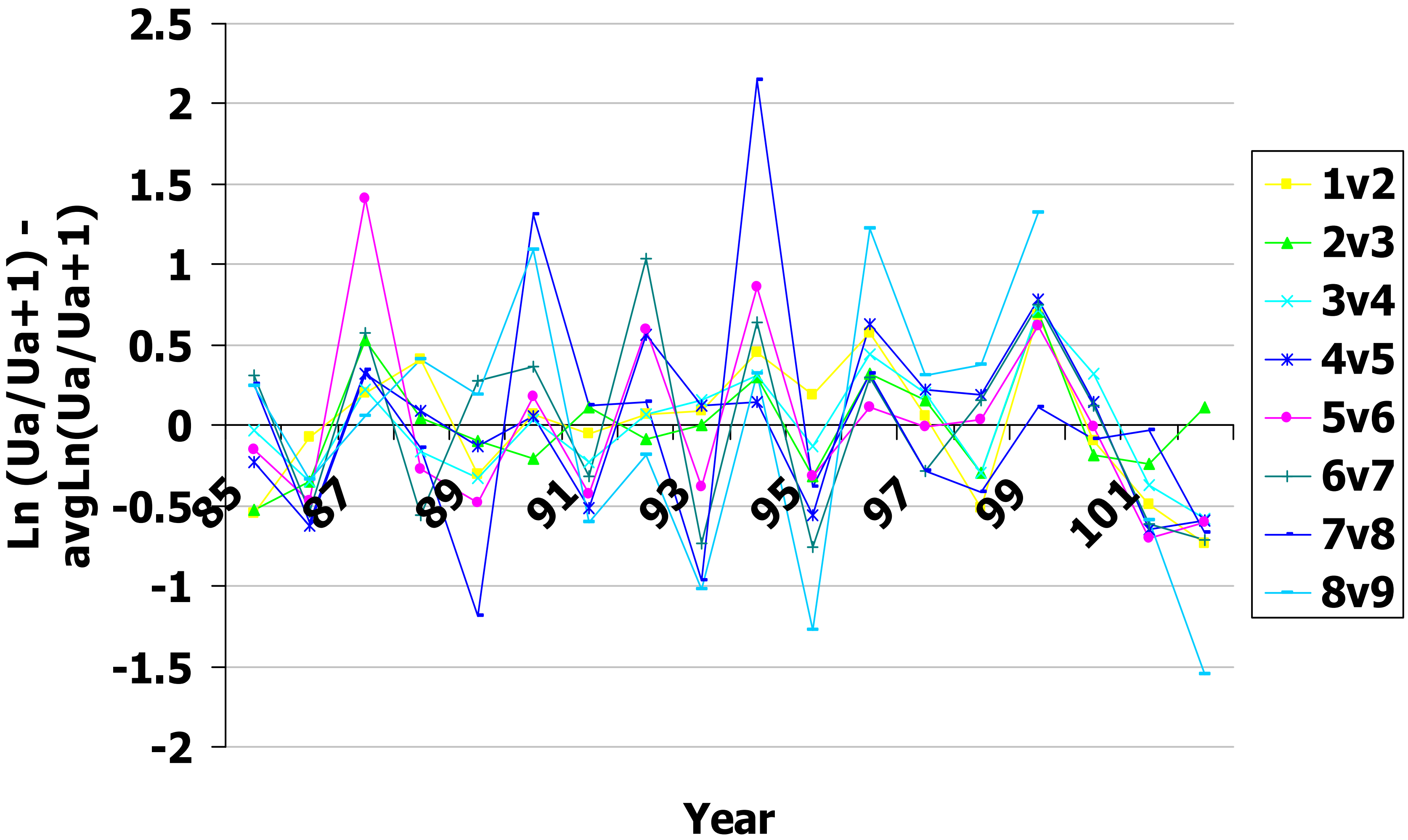


YC 98-00 becoming progressively stronger in survey

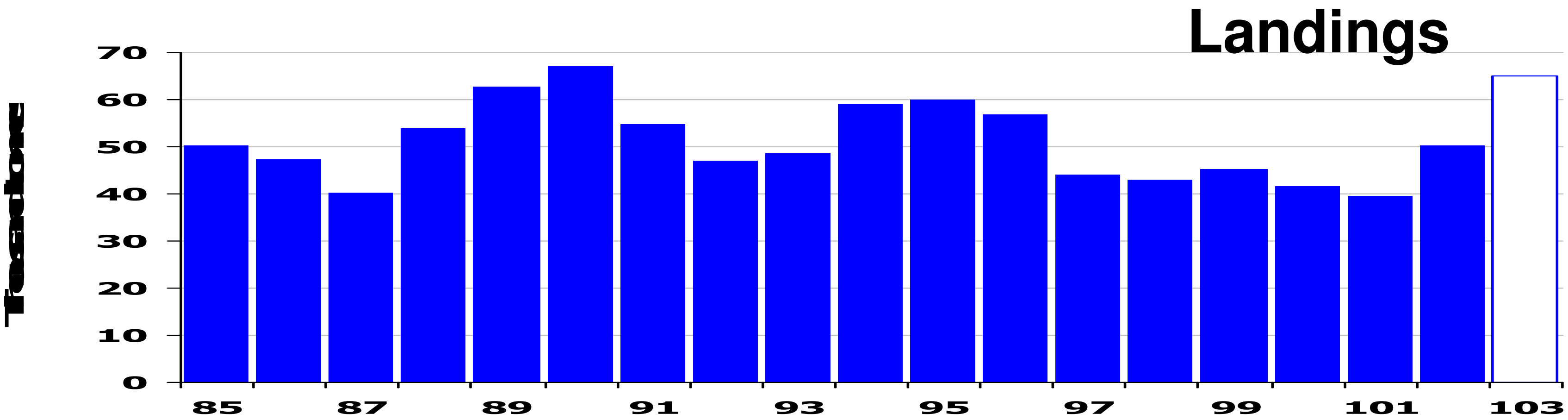
Icelandic survey: Haddock

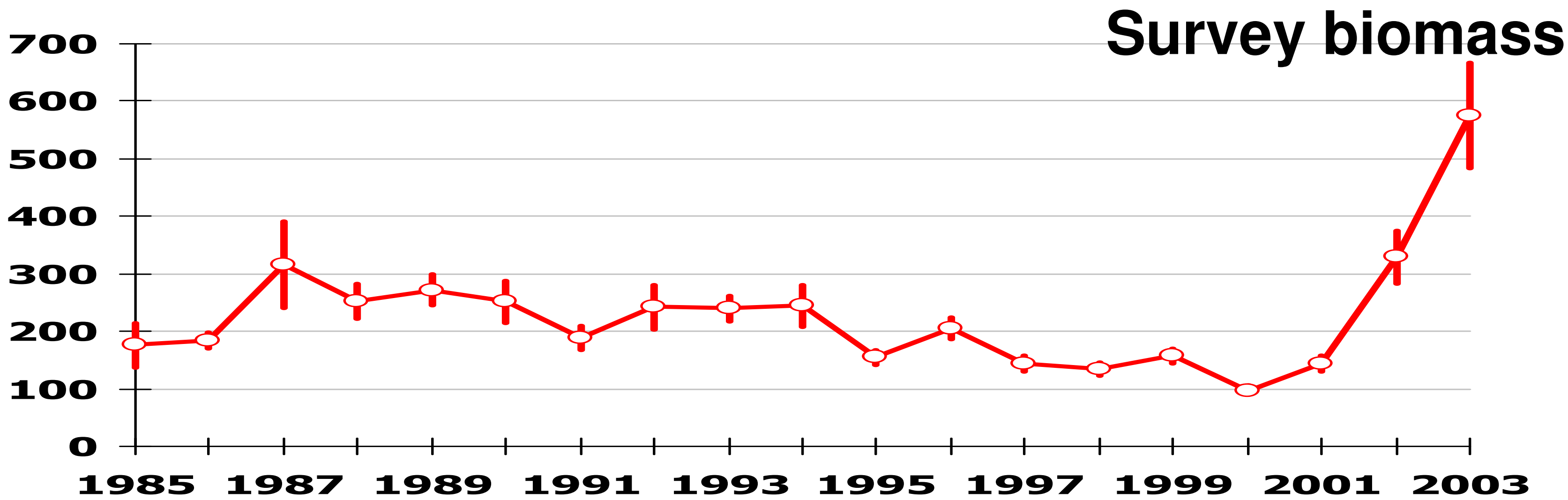


Icelandic survey: Haddock

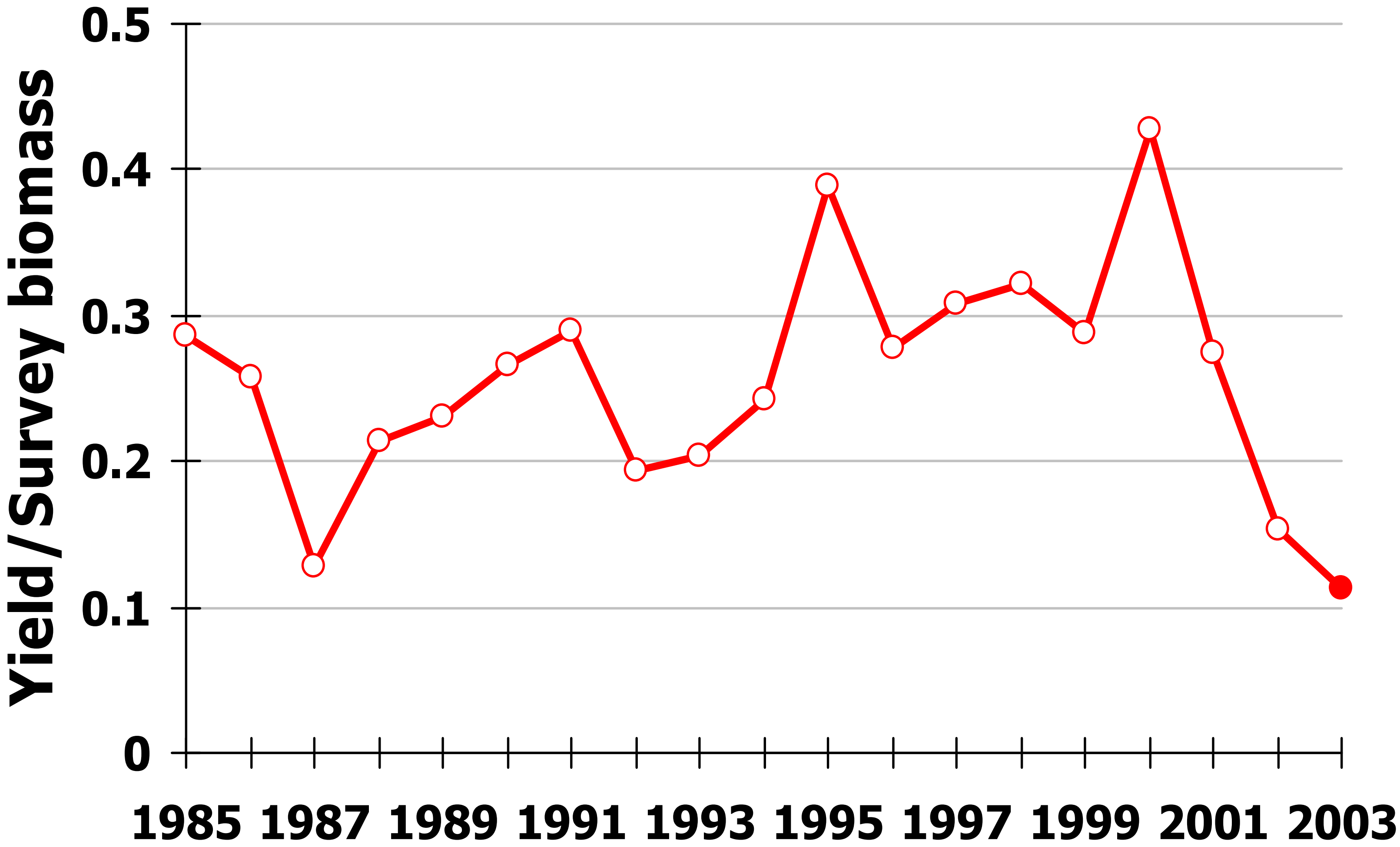


Icelandic haddock

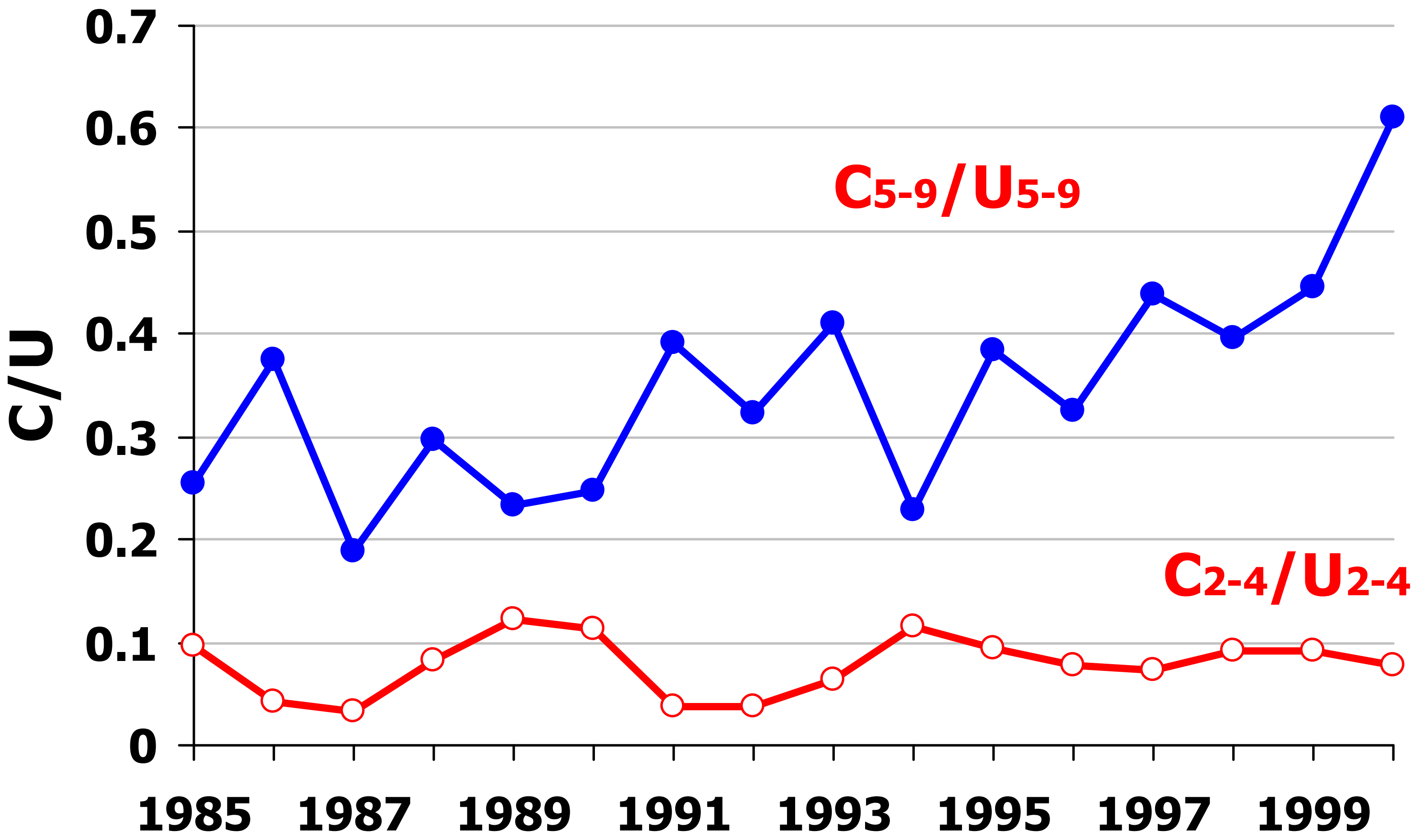




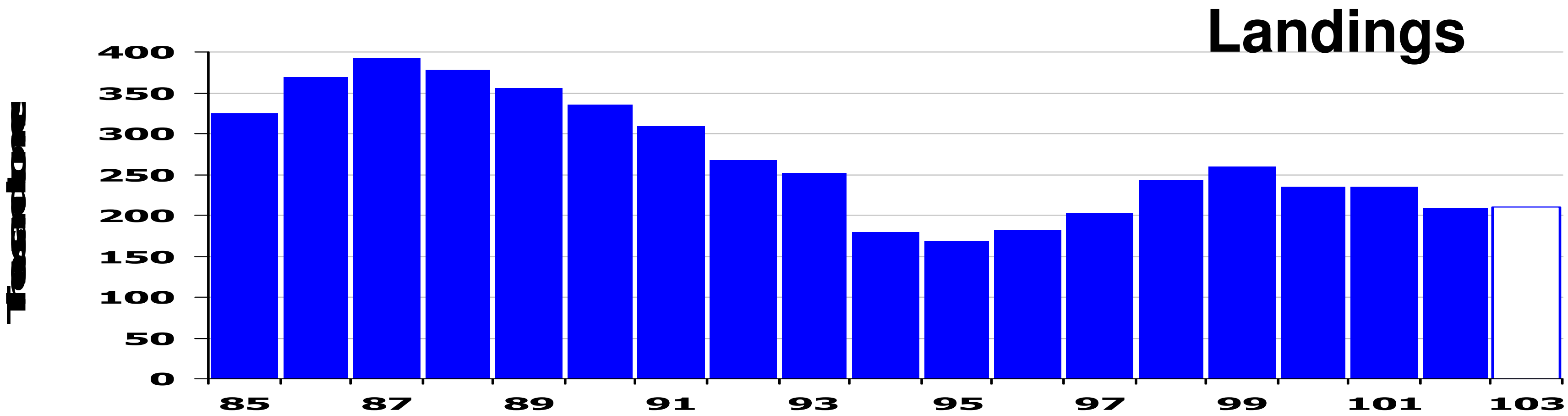
I. haddock - Exploitation proxy

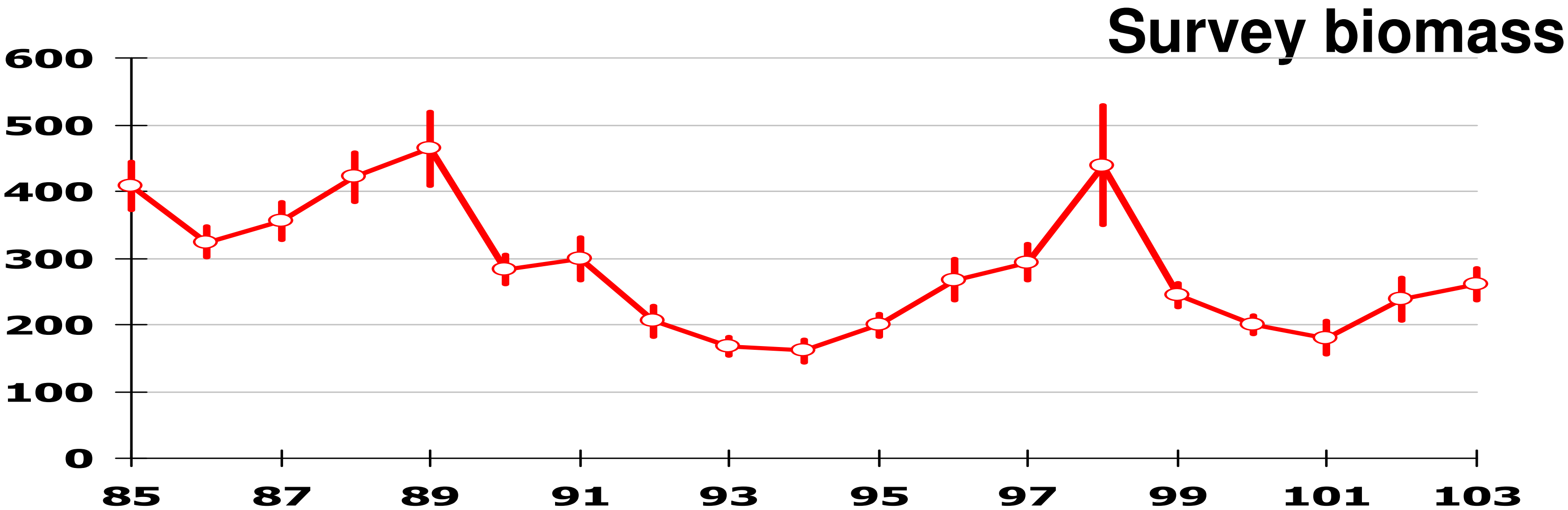


I. haddock - Exploitation proxy

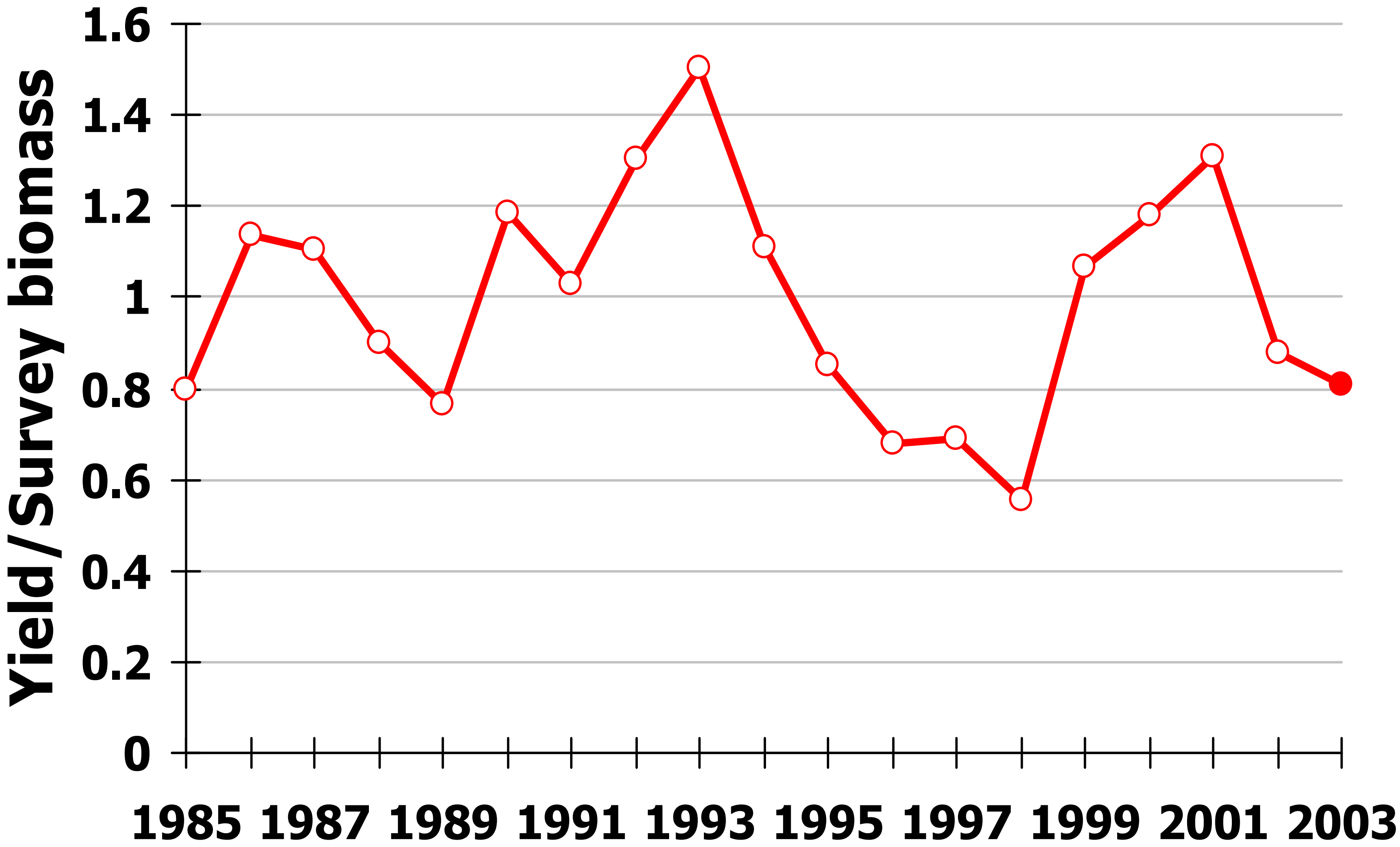


Icelandic cod





I. cod - Exploitation proxy

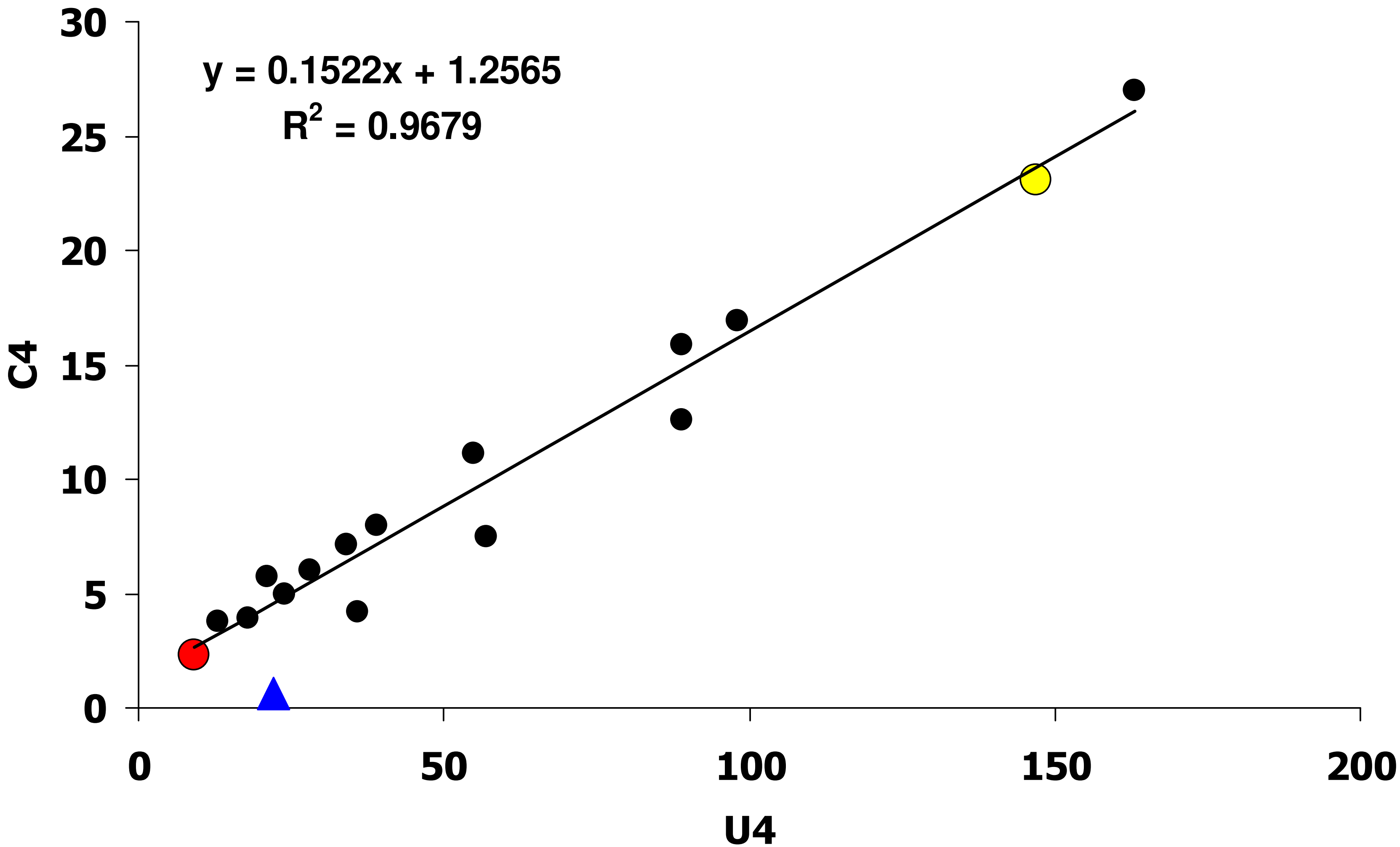


I. haddock: Survey and catch matrix

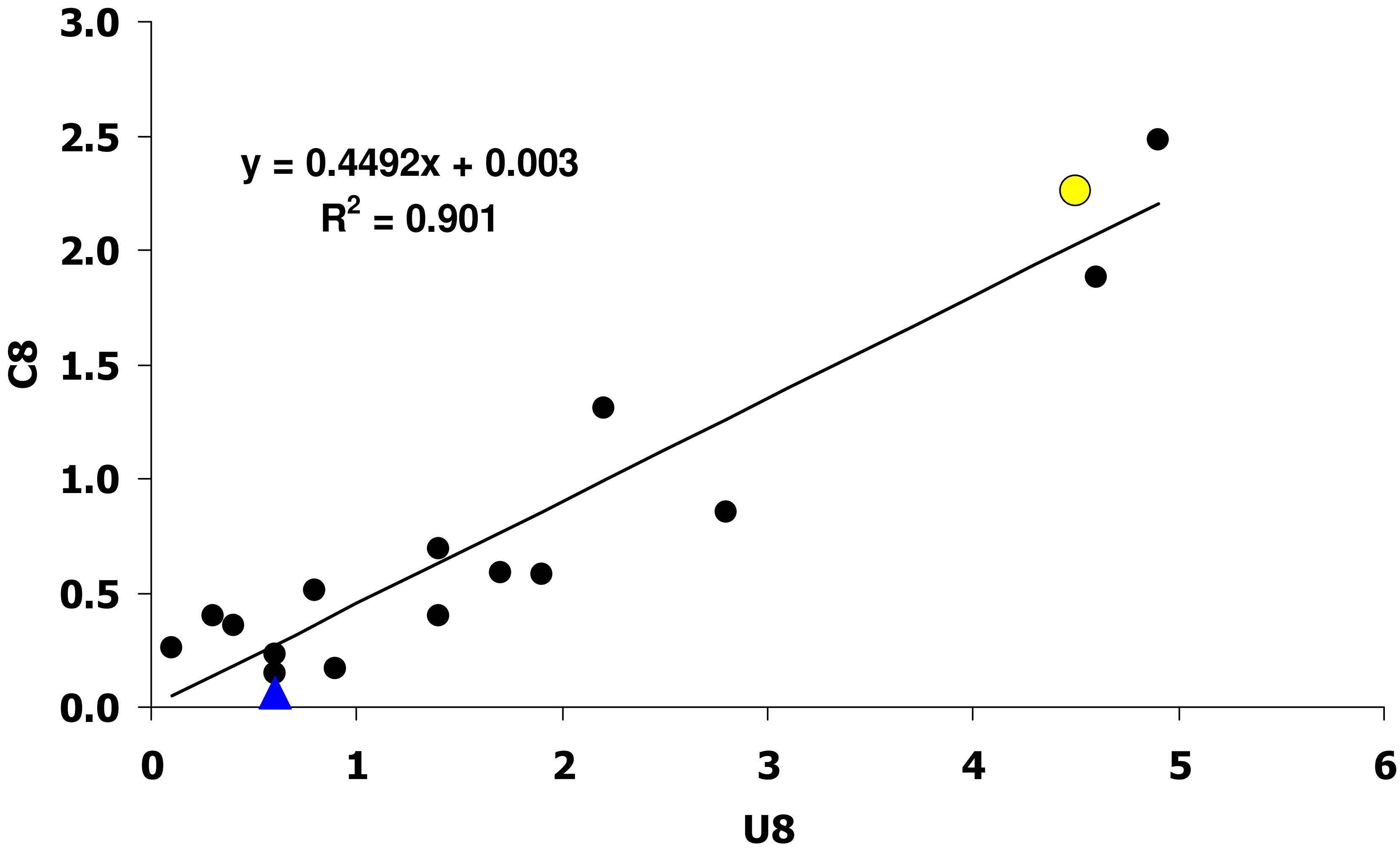
Uay	1	2	3	4	5	6	7	8	9
85	28	33	18	24	27	4	11	5	6
86	124	109	59	13	16	13	1	3	1
87	22	296	164	57	13	11	8	1	1
88	16	41	185	89	23	1	2	2	0
89	11	23	42	147	45	13	1	1	0
90	71	32	27	39	92	31	3	1	0
91	90	146	42	18	20	33	8	0	0
92	19	212	139	36	17	13	16	2	0
93	30	37	253	89	11	4	2	4	1
94	59	61	41	163	46	7	3	1	4
95	36	83	49	21	68	8	1	0	0
96	95	71	118	34	19	40	6	1	0
97	9	120	50	55	10	7	11	1	0
98	23	18	110	28	23	5	3	5	0
99	81	87	26	98	13	10	1	2	1
100	61	91	45	9	25	3	2	0	0
101	82	148	115	22	4	11	1	1	0

Cay	1	2	3	4	5	6	7	8	9
85		0.4	1.8	5.0	6.1	0.8	1.6	2.48	2.21
86		0.2	3.7	3.8	4.9	5.8	0.5	0.85	0.90
87		2.2	7.6	7.5	2.7	2.2	1.2	0.15	0.21
88		0.1	10.1	15.9	5.6	1.3	1.0	0.58	0.06
89		0.1	2.6	23.1	9.7	3.1	0.5	0.51	0.14
90		0.4	2.6	8.0	23.8	6.7	0.9	0.17	0.07
91		2.5	1.3	3.9	6.7	13.7	3.0	0.40	0.05
92		2.7	7.3	4.2	4.2	4.0	5.9	1.31	0.13
93		0.2	11.6	12.6	3.2	1.8	1.5	2.26	0.38
94		0.3	3.0	27.0	10.7	1.6	0.8	0.40	0.70
95		2.4	6.3	5.7	23.4	5.6	0.6	0.26	0.21
96		1.5	9.0	7.1	4.8	14.0	2.4	0.23	0.09
97		1.4	3.7	11.1	4.9	2.5	5.0	0.69	0.05
98		0.2	8.1	6.0	8.4	2.4	1.5	1.88	0.21
99		1.1	1.5	16.9	4.8	5.0	0.9	0.59	0.51
100		2.4	6.5	2.3	13.8	2.1	1.8	0.36	0.20
101									

I. haddock: Age 4



I. haddock: Age 8

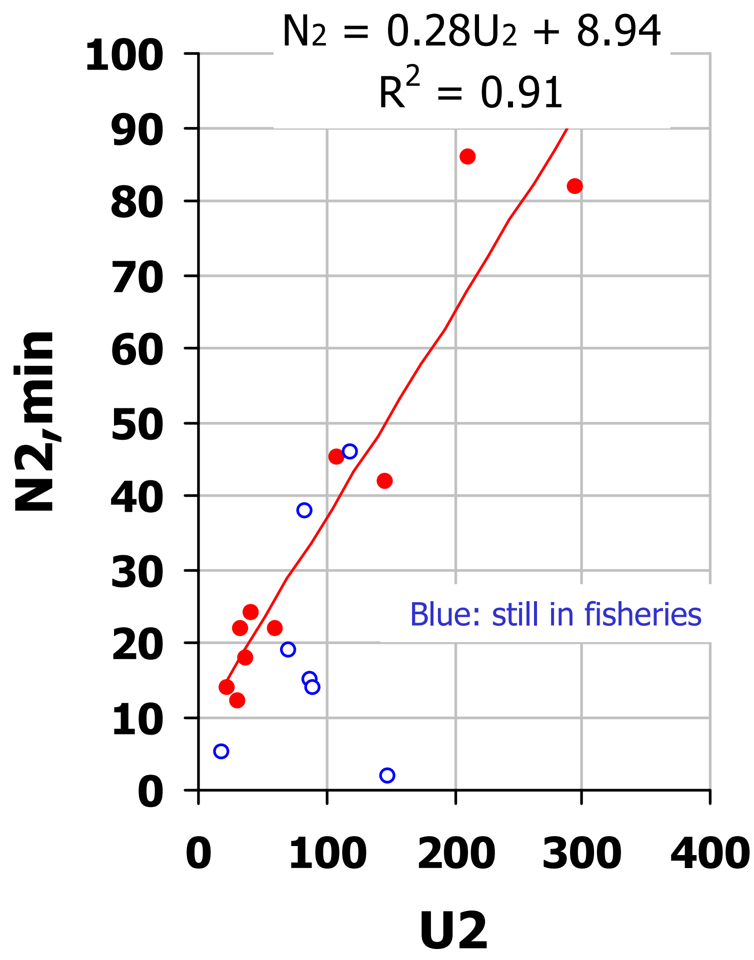


I. Haddock: U_2 og $N_{2,min}$?

U_2=Survey index, 2 years old

$N_{2,min}$= sum of catches

YC	Y_{N2}	U_2	$N_{2,min}$ (millions)
83	85	33	22
84	86	109	45
85	87	296	82
86	88	41	24
87	89	23	14
88	90	32	12
89	91	146	42
90	92	212	86
91	93	37	18
92	94	61	22
93	95	83	38
94	96	71	19
95	97	120	46
96	98	18	5
97	99	87	15
98	100	91	14
99	101	148	2



Analysing the input data

- What information is in the data about:
  - Consistency, signal, noise
  - Mortality, level and trends
  - Relative abundance of year classes, relative trends
  - Development of the fishery
    - change in targeting of age groups (selection)
    - trends in relative exploitation (C/U)
    - ….
- Can patterns/problems be explained?
  - The model will normally not tell you!

Lab 1: Some guidelines

- Data set: Icelandic haddock
- Food for thought:
  - Catch at age matrix
    - Are there big and small year classes in the data?
      - Sum the catches by year classes
    - What is the general trend in the catch by age along a cohort?
    - What year classes are likely to contribute most to the fisheries in 2007?
    - Calculate the log catch ratios, what inference can you make of the overall mortality trends?
  - Survey indices by age
    - Are there big an small year classes in the data?
    - What is the general trend in the catch by age along a cohort?
    - How consistent is the survey?
      - Plot one age group against another within the same cohort.
    - Calculate the log survey ratios, what inference can you make of the overall mortality trends? What about the noise in the survey relative to the catches?
  - Consistency among the catch and the survey data
    - Plot the survey index at age at age 2 against the sum of the catches.
    - Can you predict the future catches of the cohorts that have not gone through the fishing history?

Icelandic haddock: Annual landings