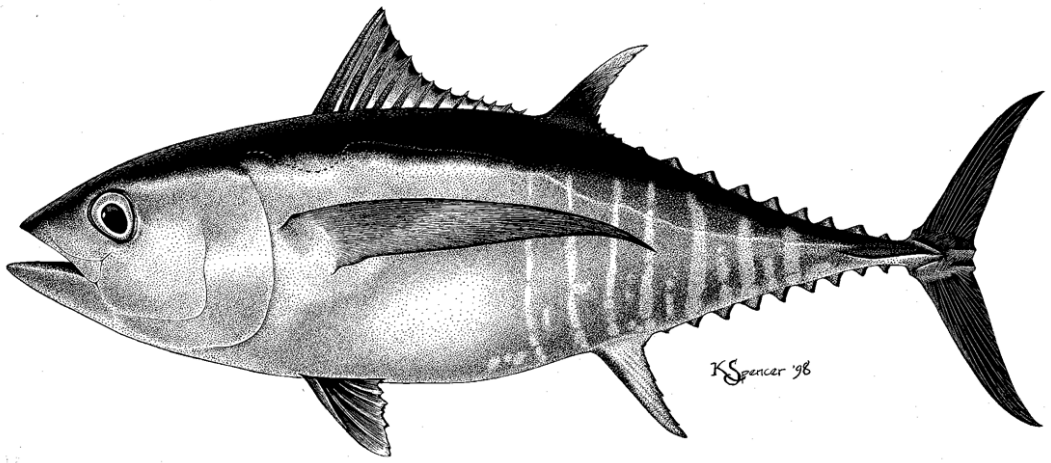
ASSESSMENT OF BIGEYE TUNA (*THUNNUS OBESUS*) IN THE EASTERN PACIFIC OCEAN

January 1975 – December 2006



CIAT
IATTC

Outline

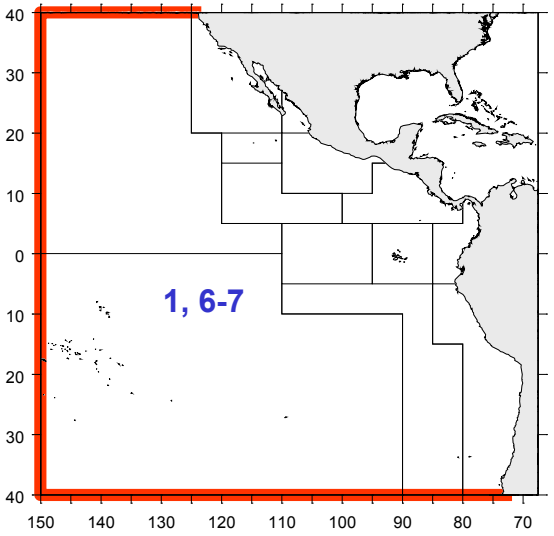
- Stock assessment
  - Overview of assessment model
  - Fishery data
  - Assumptions
  - Results of base case model
  - Projections
- Sensitivity analyses
- Summary and conclusions
- Discussion

Overview of assessment

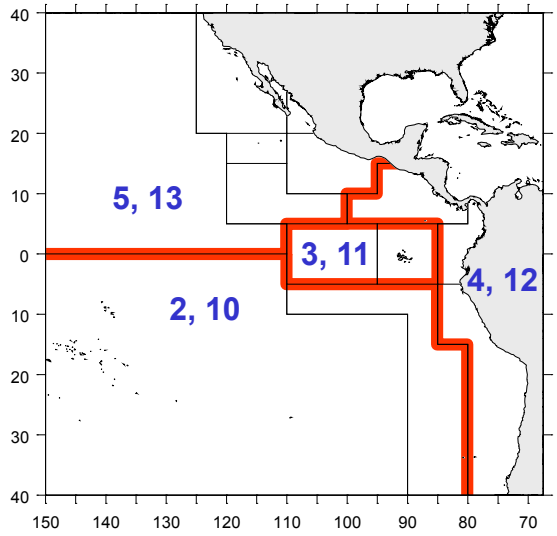
- Age-structured, statistical, catch-at-length model (Stock Synthesis II).
- Same type of model as A-SCALA or MULTIFAN-CL
- Differences between SS2 and A-SCALA

Bigeye fishery definitions

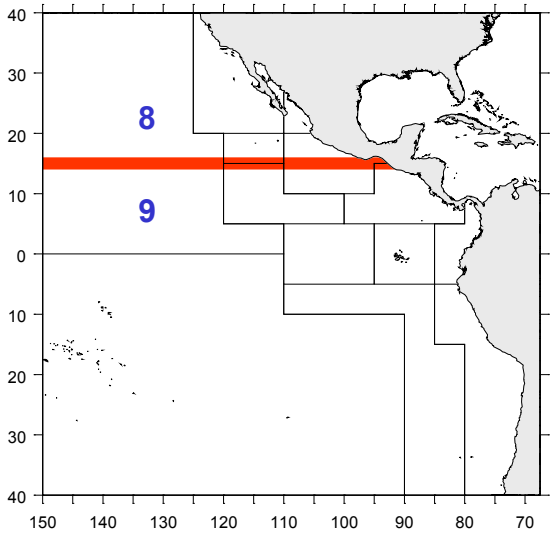
Early FLT (1)
Early & Recent UNA (6, 7)



Recent FLT (2-5)
Discards (10-13)

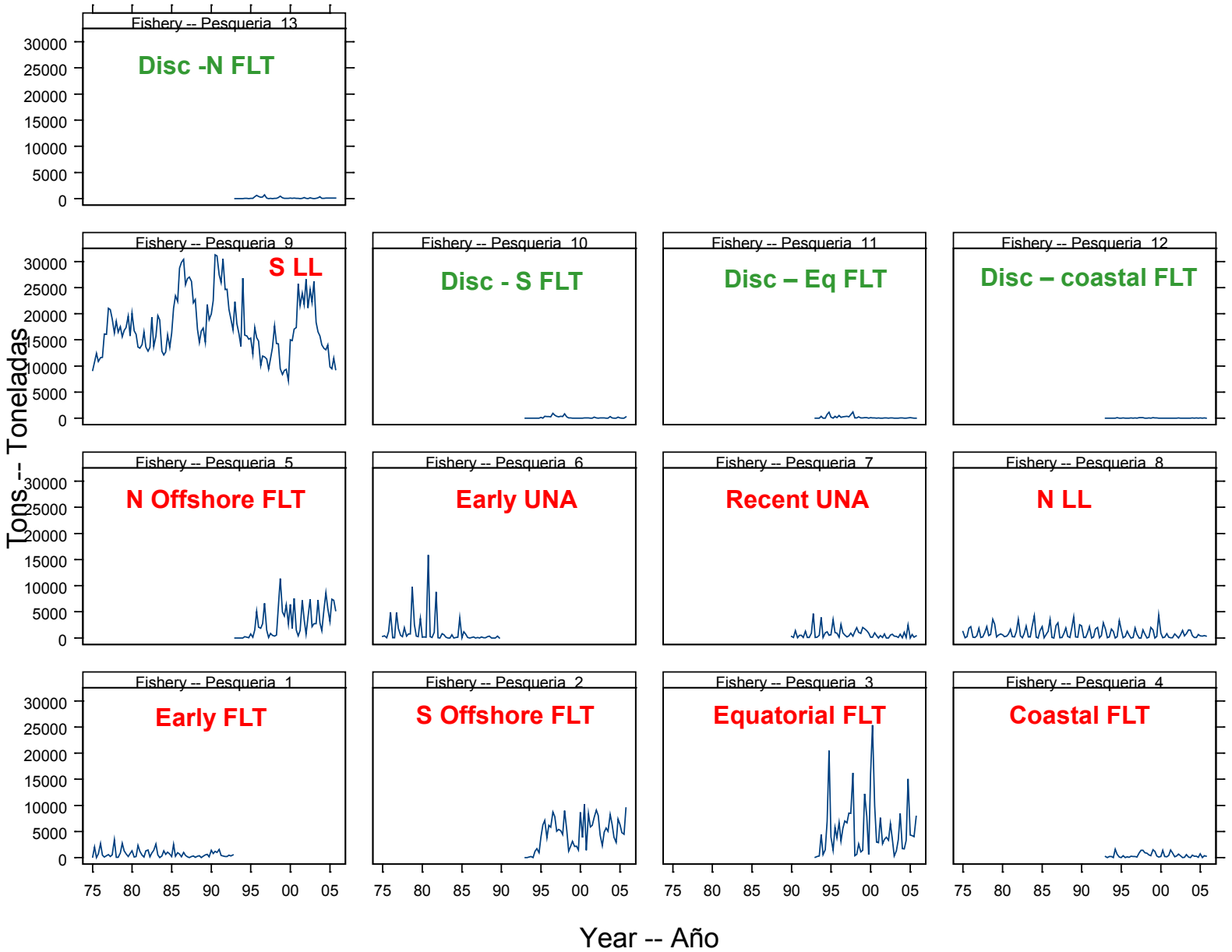


N Longline (8)
S Longline (9)

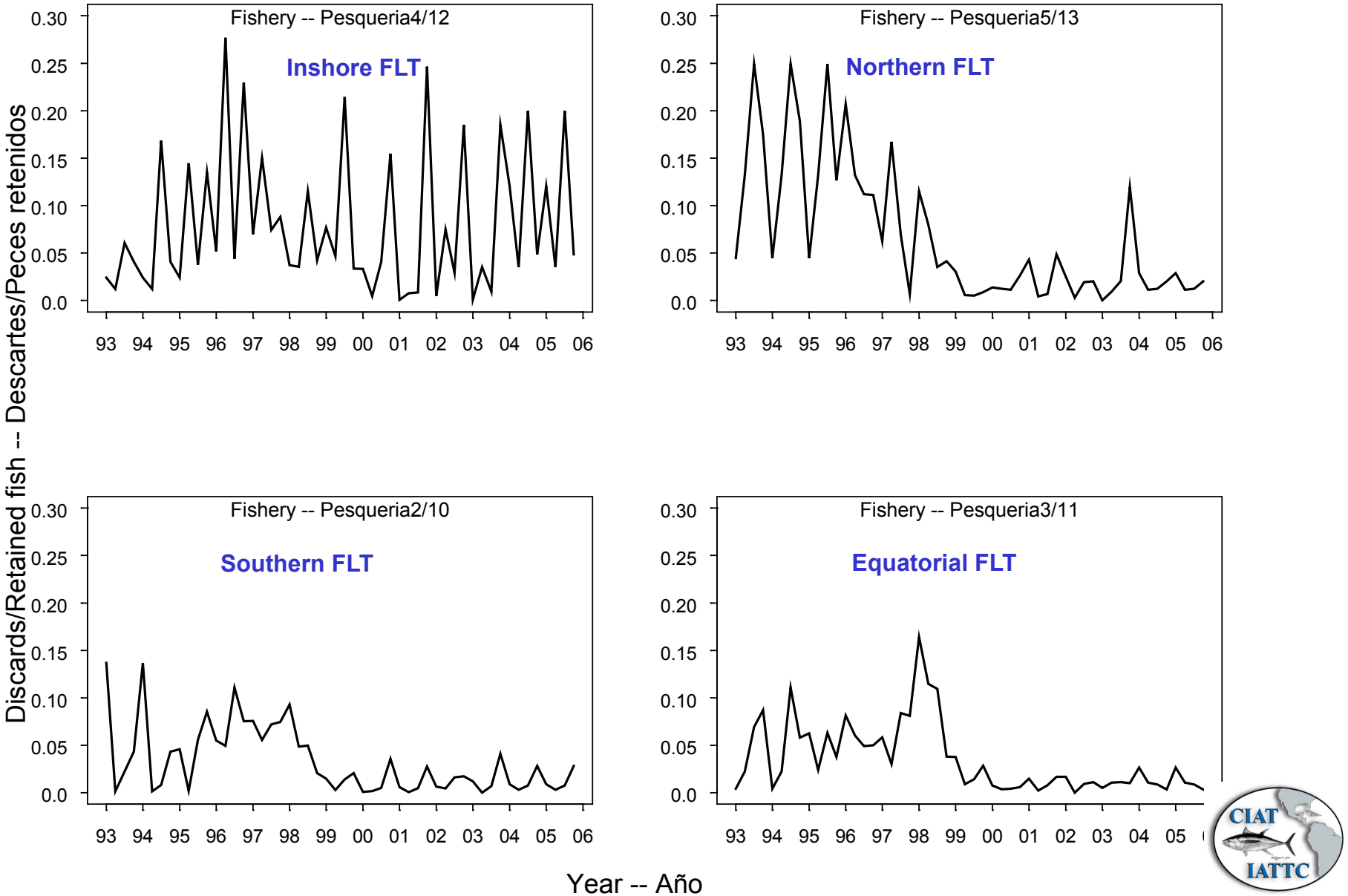


FLT – Floating objects; UNA - Unassociated

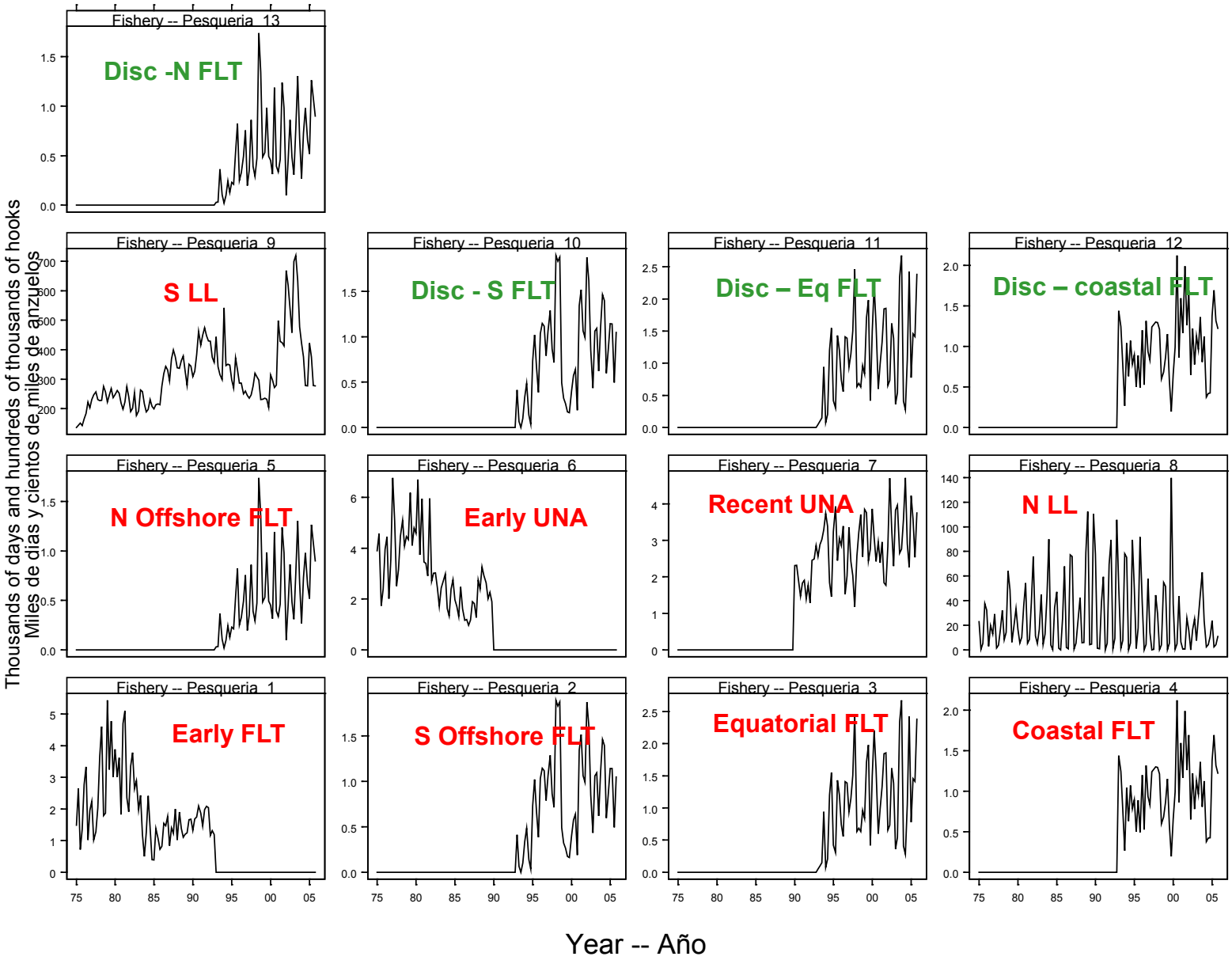
Data - catch


Fishery -- Pesqueria 13
Disc -N FLT
Fishery -- Pesqueria 9
S LL
Fishery -- Pesqueria 10
Disc - S FLT
Fishery -- Pesqueria 11
Disc – Eq FLT
Fishery -- Pesqueria 12
Disc – coastal FLT
Fishery -- Pesqueria 5
N Offshore FLT
Fishery -- Pesqueria 6
Early UNA
Fishery -- Pesqueria 7
Recent UNA
Fishery -- Pesqueria 8
N LL
Fishery -- Pesqueria 1
Early FLT
Fishery -- Pesqueria 2
S Offshore FLT
Fishery -- Pesqueria 3
Equatorial FLT
Fishery -- Pesqueria 4
Coastal FLT
Tons -- Toneladas
0
5000
10000
15000
20000
25000
30000
75
80
85
90
95
00
05
Year -- Año

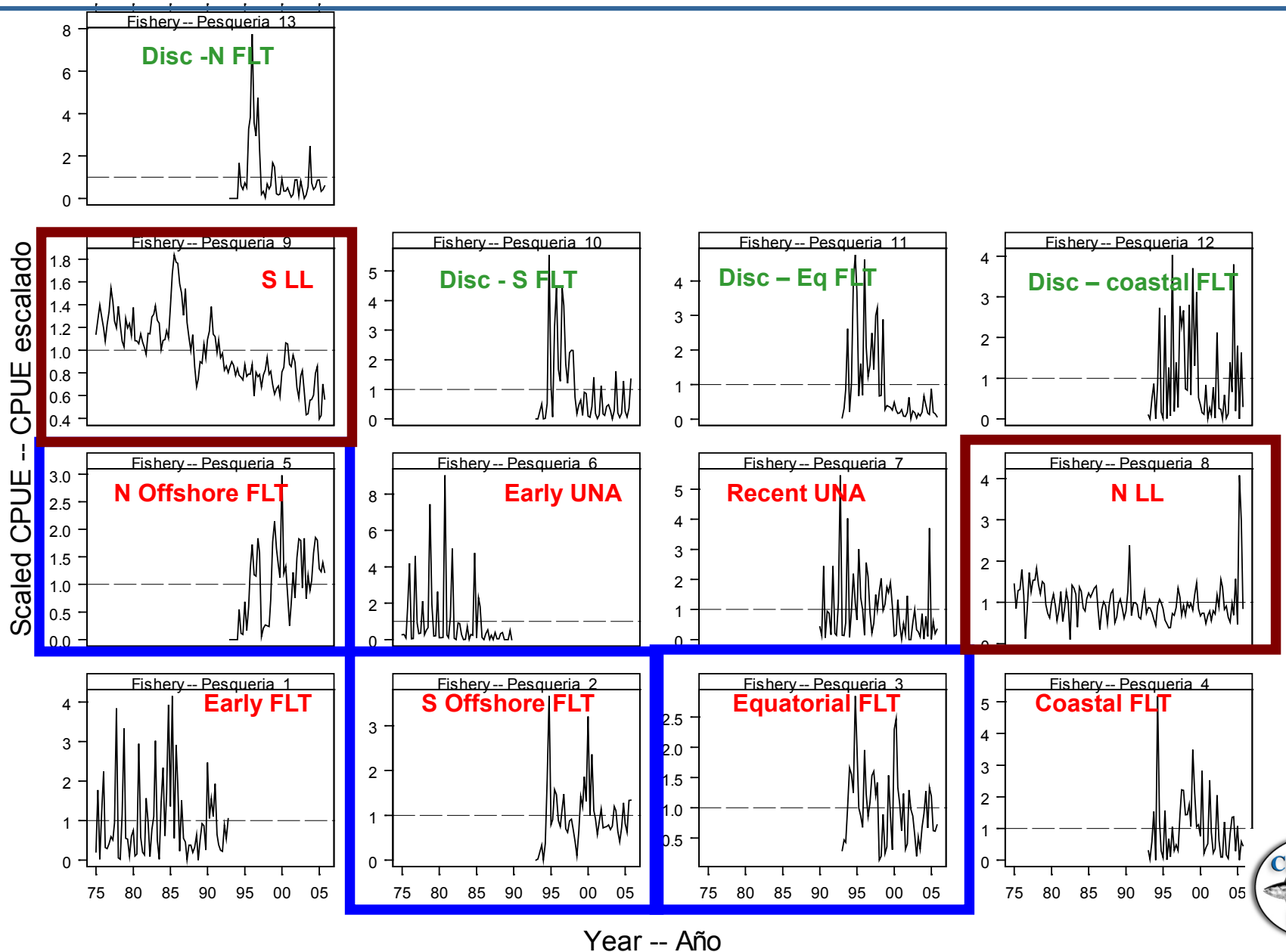
Data - discards



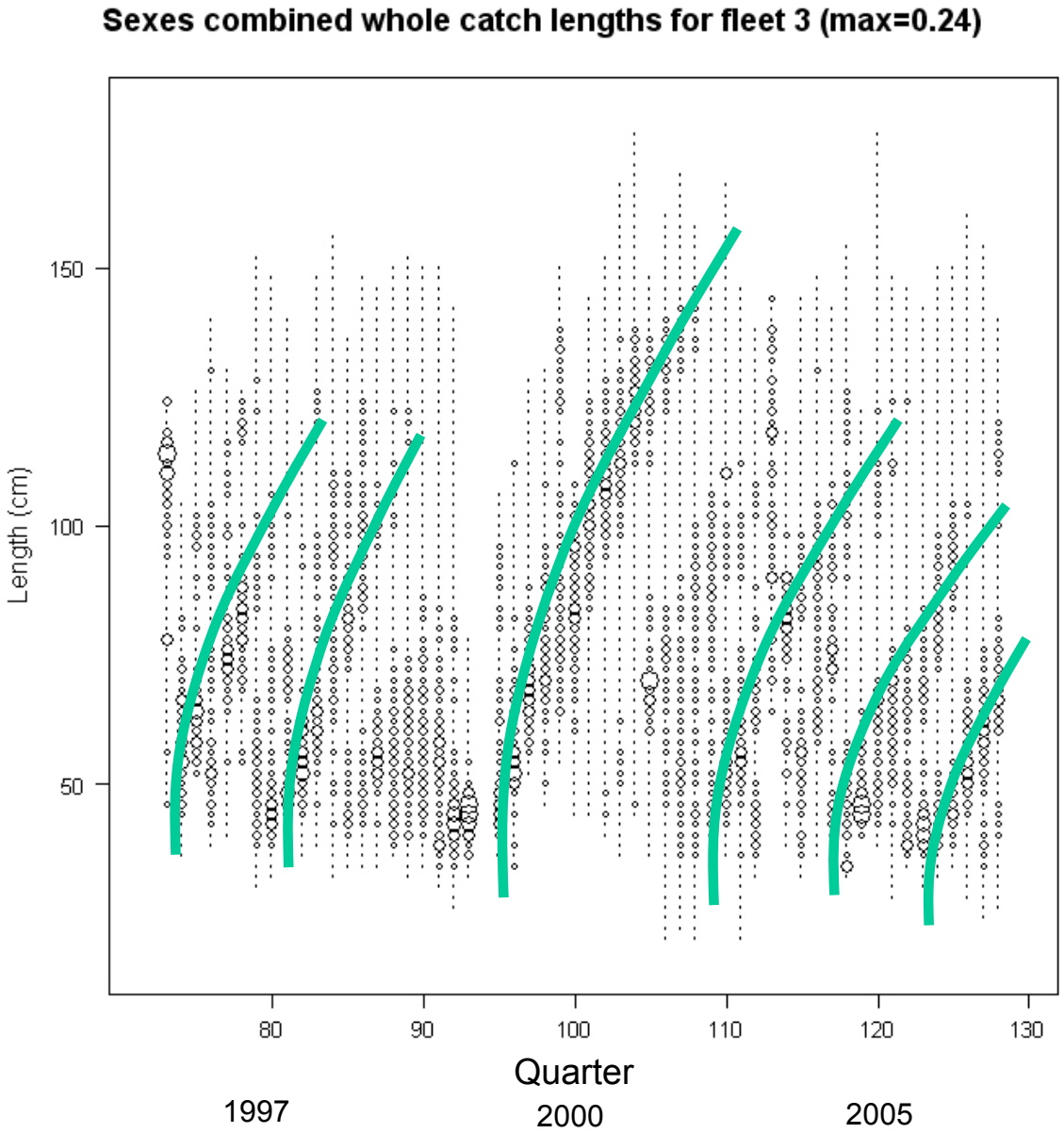
Data - effort


Fishery -- Pesqueria 13
Disc -N FLT
Fishery -- Pesqueria 9
S LL
Fishery -- Pesqueria 10
Disc - S FLT
Fishery -- Pesqueria 11
Disc – Eq FLT
Fishery -- Pesqueria 12
Disc – coastal FLT
Fishery -- Pesqueria 5
N Offshore FLT
Fishery -- Pesqueria 6
Early UNA
Fishery -- Pesqueria 7
Recent UNA
Fishery -- Pesqueria 8
N LL
Fishery -- Pesqueria 1
Early FLT
Fishery -- Pesqueria 2
S Offshore FLT
Fishery -- Pesqueria 3
Equatorial FLT
Fishery -- Pesqueria 4
Coastal FLT
Thousands of days and hundreds of thousands of hooks
Miles de dias y cientos de miles de anzuelos
75 80 85 90 95 00 05
Year -- Año

Data - CPUE


Fishery -- Pesqueria 13
Disc -N FLT
Fishery -- Pesqueria 9
S LL
Fishery -- Pesqueria 10
Disc - S FLT
Fishery -- Pesqueria 11
Disc – Eq FLT
Fishery -- Pesqueria 12
Disc – coastal FLT
Fishery -- Pesqueria 5
N Offshore FLT
Fishery -- Pesqueria 6
Early UNA
Fishery -- Pesqueria 7
Recent UNA
Fishery -- Pesqueria 8
N LL
Fishery -- Pesqueria 1
Early FLT
Fishery -- Pesqueria 2
S Offshore FLT
Fishery -- Pesqueria 3
Equatorial FLT
Fishery -- Pesqueria 4
Coastal FLT
Scaled CPUE -- CPUE escalado
75 80 85 90 95 00 05
Year -- Año

Data - Length frequency data



Assumptions (base case) - movement

DATA

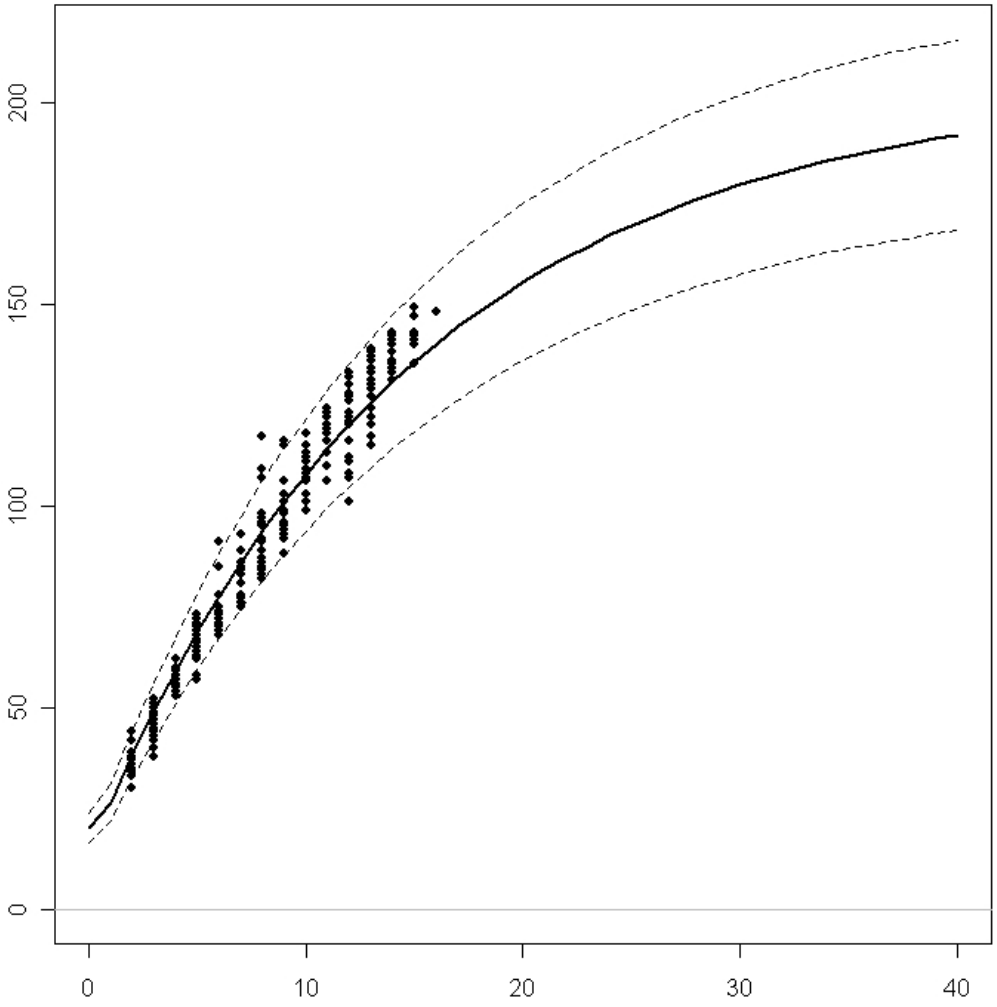
- Tagging records indicate little exchange of bigeye between E and W Pacific
- Results from conventional and archival tagging indicate regional fidelity for bigeye in EPO
- Different CPUE trends between EPO and WCP

ASSUMPTIONS

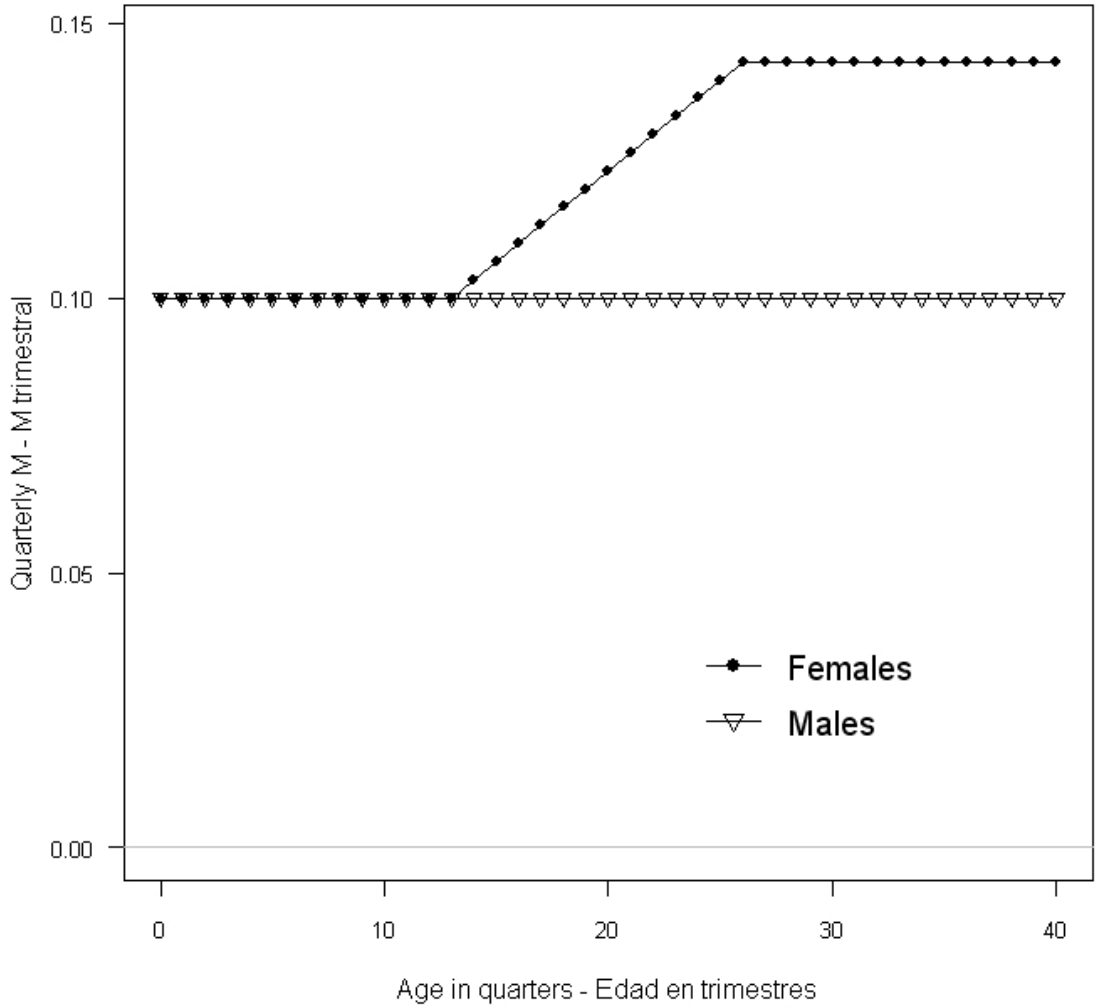
- Single stock of bigeye in EPO
- No net movement of fish between the eastern and western Pacific
- SA for EPO and Pacific wide are consistent

Assumptions (base case) - growth

- Von Bertalanffy – fixed parameters



Assumptions (base case) – M



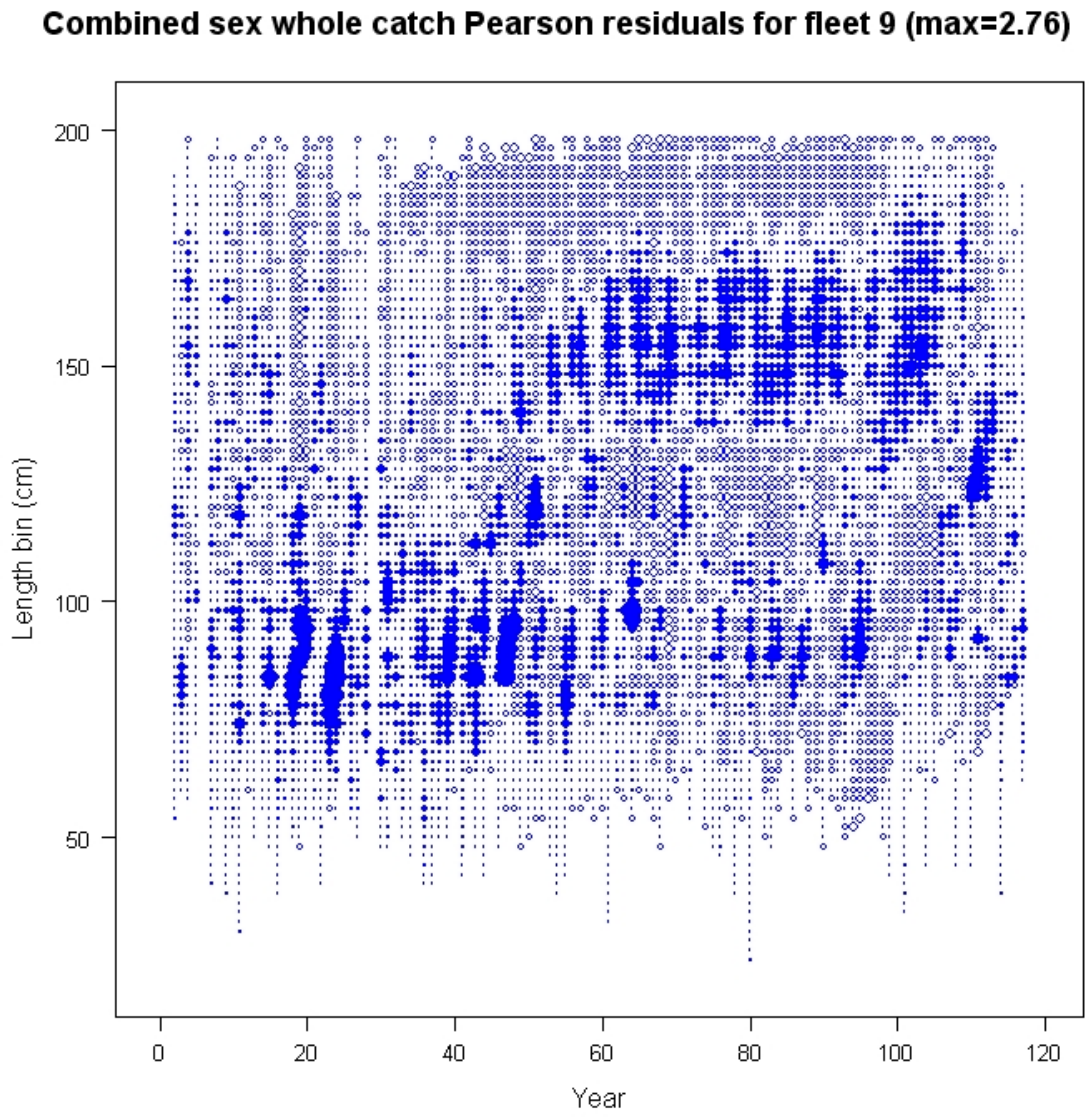
Assumptions (base case) - cont.

- Age-specific maturity and fecundity indices
- No S-R relationship (steepness = 1)

Results (base case)

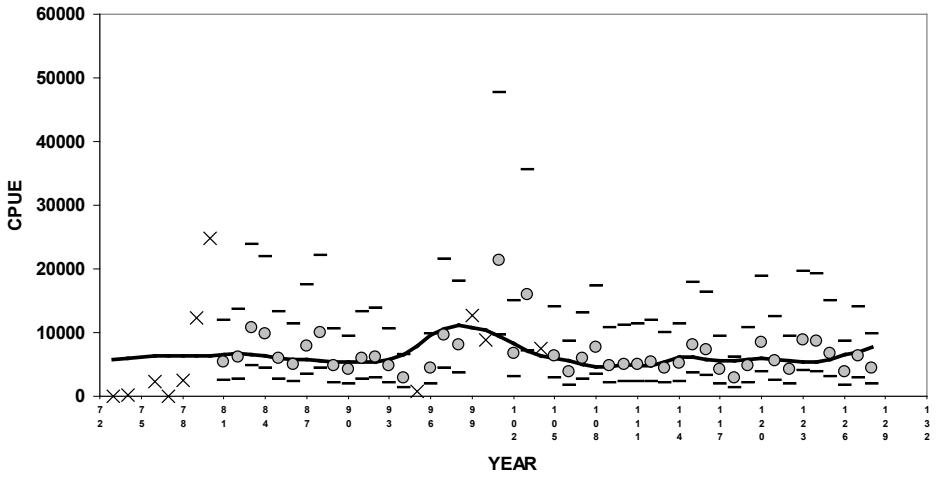
- Fit to the length frequency
- Fishing mortality
- Selectivity
- Recruitment
- Biomass

Fit to LF data – Pearson residuals

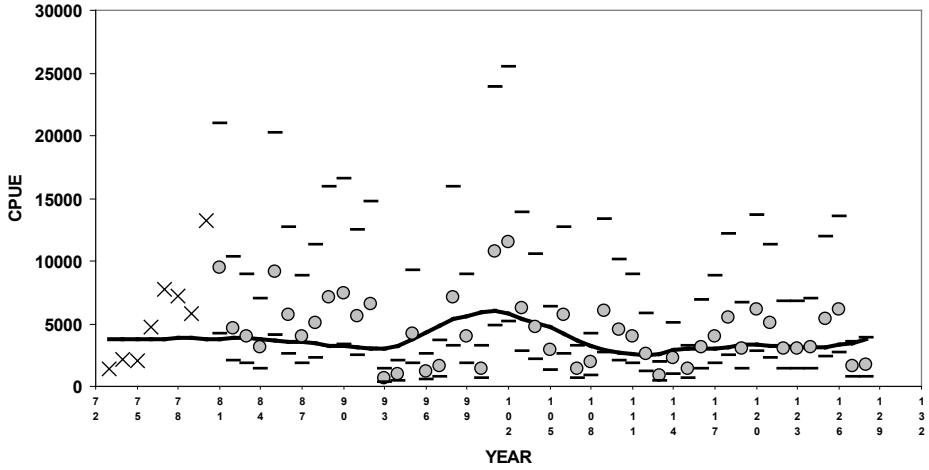


Fit to CPUE data – Floating object

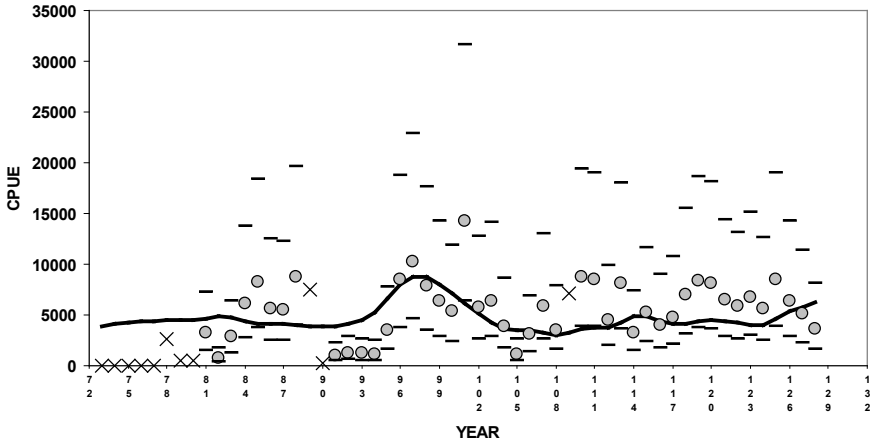
Fishery 2



Fishery 3

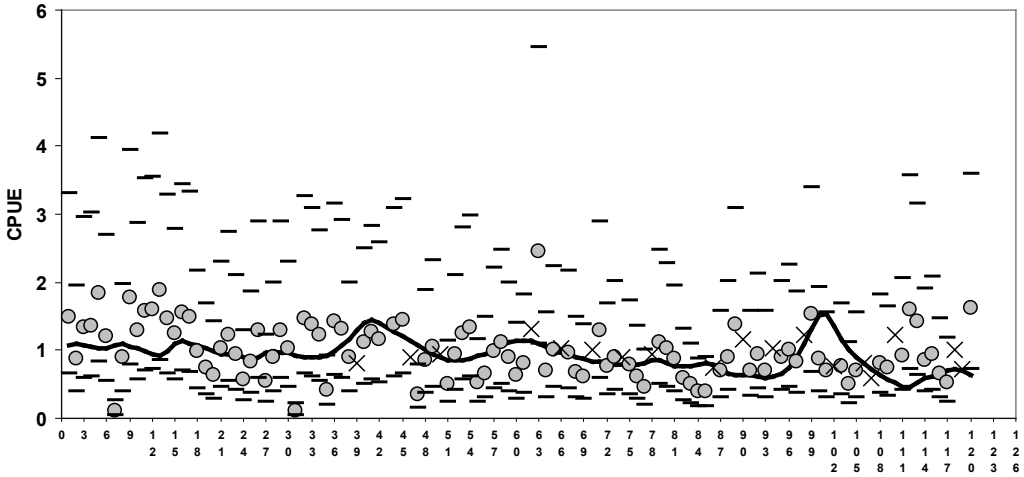


Fishery 5

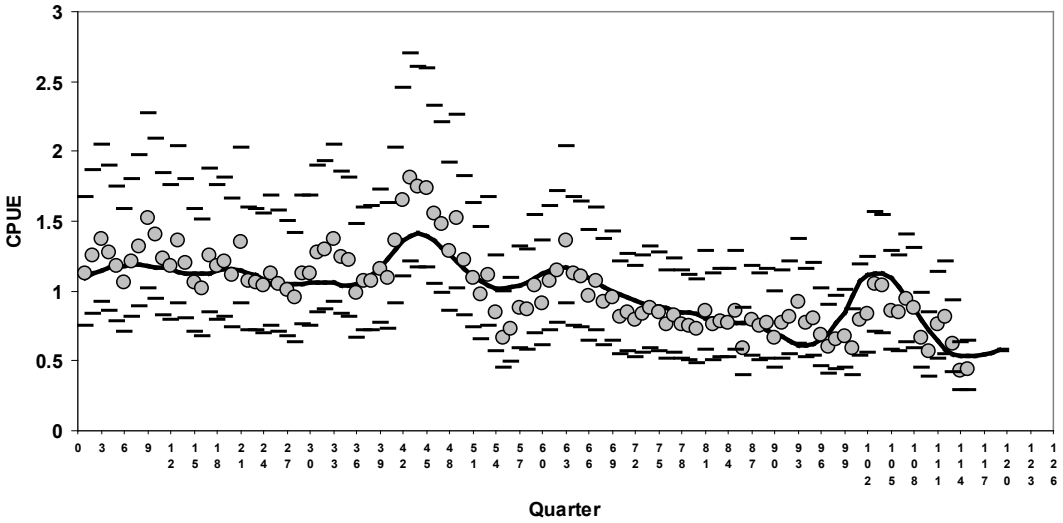


Fit to CPUE data – Longline

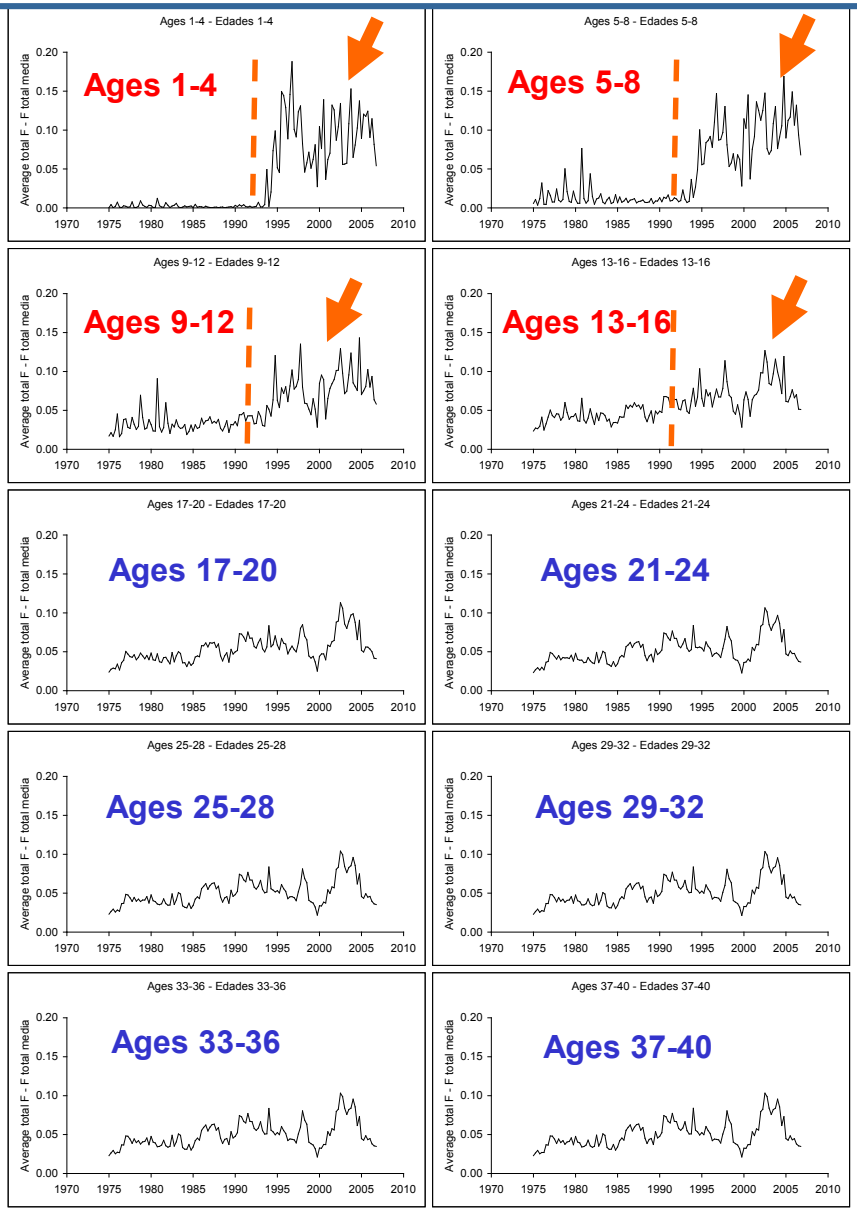
Fishery 8



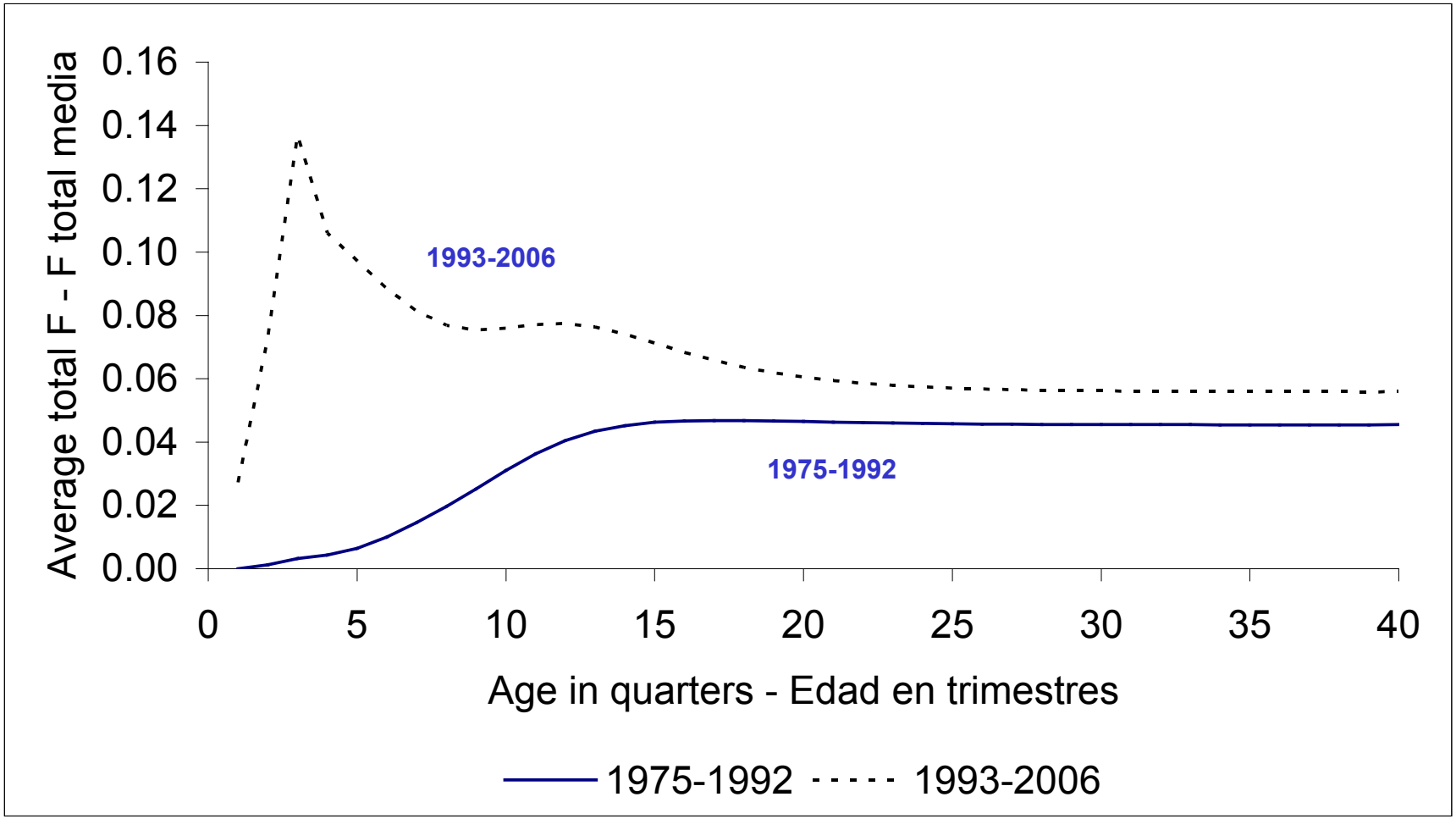
Fishery 9



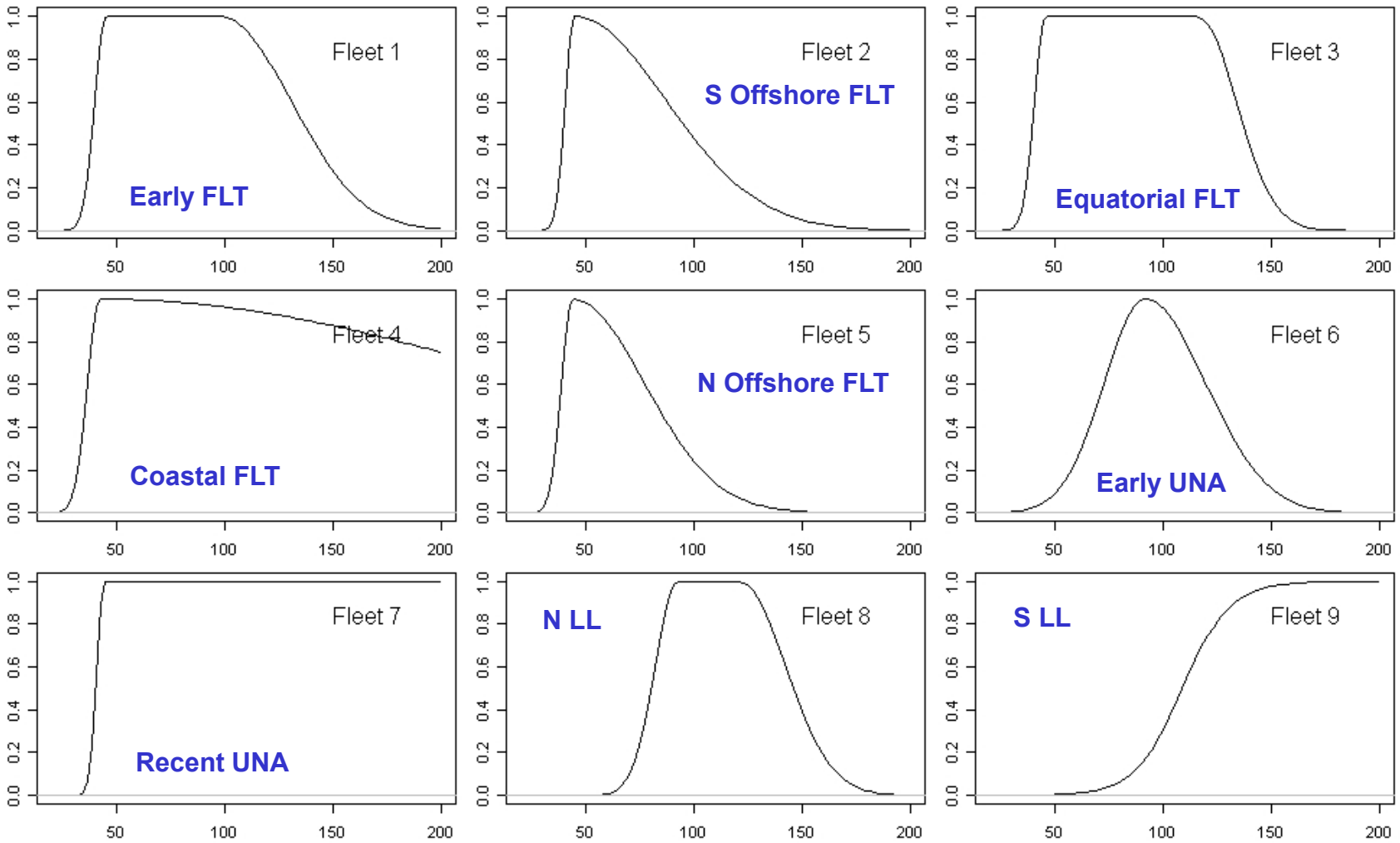
Fishing mortality



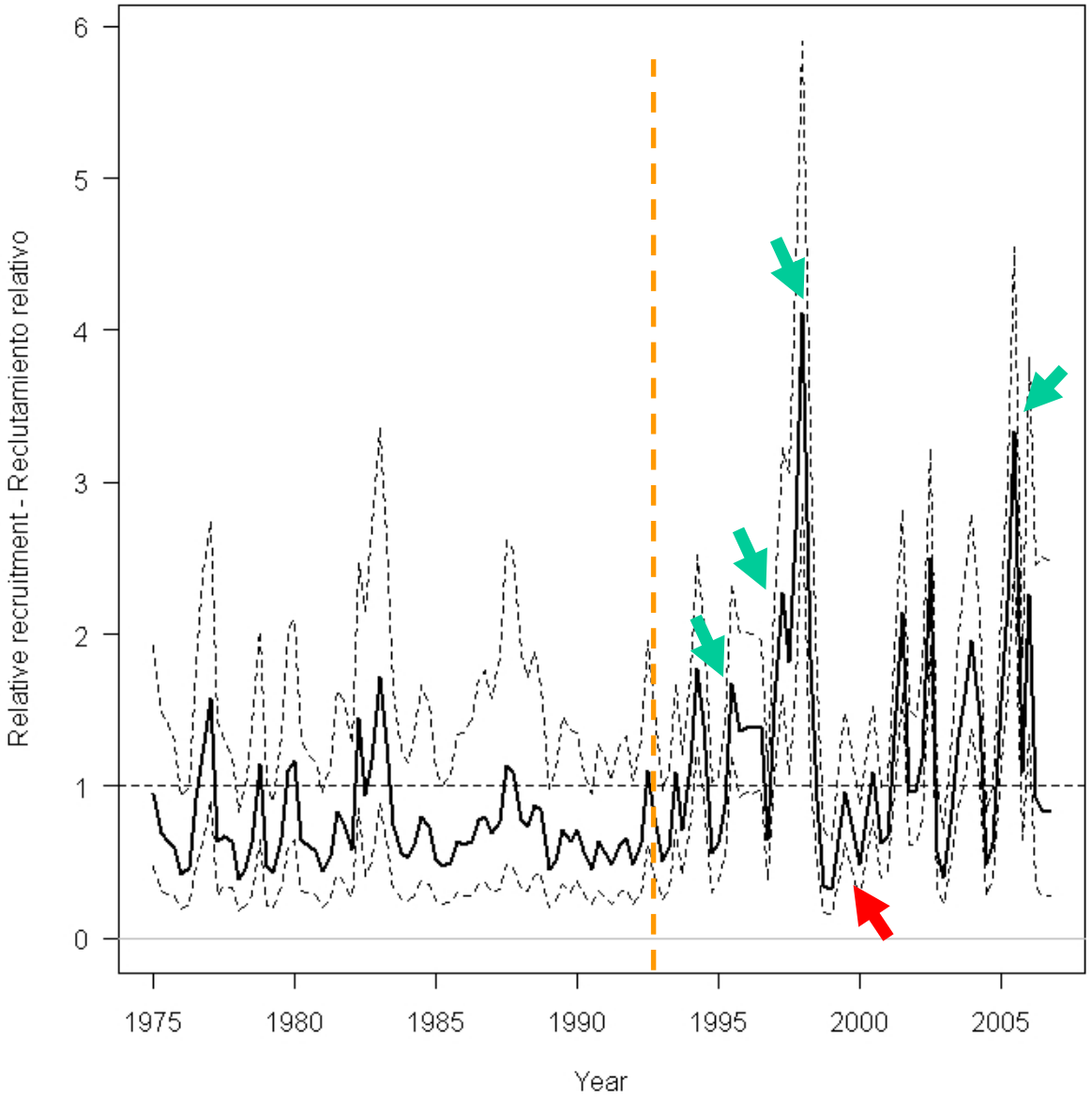
Age-specific fishing mortality



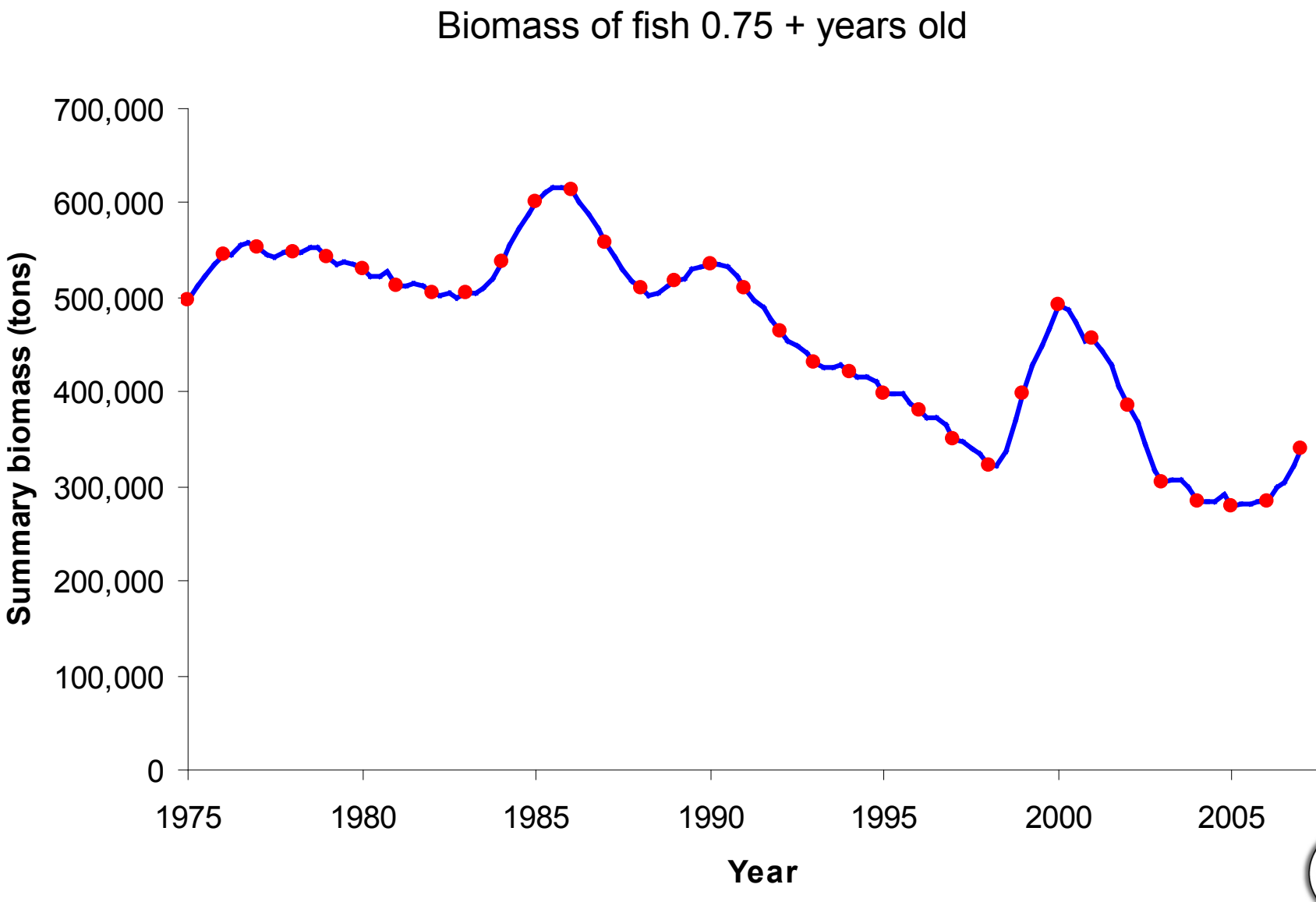
Size selectivity



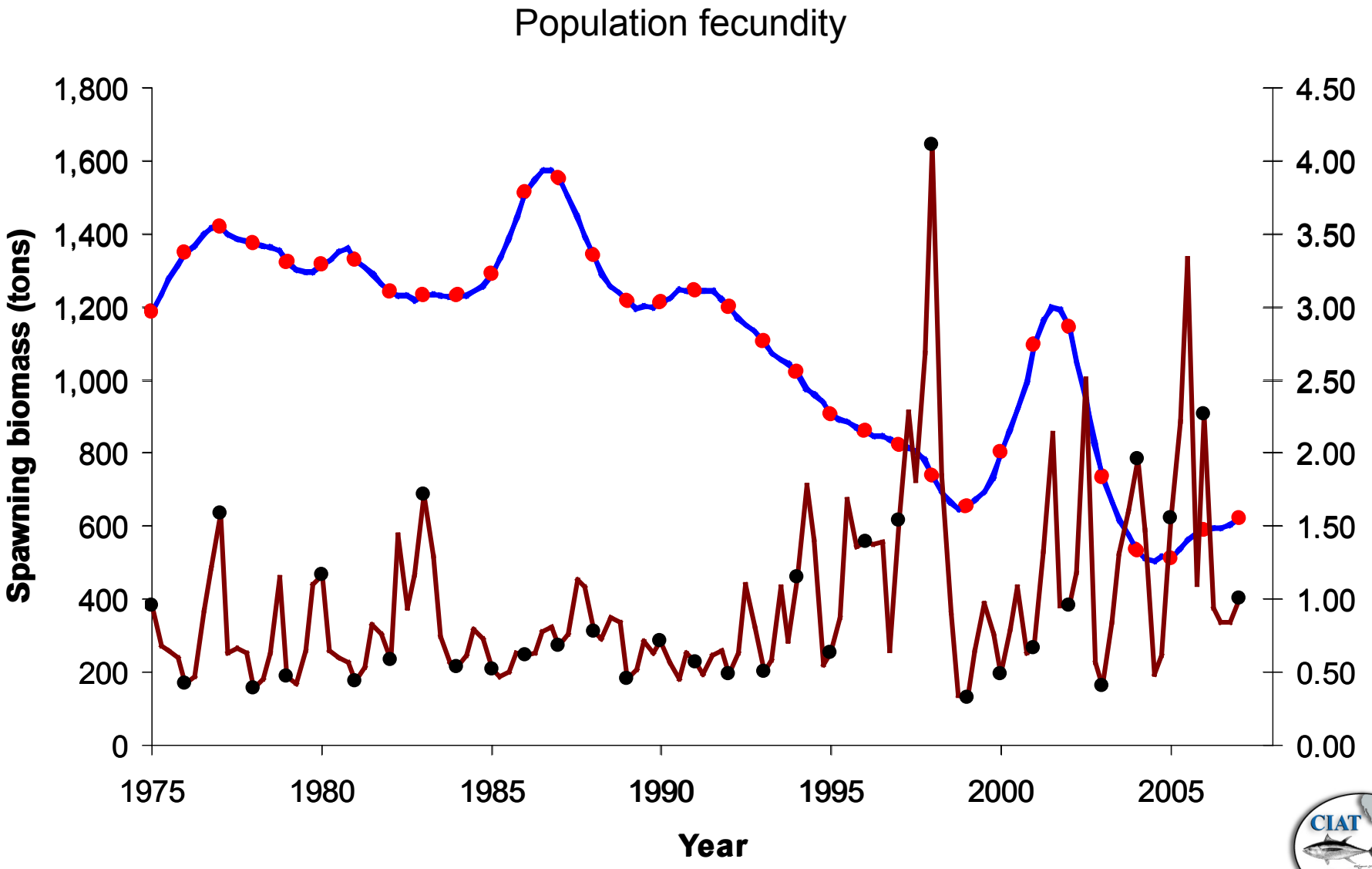
Recruitment



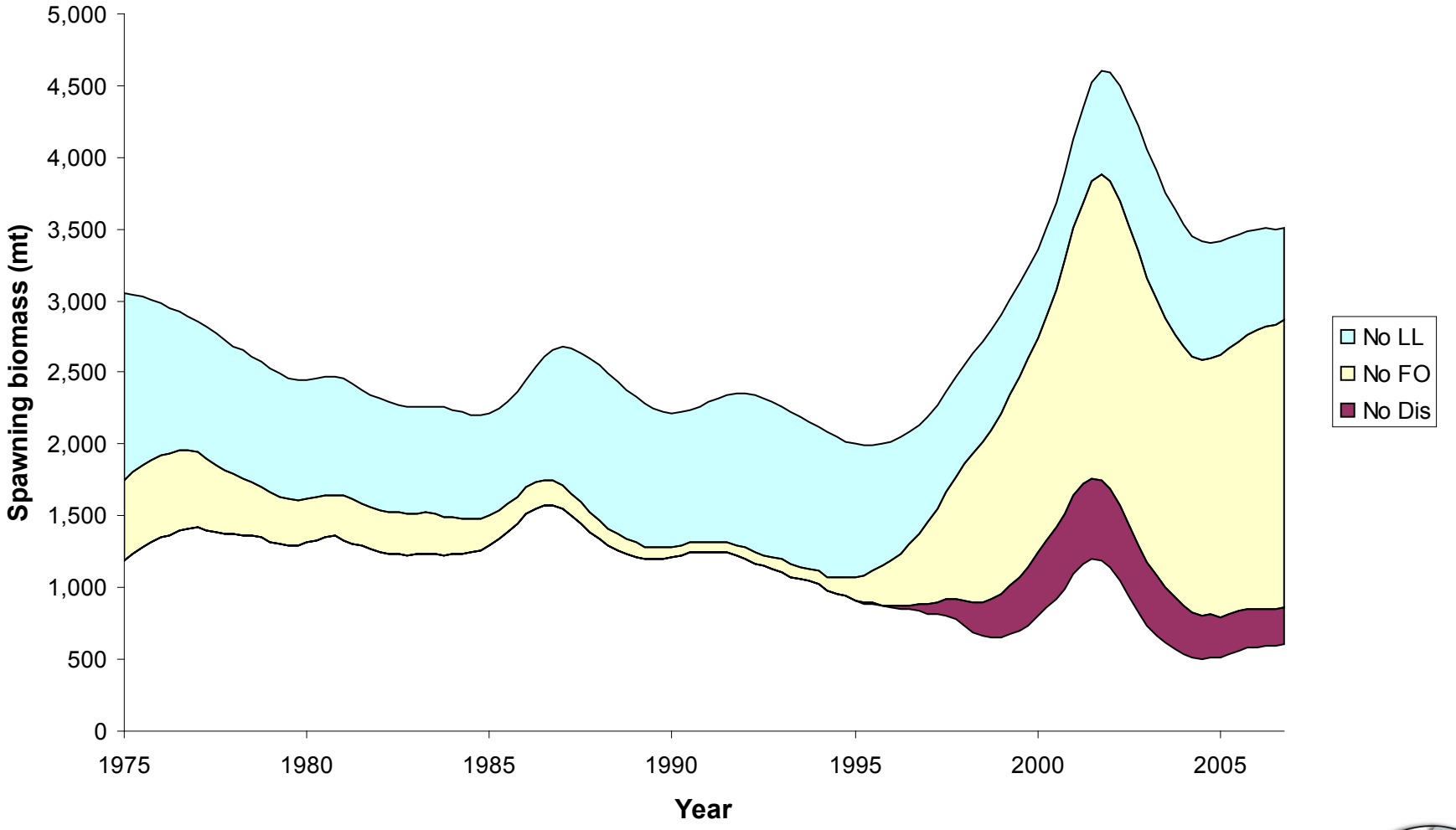
Biomass


Biomass of fish 0.75 + years old
Summary biomass (tons)
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
1975
1980
1985
1990
1995
2000
2005
Year

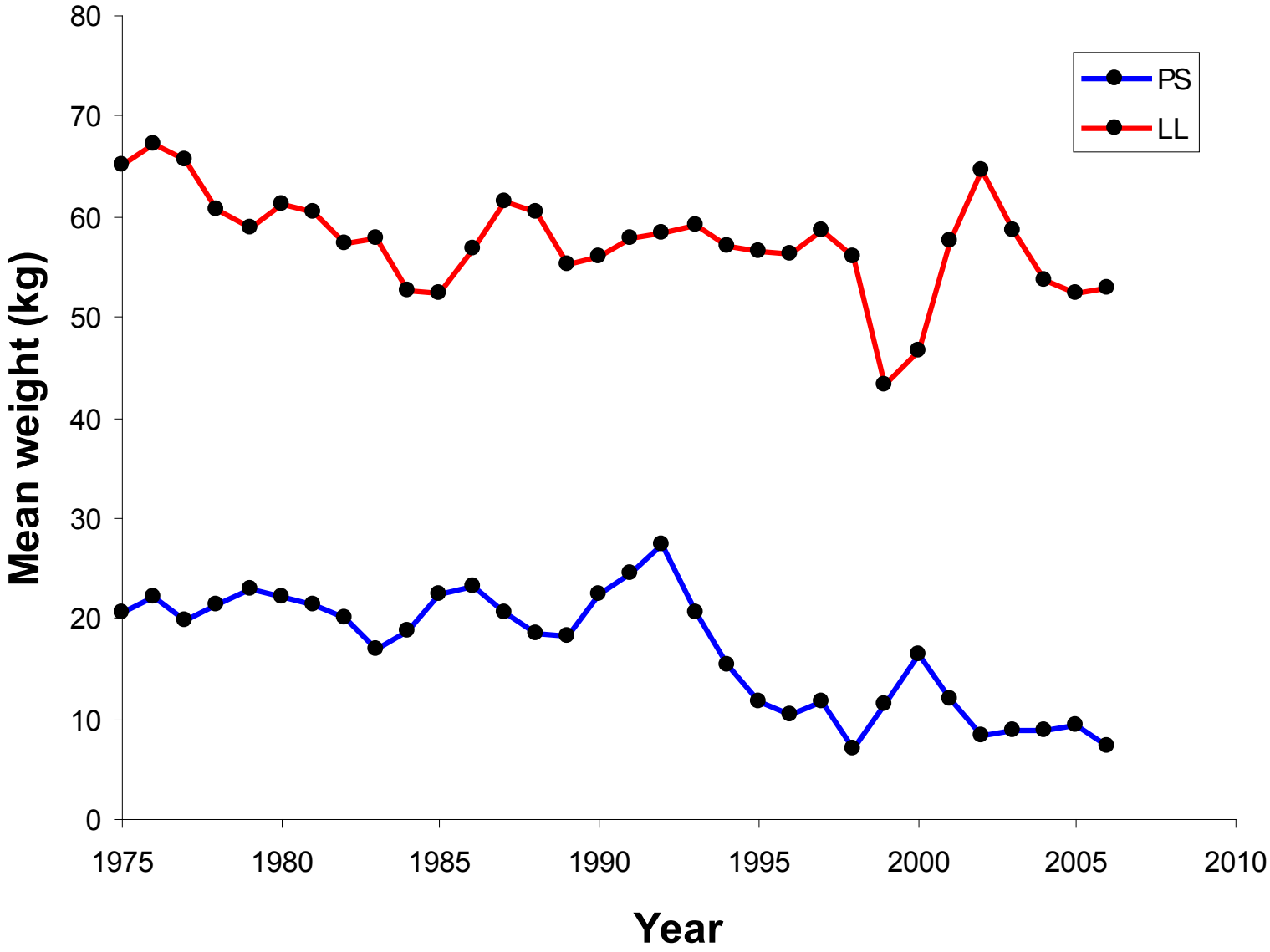
Spawning biomass



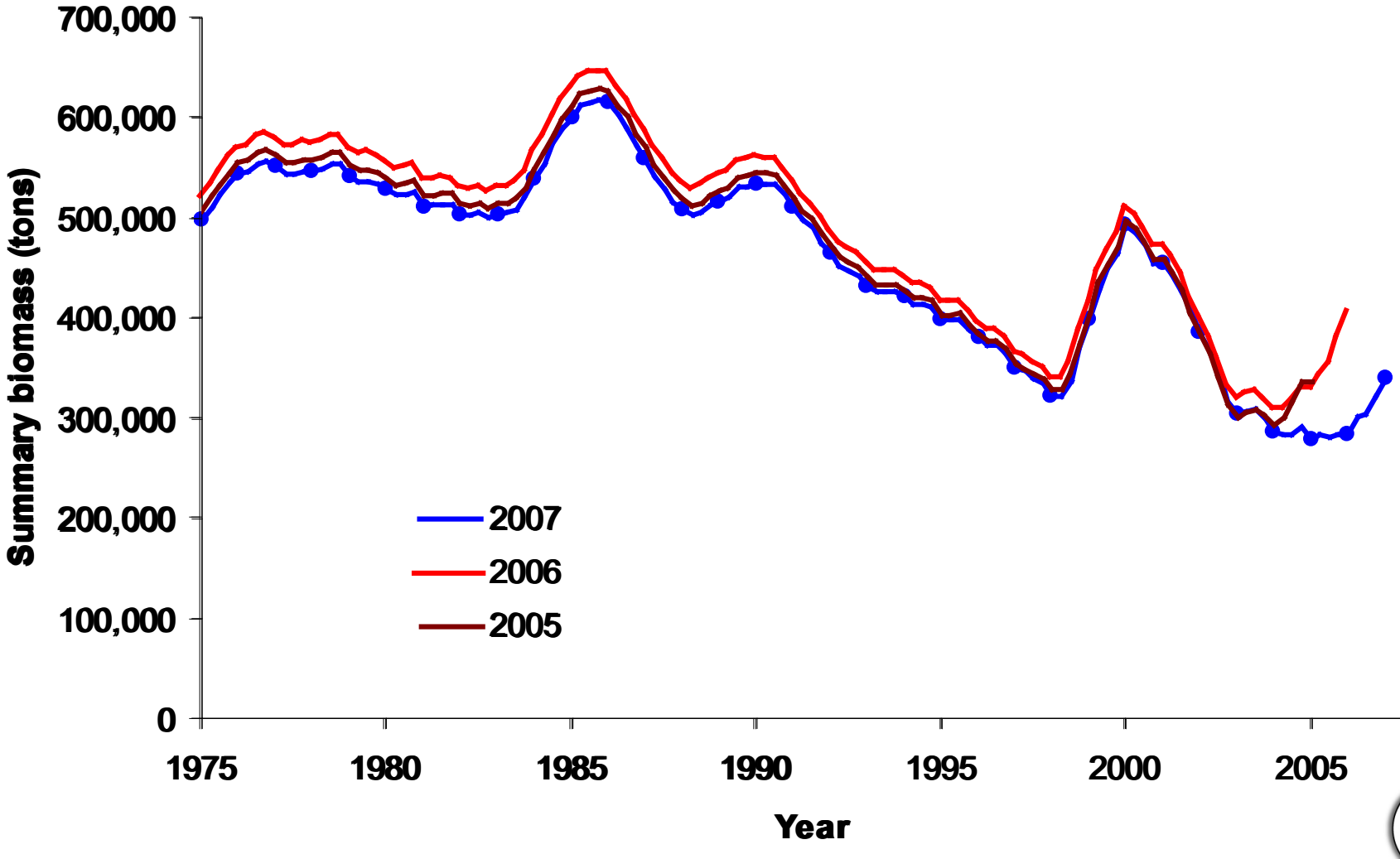
No-fishing plot



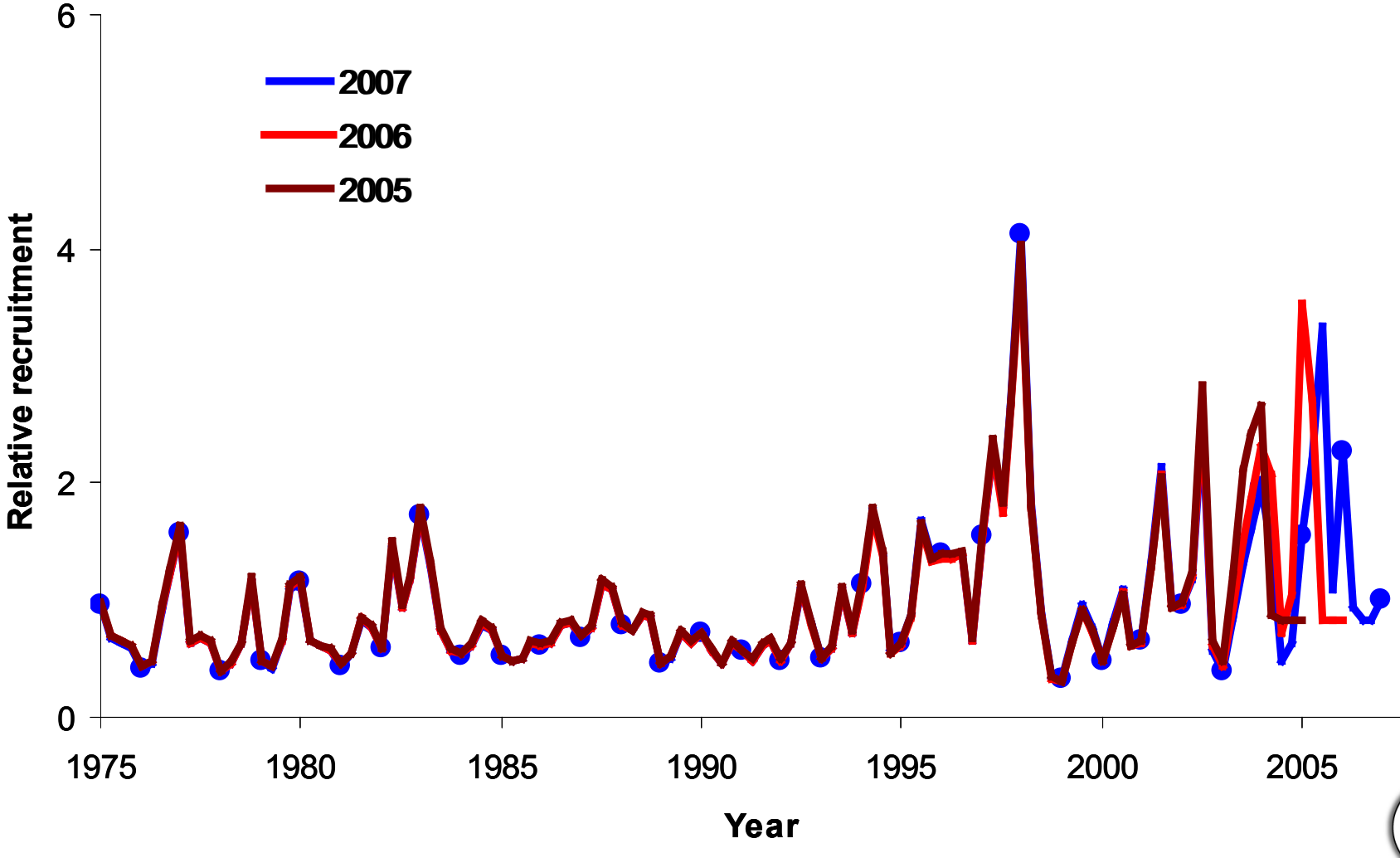
Average weight



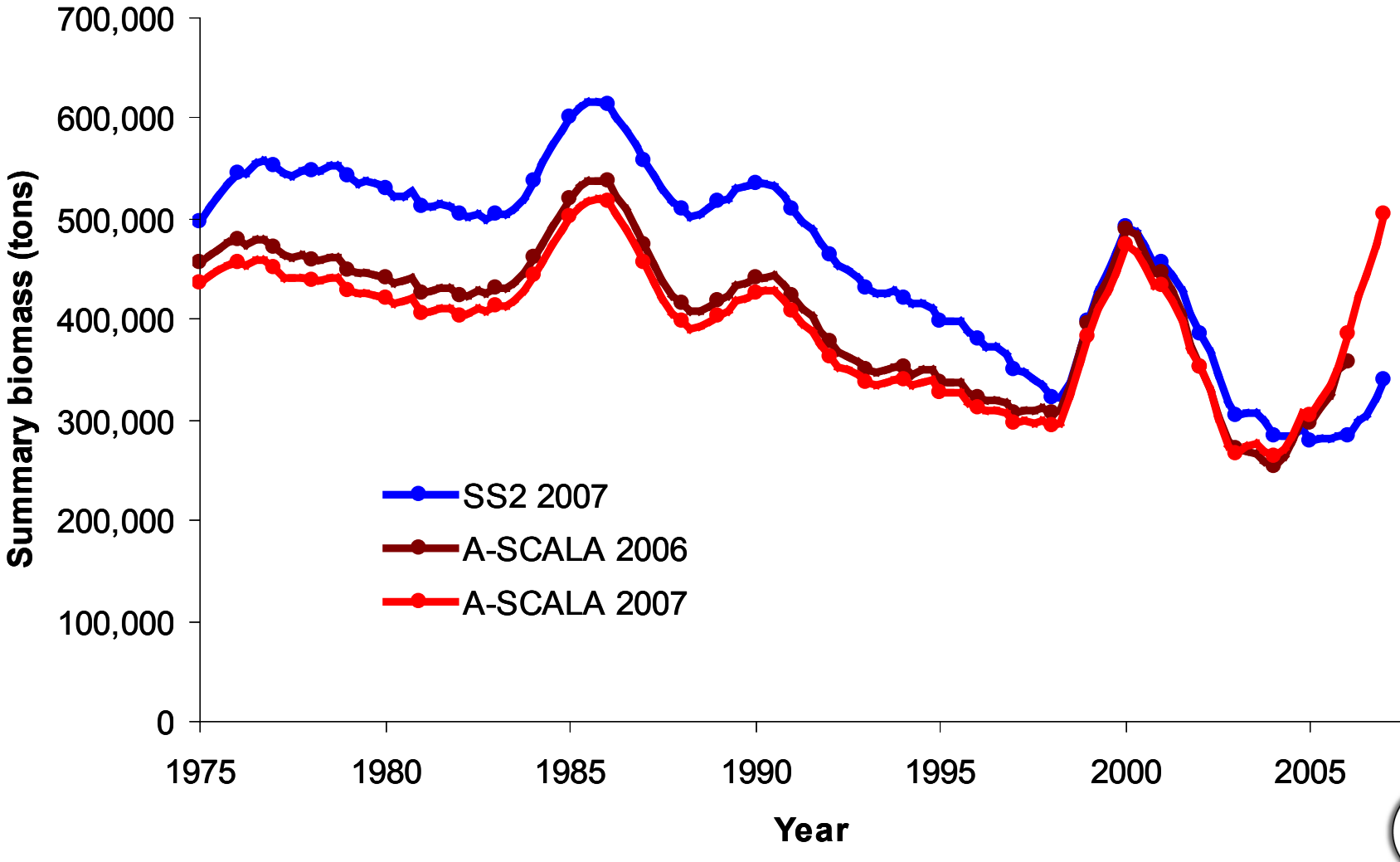
Retrospective analysis - biomass



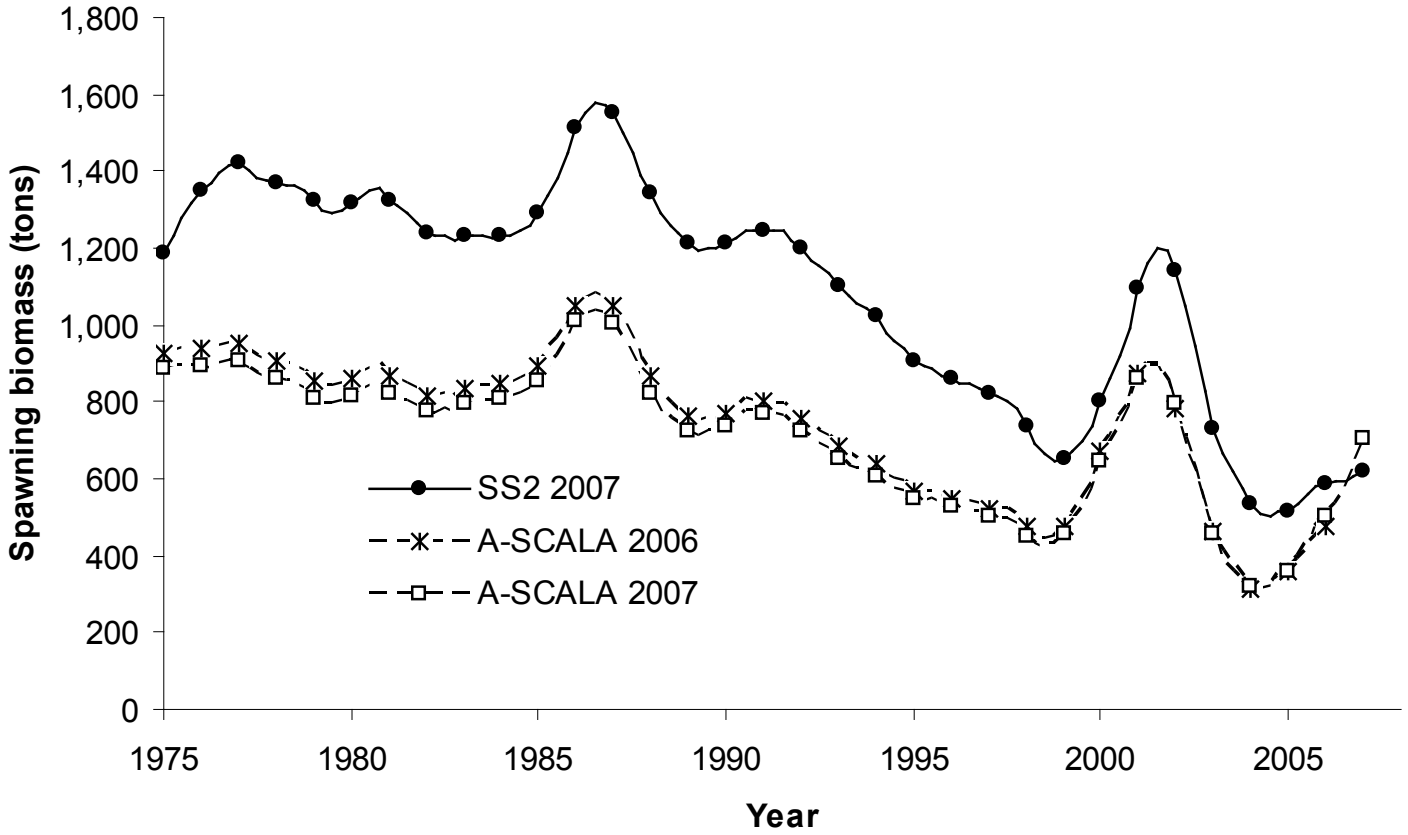
Retrospective analysis - recruitment



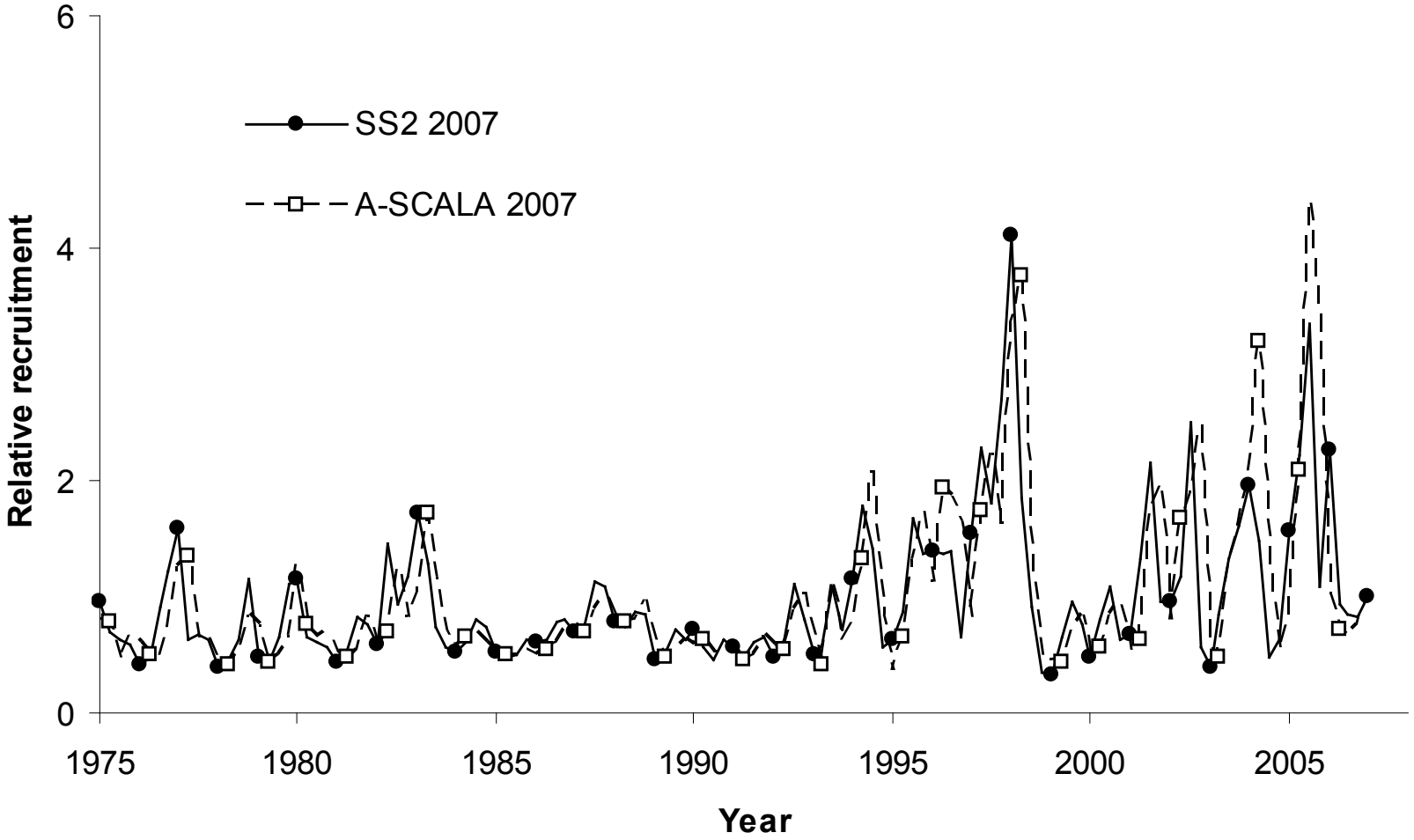
Comparisons with A-SCALA



Comparisons with A-SCALA assessments



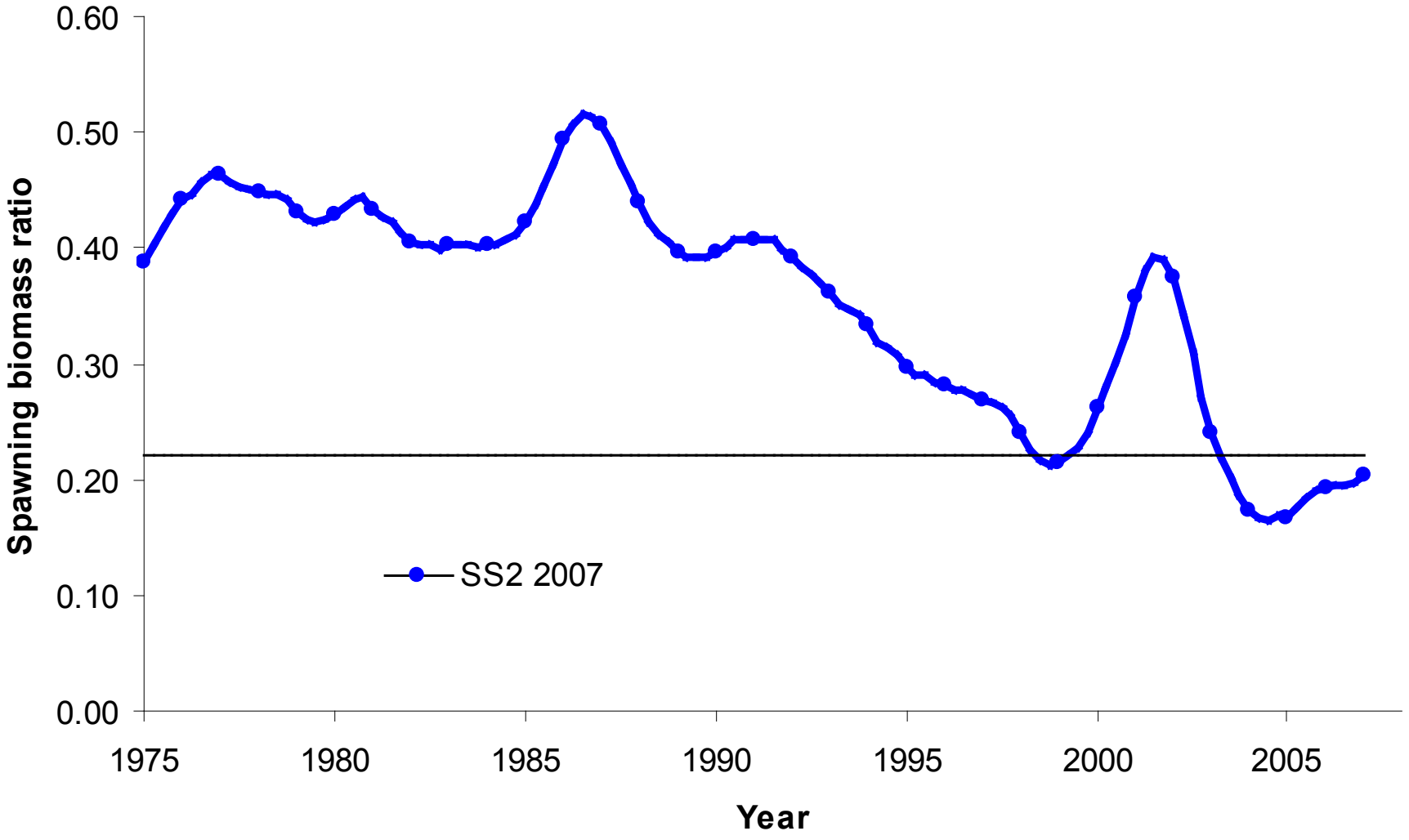
Comparisons with A-SCALA assessments



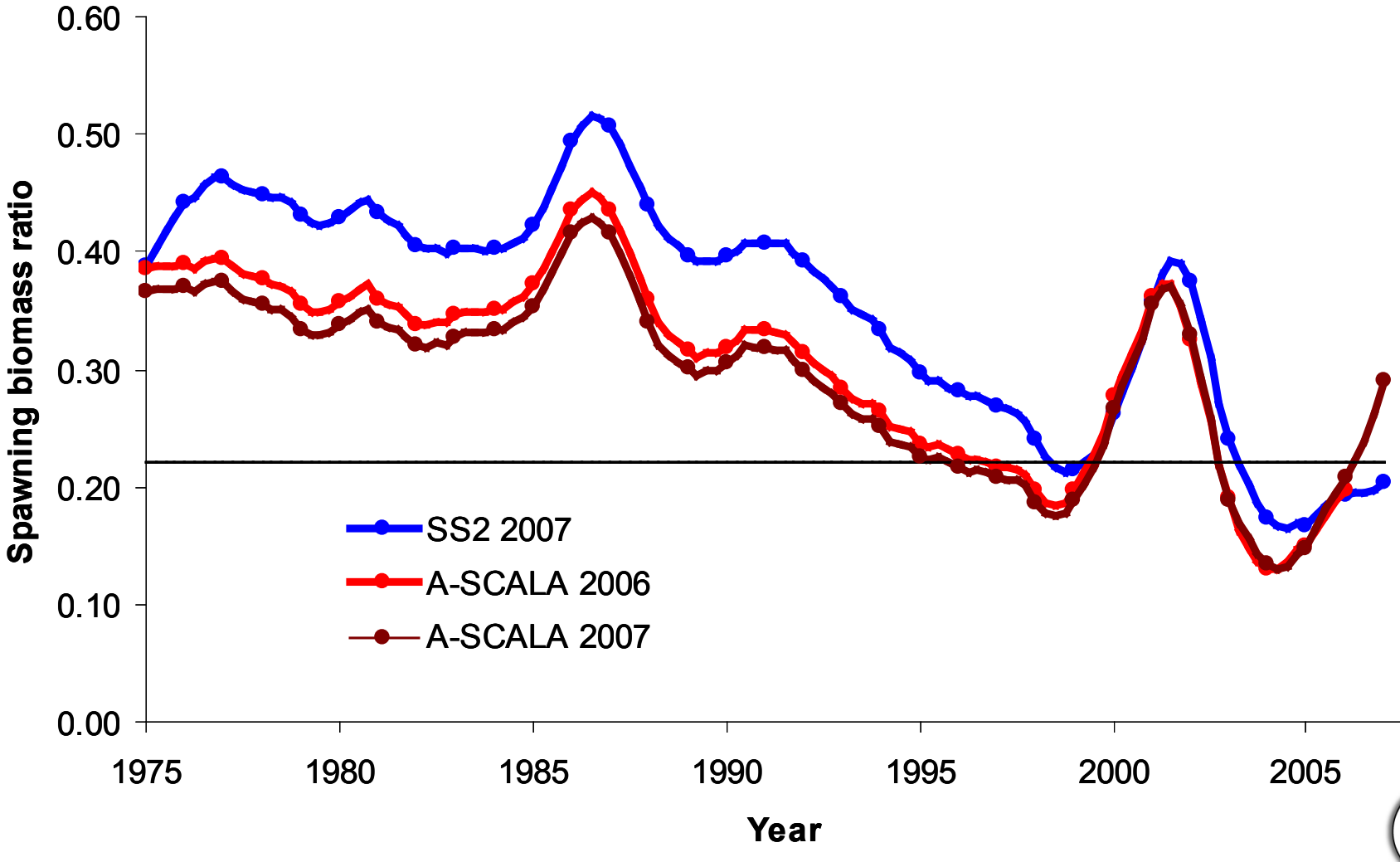
Comparisons to reference points

- Spawning biomass depletion (SBR)

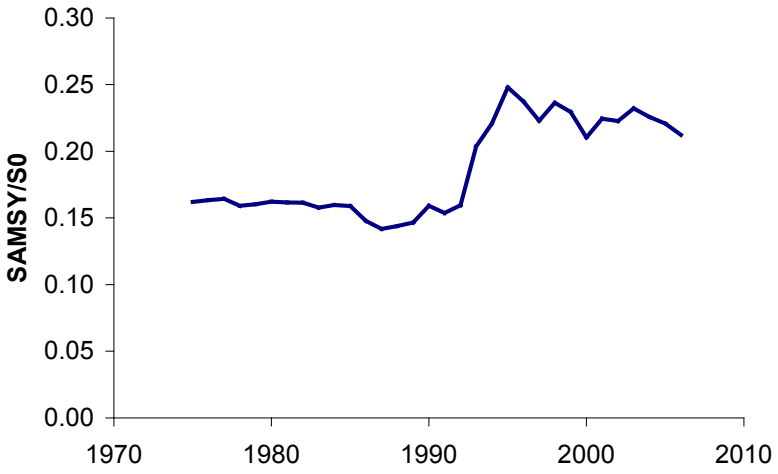
Spawning biomass ratio

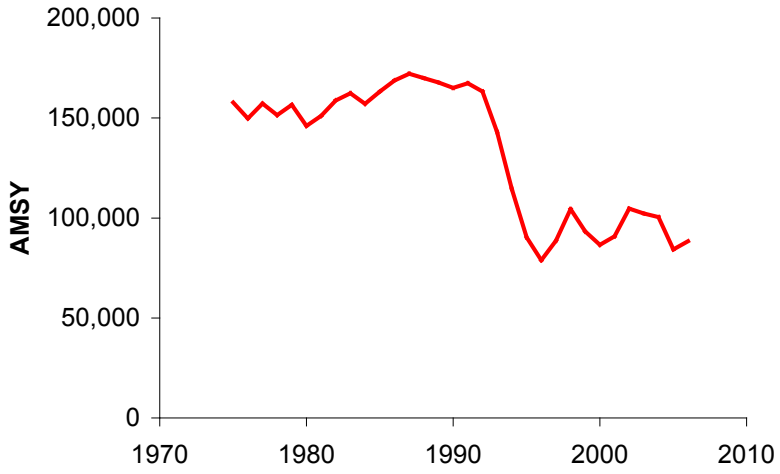


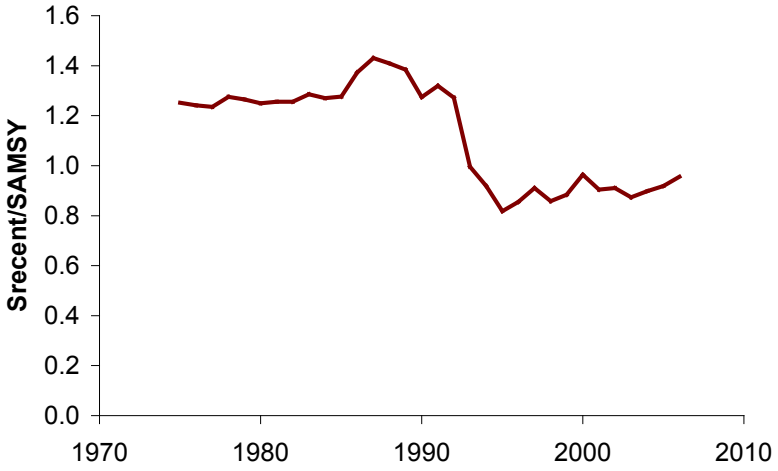
SBR comparison with A-SCALA

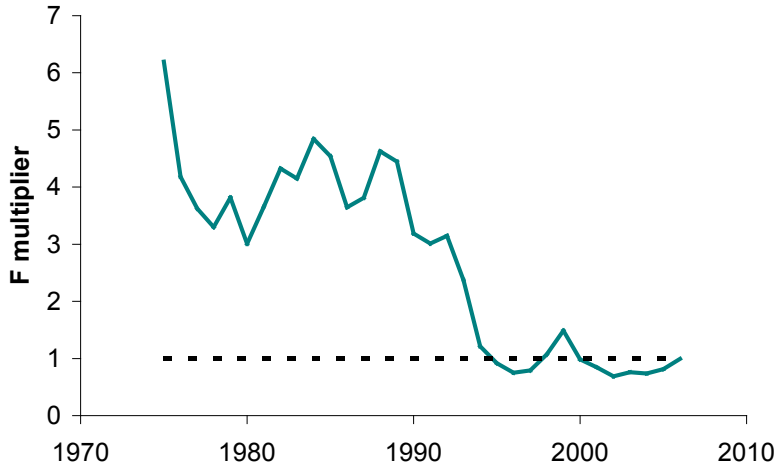


Time varying indicators







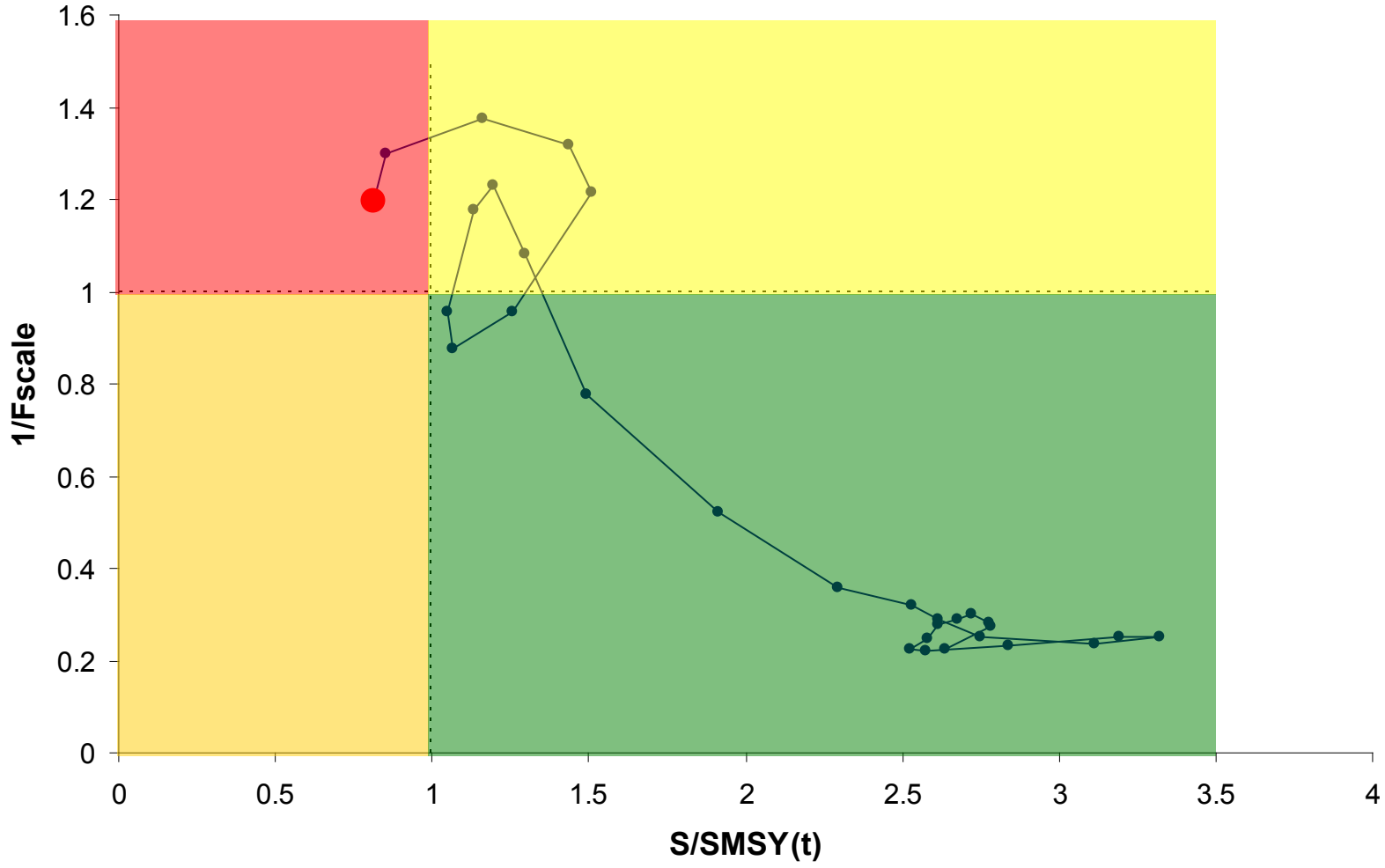


AMSY-quantities

	F's 2004 & 2005 Base case	2003-2004	2005-2006
AMSY	92,758	101,316	86,134
B_{AMSY}	313,767	325,300	300,779
S_{AMSY}	688	700	664
B_{AMSY}/B_0	0.27	0.28	0.26
S_{AMSY}/S_0	0.22	0.23	0.22
Crecent/AMSY	1.10	1.03	1.21
Brecent/B_{AMSY}	1.08	1.05	1.13
Srecent/S_{AMSY}	0.90	0.89	0.93
Fmultiplier	0.77	0.75	0.90

AMSY-quantities – by fishery

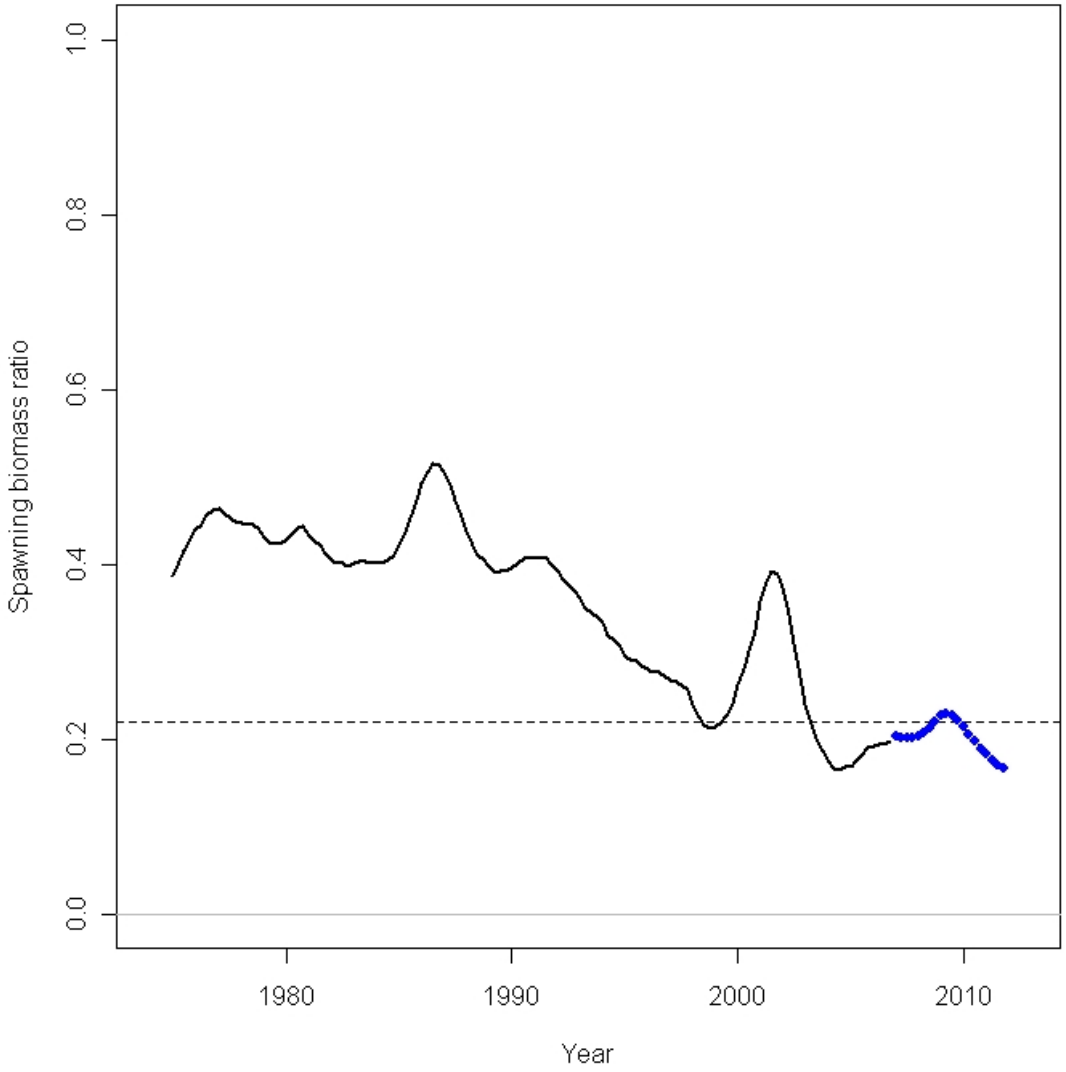
	All gears	PS only	LL only
AMSY	92,758	62,566	175,340
B_{AMSY}	313,767	230,786	312,126
S_{AMSY}	688	510	416
B_{AMSY}/B_0	0.27	0.20	0.27
S_{AMSY}/S_0	0.22	0.17	0.14
Crecent/AMSY	1.10	1.67	0.60
Brecent/B_{AMSY}	1.08	1.47	1.09
Srecent/S_{AMSY}	0.90	1.22	1.49
Fmultiplier	0.77	1.41	4.32


1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1/Fscale
0
0.5
1
1.5
2
2.5
3
3.5
4
S/SMSY(t)

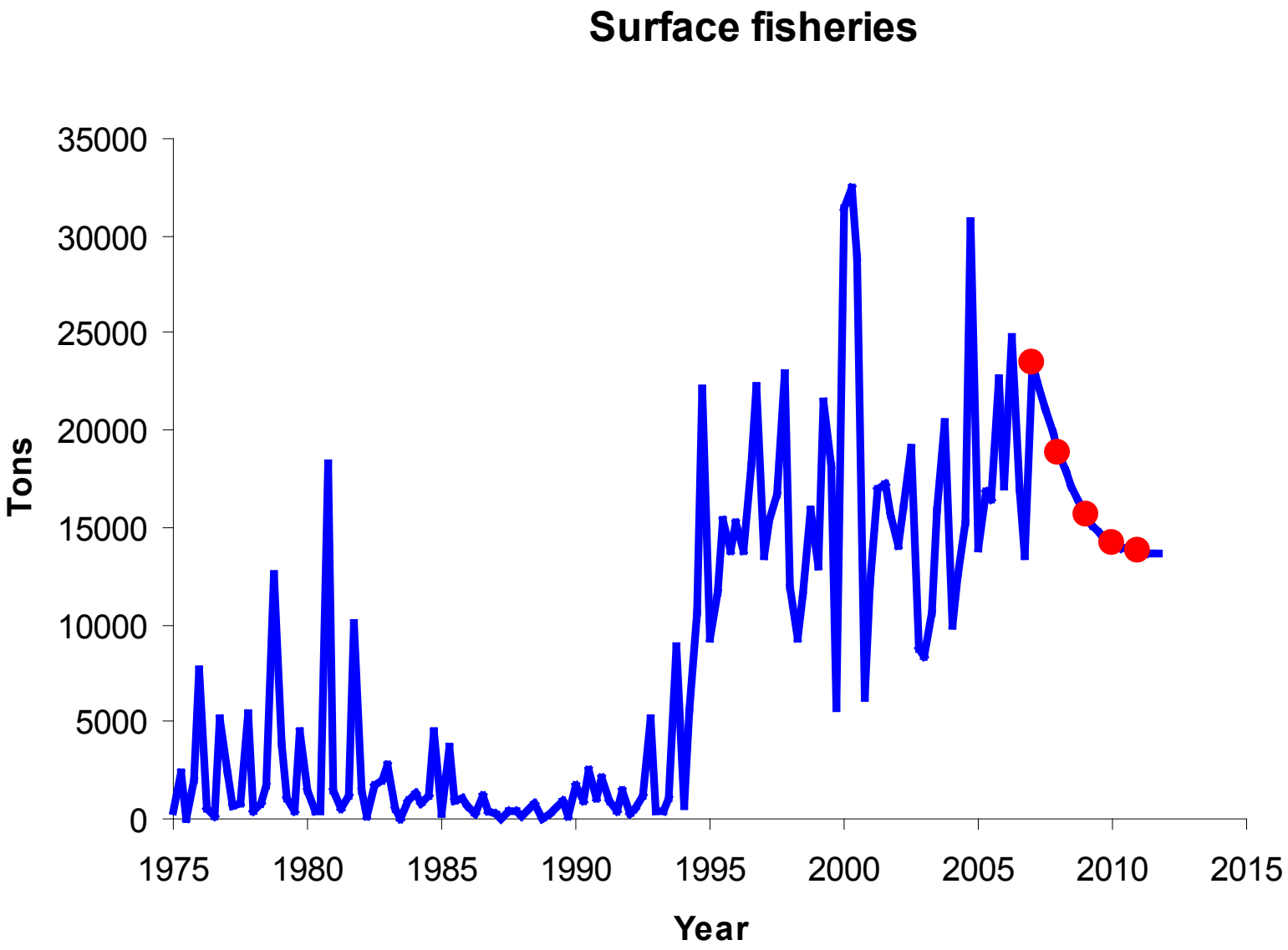
Forward simulations

- Biomass
- Spawning biomass depletion
- Surface fishery catch
- Longline catch

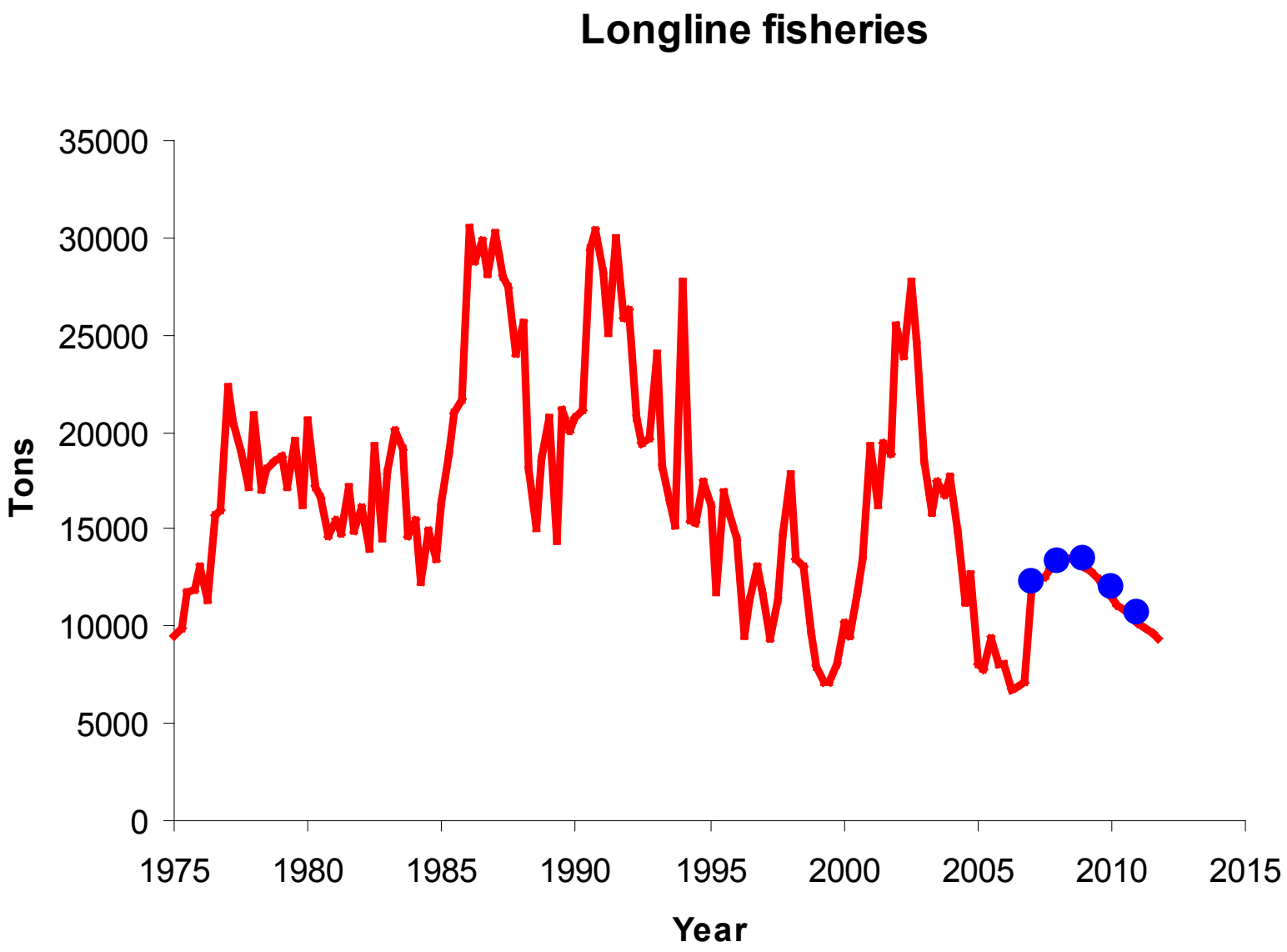
Spawning biomass ratio



Predicted catches – purse-seine



Predicted catches – longline

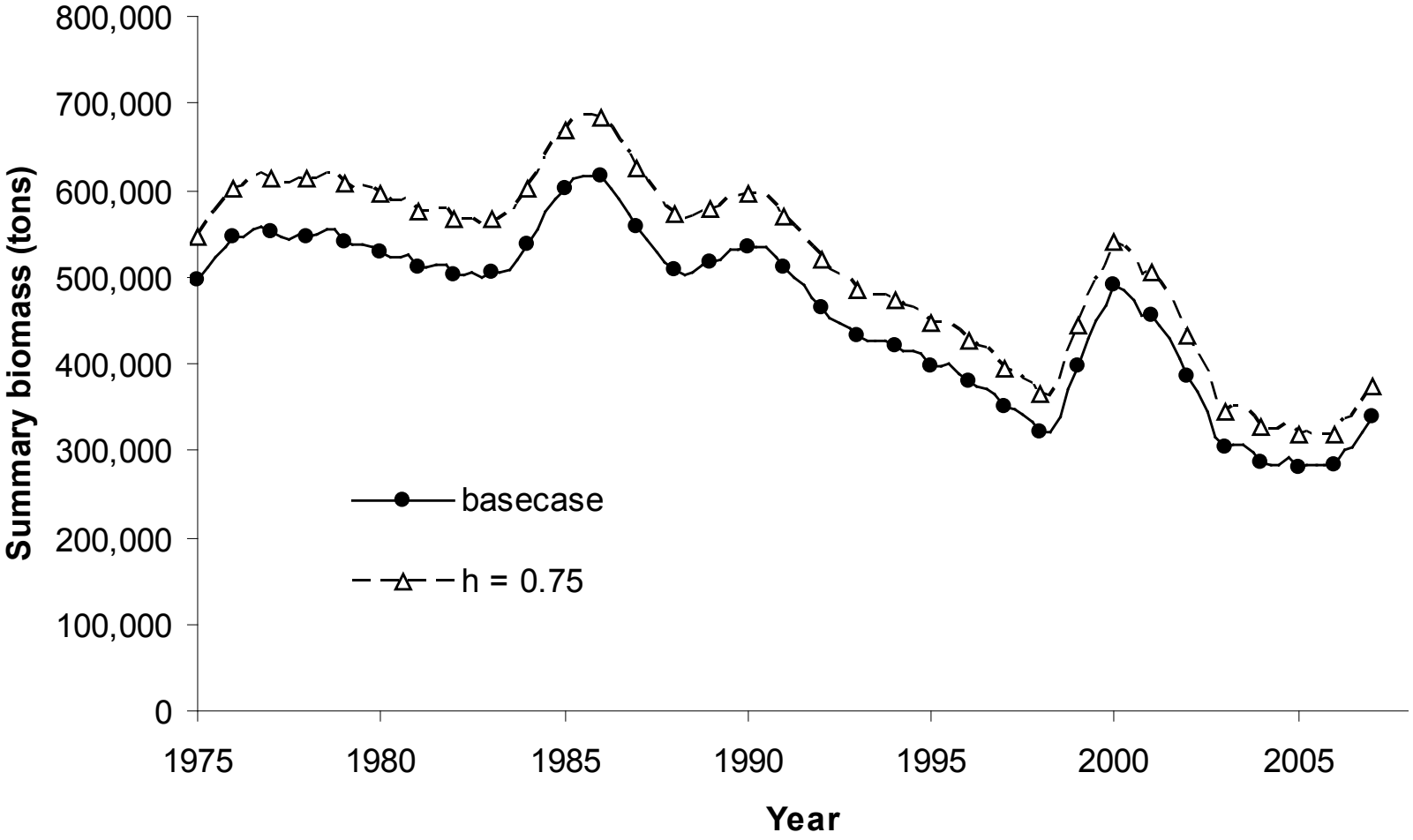


Sensitivity analyses

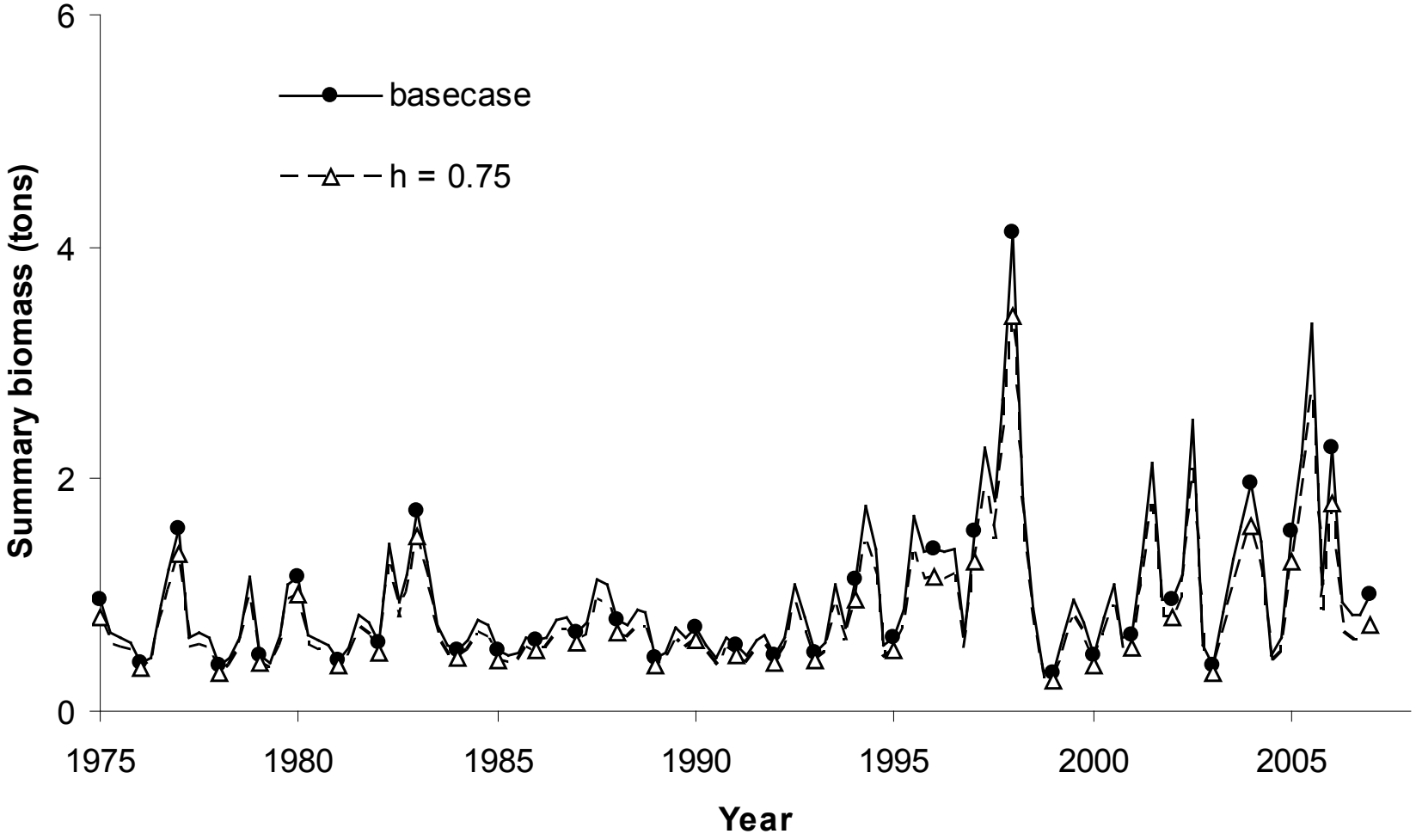
1. Spawner-recruitment relationship (steepness = 0.75)
2. Growth
   - Growth estimated
   - Linf fixed (171.5 and 201.5)
3. Fitting to the initial equilibrium catch
4. Use of iterative reweighting of data
5. Time blocking of selectivity and catchability for southern longline fishery
6. Inclusion of new Japanese longline data

Stock-recruitment relationship (h = 0.75)

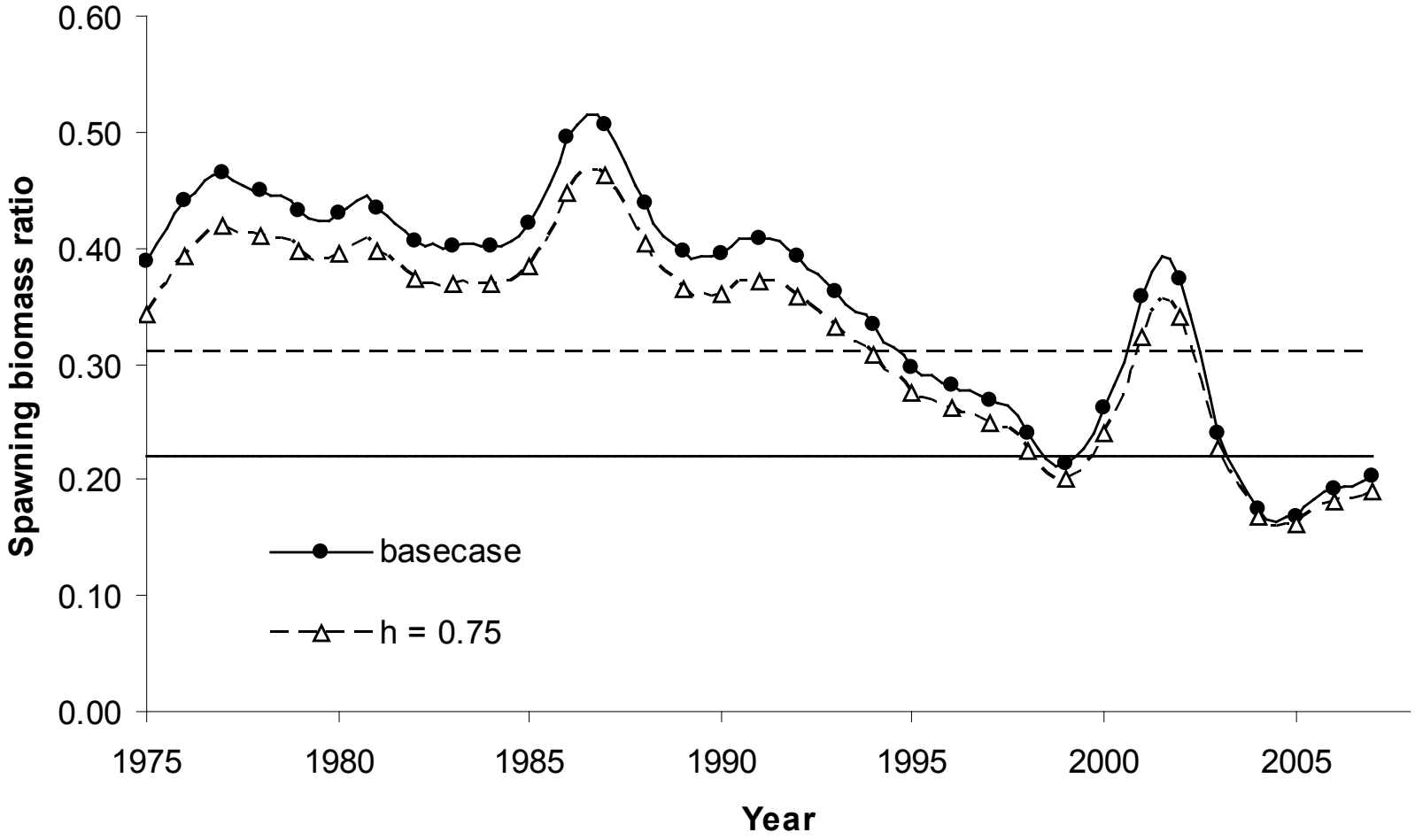
Biomass


800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Summary biomass (tons)
basecase
h = 0.75
1975
1980
1985
1990
1995
2000
2005
Year

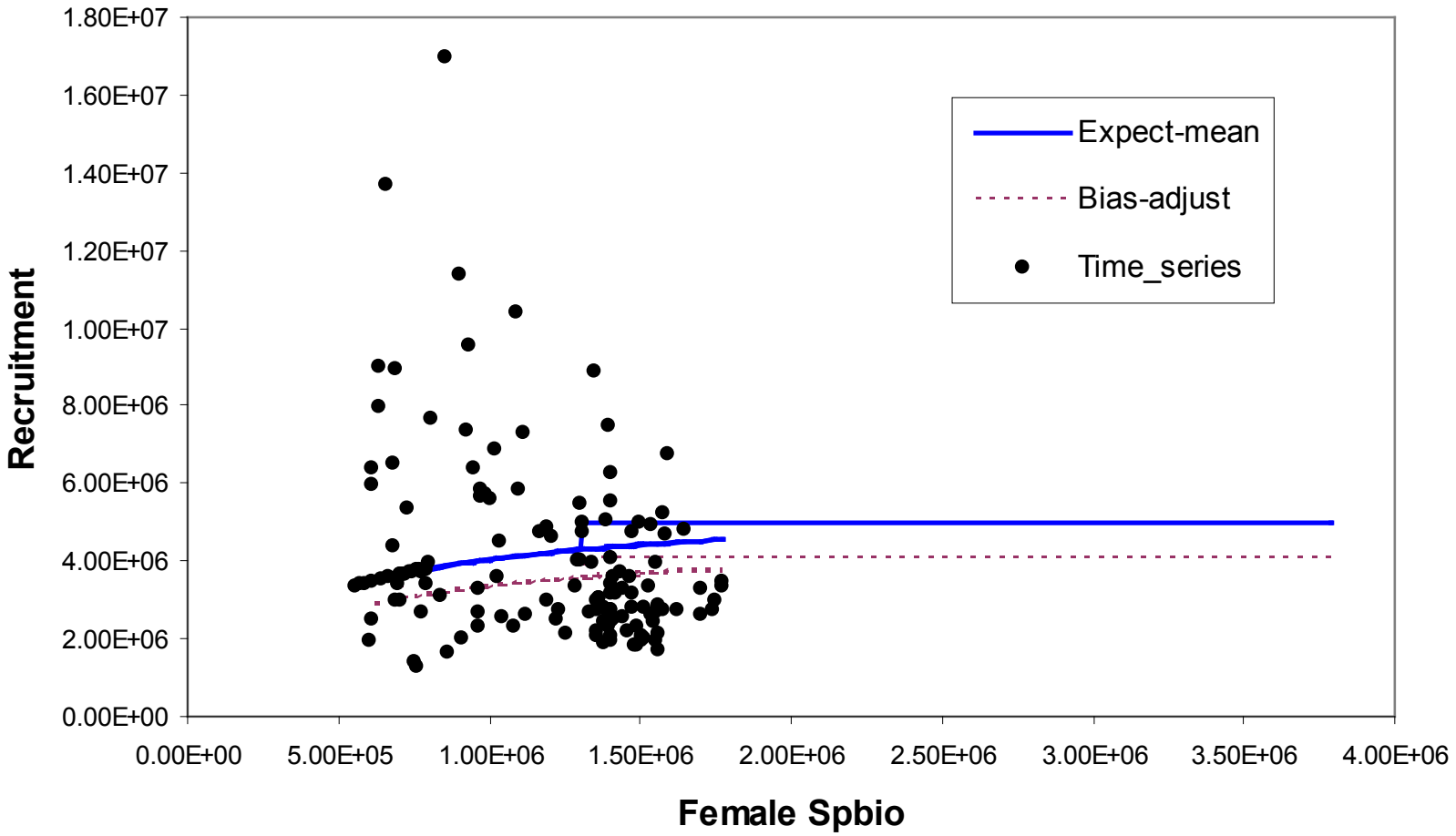
Recruitment



Spawning biomass ratio

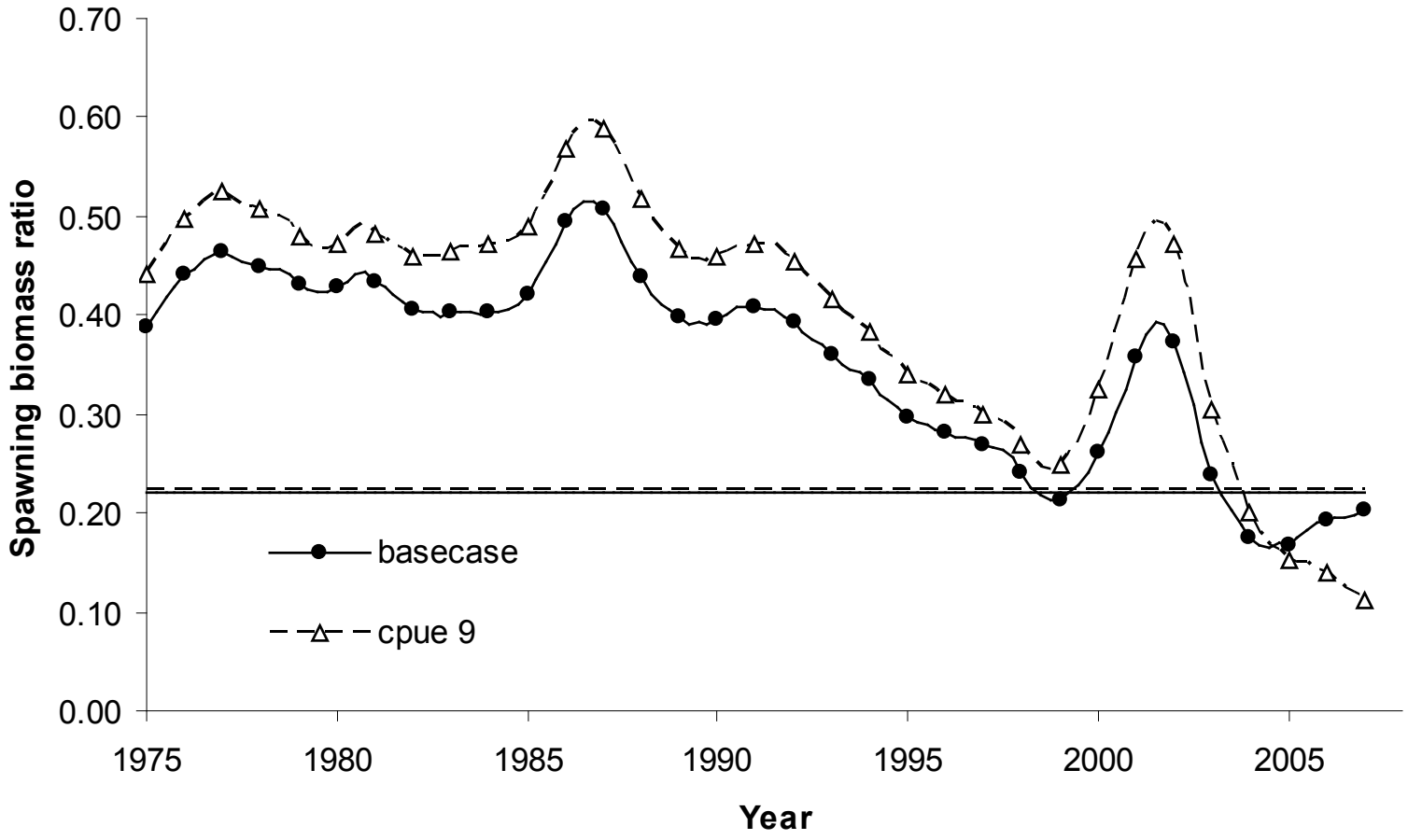


Spawner-recruitment curve

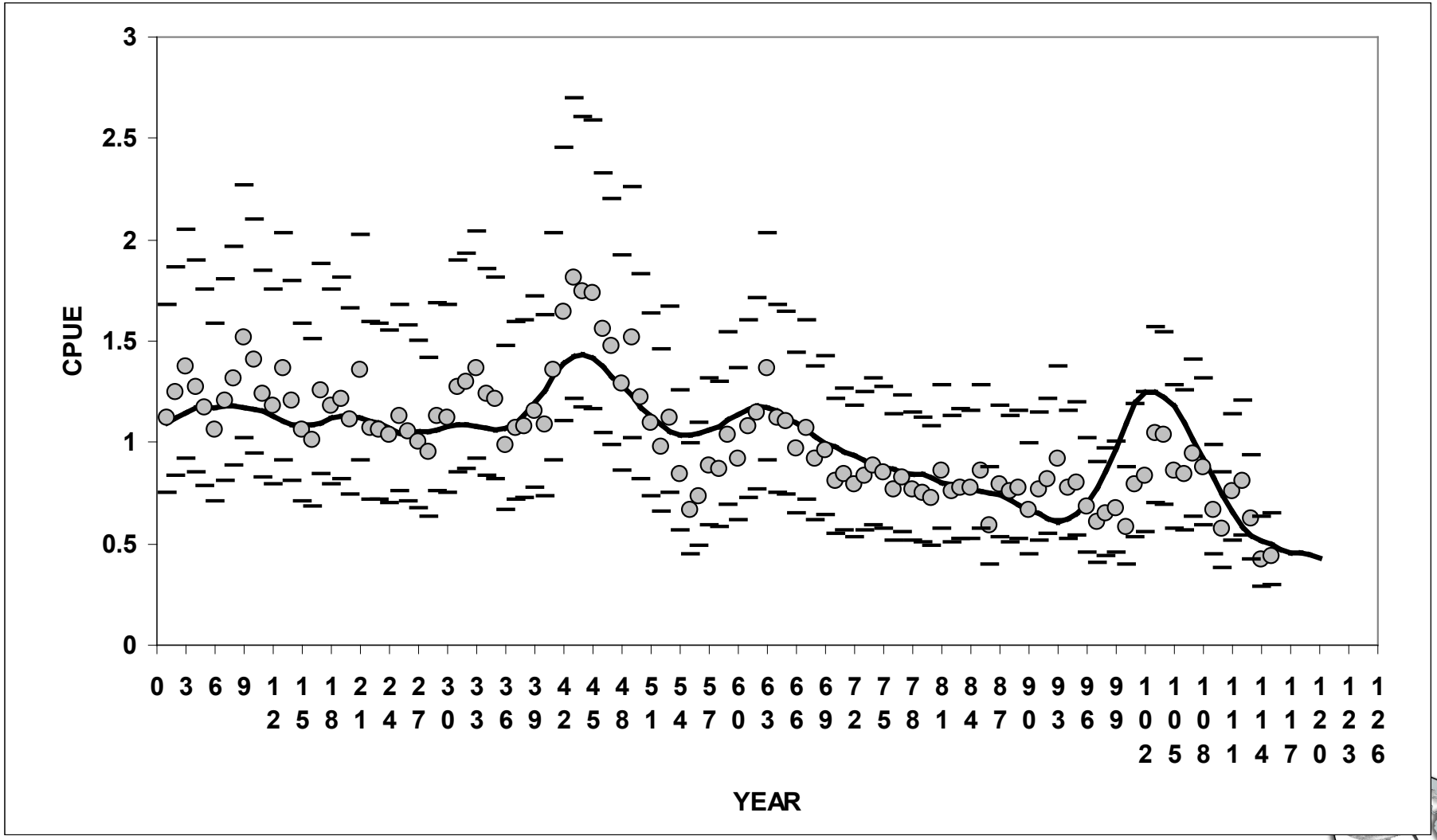


Use of CPUE time series for southern longline fishery only

Spawning biomass ratio

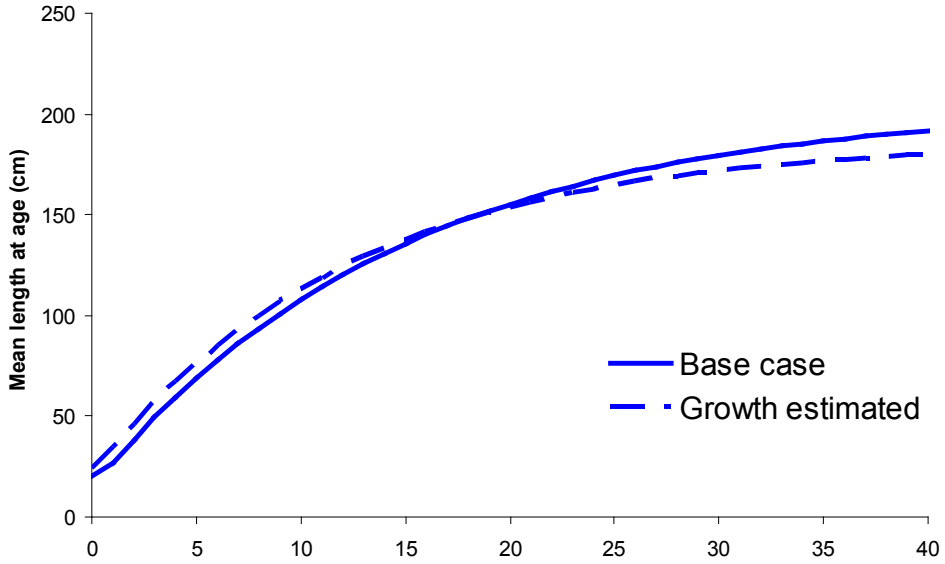


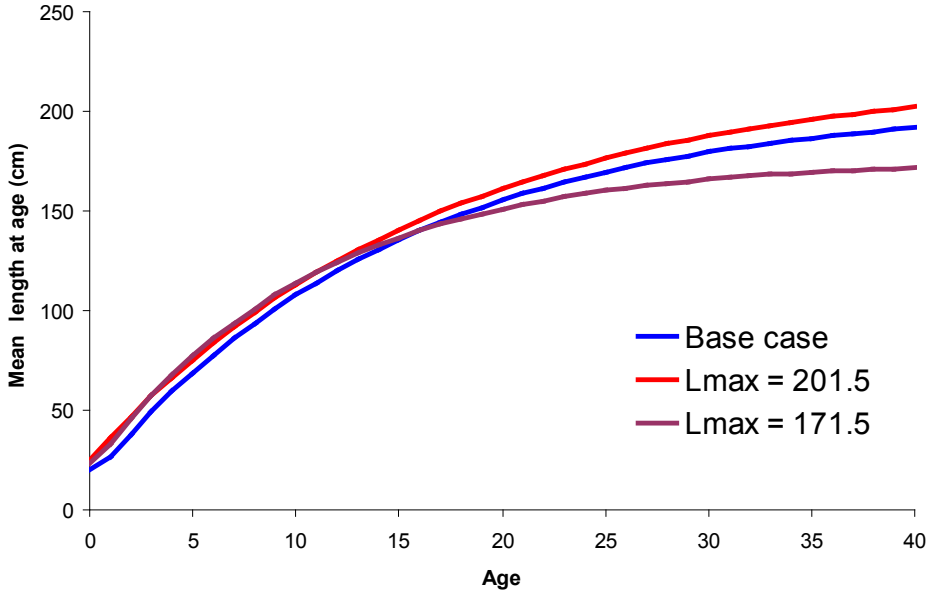
Model fit to CPUE data



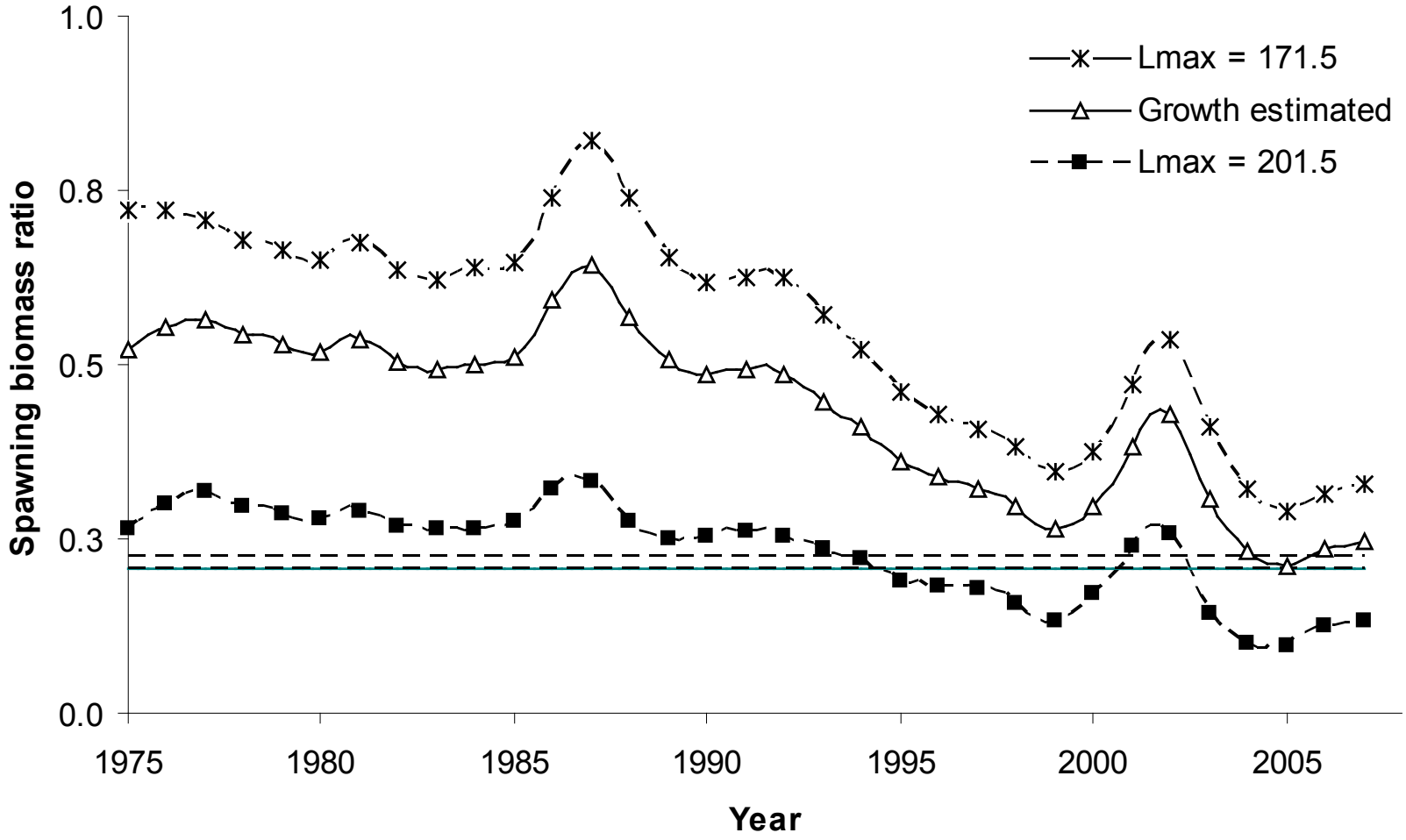
Assumed value for the asymptotic length parameter of the VB growth curve

Growth curves



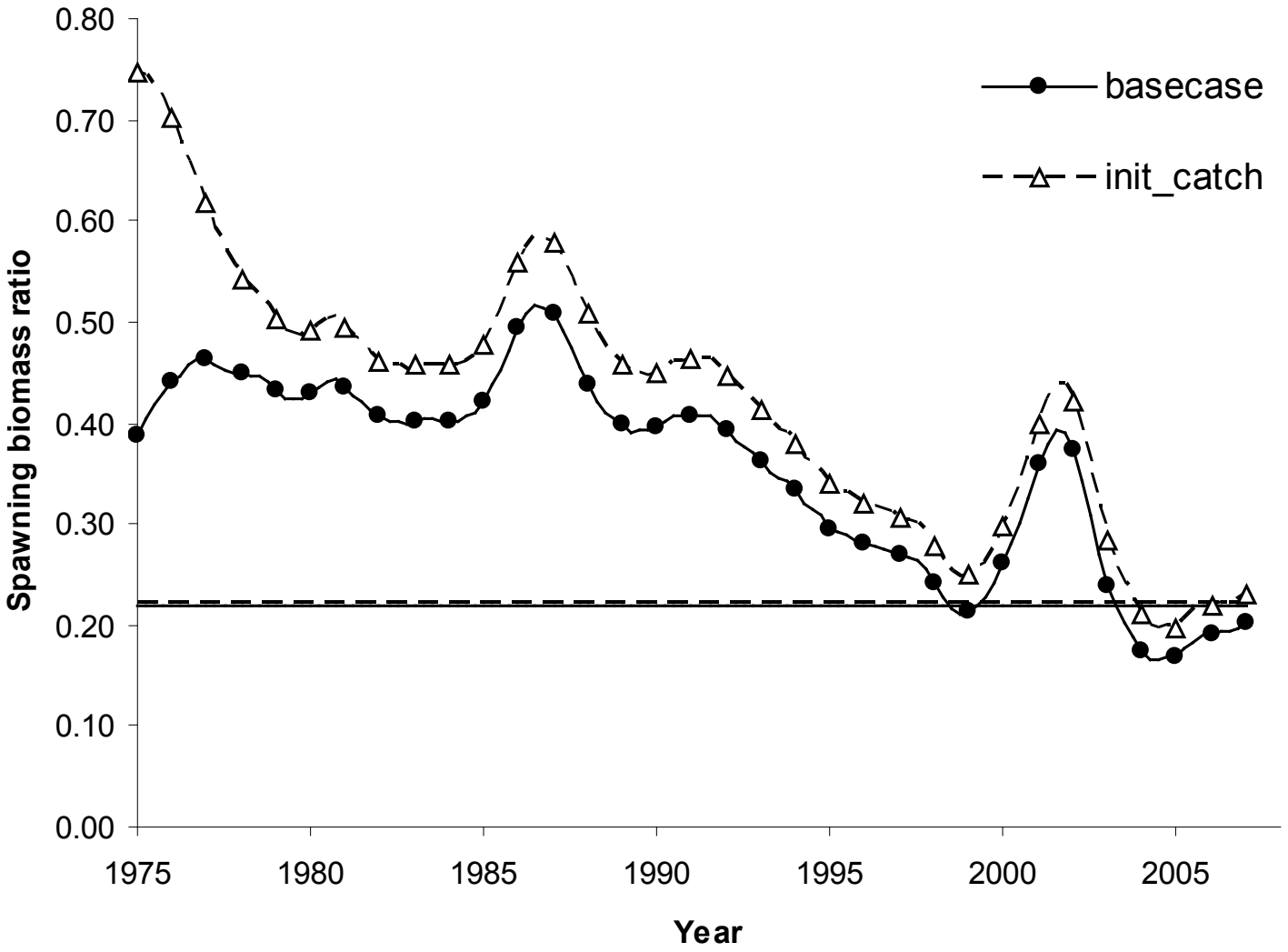


SBR


Lmax = 171.5
Growth estimated
Lmax = 201.5
Spawning biomass ratio
1.0
0.8
0.5
0.3
0.0
1975
1980
1985
1990
1995
2000
2005
Year

Fit to initial equilibrium catch

Spawning biomass ratio

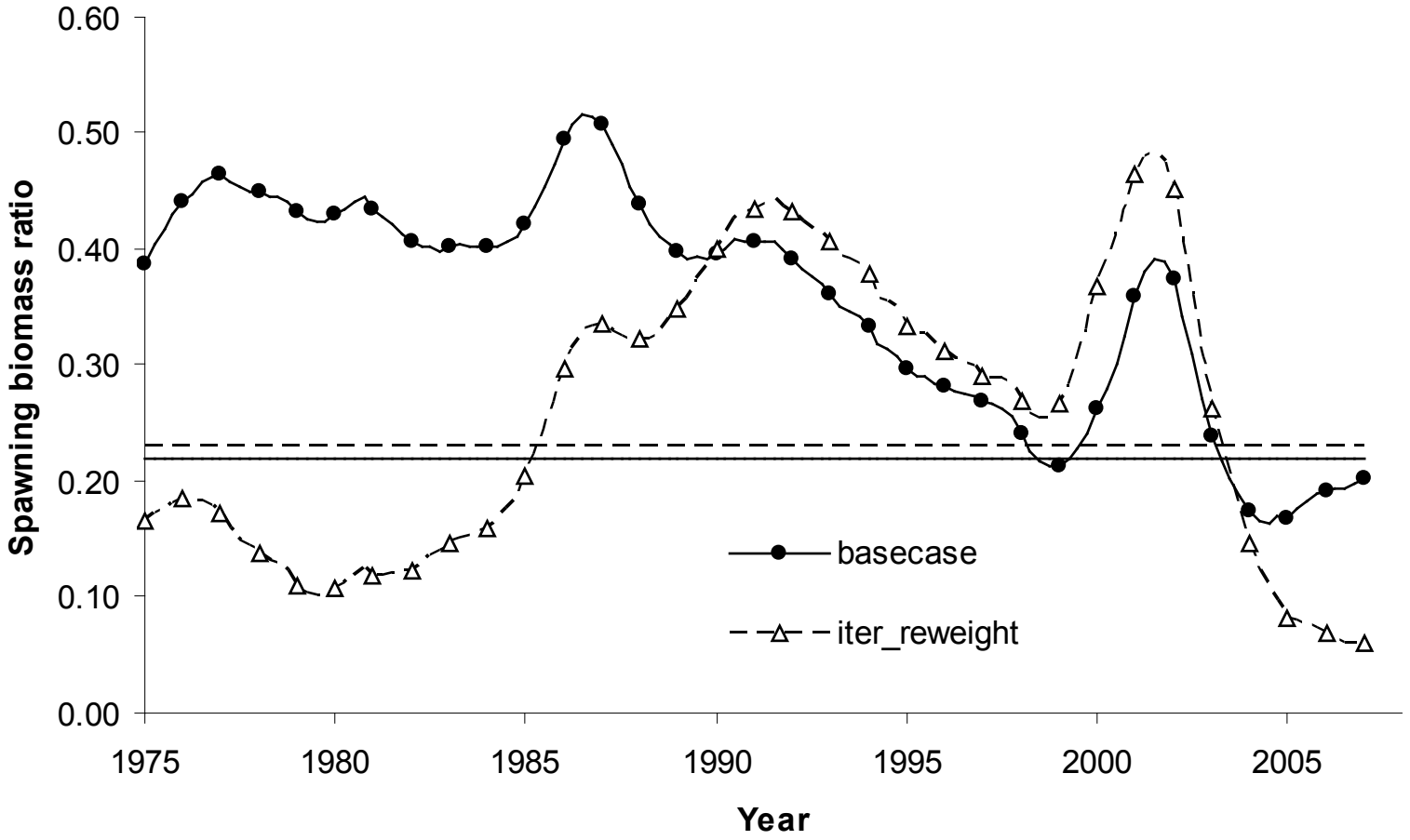


Use of iterative reweighting

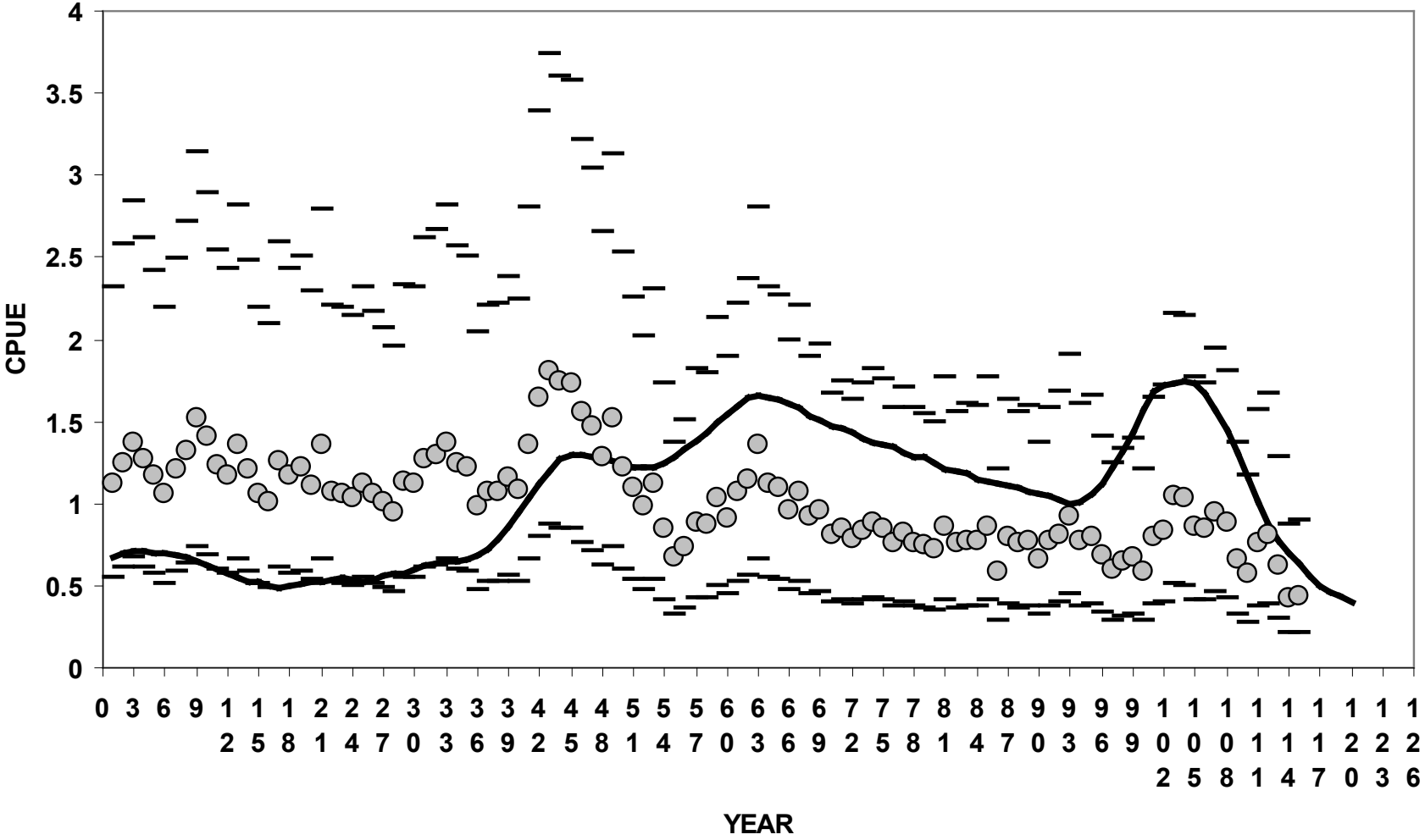
Iterative reweighting

		Basecase	Iteration 1 used	Iteration 2 used	Iteration 2 mse
Rec		0.60	0.50	0.63	0.68
Mean input SE					
CPUE					
	2	0.40	0.38	0.41	0.44
	3	0.40	0.67	0.73	0.76
	5	0.40	0.67	0.76	0.80
	8	0.40	0.52	0.59	0.66
	9	0.20	0.16	0.36	0.54
Mean effective sample size					
LF					
	1	3.77	21.75	21.86	19.82
	2	15.02	73.04	74.78	74.33
	3	13.58	67.41	64.30	62.51
	4	1.88	7.28	7.05	7.43
	5	9.89	52.89	56.95	57.47
	6	6.45	30.25	31.62	31.63
	7	2.91	15.26	15.66	15.51
	8	4.22	63.96	72.83	73.66
	9	14.64	222.61	255.92	258.21

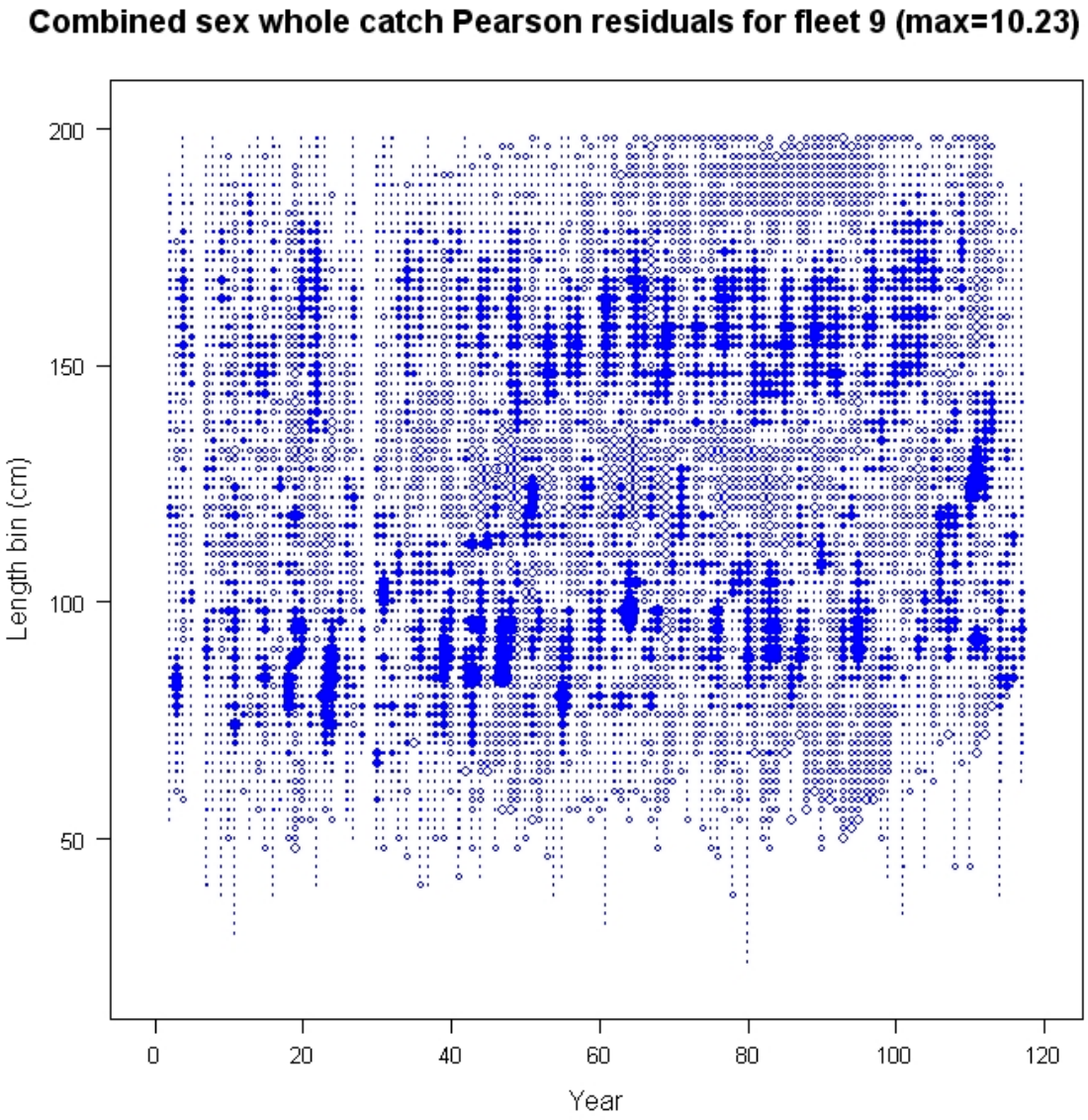
Spawning biomass ratio



Fit to CPUE data

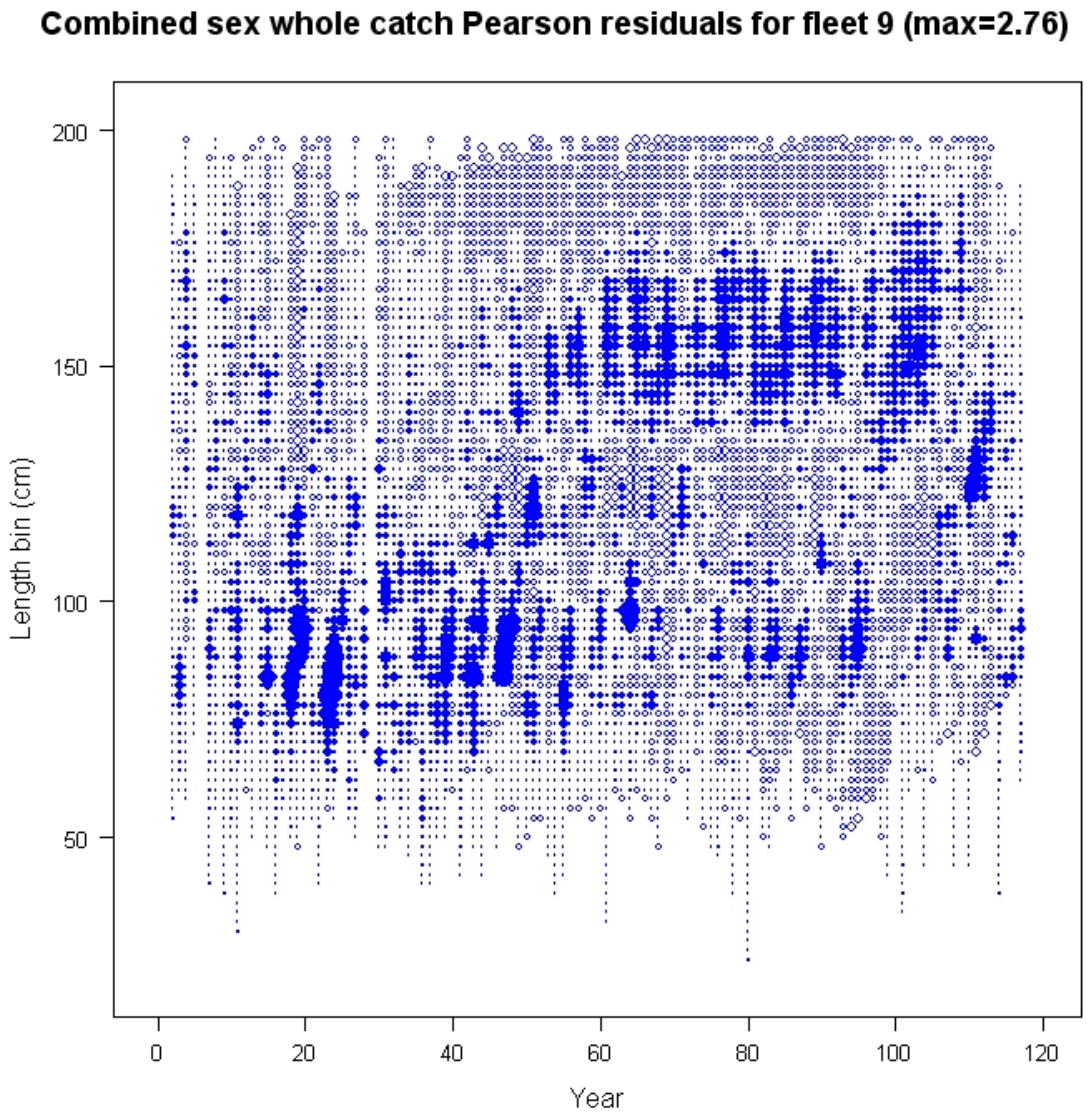


Residual plot

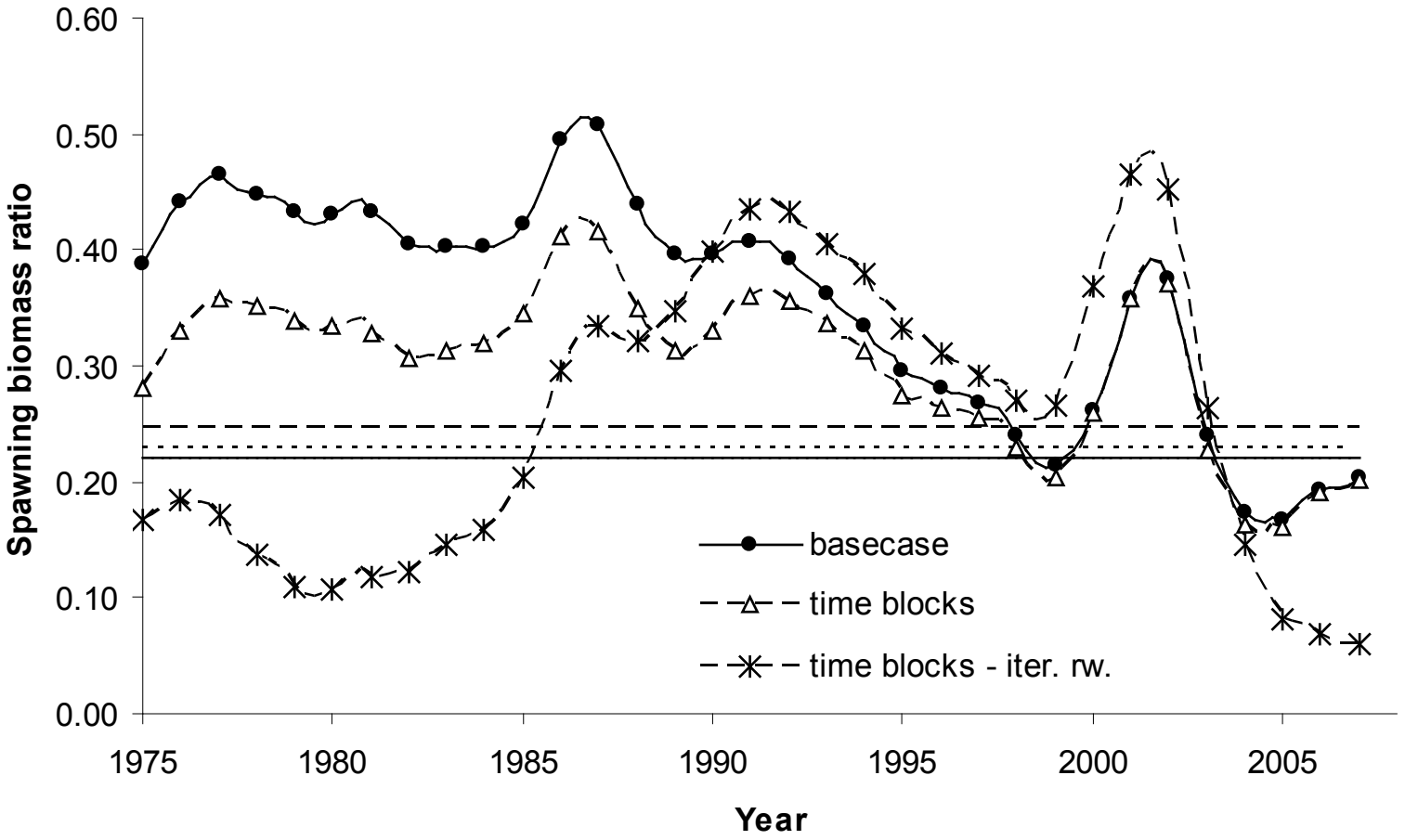


Use two time blocks for selectivity and catchability of the southern longline fishery

Fit to LF data – base case

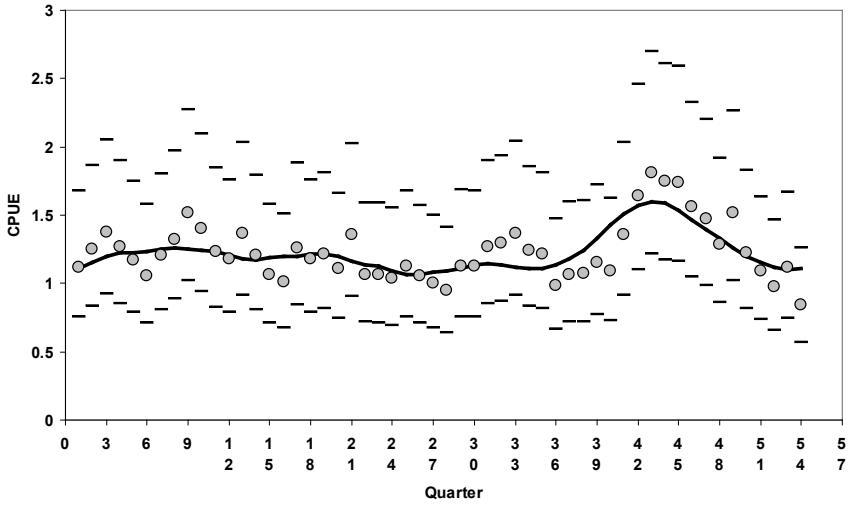


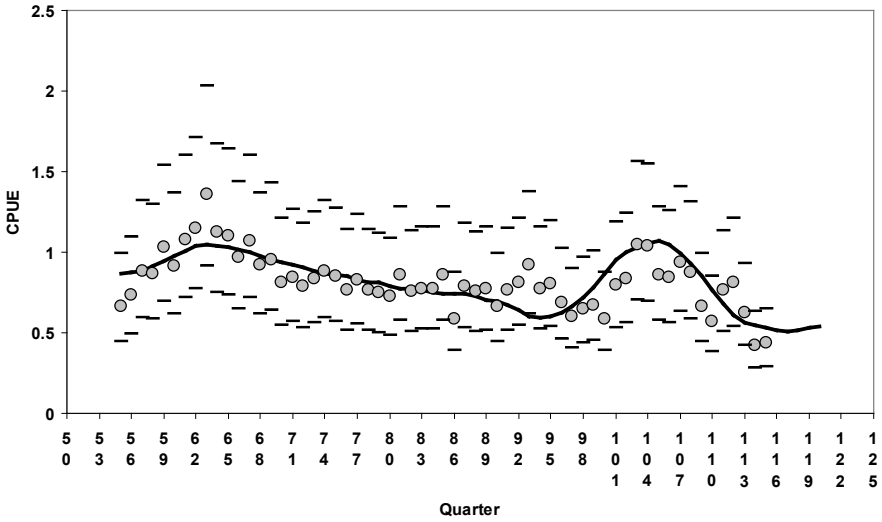
Spawning biomass ratio



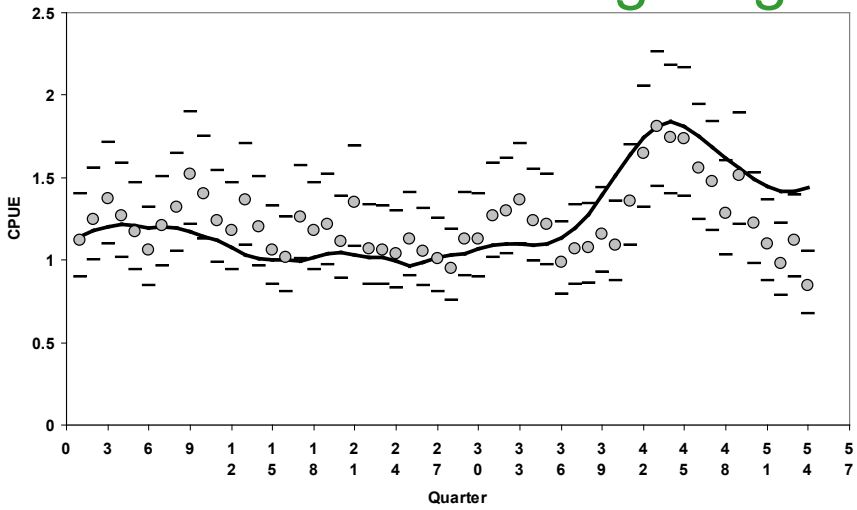
Fit to CPUE data

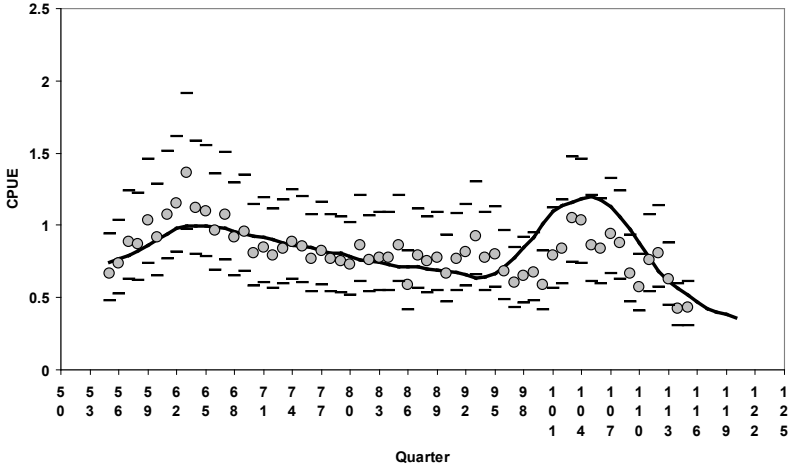
Without iterative reweighting



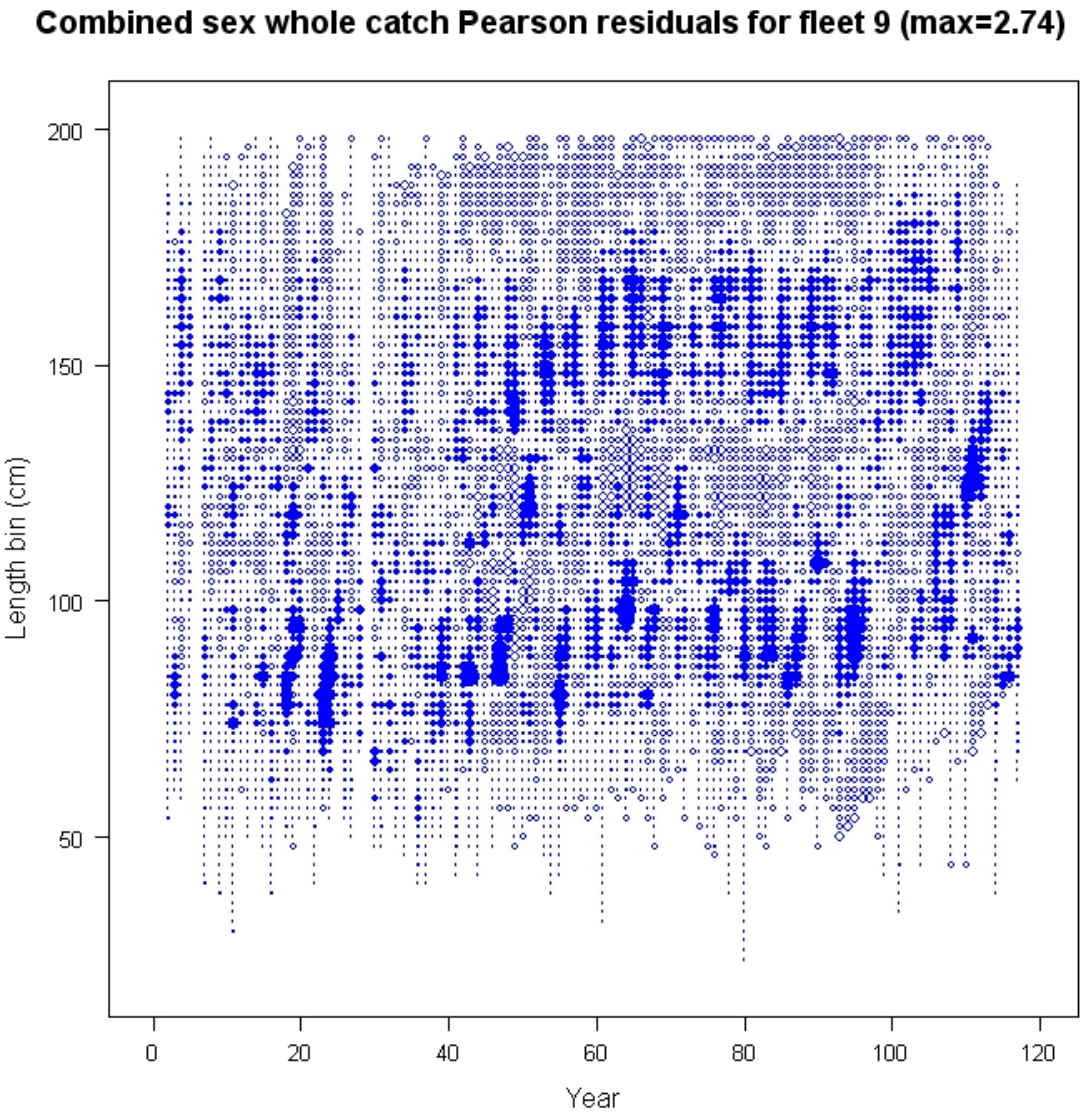


With iterative reweighting



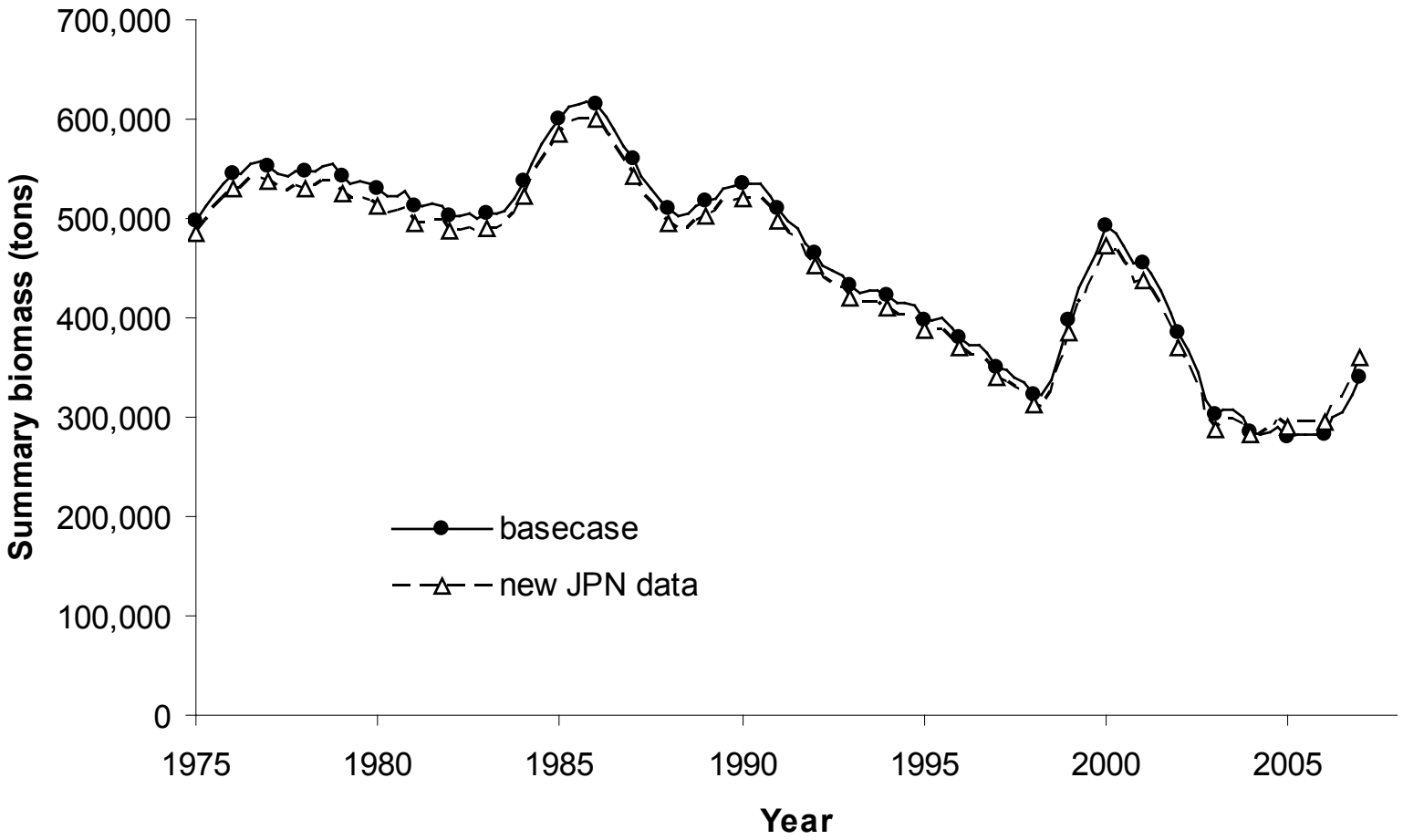


Residual plot

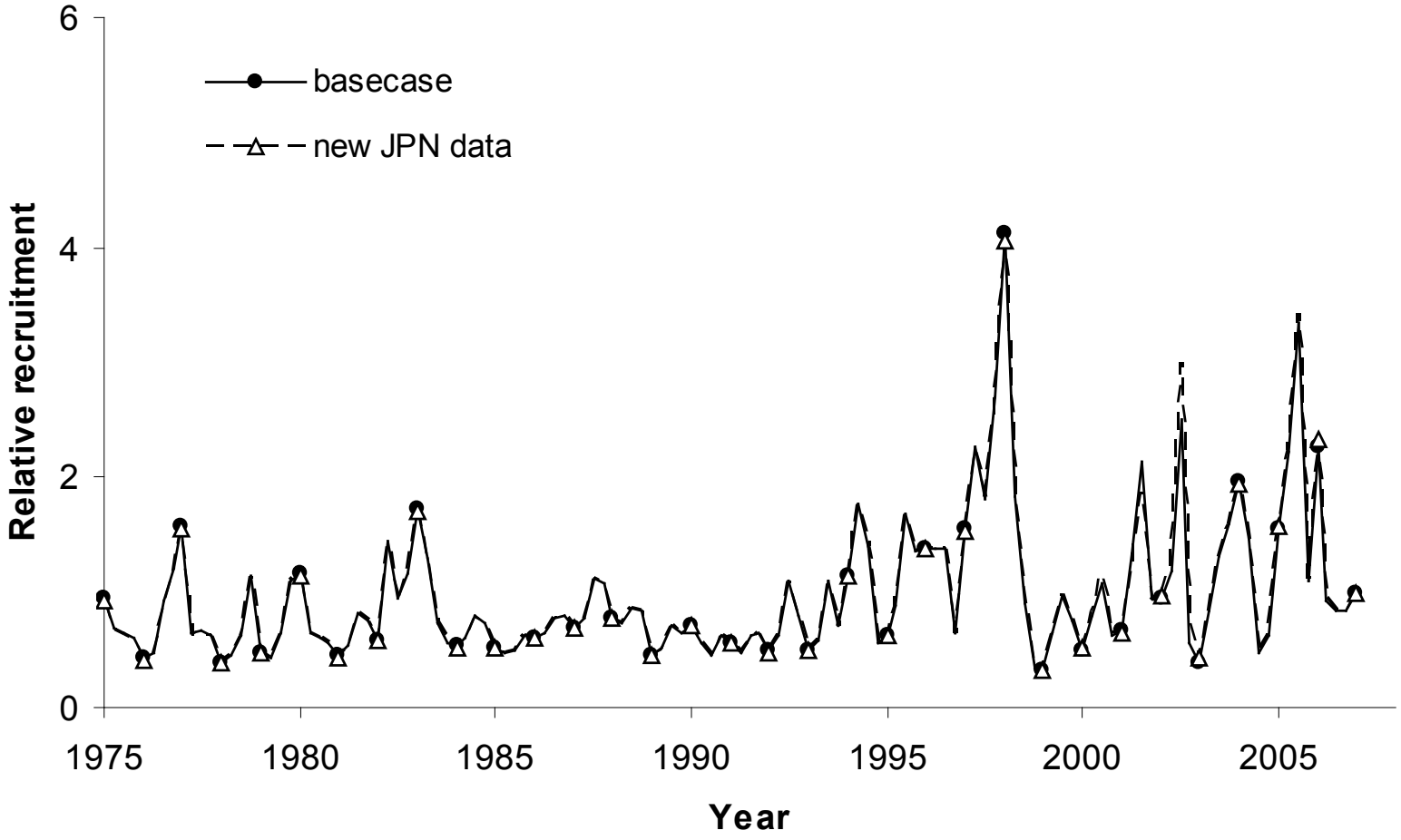


Inclusion of the new Japanese longline data

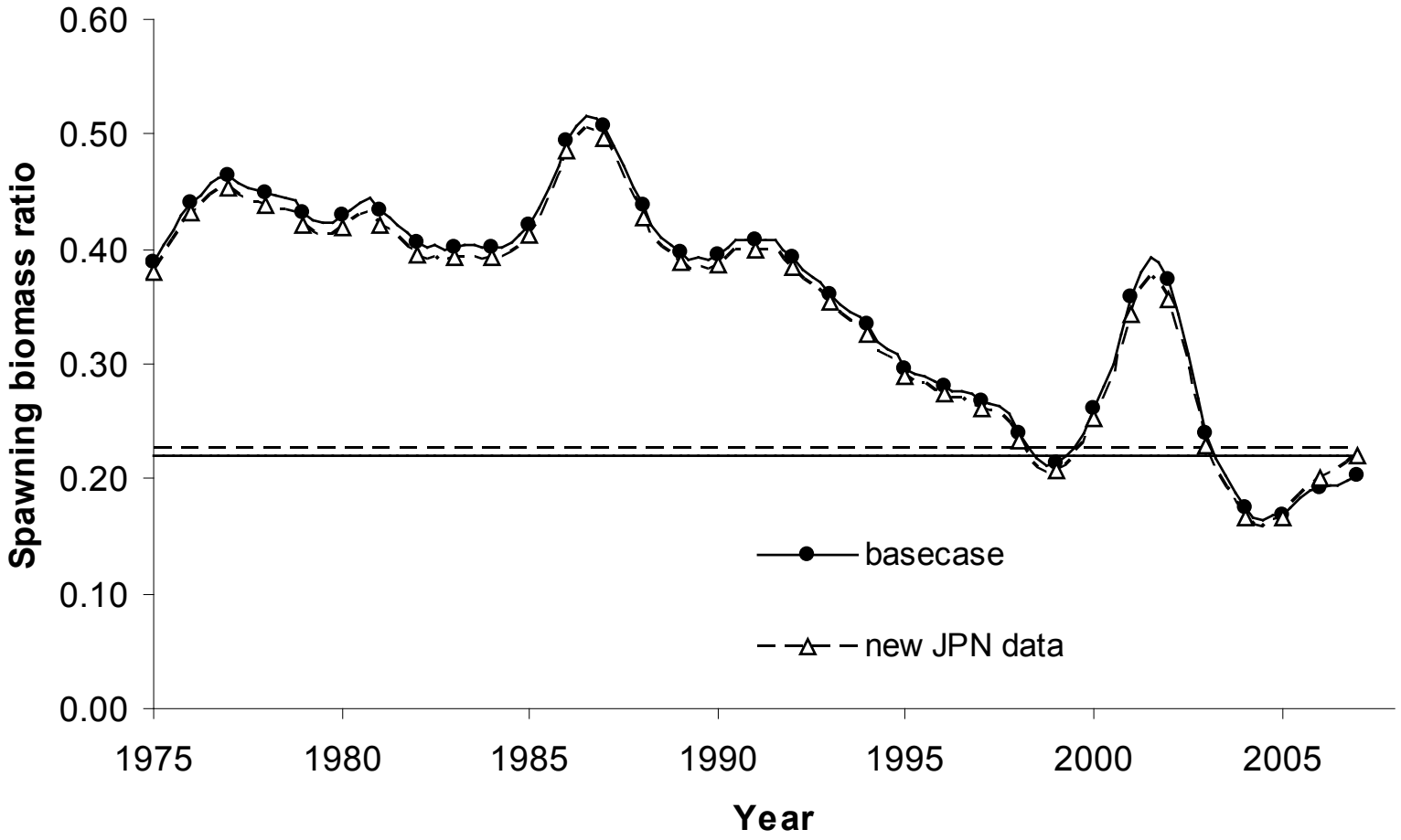
Biomass


700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Summary biomass (tons)
1975
1980
1985
1990
1995
2000
2005
Year
basecase
new JPN data

Recruitment



SBR


0.60
0.50
0.40
0.30
0.20
0.10
0.00
Spawning biomass ratio
1975
1980
1985
1990
1995
2000
2005
Year
basecase
new JPN data

Comparisons between models

	Smsy/S0	Srecent/Smsy	Fmultiplier
Basecase	0.22	0.90	0.77
h = 0.75	0.31	0.61	0.55
cpue9	0.22	0.50	0.61
growth est.	0.21	1.19	0.98
Lmax = 171.5	0.21	1.58	1.34
Lmax = 201.5	0.22	0.60	0.57
iter. rwt	0.23	0.26	0.79
t. blocks	0.25	0.82	1.11
t. blocks (iter. rwt)	0.23	0.26	0.79

Summary: Main results

- Both total and spawning biomass is estimated to have substantially declined since 2000
- Current biomass level is low compared to average unexploited conditions
- The current effort levels are too high to maintain the population at level that will support AMSY
- Yileds could be increased if more of the catch was taken in the longline fisheries

What is robust

- Fishing mortality levels are greater than that necessary to achieve the maximum sustainable yield
- Two exceptions: Lmax fixed and time blocks

Plausible Sensitivities and Uncertainties

- Results are more pessimistic with the inclusion of a stock-recruitment relationship
- Biomass trends are sensitive to the weighting of different datasets
- Recent estimates are uncertain and subject to retrospective bias

Conclusions

- Current spawning biomass is unlikely to remain at or above the level required to produce AMSY.
- In the most recent years the fishing mortality is greater than that required to produce AMSY.
- Under average recruitment, the stock is predicted to be below the level that would support AMSY unless fishing mortality levels are reduced further than the current restrictions.

Comparisons between models

Data	Basecase	h = 0.75	cpue 9	Growth estimation			Fit init. catch	Iter. reweight	t. blocks	t_blocks (iter. rw)
				All params	Lmax = 171.5	Lmax = 201.5				
CPUE										
2	-20.72	-20.59	-	-20.16	-19.04	-22.13	-20.24	-13.60	-20.79	-16.8392
3	23.61	23.53	-	23.87	25.01	22.41	23.86	10.76	23.69	8.9456
5	21.41	21.82	-	22.56	23.83	18.99	22.93	12.56	21.20	10.7926
8	-5.60	-5.83	-	-7.15	-6.49	-7.42	-5.22	9.95	-5.15	0.0755354
9	-153.53	-154.17	-138.23	-156.17	-156.97	-151.35	-154.22	14.02	-160.81	-107.21
Size comps.										
1	166.84	166.73	166.11	165.71	165.29	167.37	166.79	984.33	166.70	958.902
2	195.64	196.72	186.15	205.48	211.91	196.34	196.88	962.80	197.08	945.143
3	246.40	246.55	236.11	251.42	258.01	243.94	246.64	1229.45	245.82	1277.03
4	70.93	75.51	73.64	72.02	70.70	70.10	71.93	268.08	75.36	256.279
5	136.75	137.08	129.47	144.17	148.92	136.10	137.49	724.54	137.23	688.79
6	132.05	132.21	131.48	133.66	134.39	132.97	130.95	655.15	131.98	621.809
7	129.59	129.00	128.32	129.50	122.77	136.08	128.03	714.51	129.65	713.554
8	124.17	123.89	123.66	119.90	119.22	123.74	123.49	1631.91	123.36	1469.02
9	272.40	274.77	276.30	244.80	222.73	289.84	286.84	3695.10	236.49	3417.48
Age at length	-	-	-	103.72	112.73	81.44	-	-	-	-
Recruitment	-24.72	-20.69	-26.70	-30.02	-32.91	-19.84	-21.23	17.30	-20.16	18.9462
Total	**1315.22**	**1326.52**	**1286.32**	**1403.29**	**1400.07**	**1418.58**	**1334.92**	**10916.86**	**1281.65**	**10262.72**