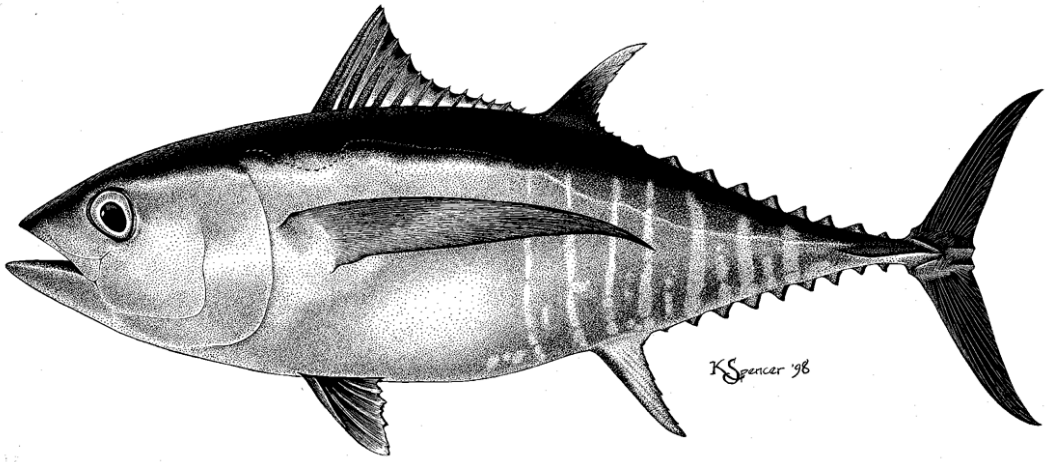
STATUS OF BIGEYE TUNA IN THE EASTERN PACIFIC OCEAN IN 2012

January 1975 – December 2012



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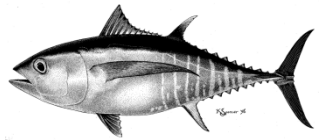
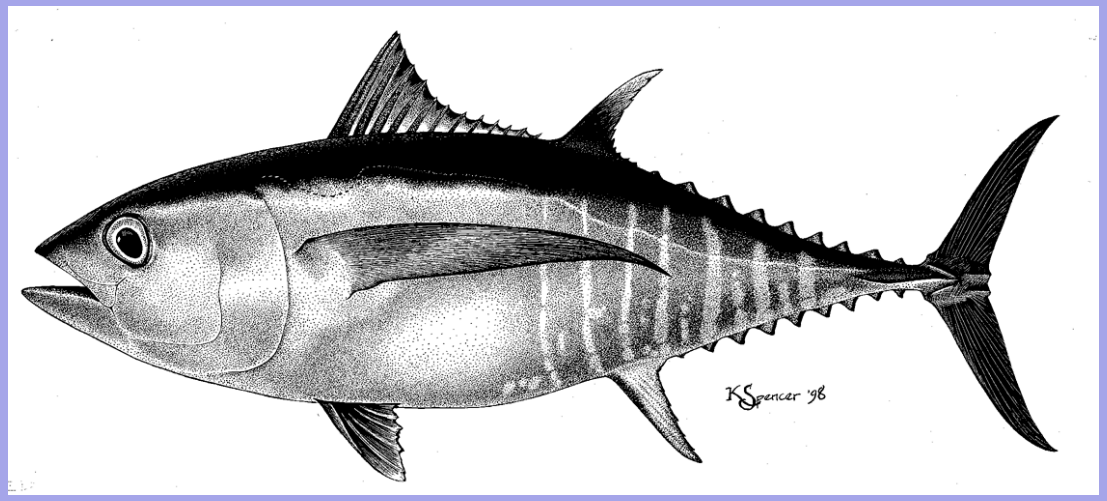
Outline



- Stock assessment (base case model)
  - Fishery data updates
  - Model assumptions (biology, data weighting)
  - Results (fishing mortality, recruitment, biomasses)
  - Stock status (base case)
  - Population projections (*status quo*, $F_{MSY,}$ and effect of resolutions)
  - Retrospective analysis
  - Comparison to previous assessment
- Sensitivity analyses
- Conclusions

Overview of assessment model

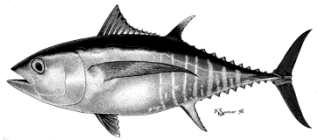
- Age-structured, statistical, catch-at- length model (Stock Synthesis – Version 3)
- Integrated analysis
- Same type of model as MULTIFAN-CL, A-SCALA and CASAL



Fishery data

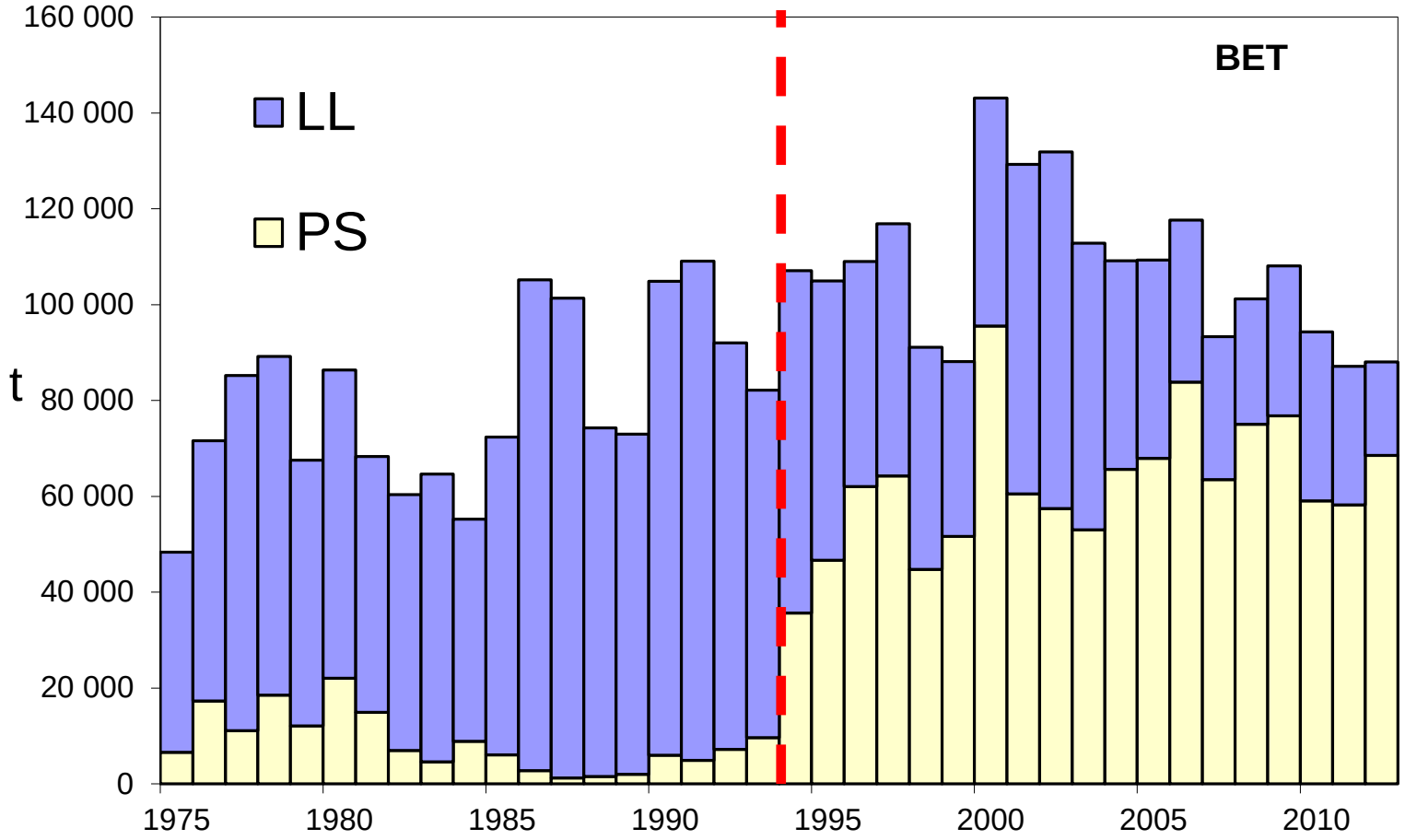
- Catches
- Fishery definitions
- Discards
- Fishing effort
- Catch-per-unit-effort (CPUE)
- Size compositions

New or updated data



- Surface fisheries
  - Catch, CPUE and size-frequency data updated to include new data for 2012 and revised data for earlier years
- Longline fisheries
  - New or updated longline catch data: China (2009 and 2011), Chinese Taipei (2009-2011), Japan (2009-2011), Korea (2011), US (2010-2011), and Vanuatu (2005-2011)
  - 2012 longline catch data available from monthly reports: China, Chinese Taipei, Japan, Korea and Vanuatu
  - New or updated CPUE data available for Japan (2009-2011)
  - New or updated longline size-frequency for Japan (2006-2011)

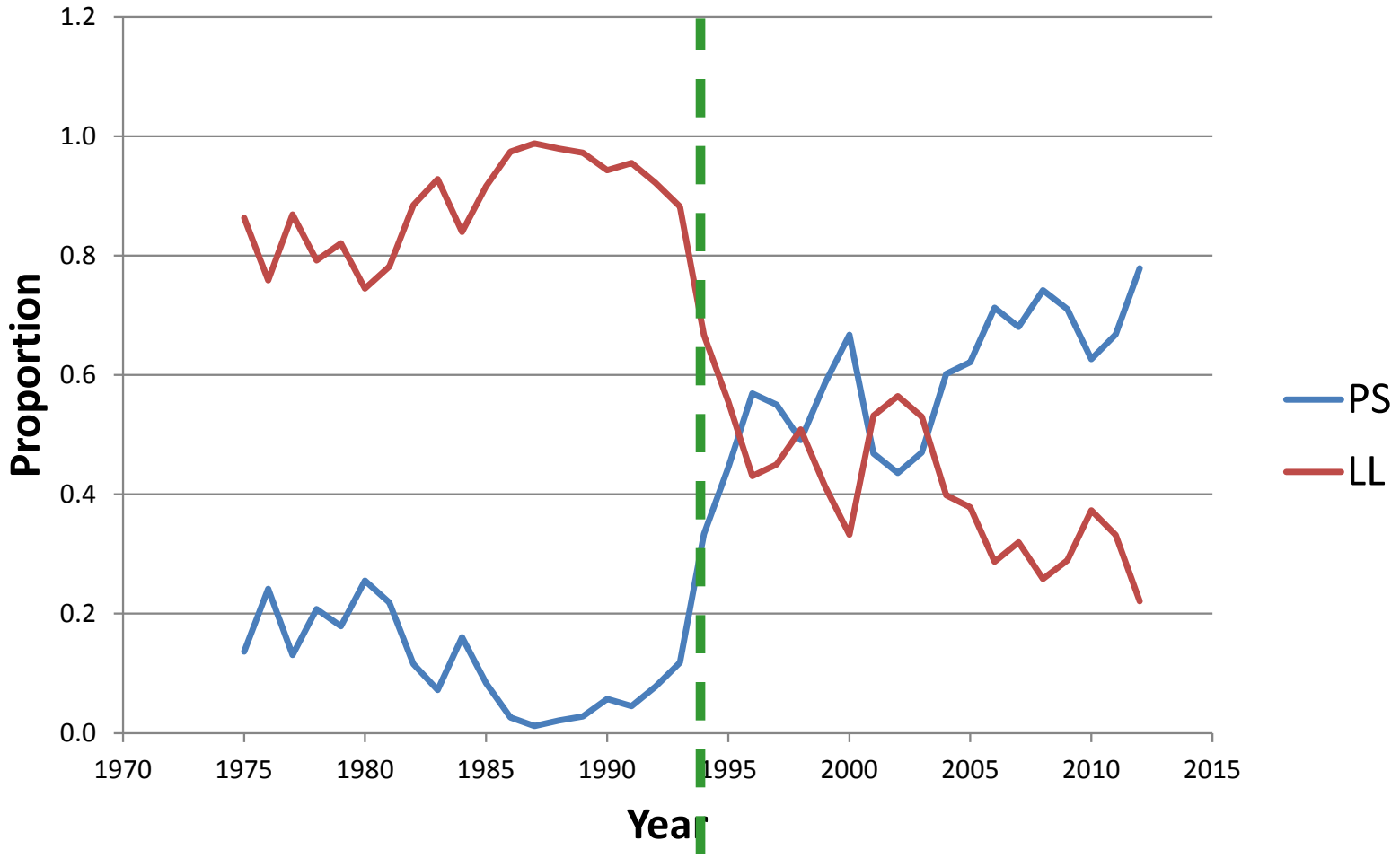
Total catches



Expansion of FAD fishery

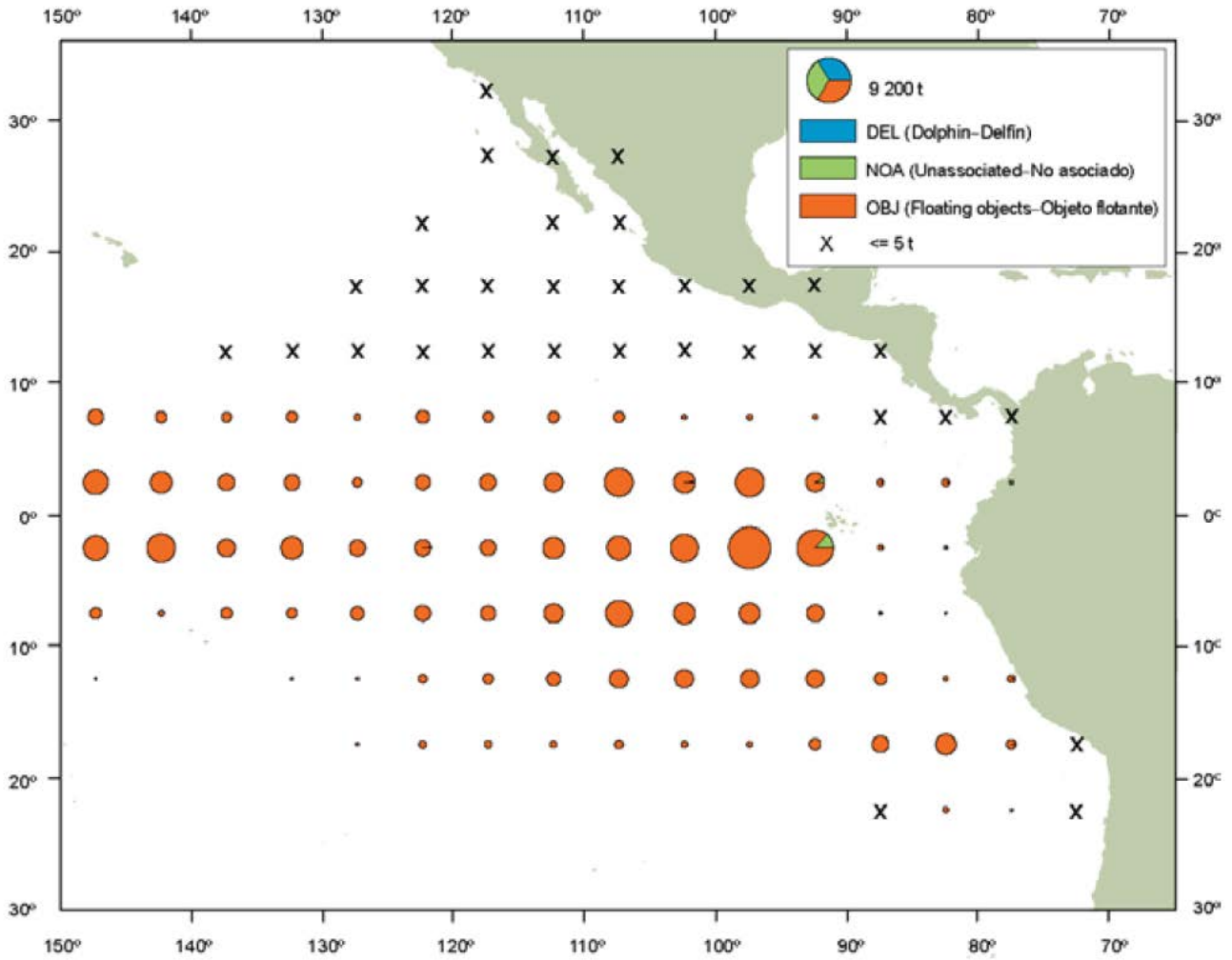
Fishery data

Catch proportions by fishery



Expansion of FAD fishery

Spatial distribution of PS catches



Annual distribution of BET PS catches, 2012

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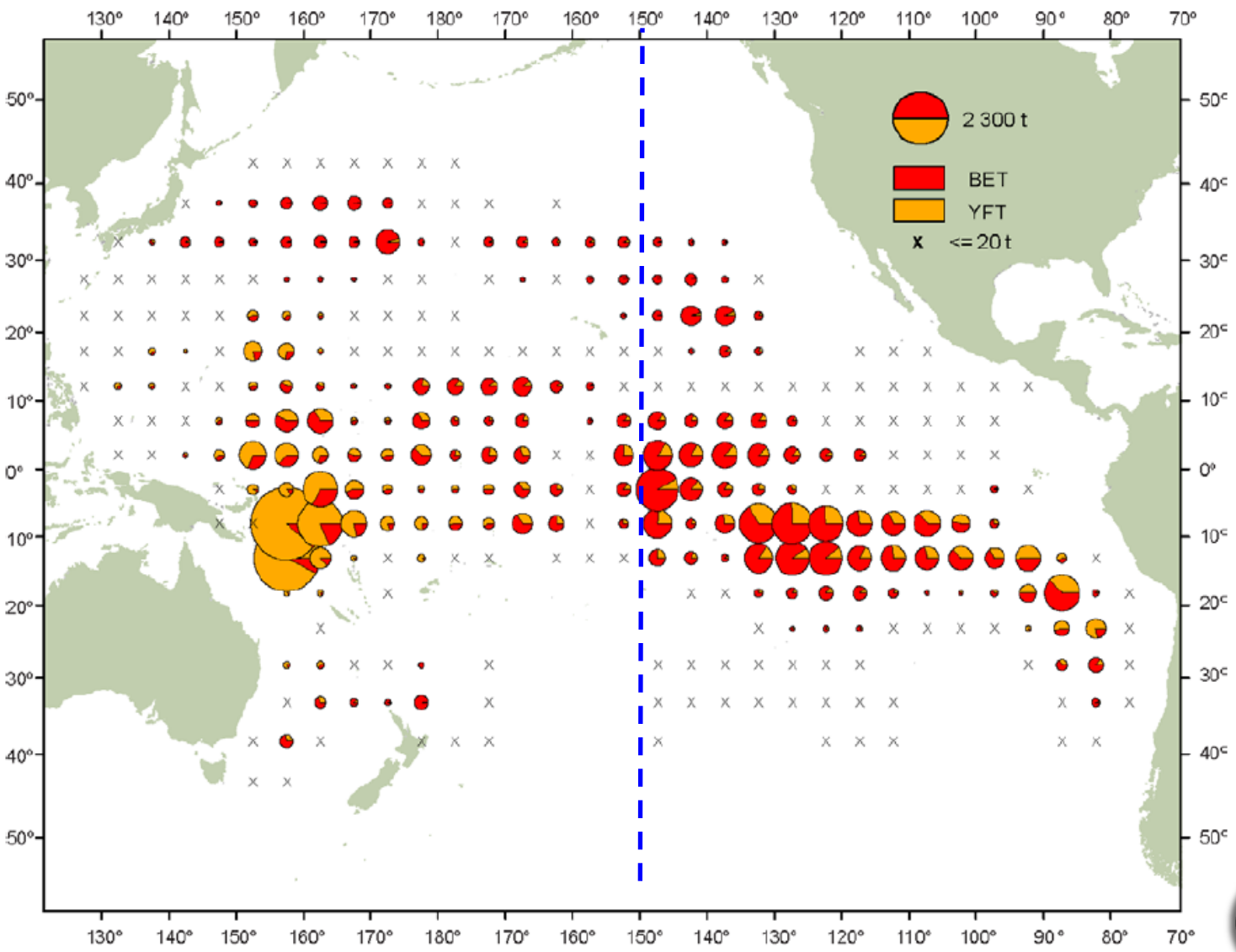
Spatial distribution of LL catches



Average annual LL catch, 2004-2008

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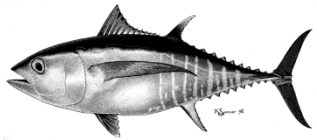
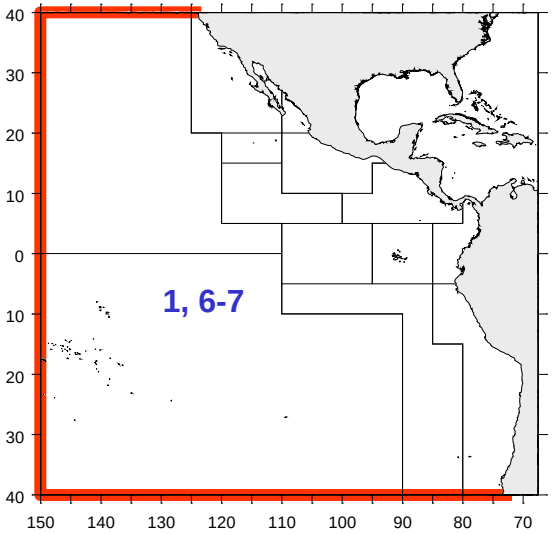
BET fishery definitions

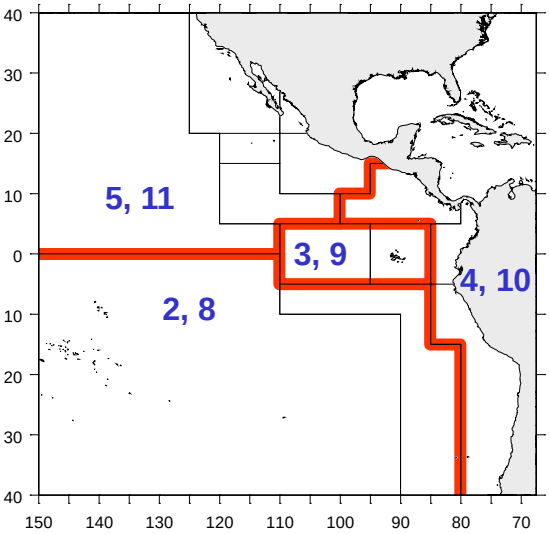


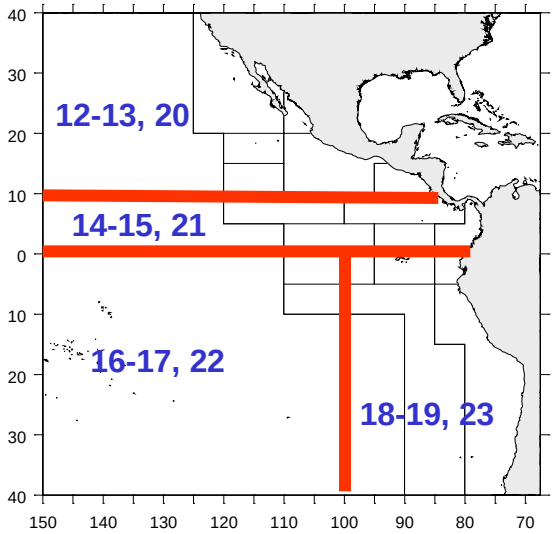
Early OBJ (1)
Early & Late DEL&NOA (6, 7)

Recent OBJ (2-5)
Discards (8-11)

Early/Late LL N (12-13, 20)
Early/Late LL C (14-15, 21)
Early/Late LL S (16-17, 22)
Early/Late LL I (18-19, 23)







GEAR TYPE: PS, LP, LL

PS set type (OBJ, NOA and DOL)

Time period

The IATTC sampling areas

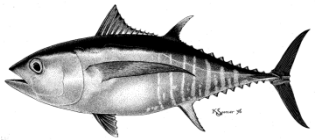
DEL – sets on dolphins

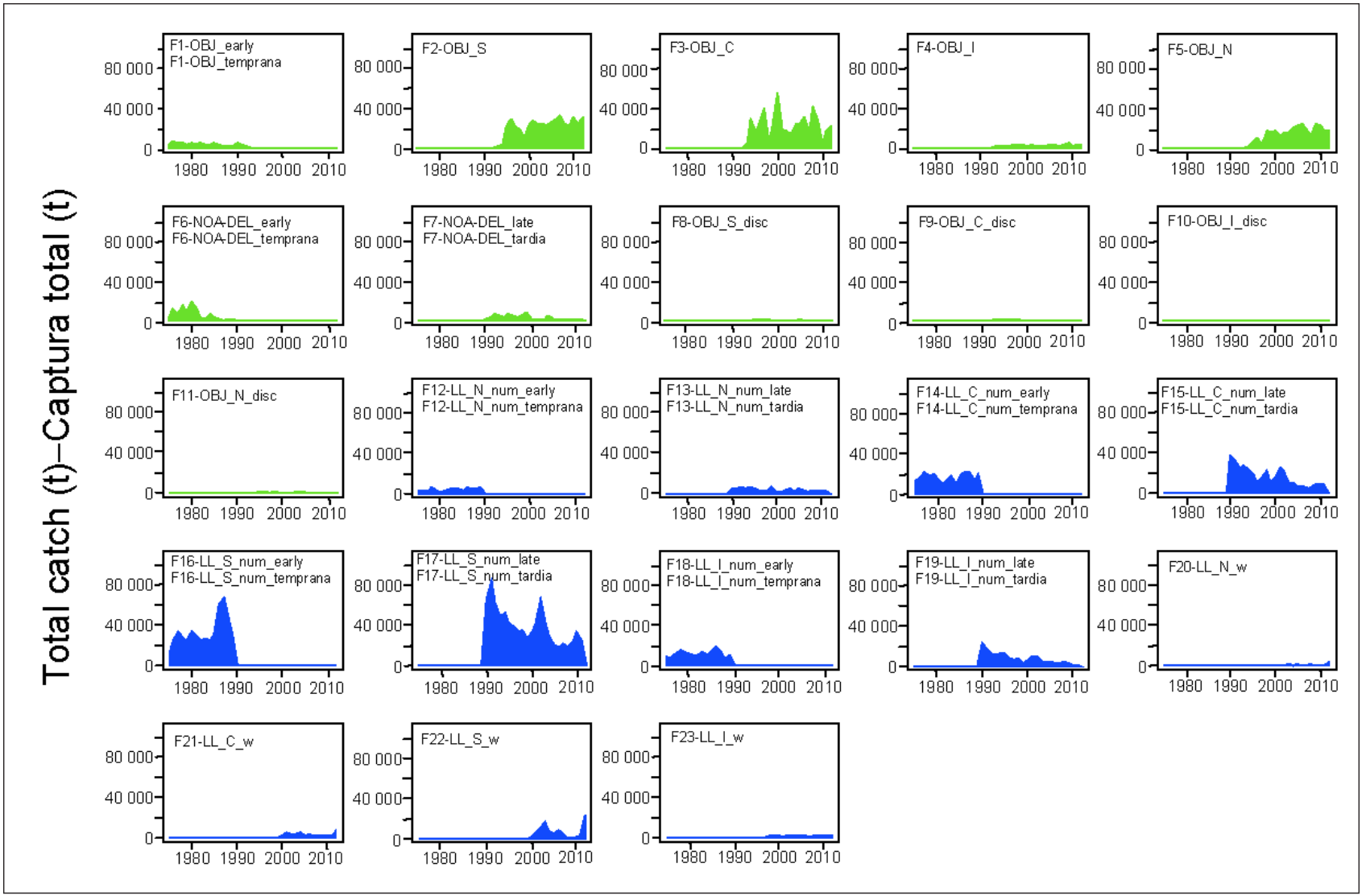
NOA – sets on unassociated fish

OBJ – sets on floating objects

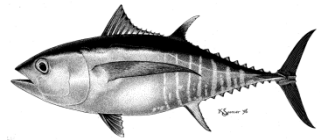
LL – longline sets

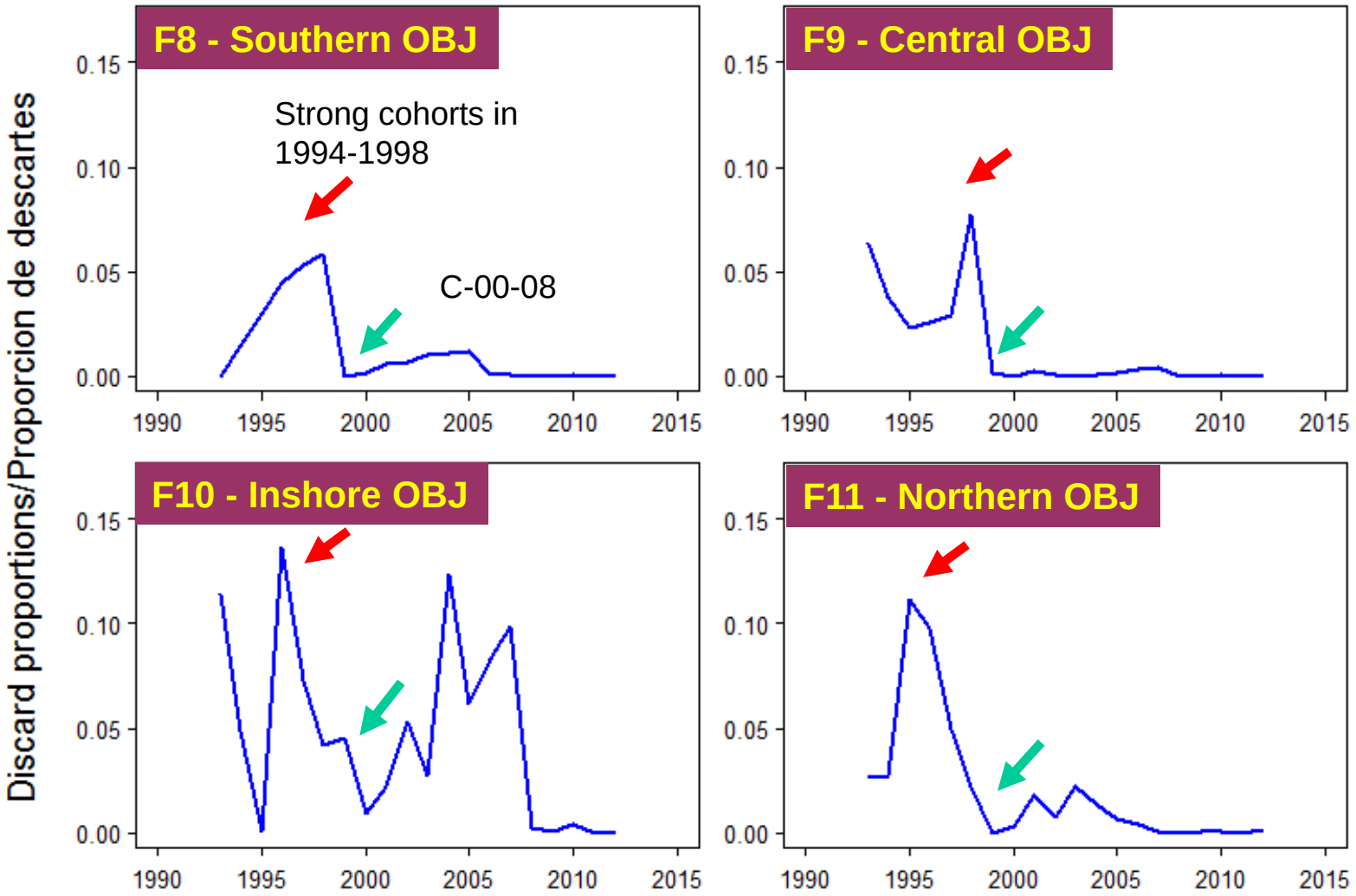
Annual catches by fishery



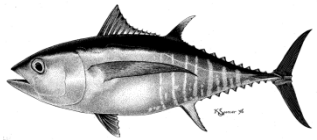


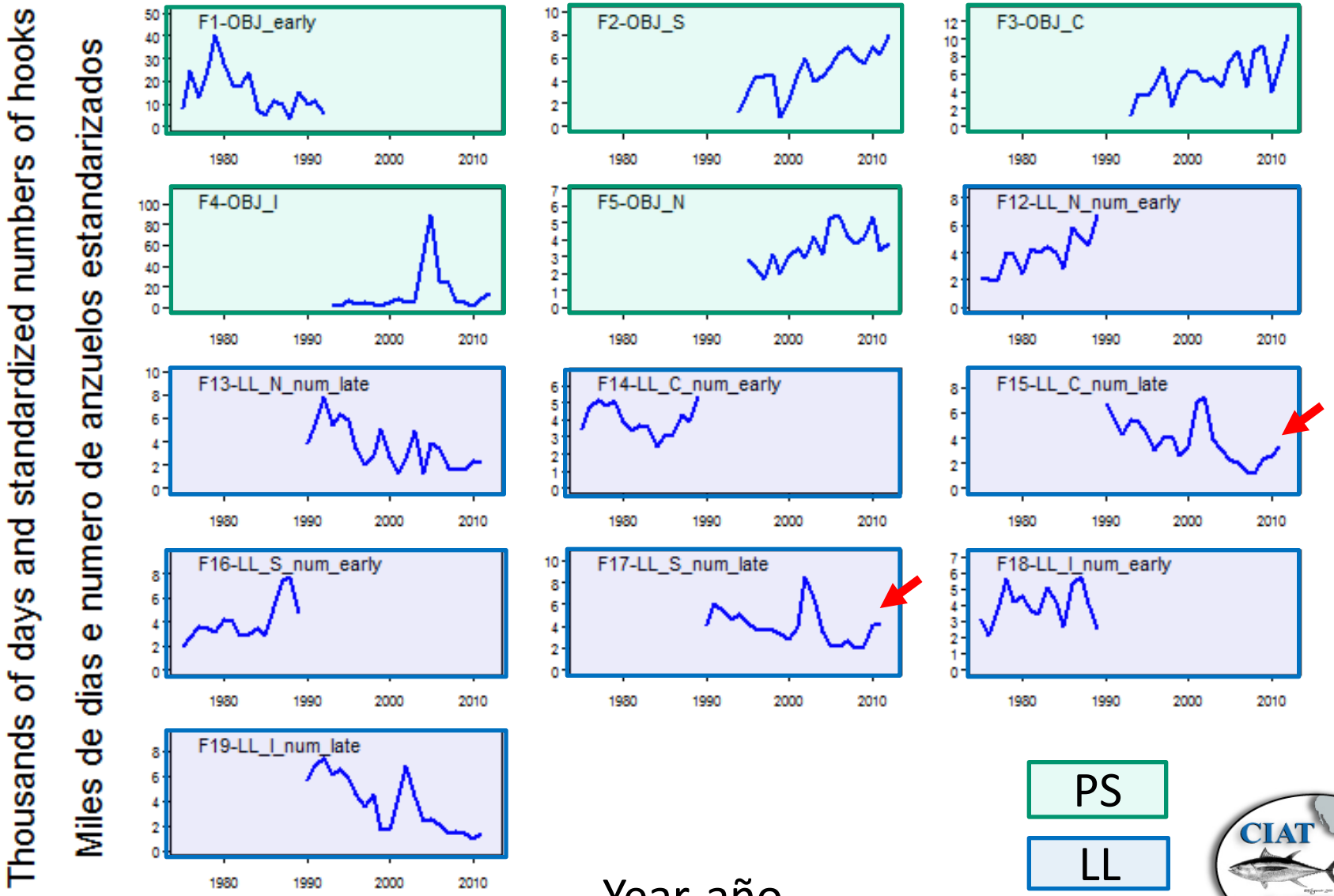
Discards



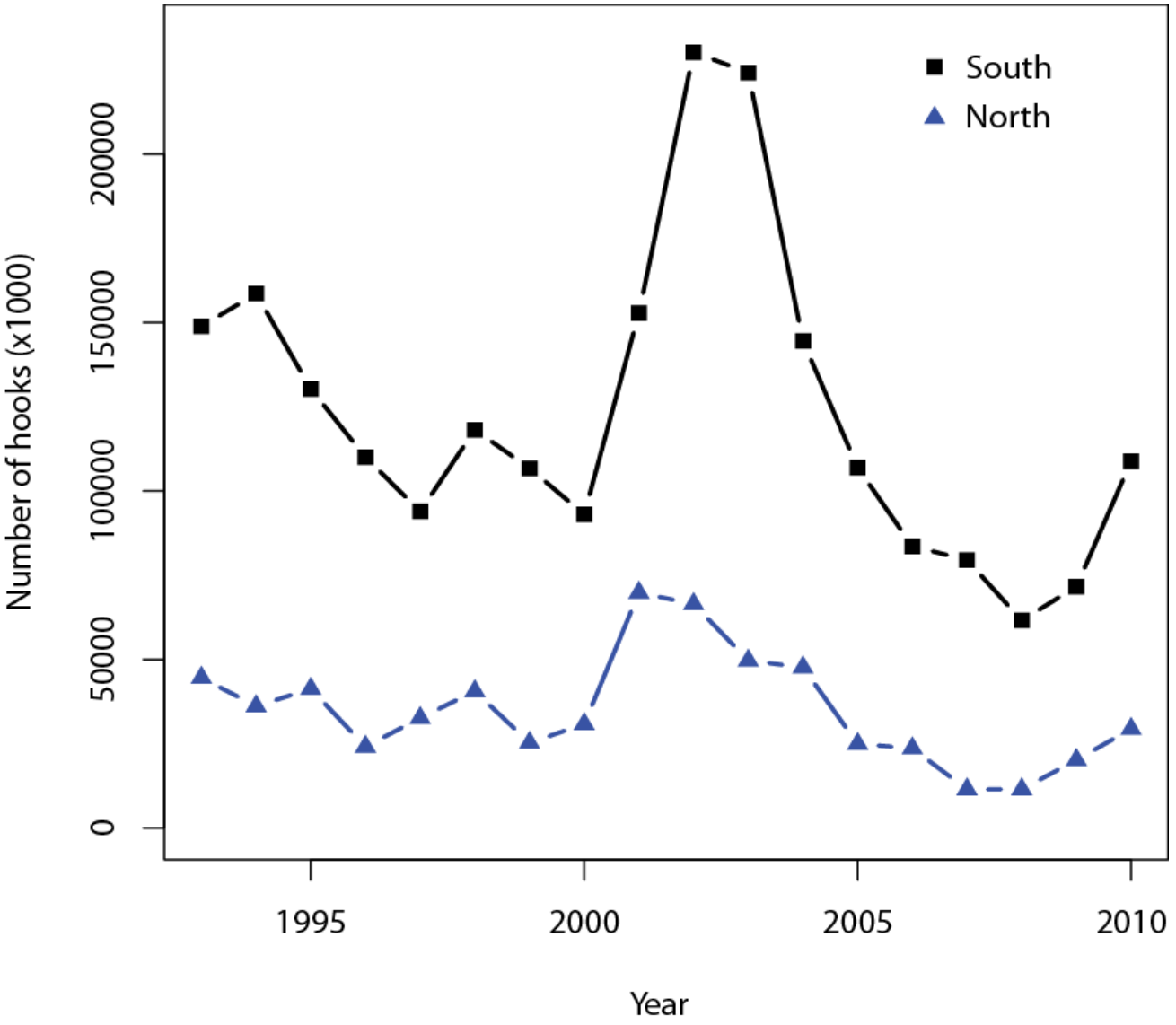

F8 - Southern OBJ
Strong cohorts in
1994-1998
C-00-08
F9 - Central OBJ
F10 - Inshore OBJ
F11 - Northern OBJ
Discard proportions/Proporcion de descartes
0.15
0.10
0.05
0.00
1990
1995
2000
2005
2010
2015
Year-año

Fishing effort

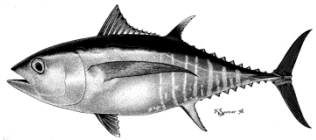


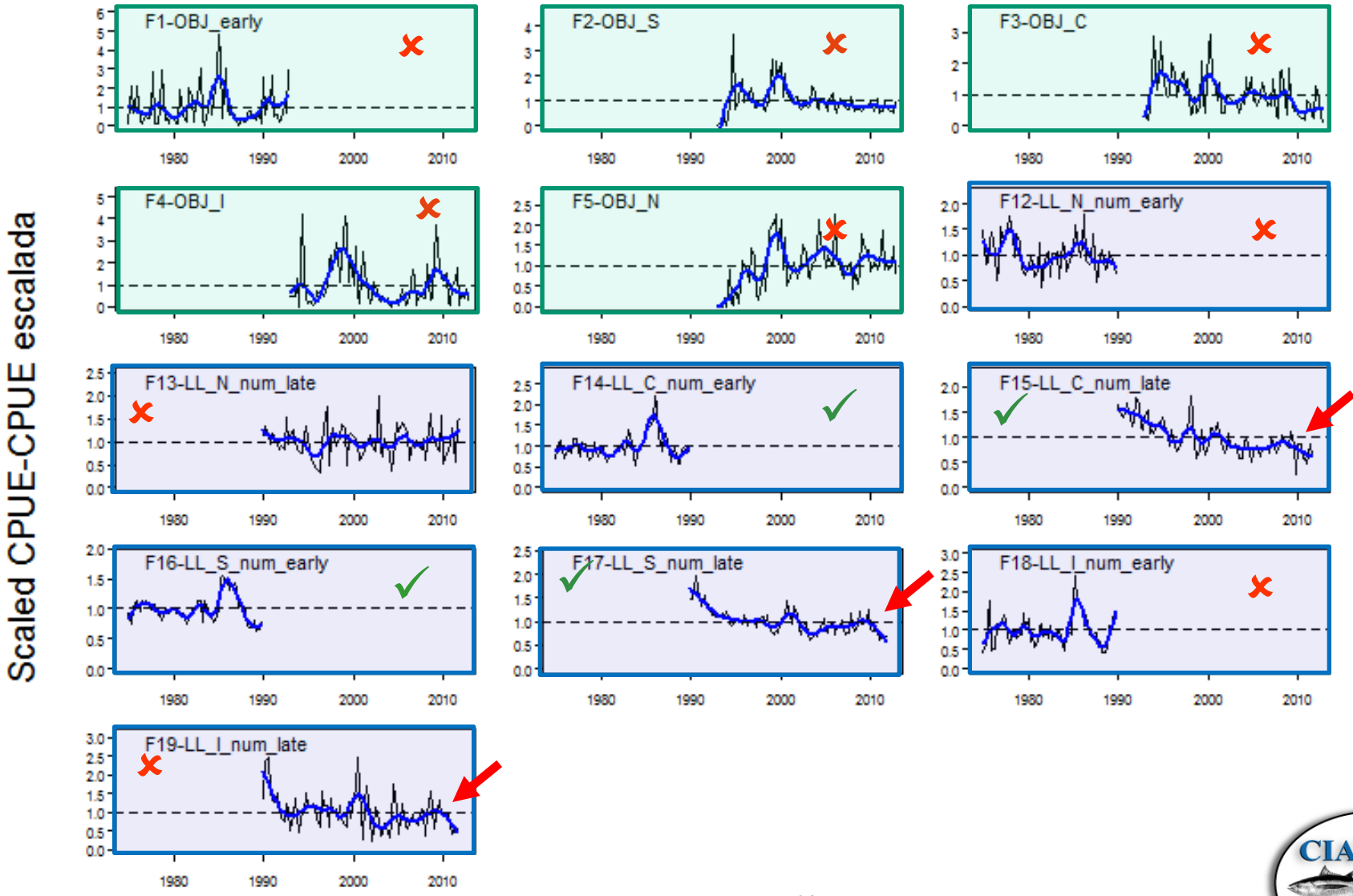


Nominal longline effort

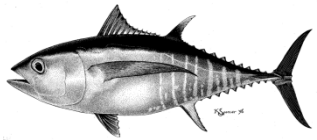


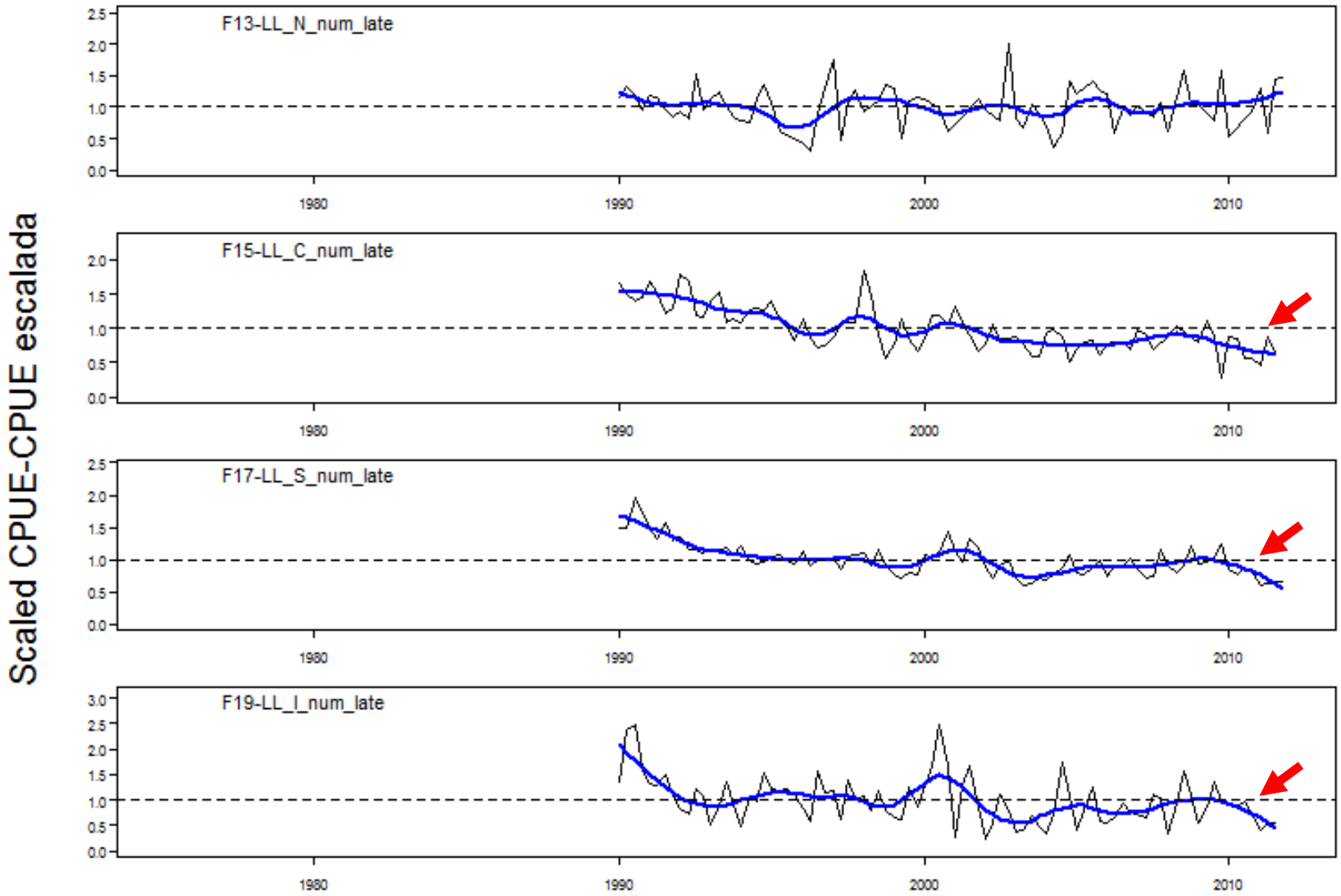
Catch-per-unit effort (CPUE)



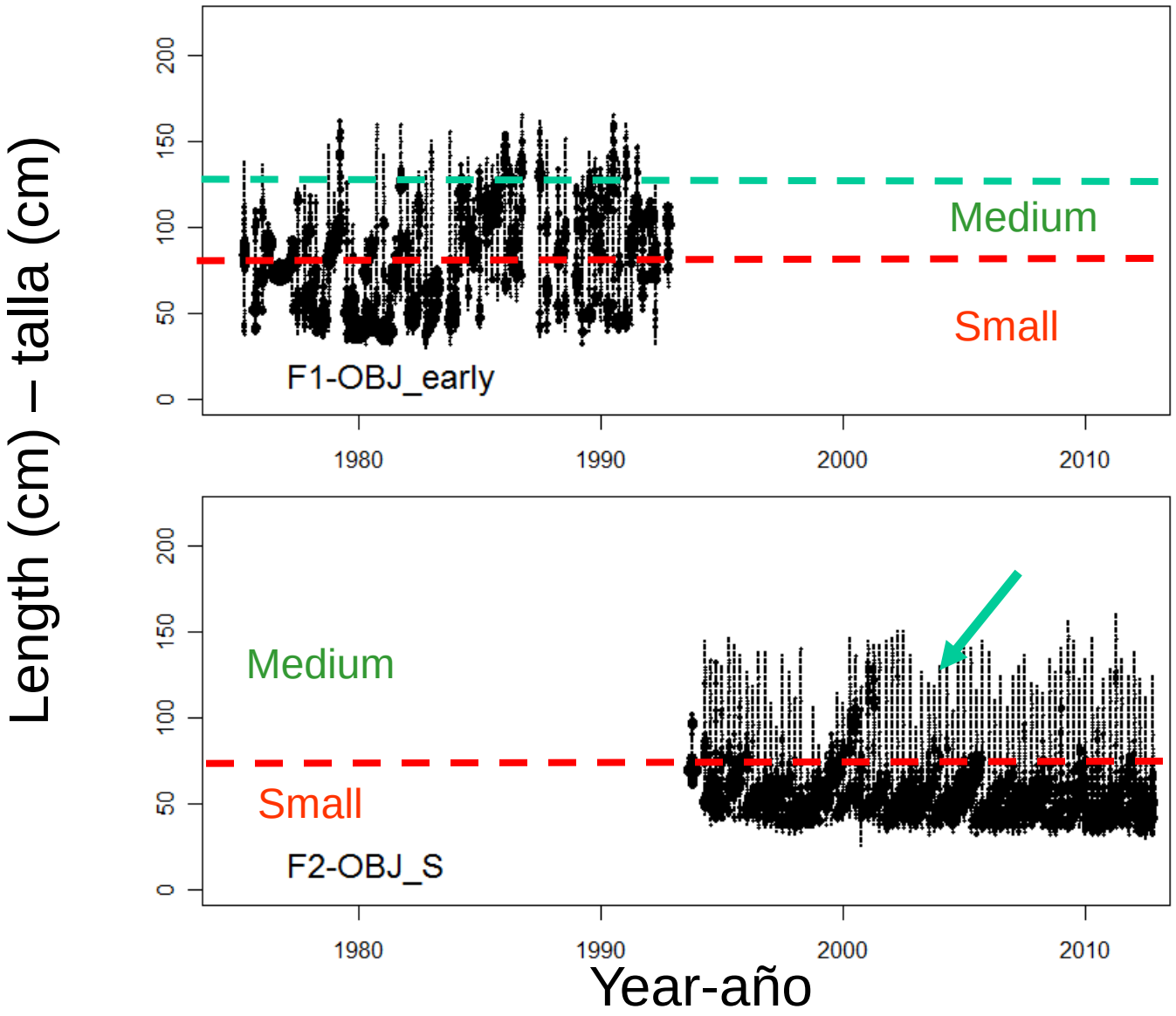


Longline standardized CPUE

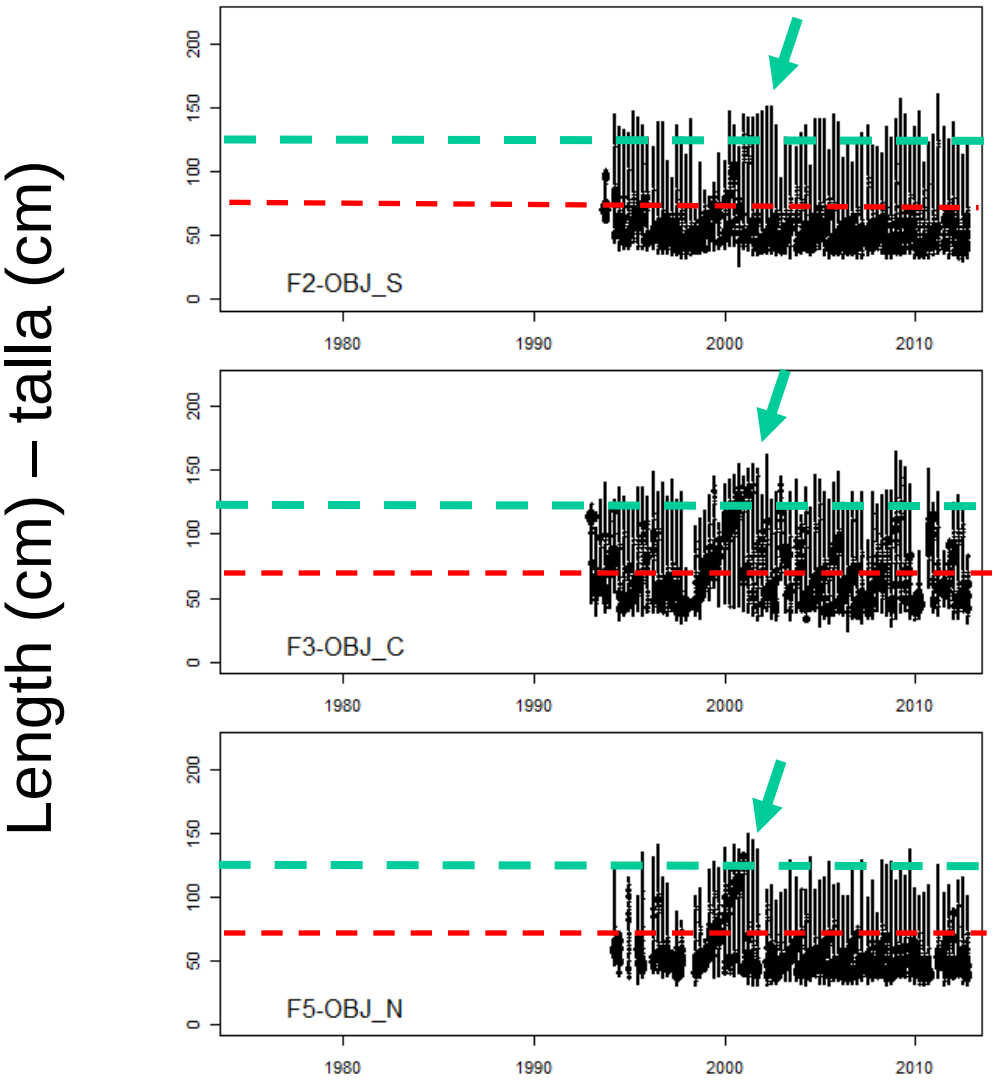




Length compositions – OBJ transition



Length compositions – OBJ fisheries

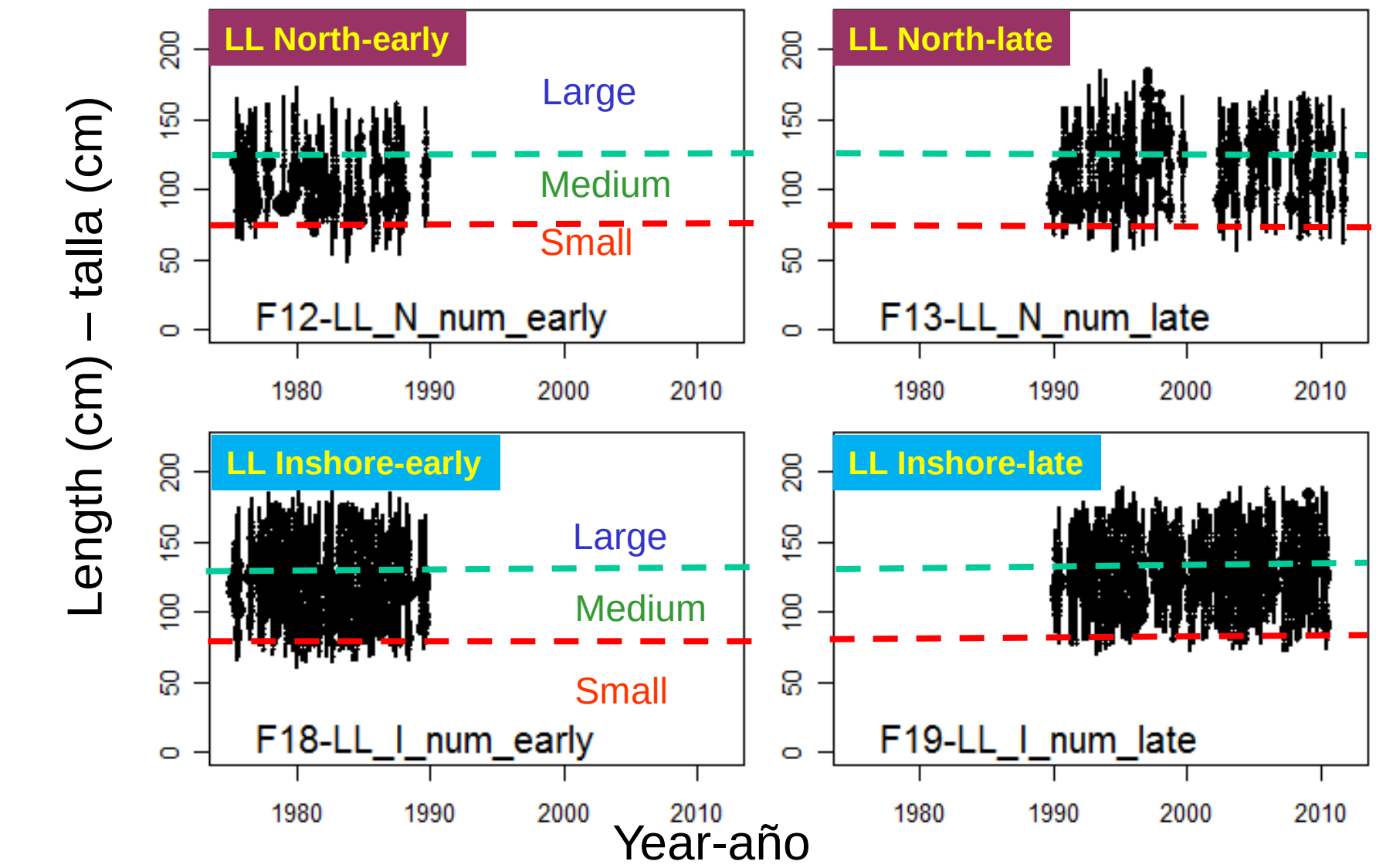


Medium

Small

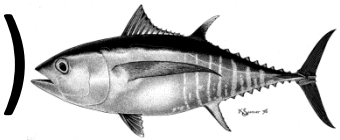
Fishery data

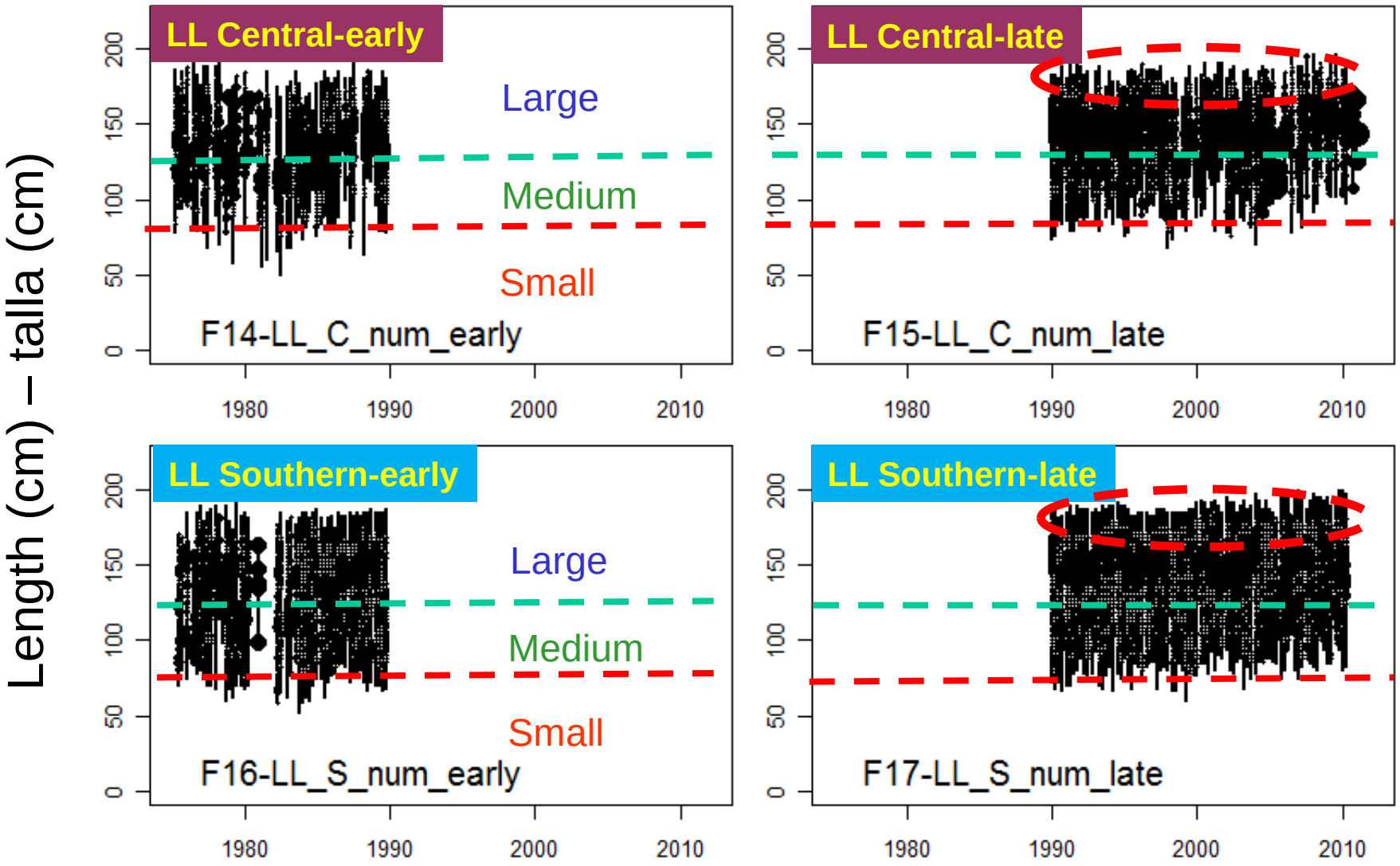
Length compositions – LL

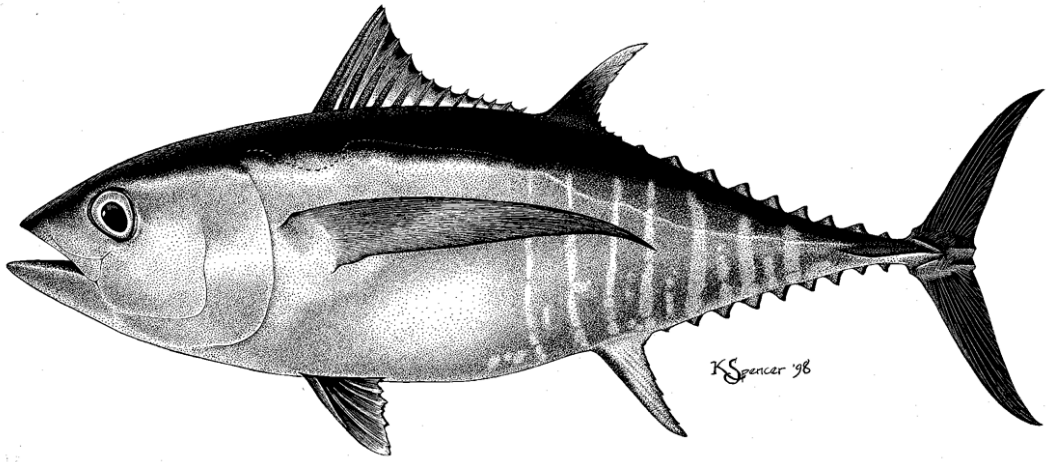


Fishery data

Length compositions – LL (cont.)



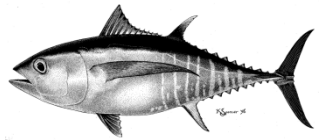




Model assumptions (base case)

- Stock structure
- Biology (growth, natural mortality and maturity)
- Stock-recruitment relationship (S-R)

Model assumptions



- Improved after External Review in May 2010 and recent diagnostics work (R_0 profile)
- Fishery definitions: 23 fisheries
- Data weighting:
  - Down-weighting size composition data of all fisheries
  - Fit to Central and Southern LL CPUE series (CV=0.15), no fit to purse seine CPUE
- Growth modeling: New growth curve estimated externally, L_2 and variance of length-at-age fixed
- Modeling of catchability and selectivity:
  - Two time blocks for all LL fisheries (split at 1990)
  - Early dome, late asymptotic selectivities

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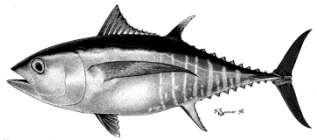

BET stock structure

- Minimal net movement of fish between the EPO and WCPO
- Single stock of bigeye in EPO
- Pacific-wide collaborative assessment with SPC and sensitivity analysis extending the western boundary of stock to 170°E
- See update on results from collaborative tagging program with SPC in the CPO

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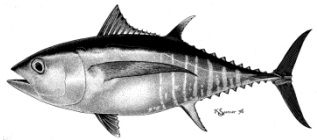
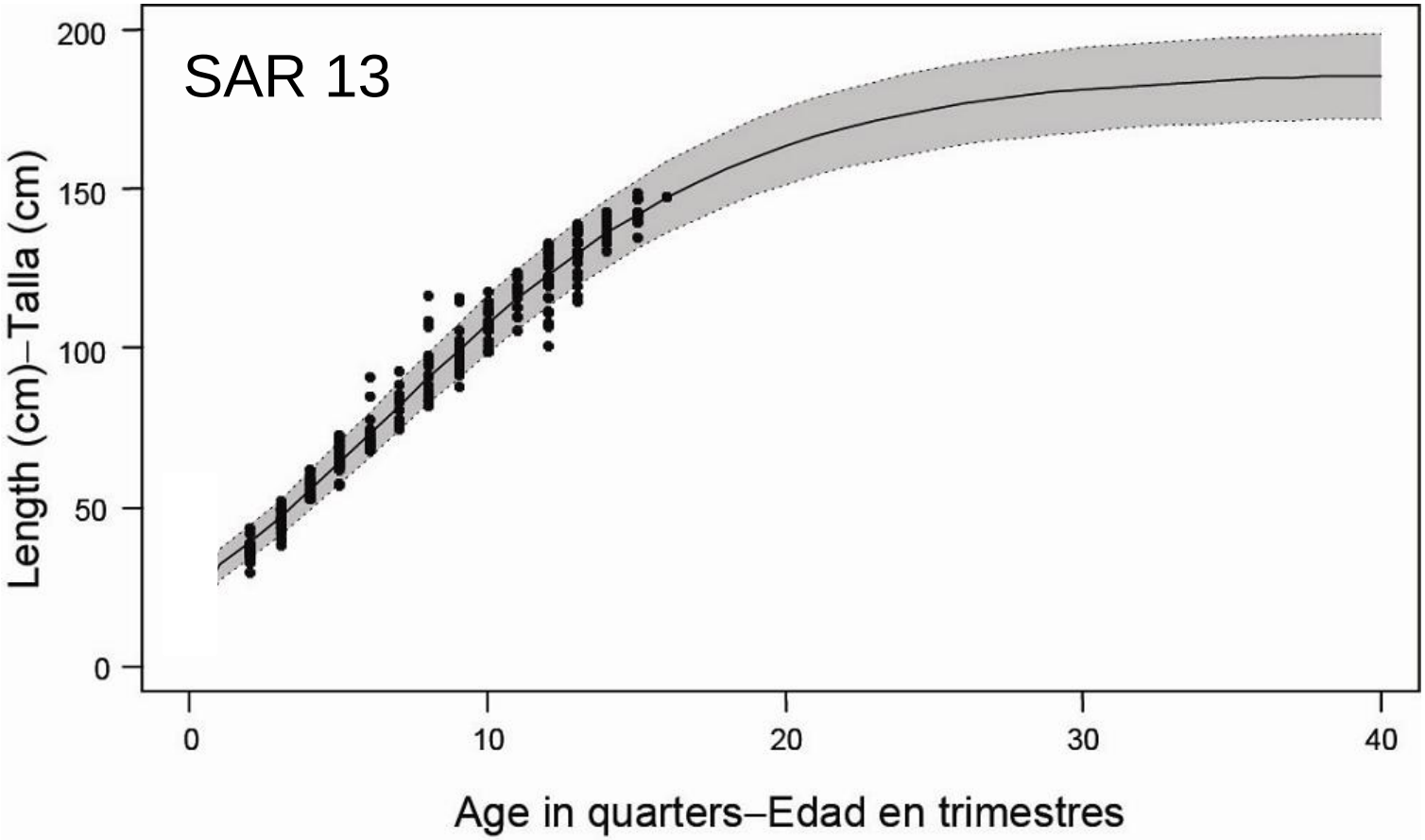
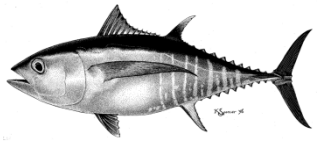
Age and growth – Previous assessment



- Richards growth curve
  - L_2 fixed (185 cm)
  - Variability of length-at-age (LSD) estimated



BET L_2 assumption?



- Length of the largest fish observed (close to virgin population)

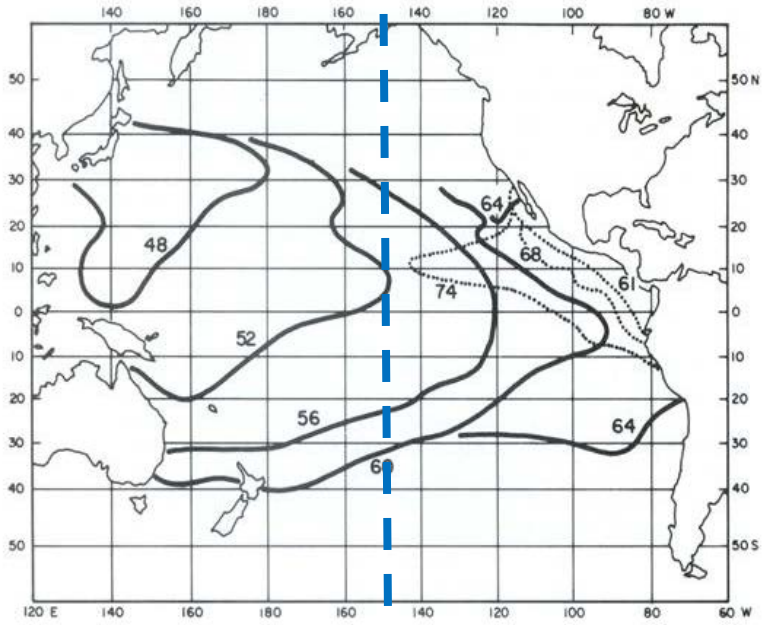


FIGURE 1. Geographical expansion of the Japanese longline fishery (solid curves) and the surface fishery in the eastern Pacific (dotted curves). Numerals denote calendar year.

Suzuki, Tomlinson and Honma (1978)

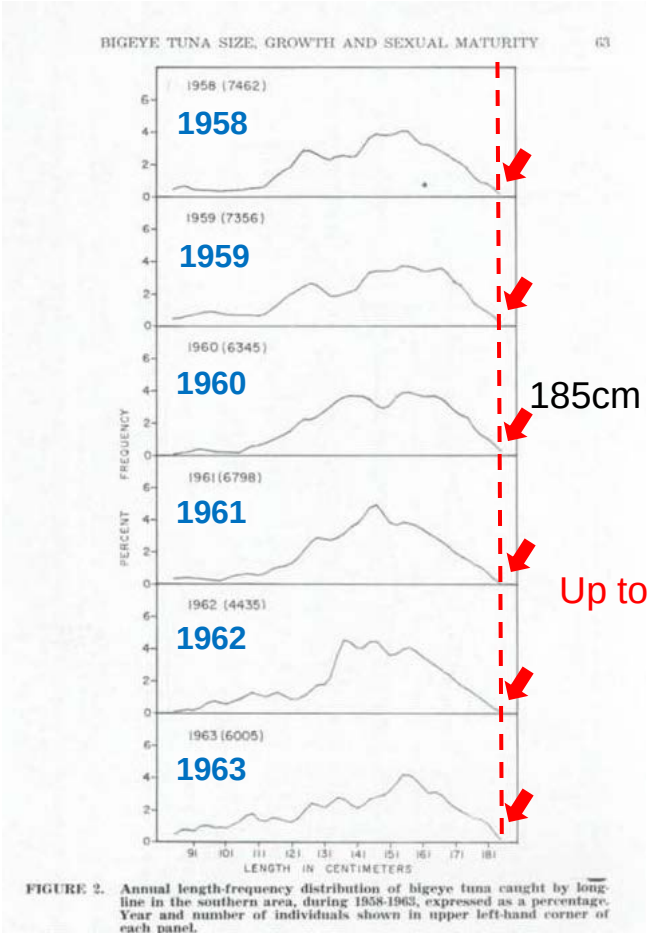
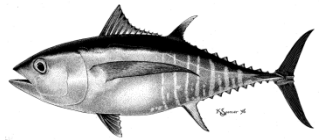
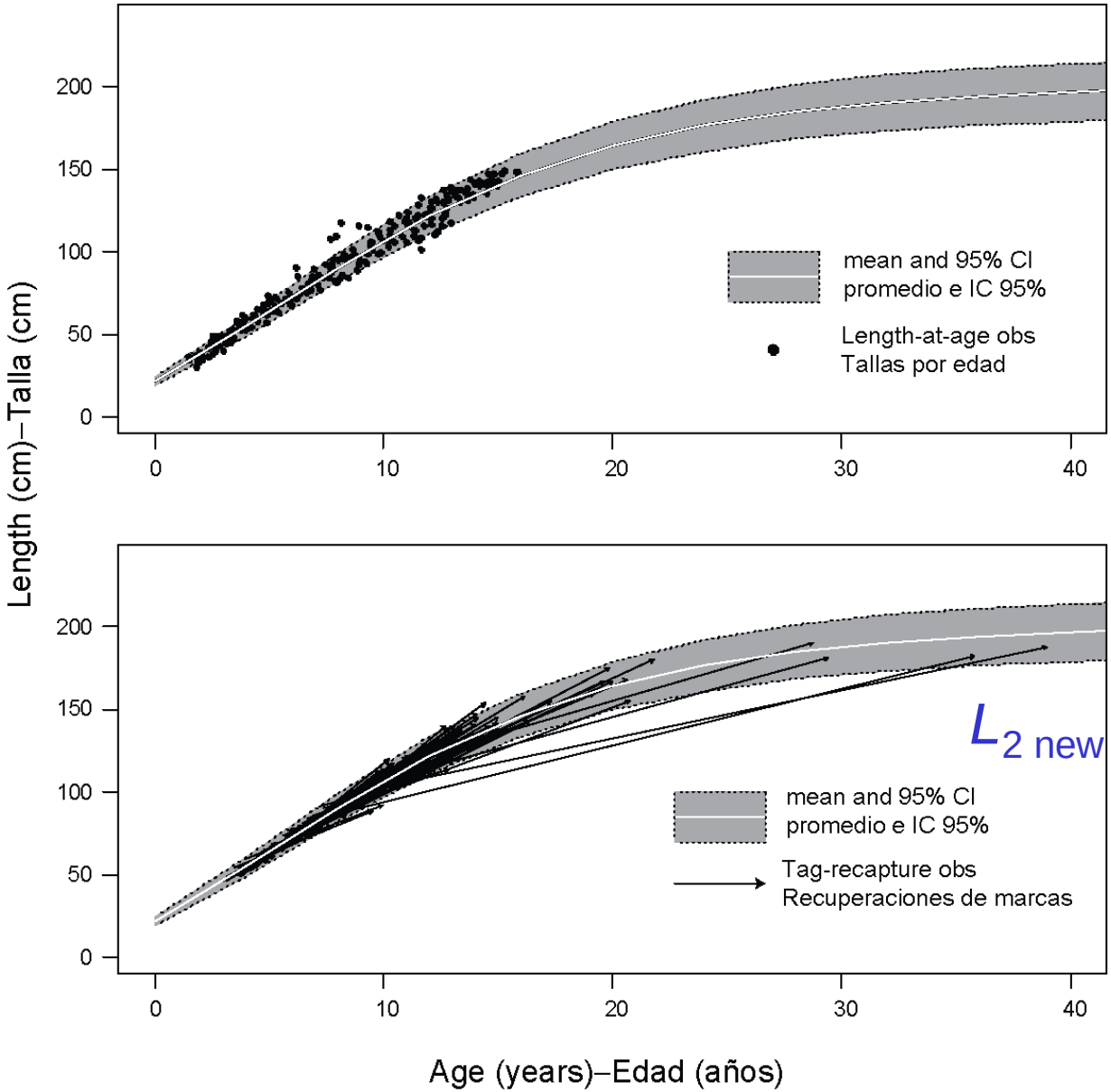


FIGURE 2. Annual length-frequency distribution of bigeye tuna caught by longline in the southern area, during 1958-1963, expressed as a percentage. Year and number of individuals shown in upper left-hand corner of each panel.

Kume and Joseph (1966)

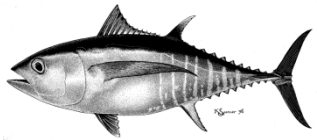
Age and growth

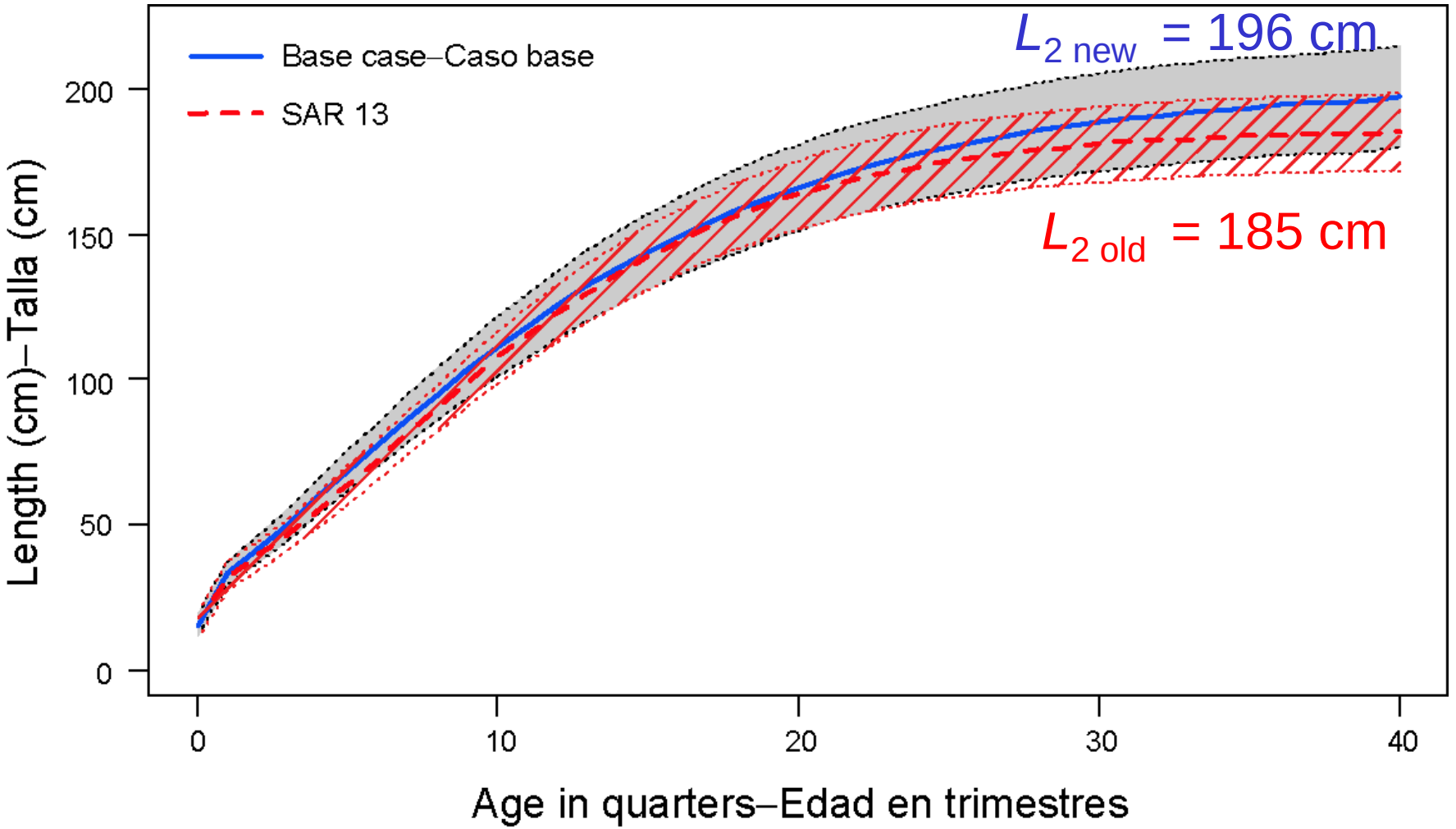




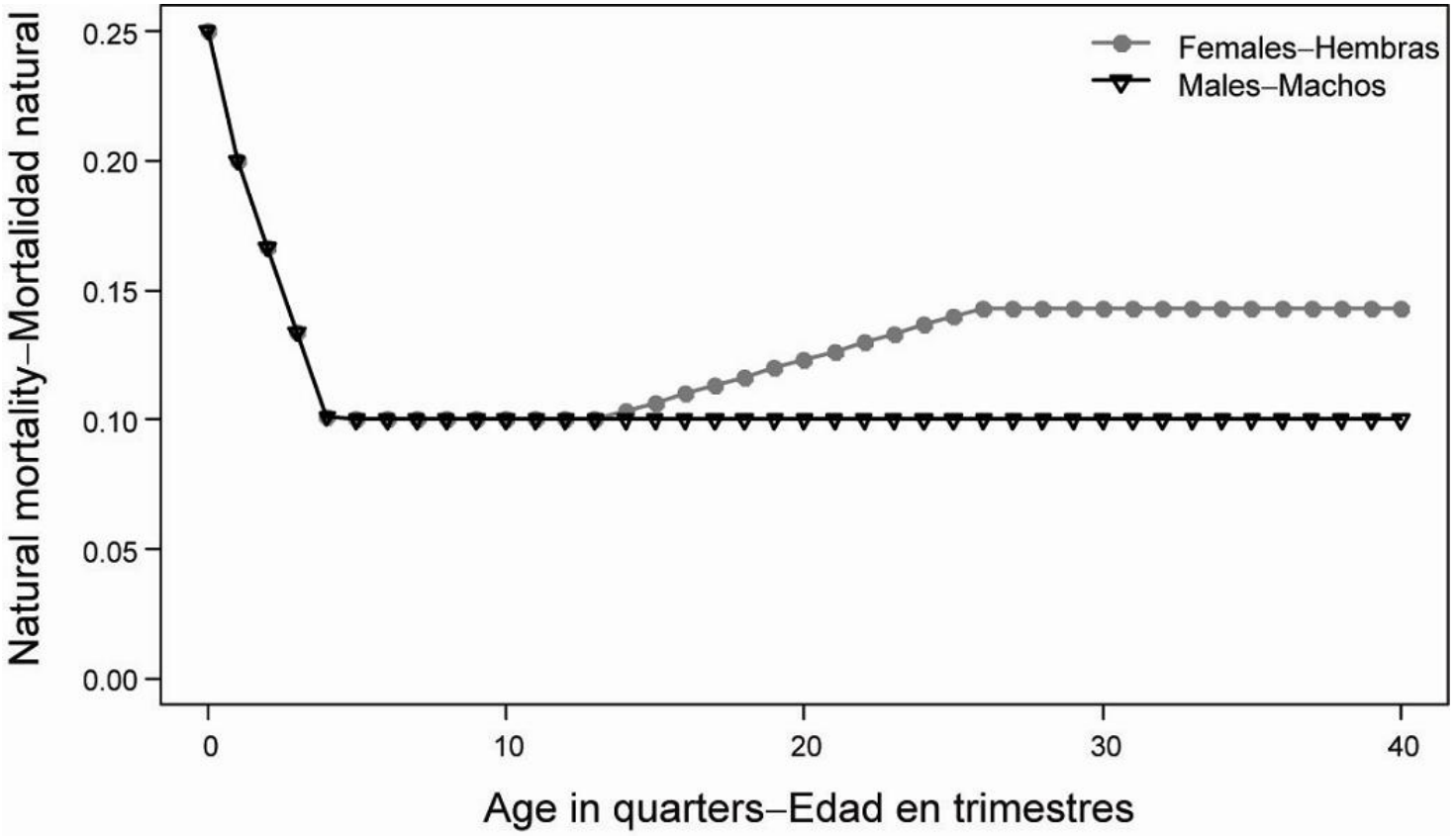
$L_{2\ new}$ = 196 cm

Age and growth





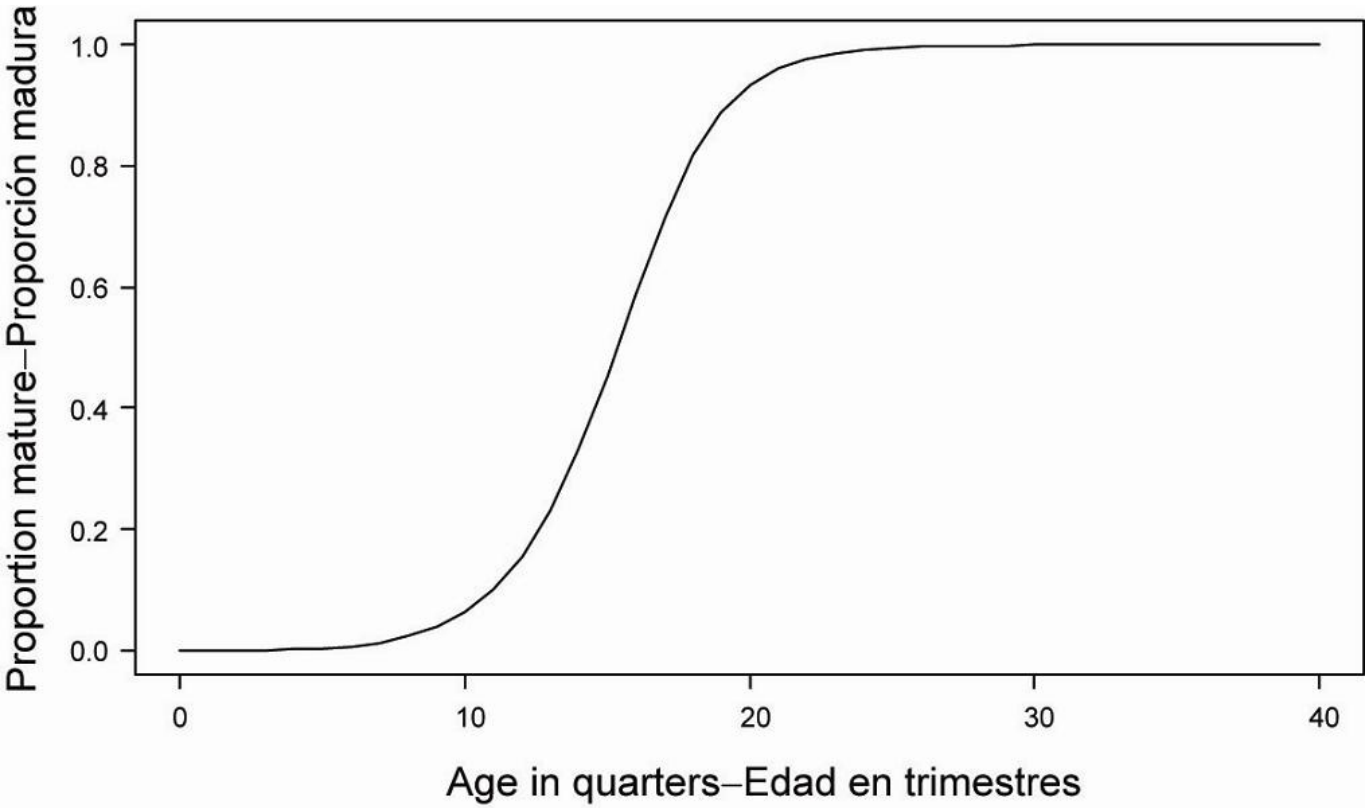
Natural mortality



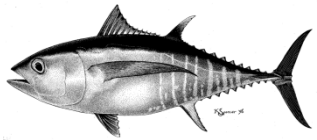
- Sensitivity analysis
  - Juvenile *M* (SARM-9-INF-B)
  - Adult *M* (Appendix B)

Maturity schedule

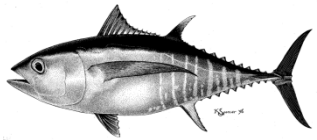
- Age-specific maturity (Schaefer and Fuller, 2006)



Stock-recruitment relationship

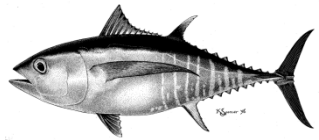


- Beverton-Holt relationship
- No S-R relationship (steepness = 1)
- Sensitivity analysis (Appendix B)
  - Steepness = 0.75
  - Likelihood profile on steepness (0.5, 0.6, 0.7, 0.8, 0.9, 1.0)



Fixed parameters

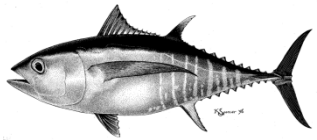
- Mean length-at-age and the variability of the length-at-age
- Sex and age-specific mortality-rates (*M*)
- Age-specific maturity schedule
- CV of LL-C and LL-S CPUE (0.15)
- Selectivity curves for discard fisheries
- Steepness of stock-recruitment relationship (*h*=1)



Estimated parameters

- Recruitment in every quarter from 1975 to 2012 (average recruitment and temporal recruitment anomalies)
- Catchability coefficients for the 4 LL CPUE time series (LL-C and LL-S, two time blocks)
- Selectivity curves for late Central and Southern LL fisheries are assumed to be logistic (catch larger fish)
- Selectivities for all other fisheries (except discards) are assumed to be dome-shaped (double normal)
- Initial population age-structure

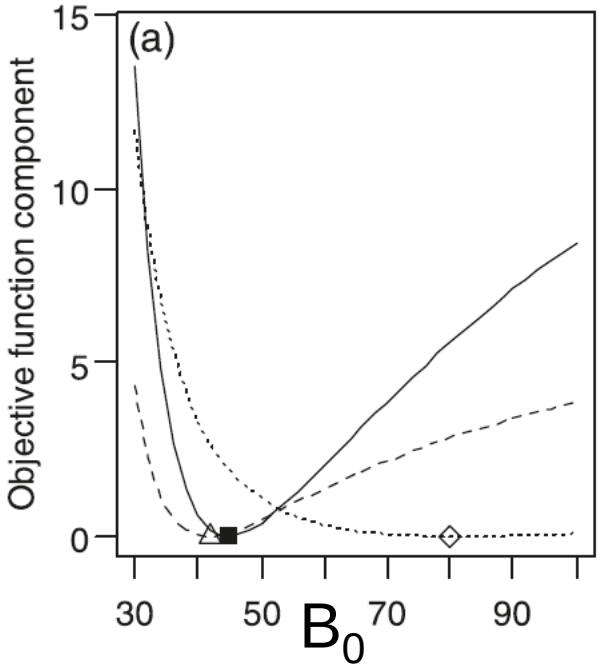
Data weighting



PERSPECTIVE / PERSPECTIVE

Data weighting in statistical fisheries stock assessment models

R.I.C. Chris Francis



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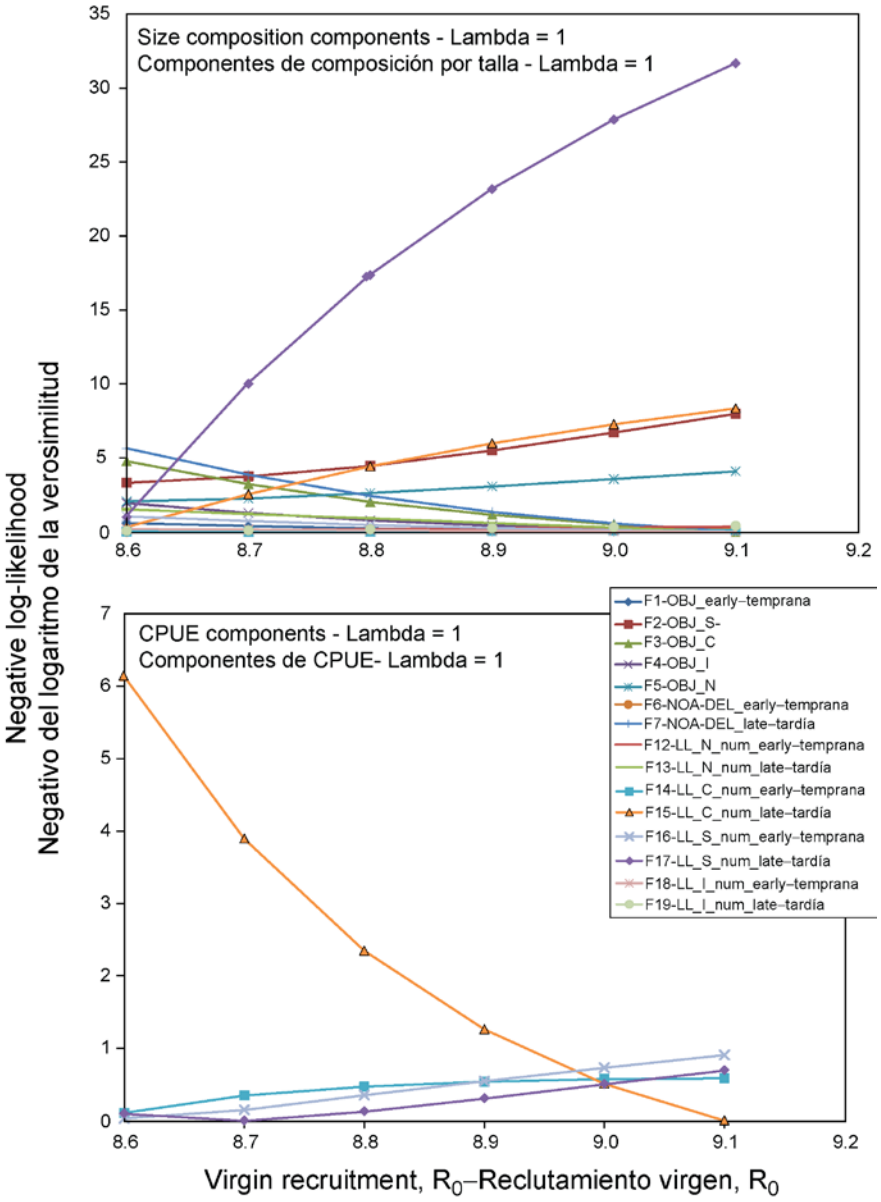
IATTC

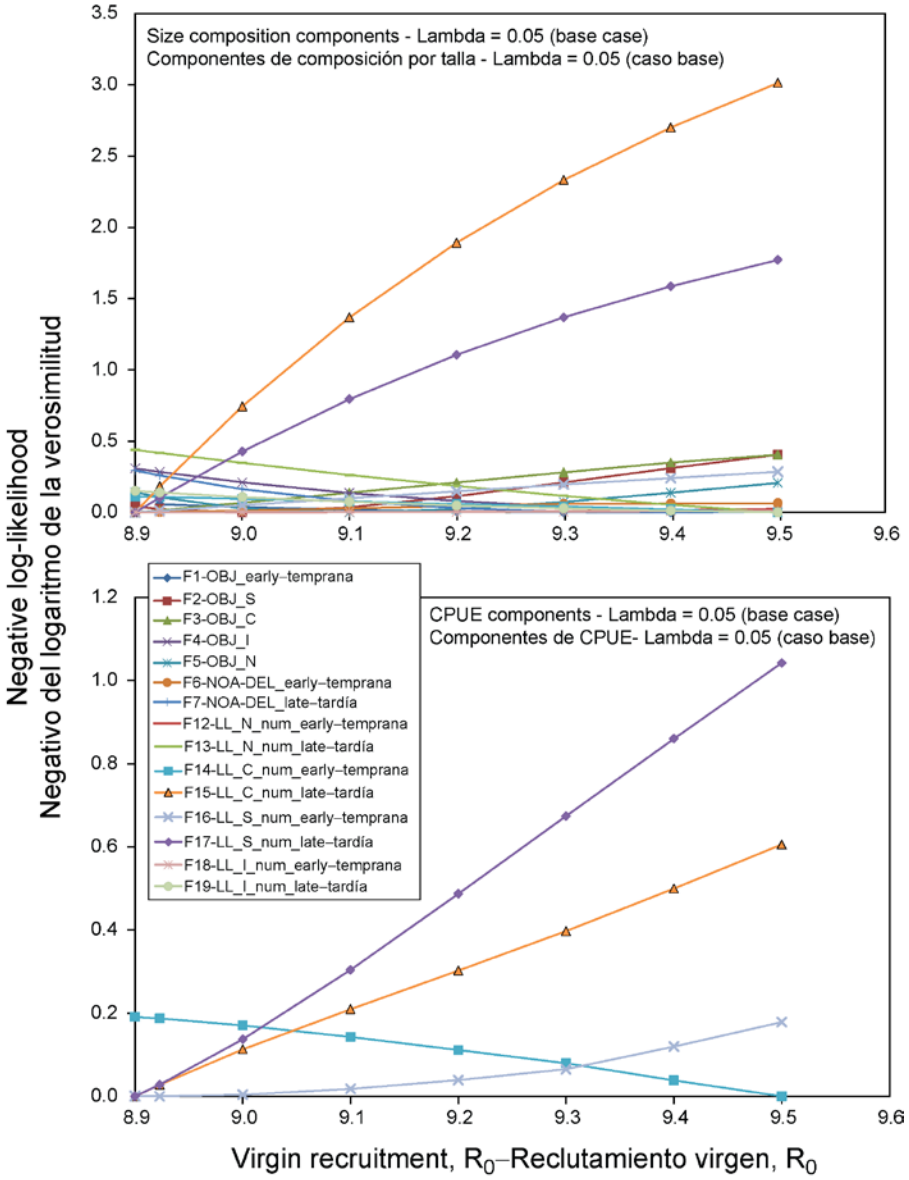
Data weighting

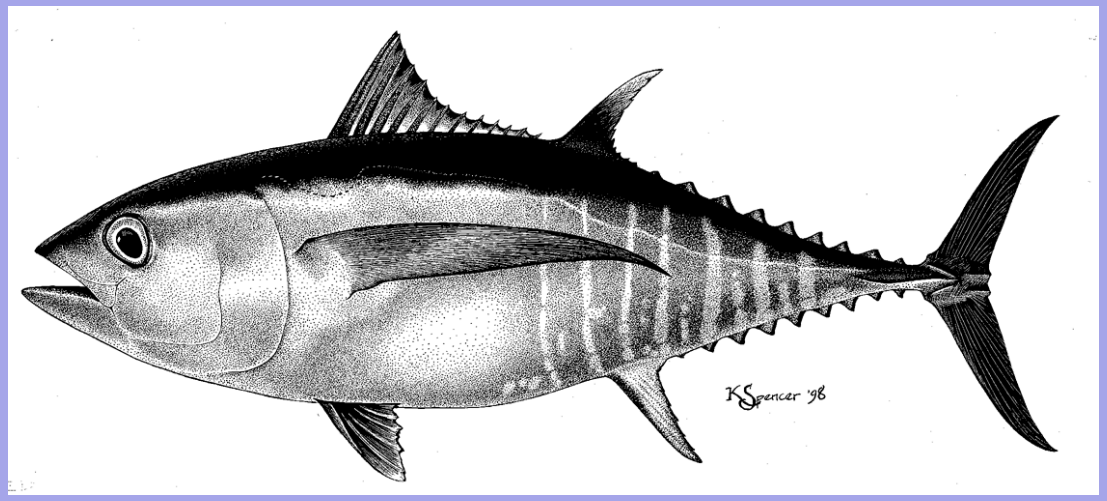
Previous base case
SAR13 (2012)



Data weighting

Current base case





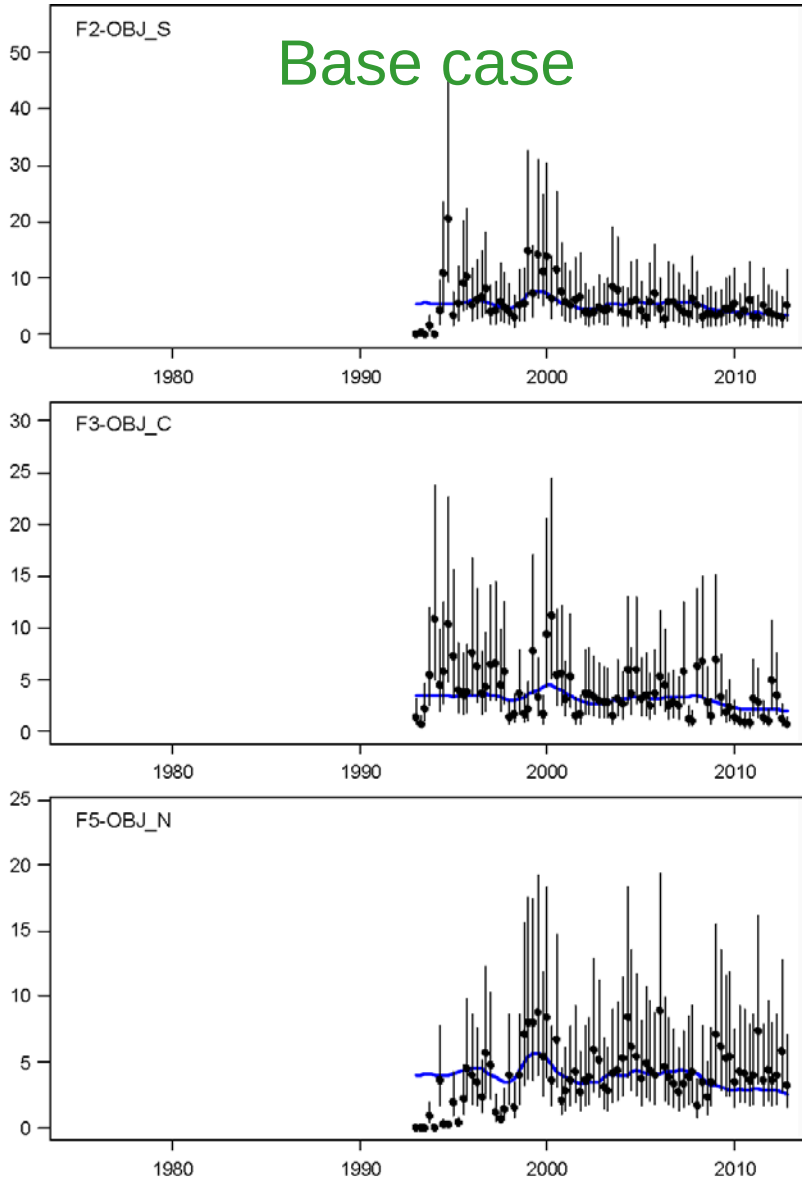
Results (base case)

- Model fits (CPUE and size compositions)
- Fishing mortality
- Selectivity
- Recruitment
- Biomass

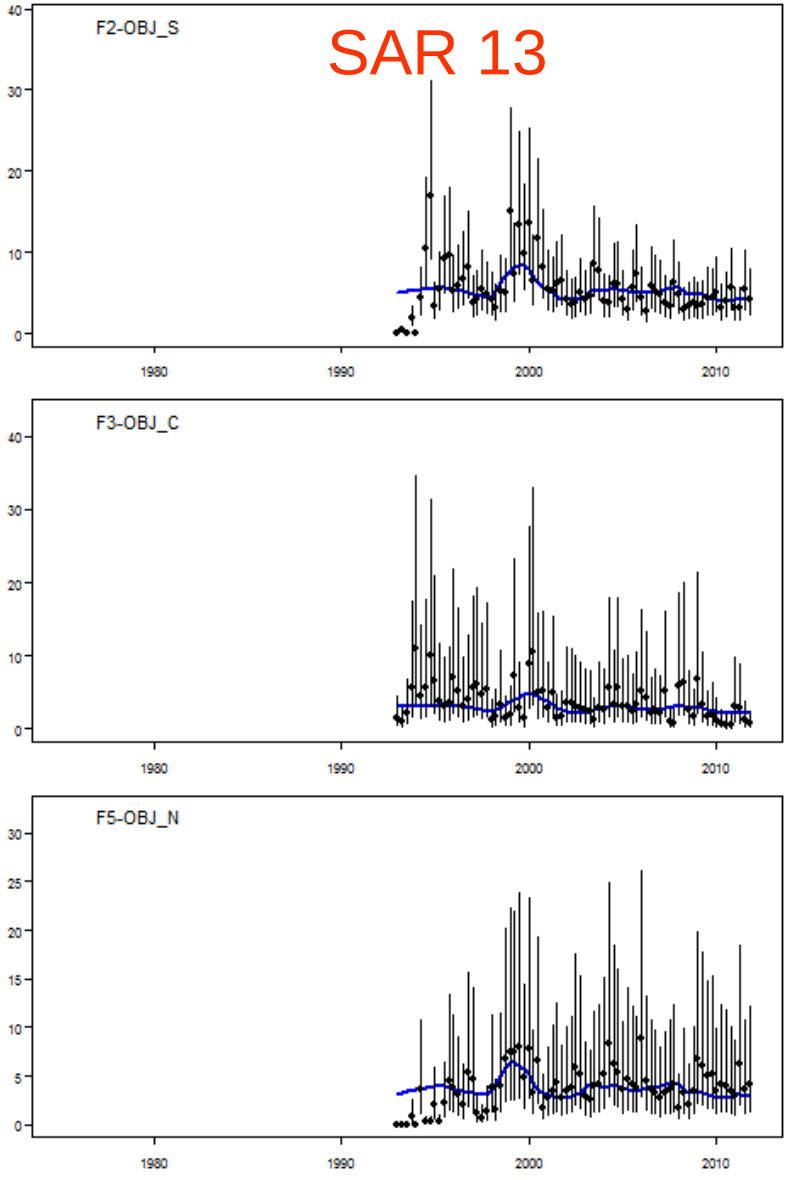
Fit to CPUE – OBJ fisheries

Results (base case)

Base case



SAR 13

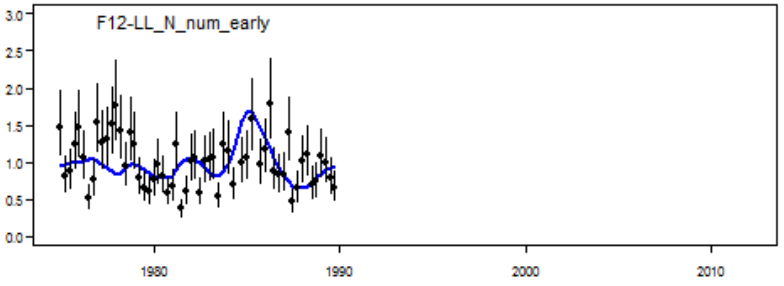


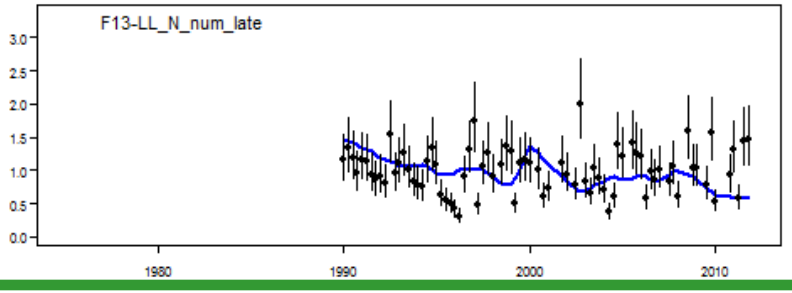
Fit to CPUE – LL fisheries

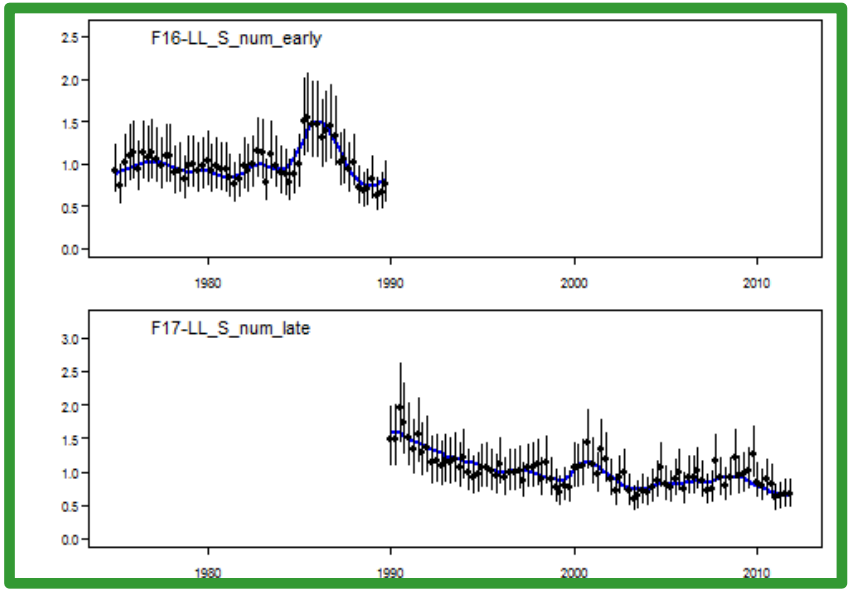
Results (base case)

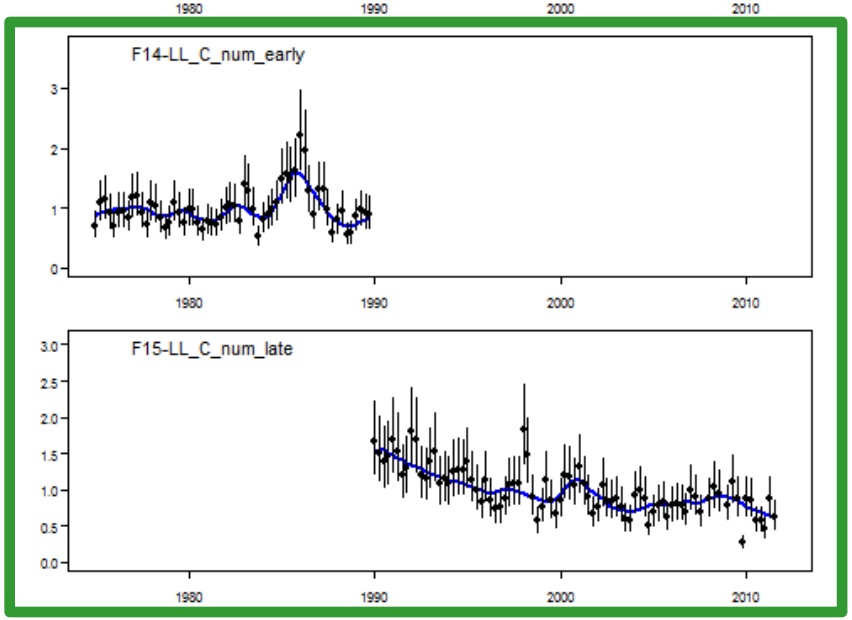
Catch per day (t) - Captura por dia (t)

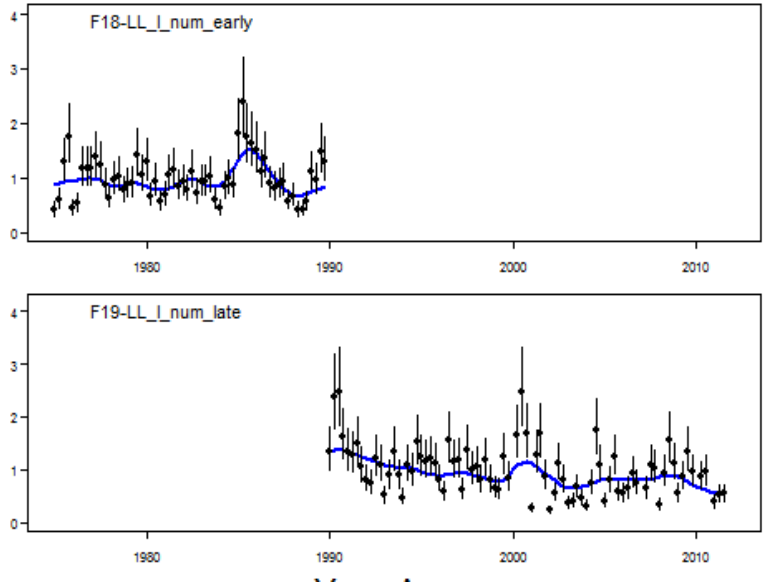
Standardized CPUE - CPUE estandarizada





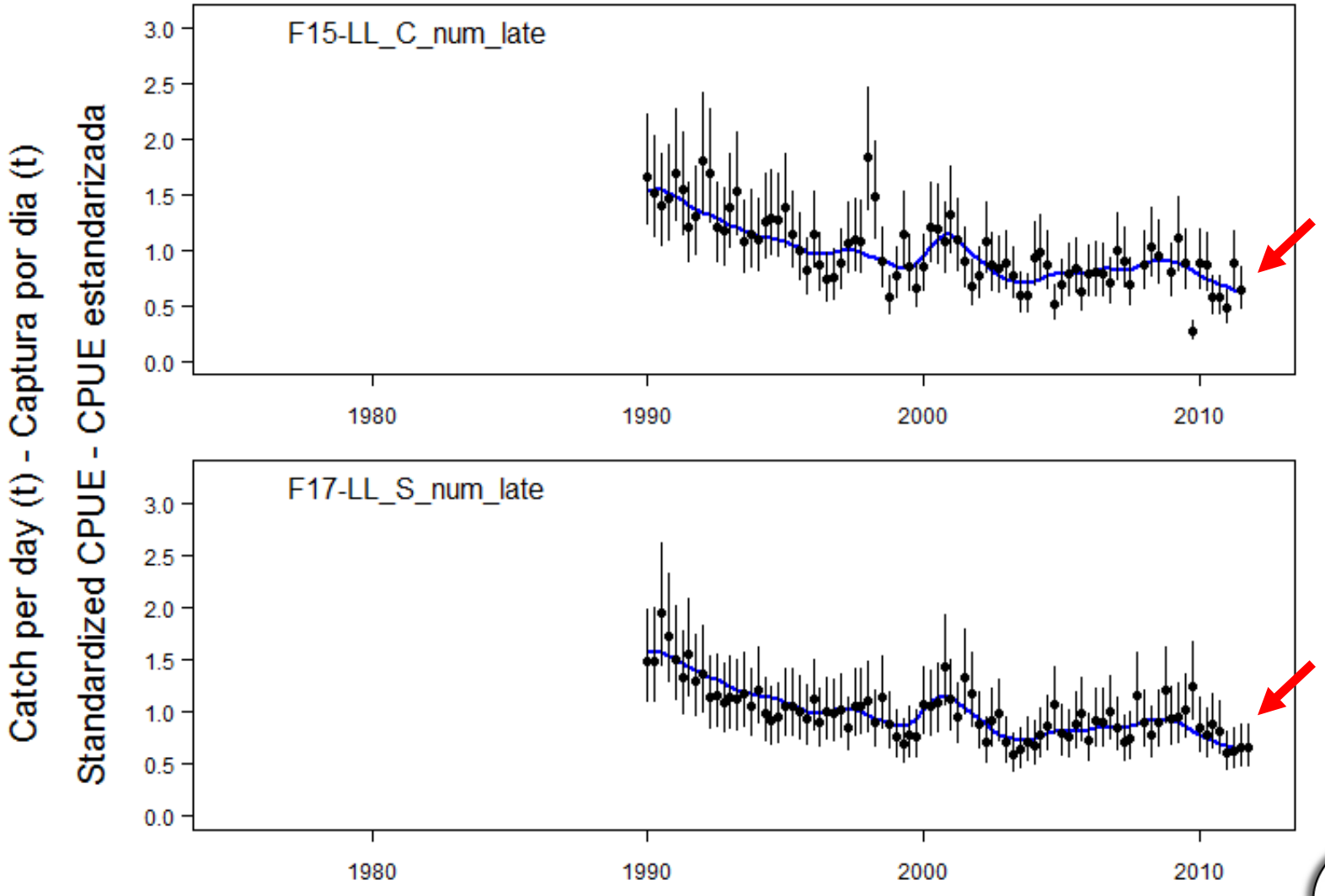






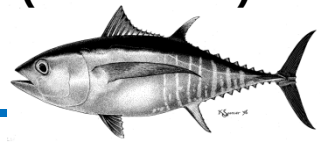
Fit to CPUE – Late LL fisheries

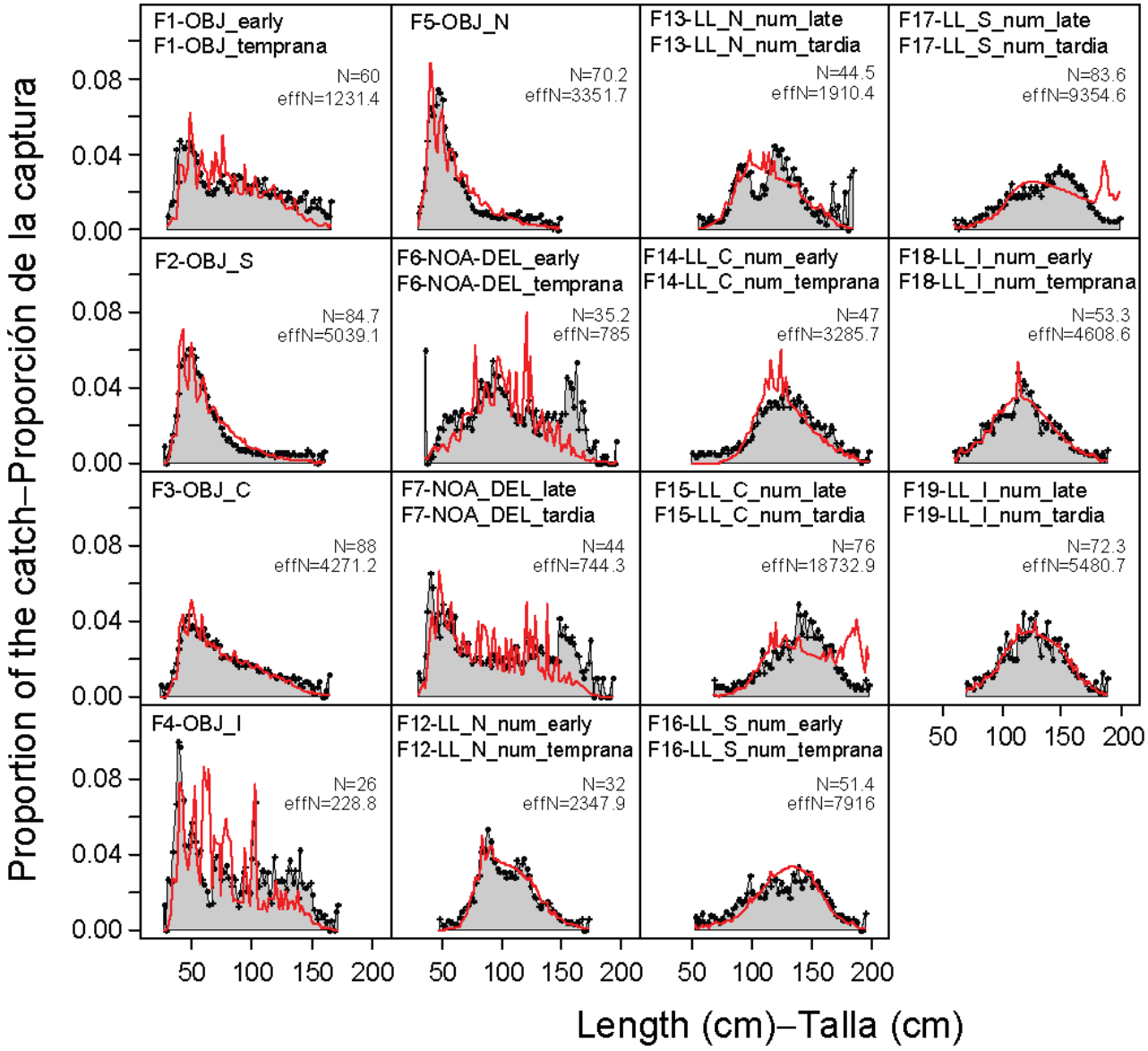
Results
(base case)



Average fits to size comps.

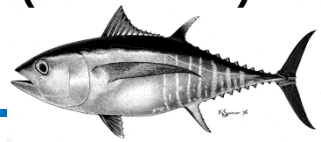
Results (base case)

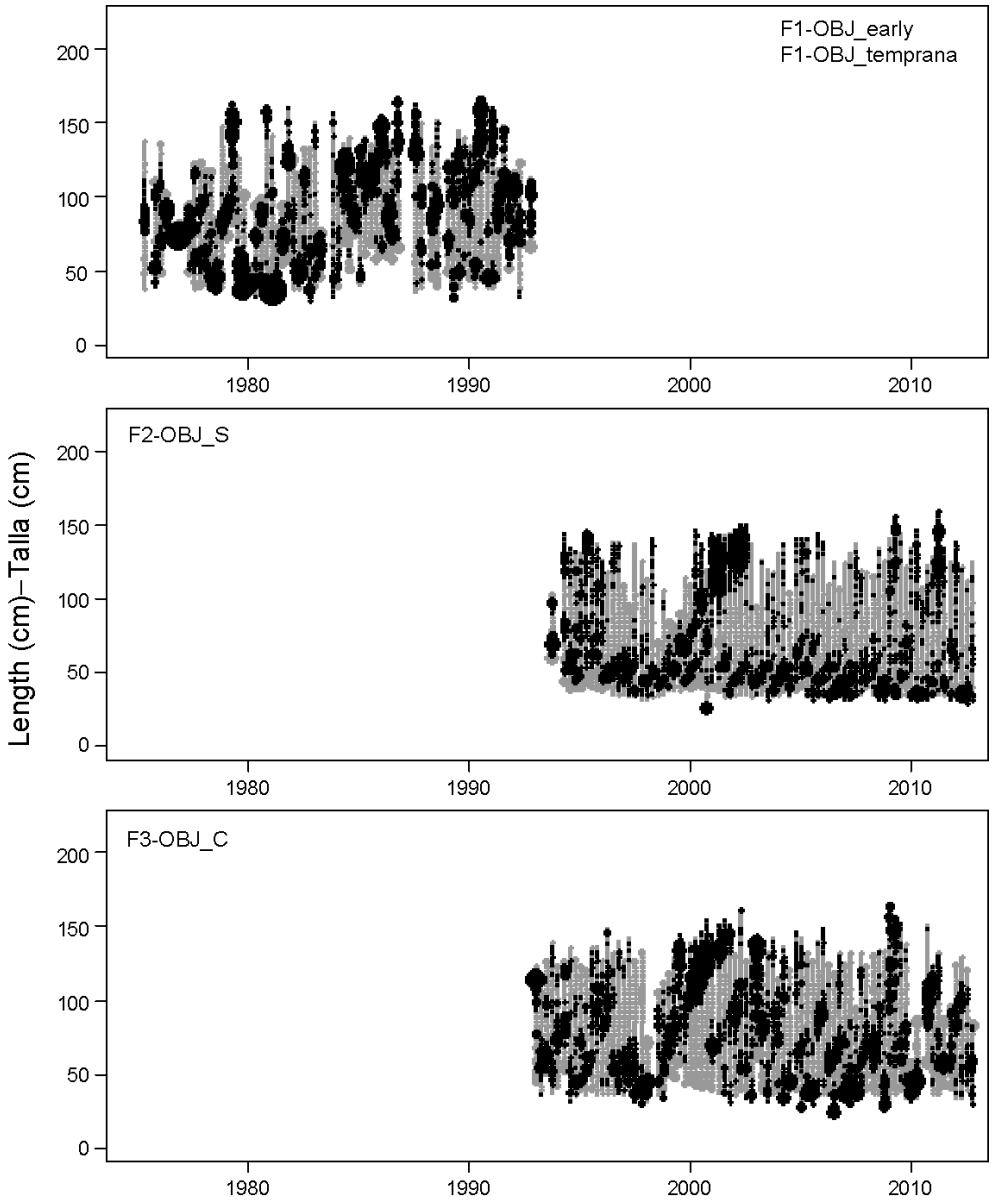




PS Size comp. residual pattern

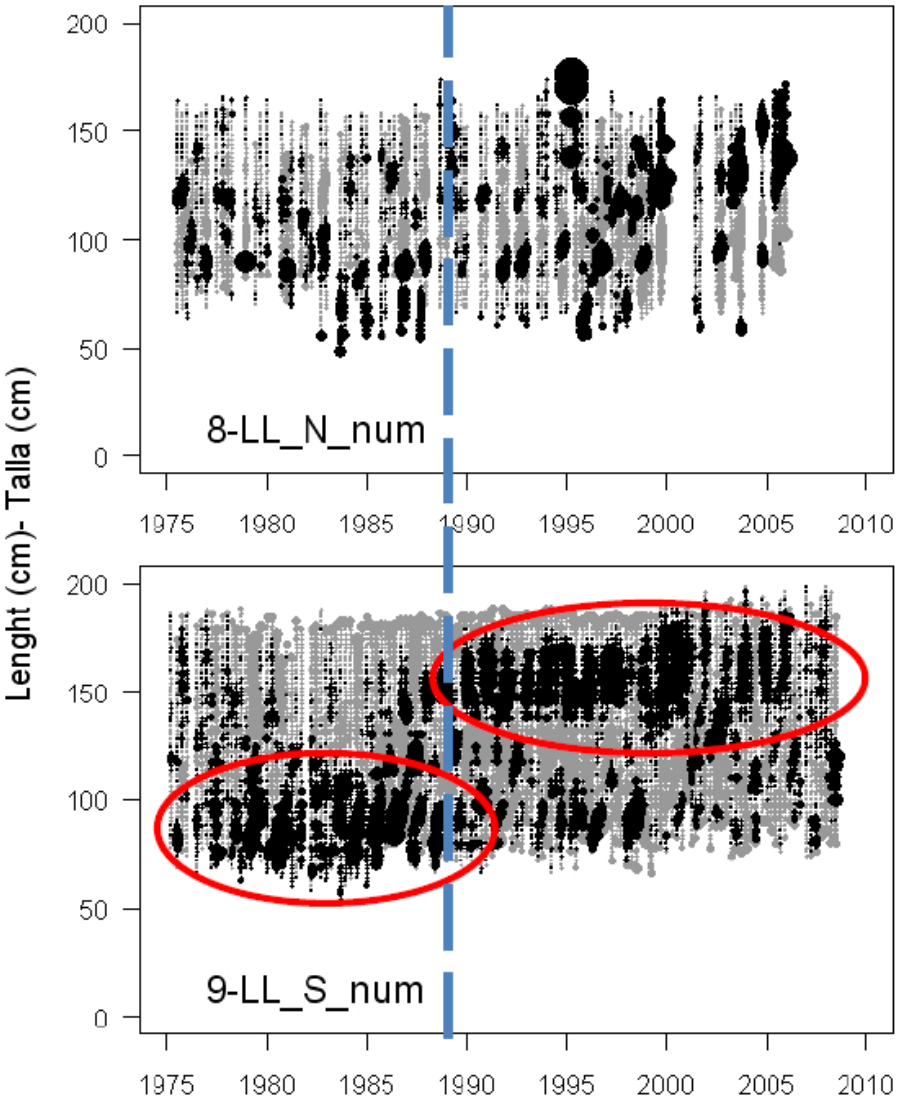
Results (base case)





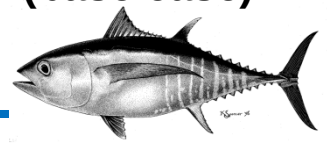
Two time blocks for LL?

SAR 10 (2009)

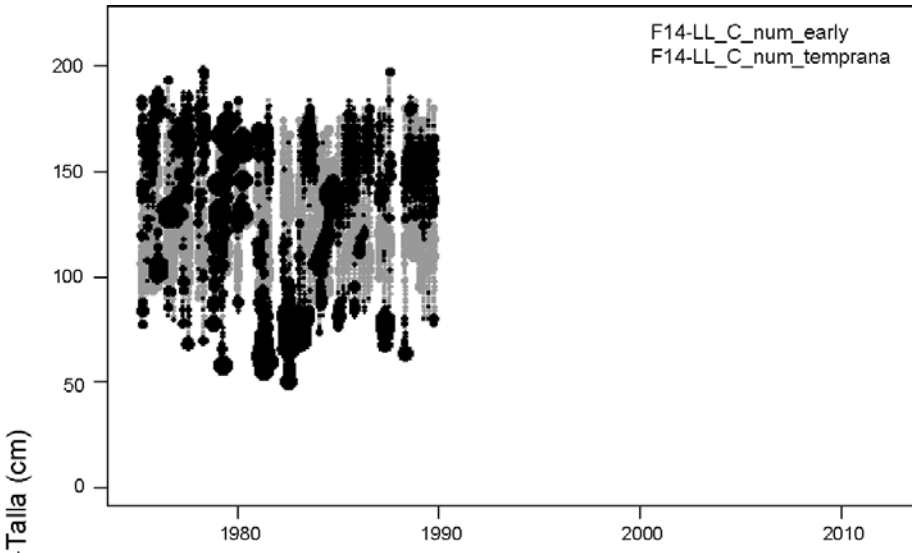


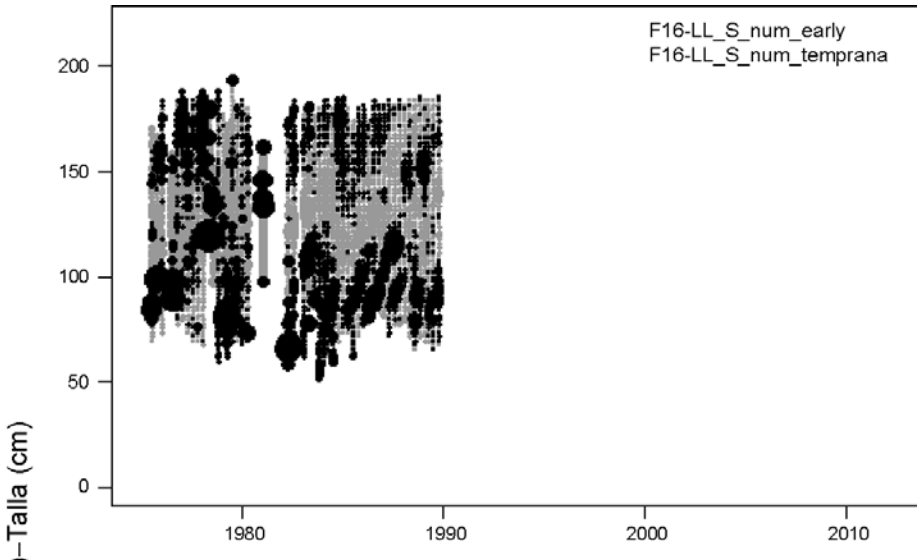
LL Size comp. residual pattern

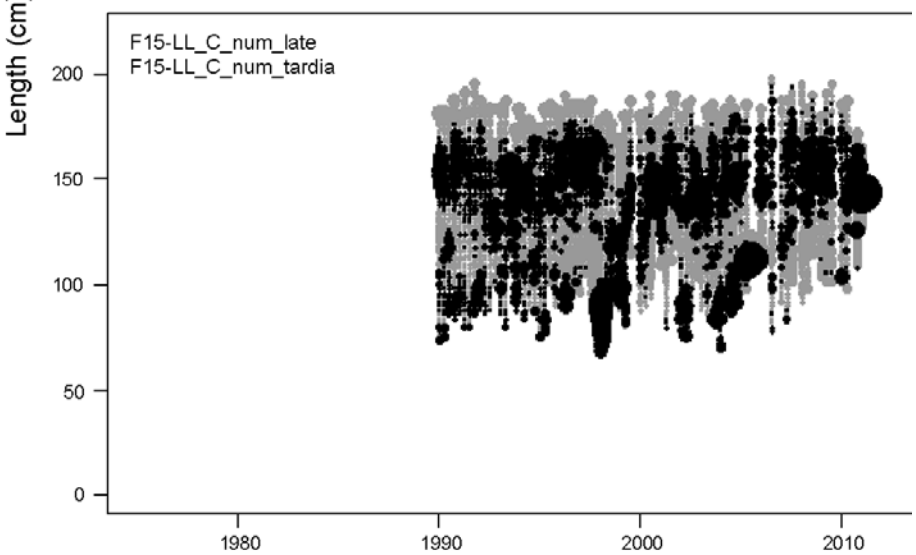
Results (base case)

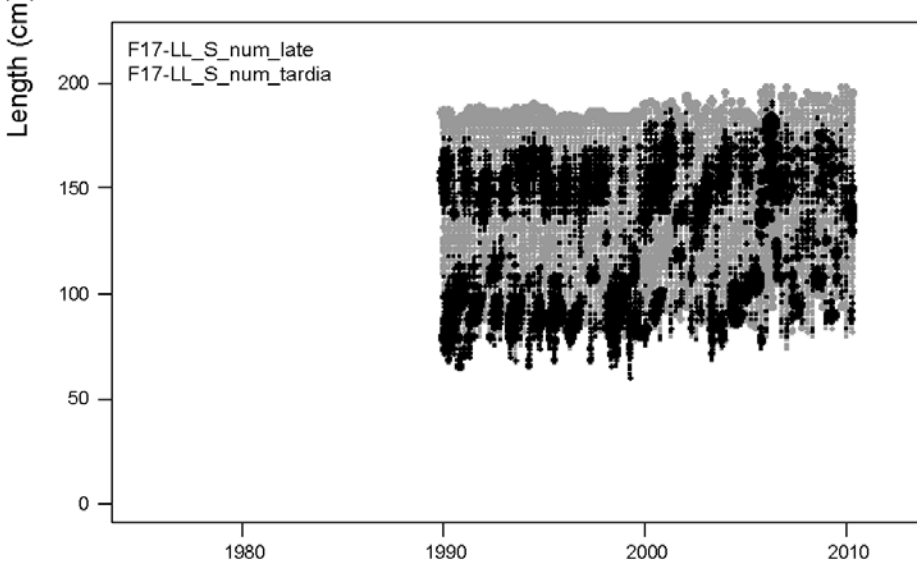


Base case



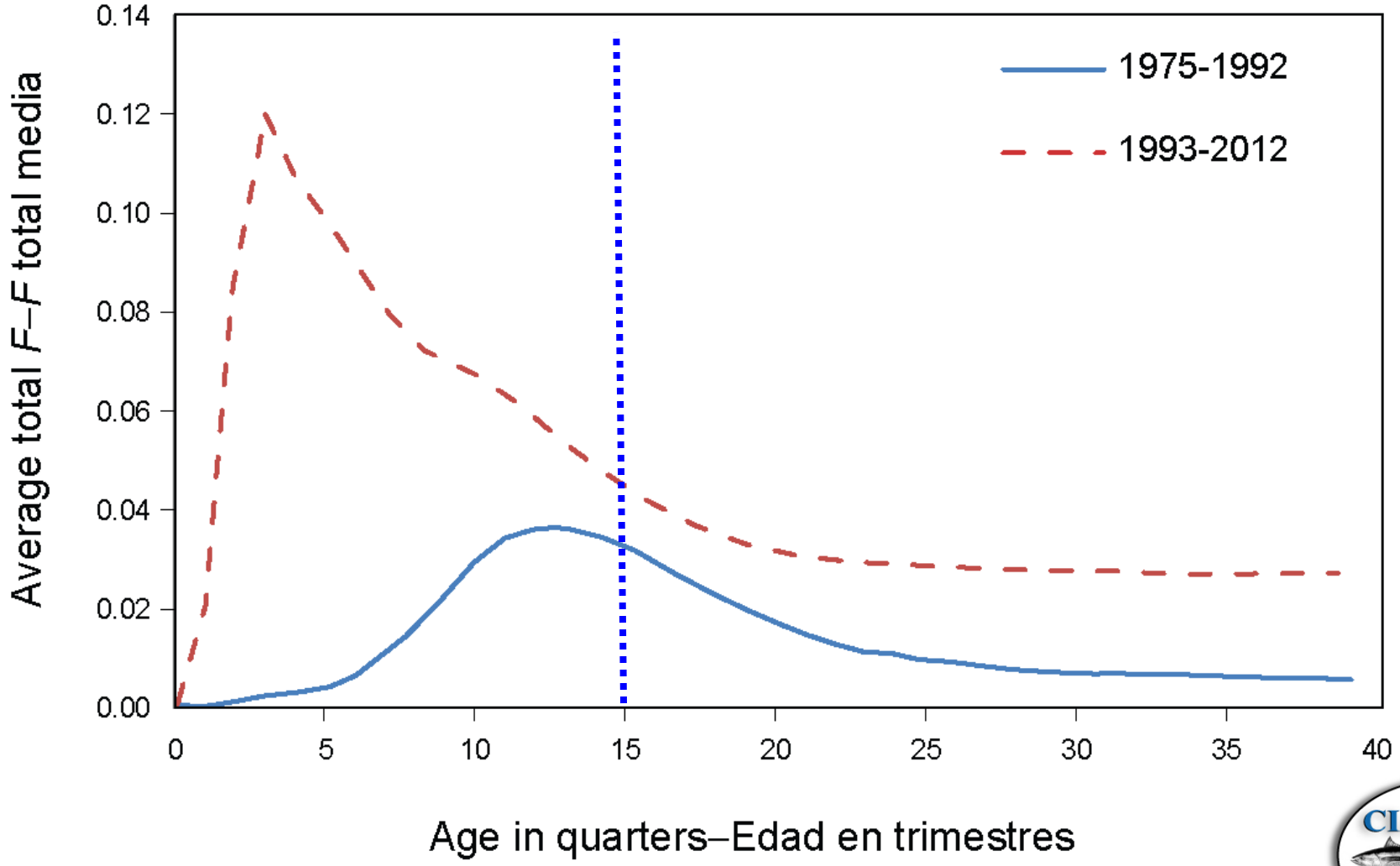






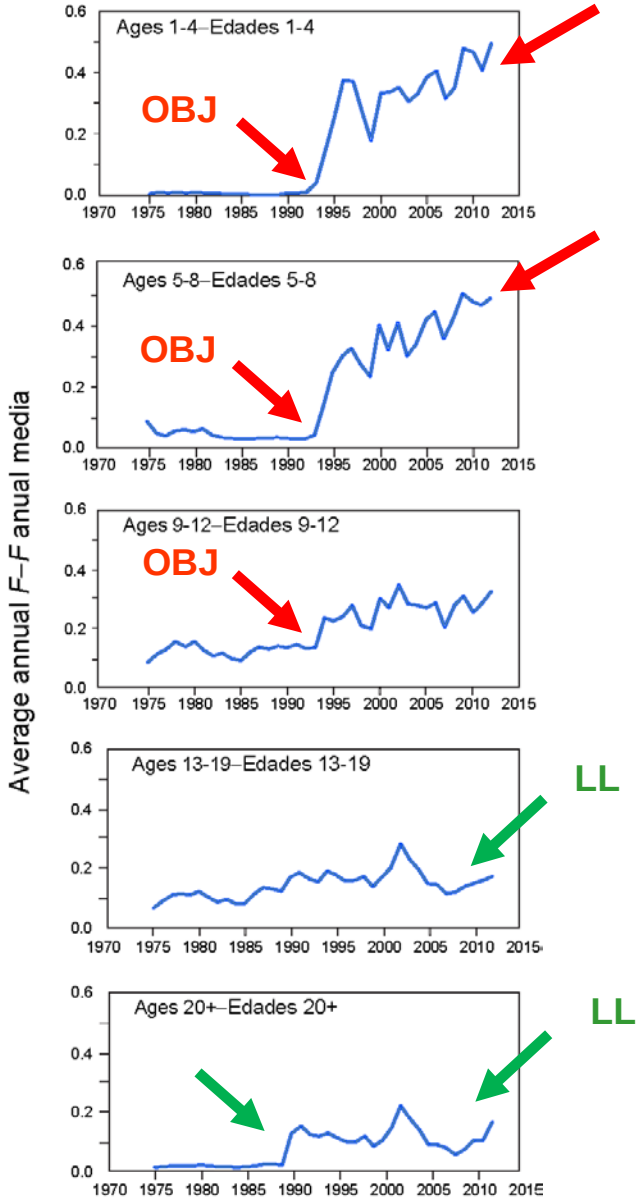
Age-specific fishing mortality

Results
(base case)



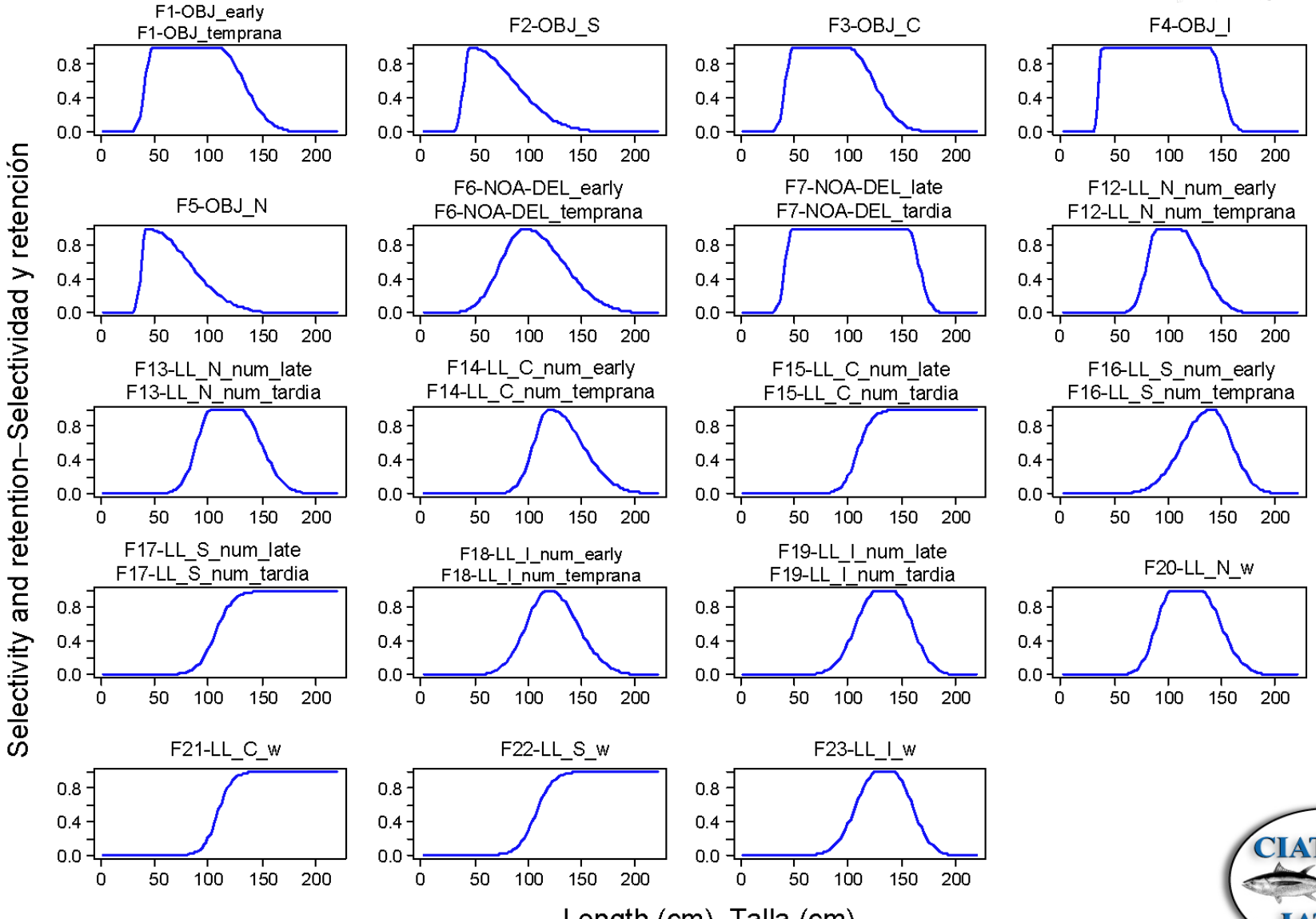
Fishing mortality

Results (base case)



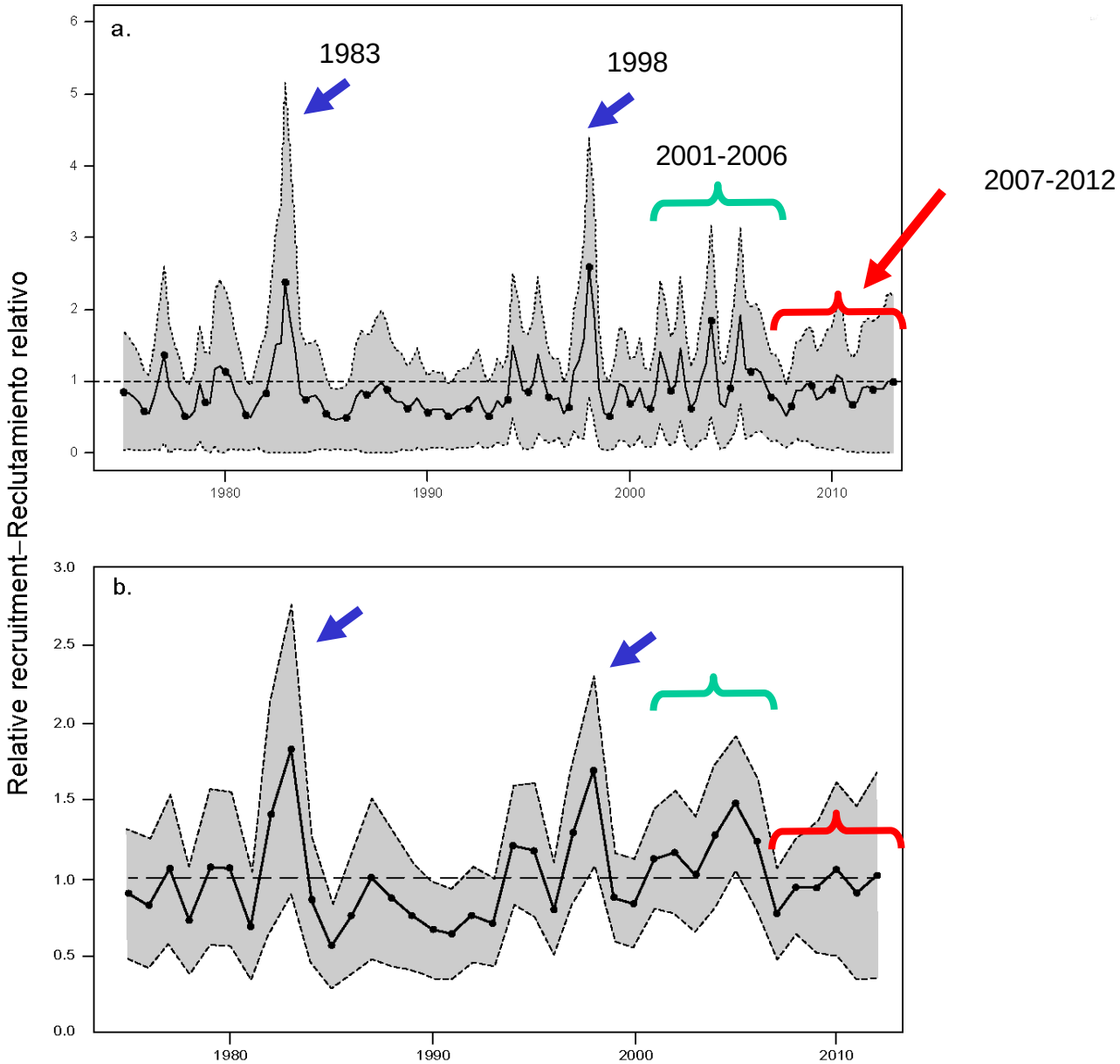
Size selectivity

Results (base case)



Recruitment

Results (base case)



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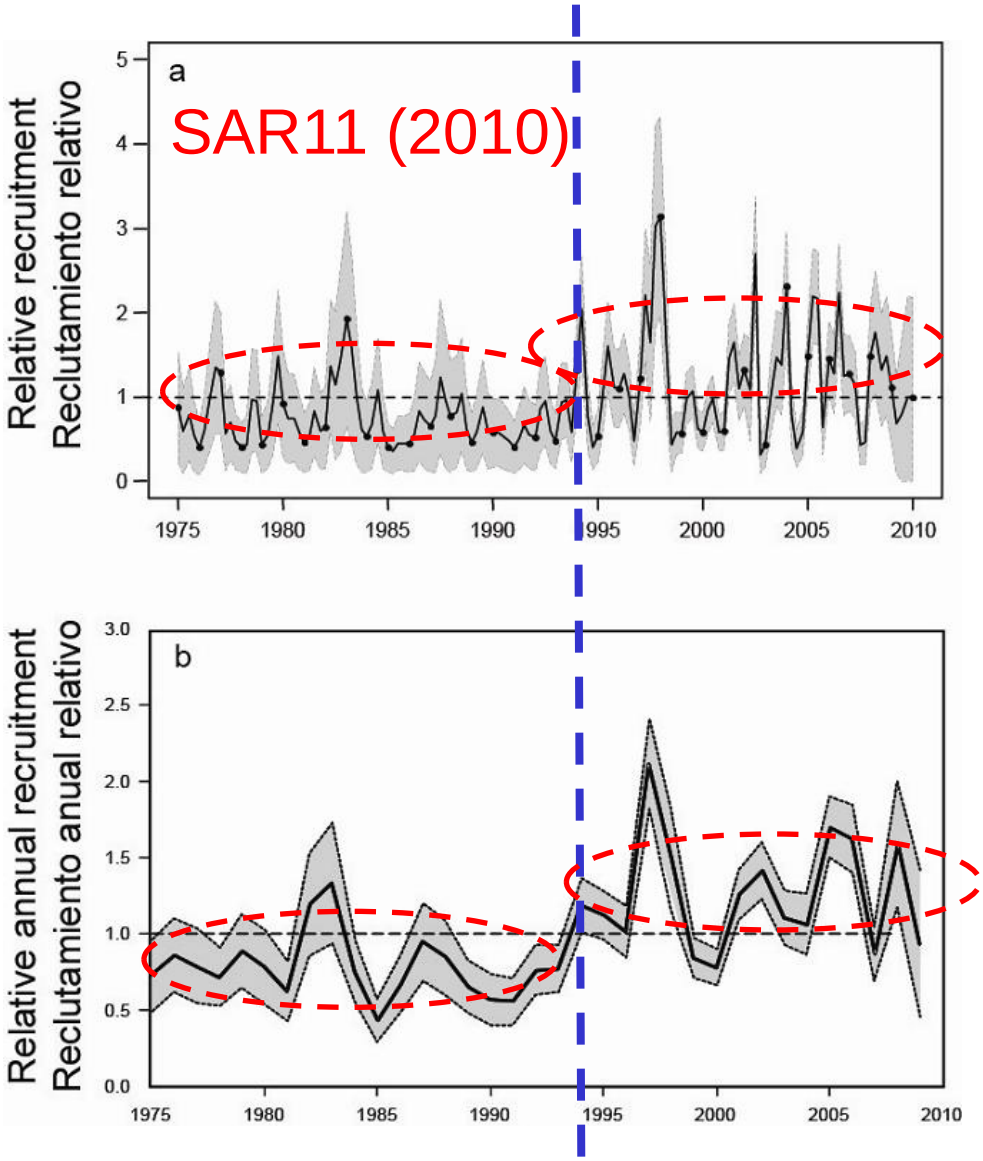
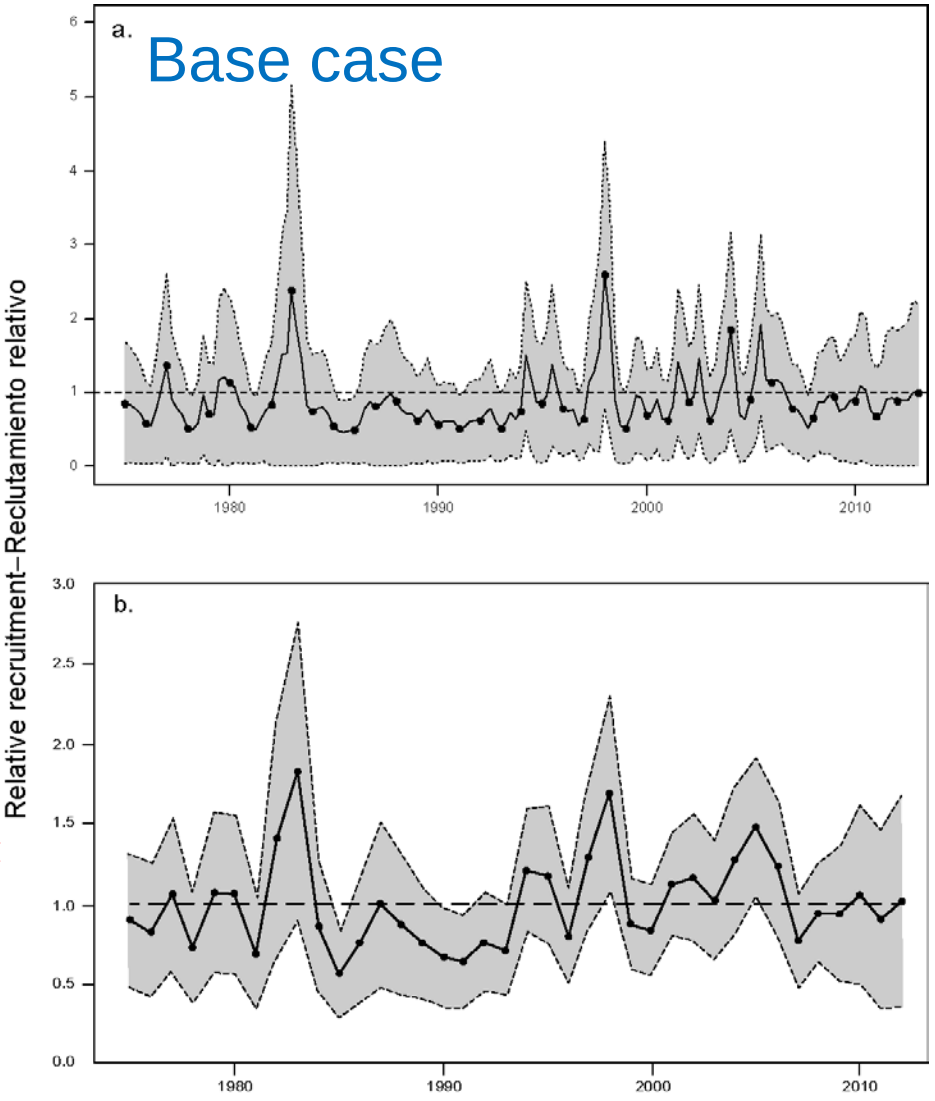
Previous recruitment pattern

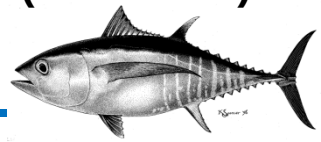
Results (base case)

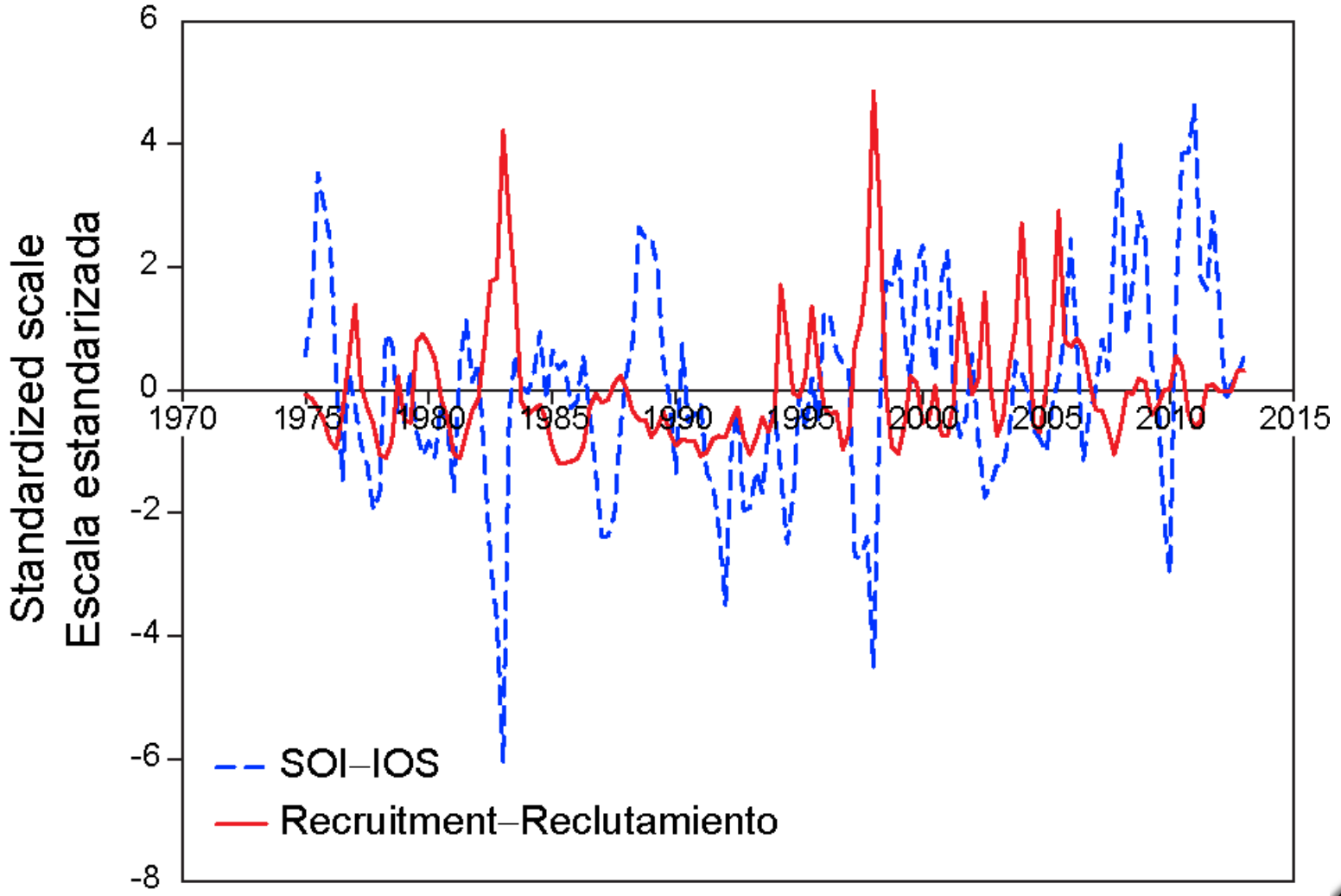




Recruitment and environment

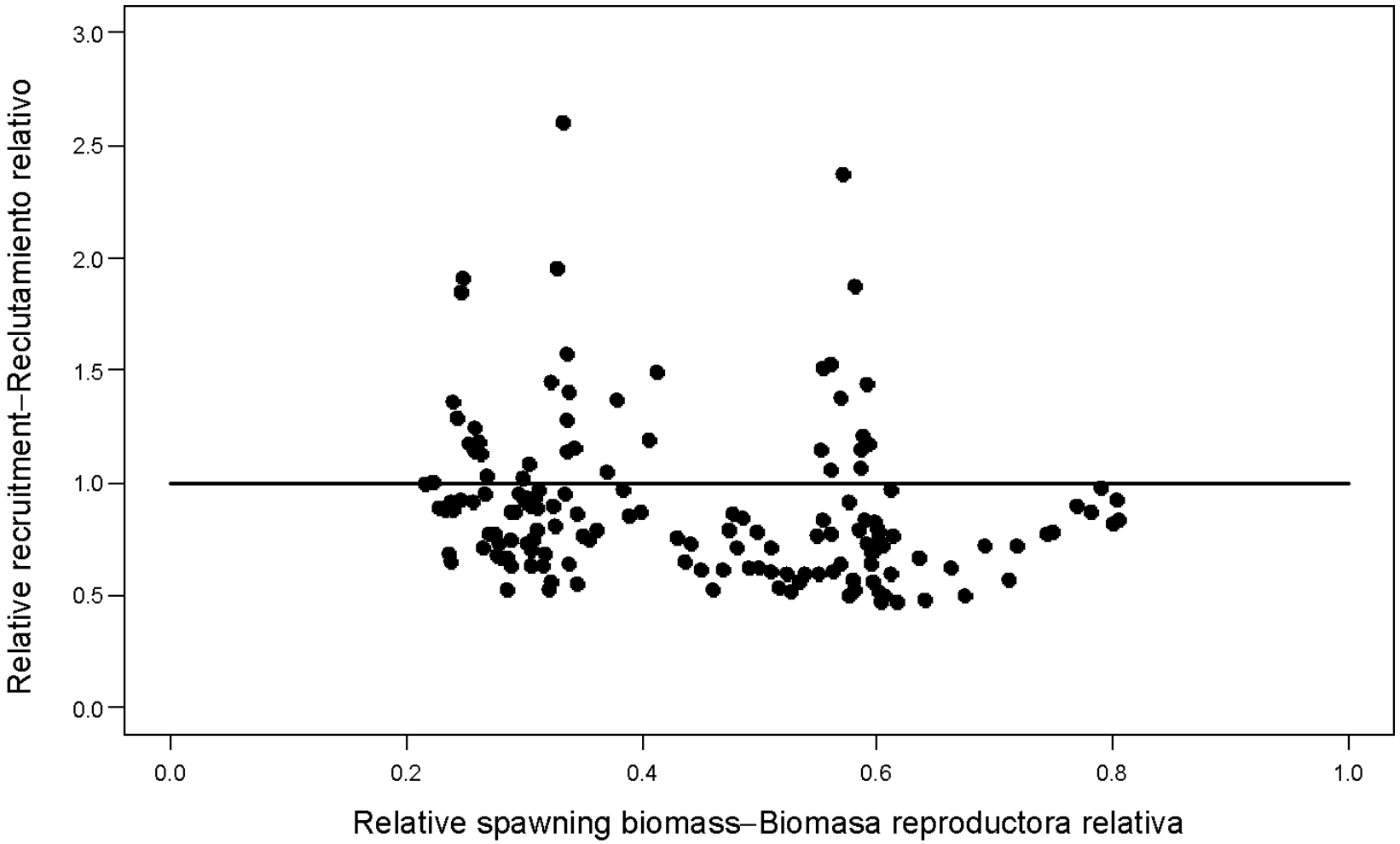
Results
(base case)





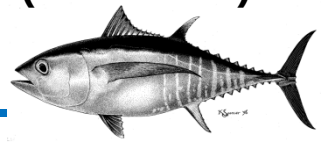
Stock-recruitment

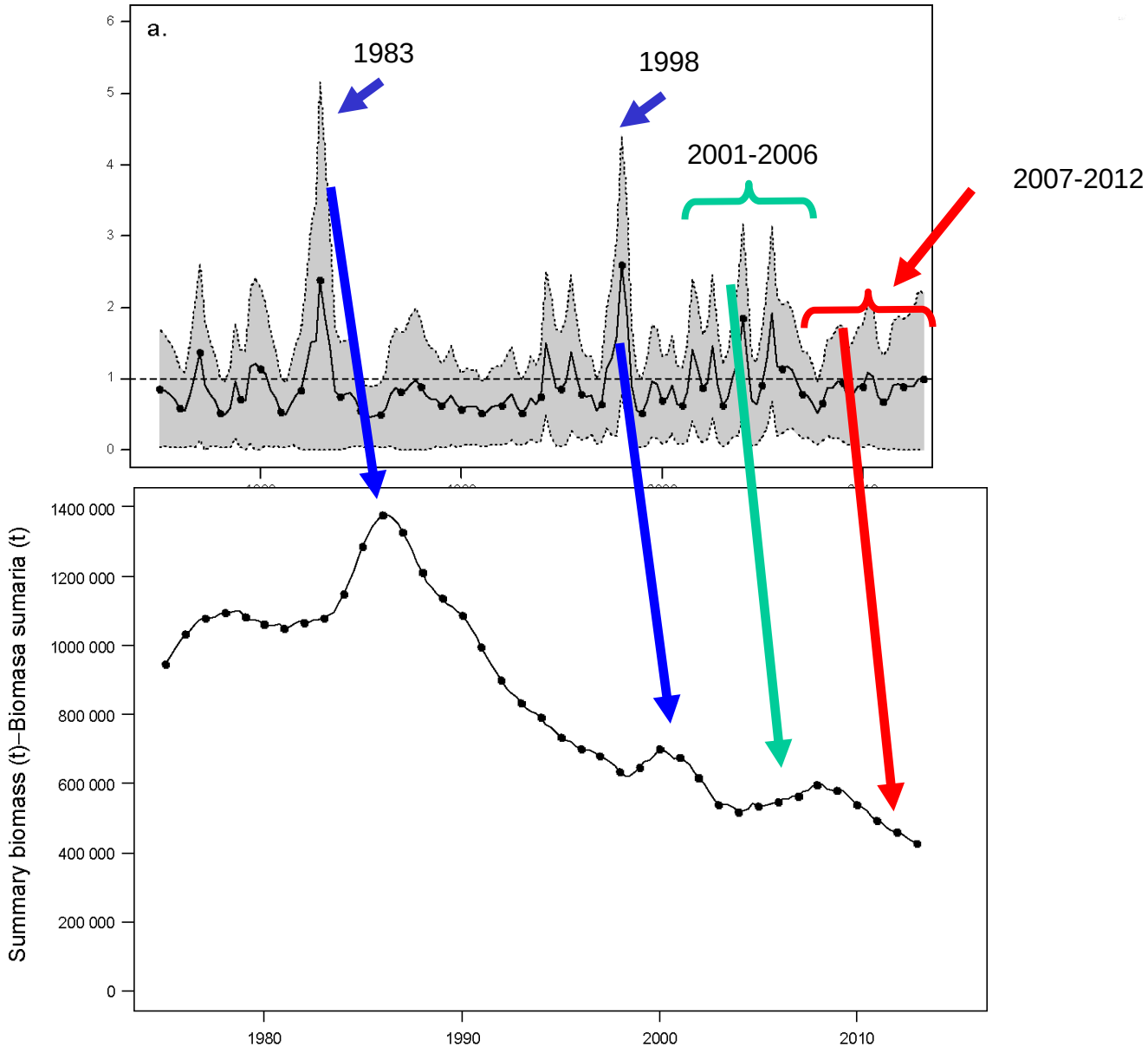
Results
(base case)



Summary biomass

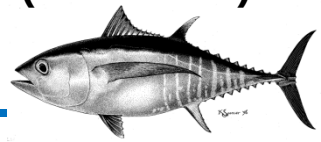
Results (base case)

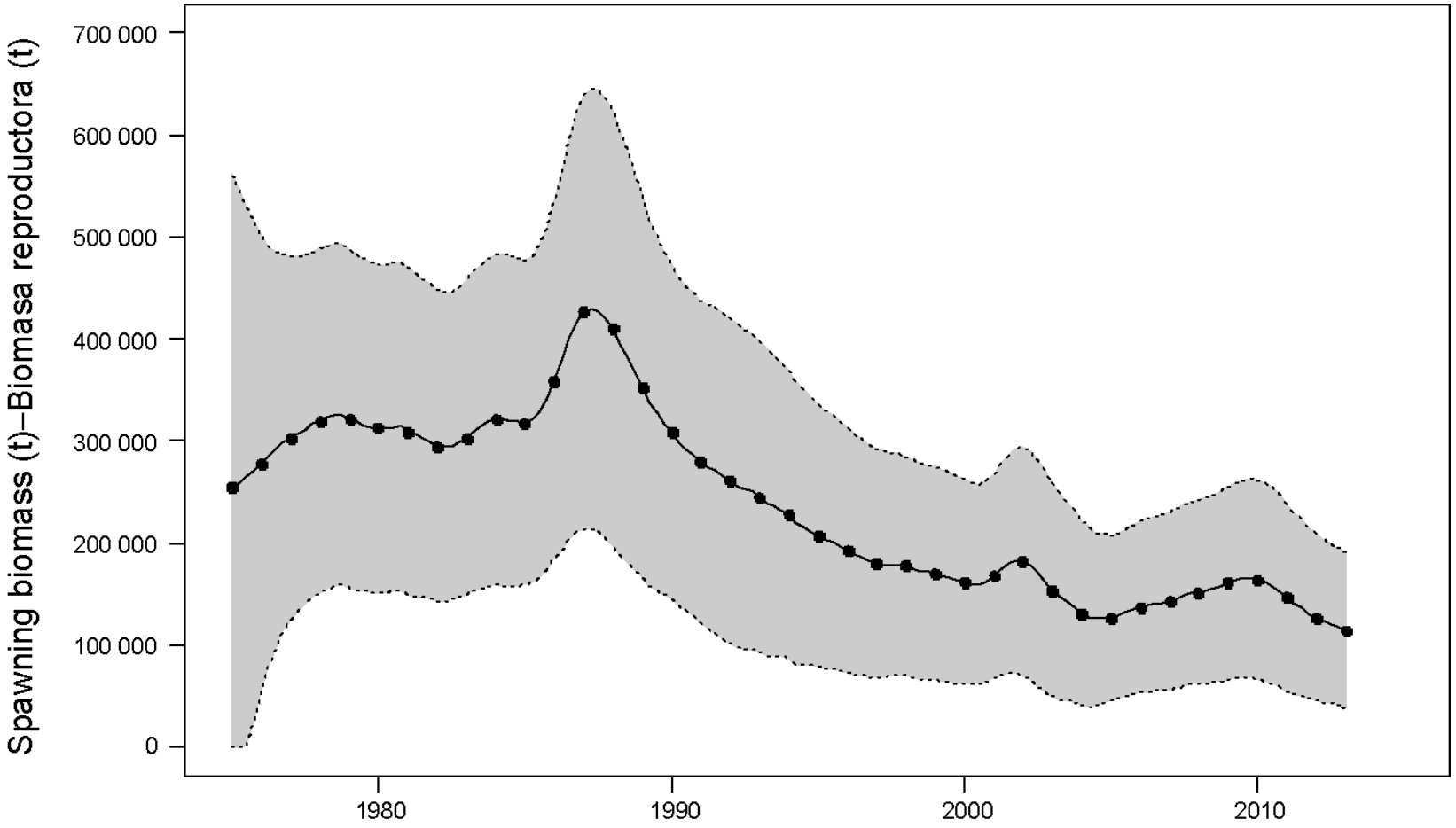




Spawning biomass

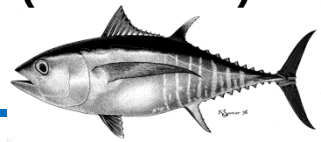
Results
(base case)

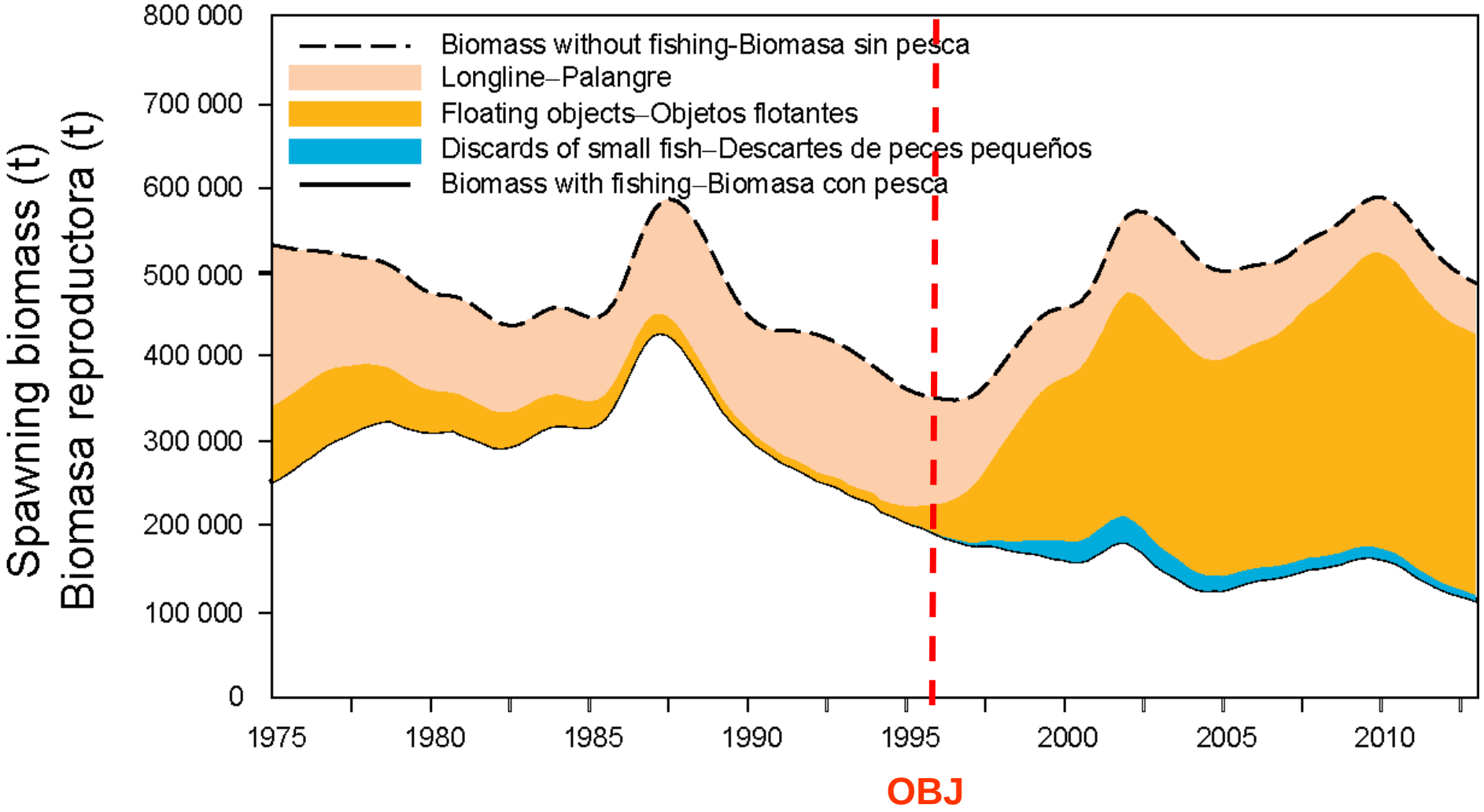




Fishery impact

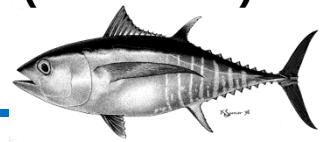
Results
(base case)

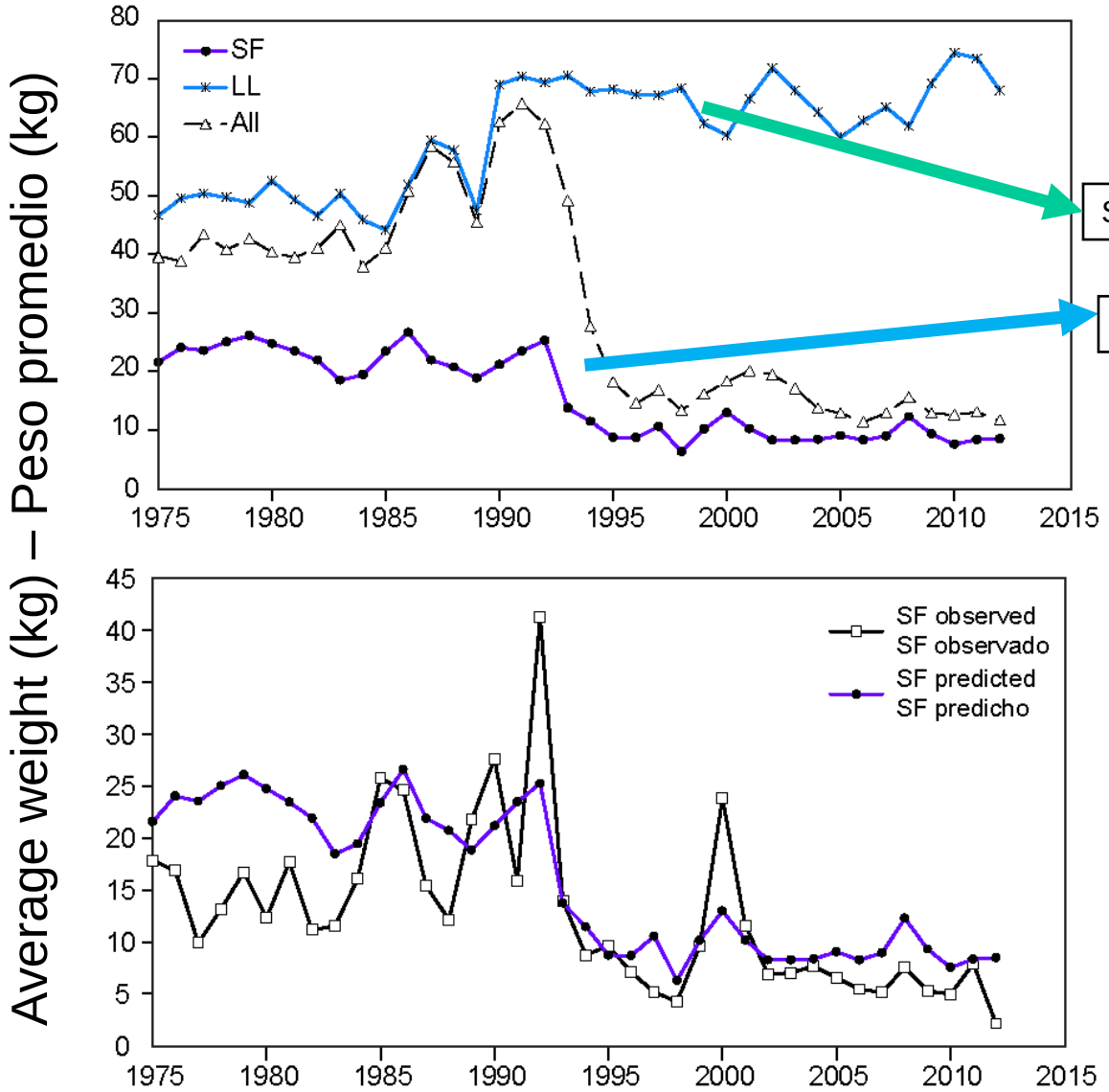




BET average weight - PS

Results (base case)



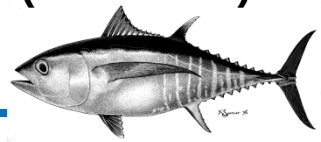


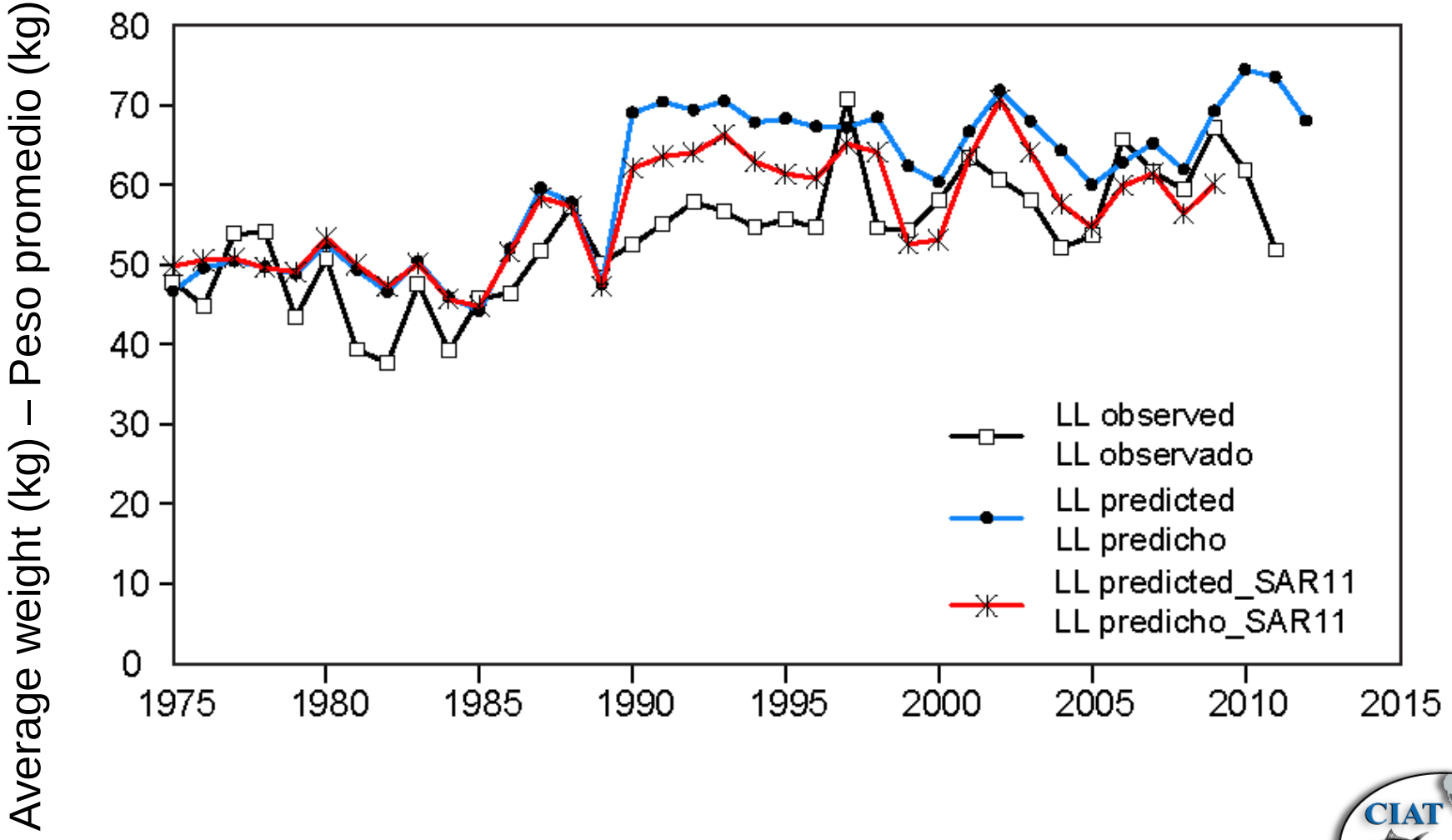
Strong cohort in 1997-1998

OBJ expansion (1993)

BET average weight - LL

Results
(base case)





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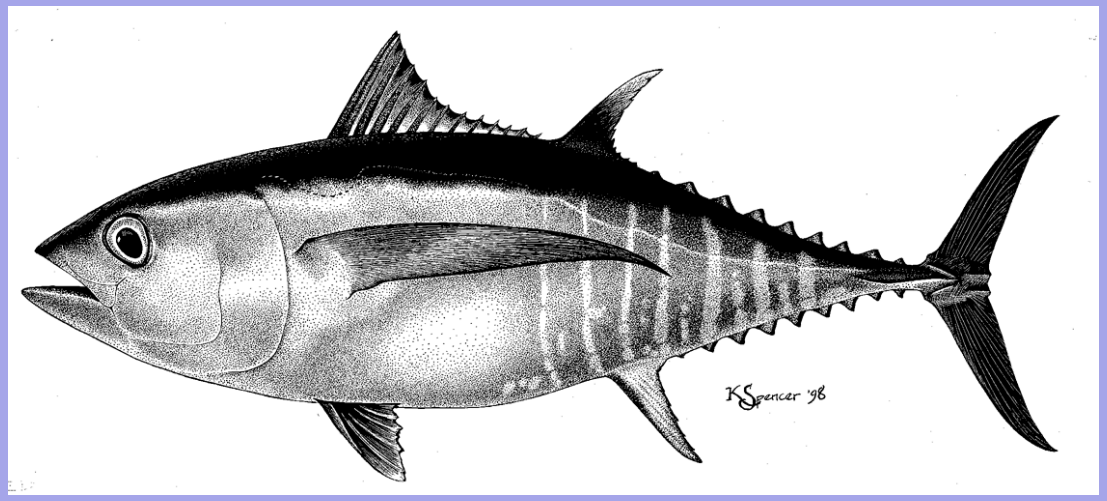
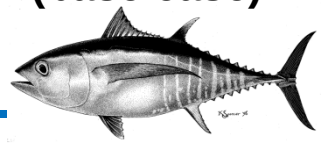


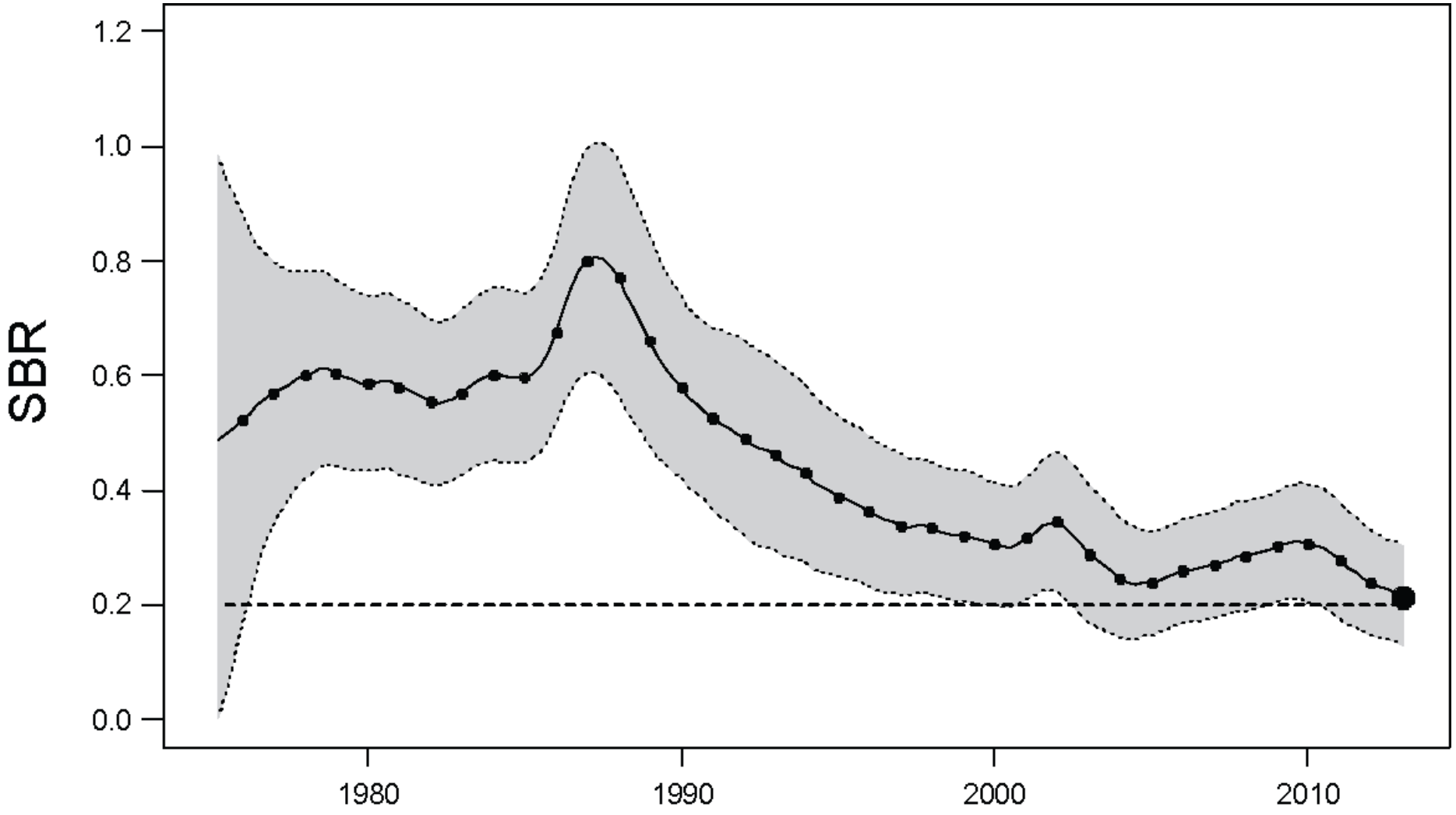
Stock status (base case)

- Spawning Biomass Ratio (SBR)
- Maximum Sustainable Yield (MSY)

Spawning Biomass Ratio (SBR)

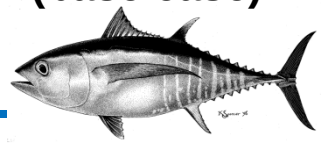
Stock status (base case)





Management quantities

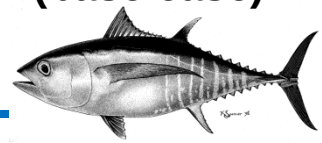
Stock status (base case)

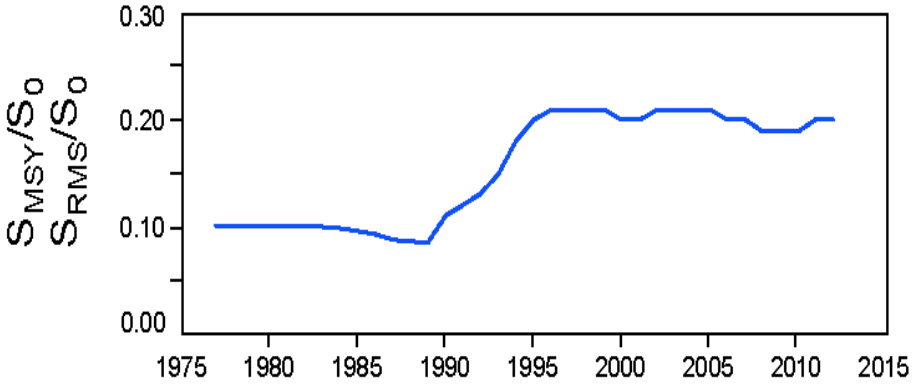


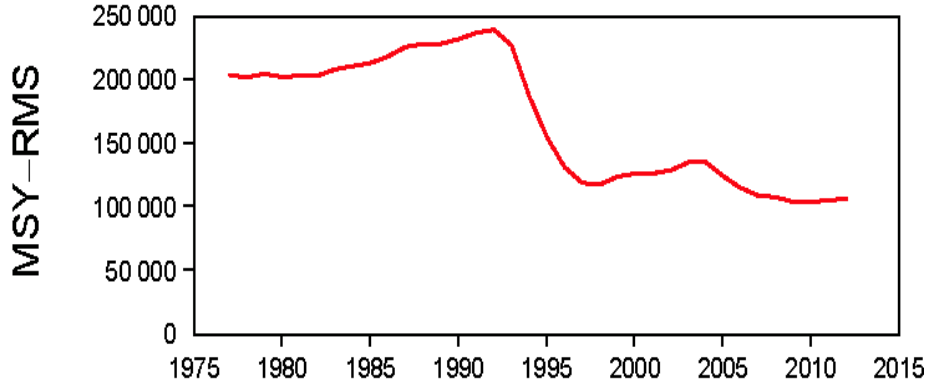
	Base case-Caso base	2010-2011
MSY-RMS	106,706	108,281
B_{MSY}- B_{RMS}	418,468	426,310
S_{MSY}- S_{RMS}	105,969	108,054
B_{MSY}/B_0- B_{RMS}/B_0	0.24	0.25
S_{MSY}/S_0- S_{RMS}/S_0	0.20	0.20
C_{recent}/MSY- C_{recent}/RMS	0.97	0.95
B_{recent}/B_{MSY}- B_{recent}/B_{RMS}	1.02	1.00
S_{recent}/S_{MSY}-S_{recent}/S_{RMS}	1.08	1.06
F multiplier-Multiplicador de F	1.05	1.09

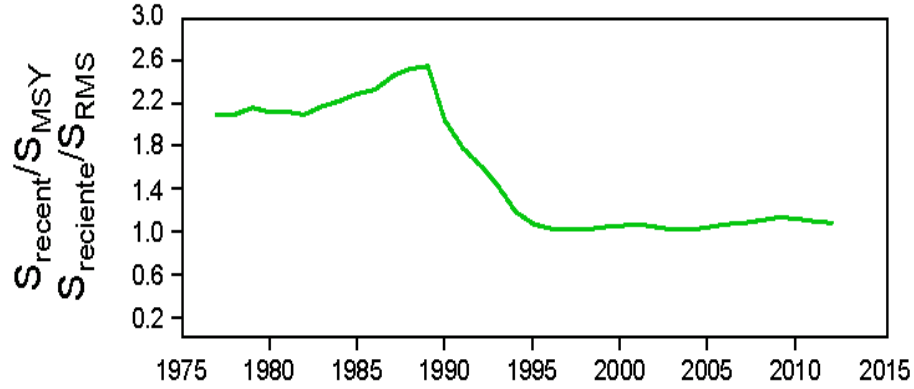
Time varying indicators

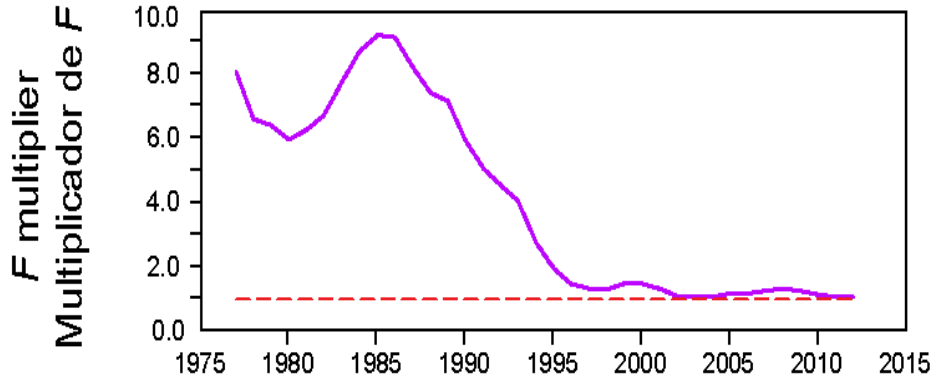
Stock status (base case)



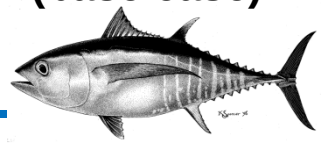








MSY-quantities by fishery



	Base case-Caso base	PS only-solamente	LL only-solamente
MSY-RMS	106,706	77,766	254,983
B_{MSY}- B_{RMS}	418,468	323,018	464,742
S_{MSY}- S_{RMS}	105,969	84,446	61,676
B_{MSY}/B_0- B_{RMS}/B_0	0.24	0.19	0.27
S_{MSY}/S_0- S_{RMS}/S_0	0.20	0.16	0.12
C_{recent}/MSY- C_{recent}/RMS	0.97	1.32	0.40
B_{recent}/B_{MSY}- B_{recent}/B_{RMS}	1.02	1.33	0.92
S_{recent}/S_{MSY}-S_{recent}/S_{RMS}	1.08	1.36	1.86
F multiplier-Multiplicador de F	1.05	1.54	8.57

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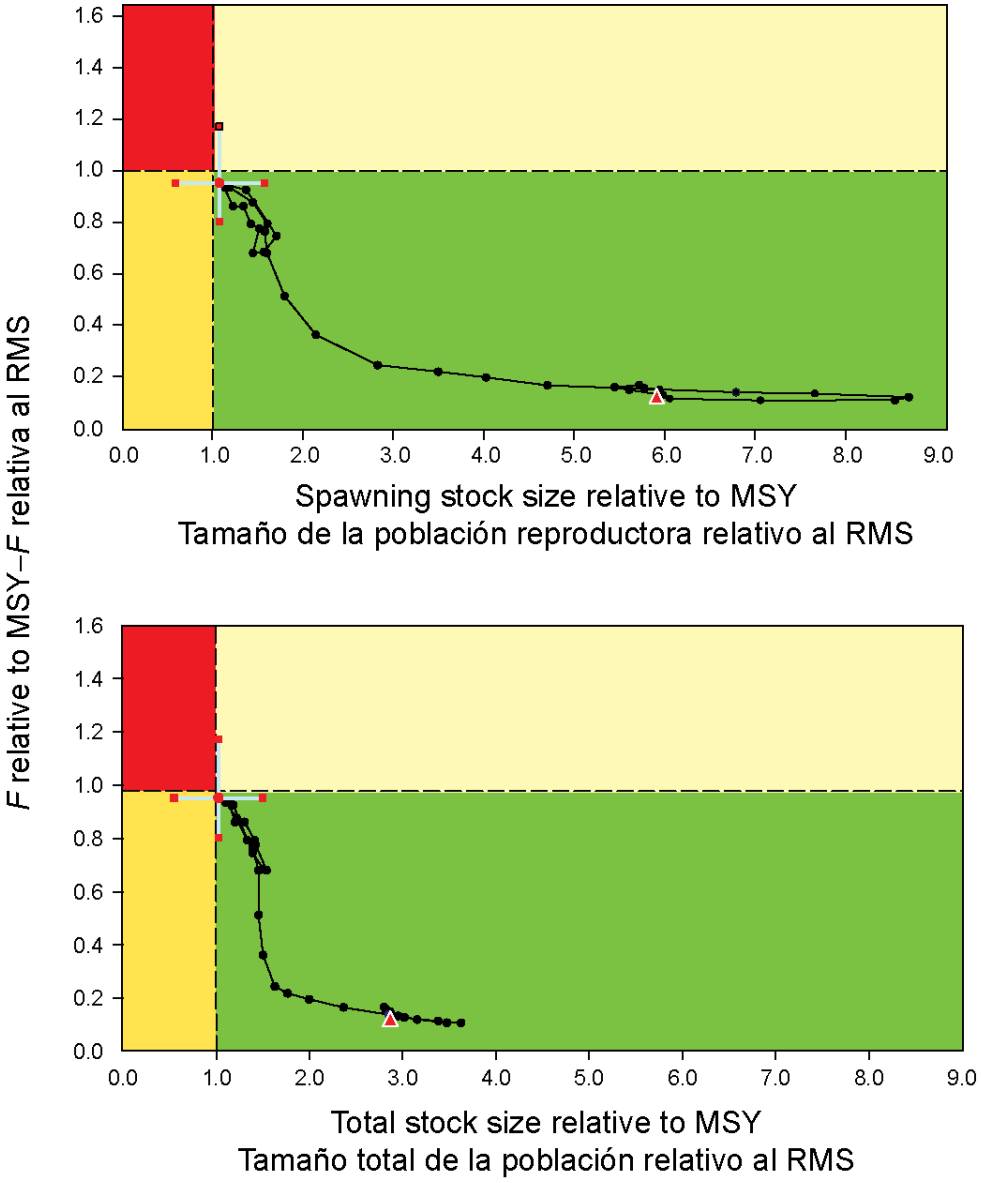
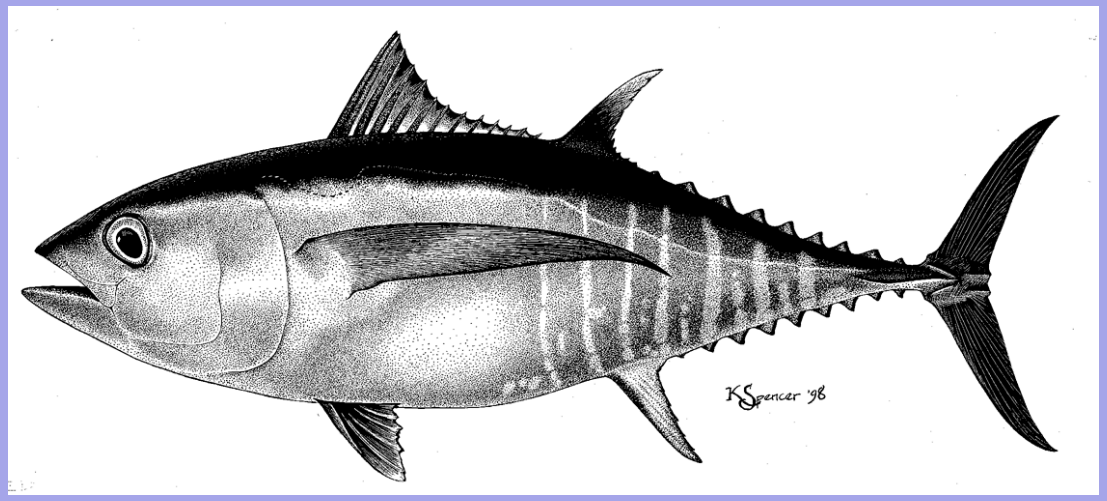
Target Kobe plots

Stock status (base case)





Projection simulations (base case)

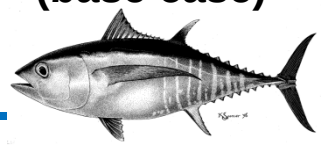
- Status quo fishing strategy
- MSY fishing strategy
- Effect of tuna conservation resolutions (2004-2012)

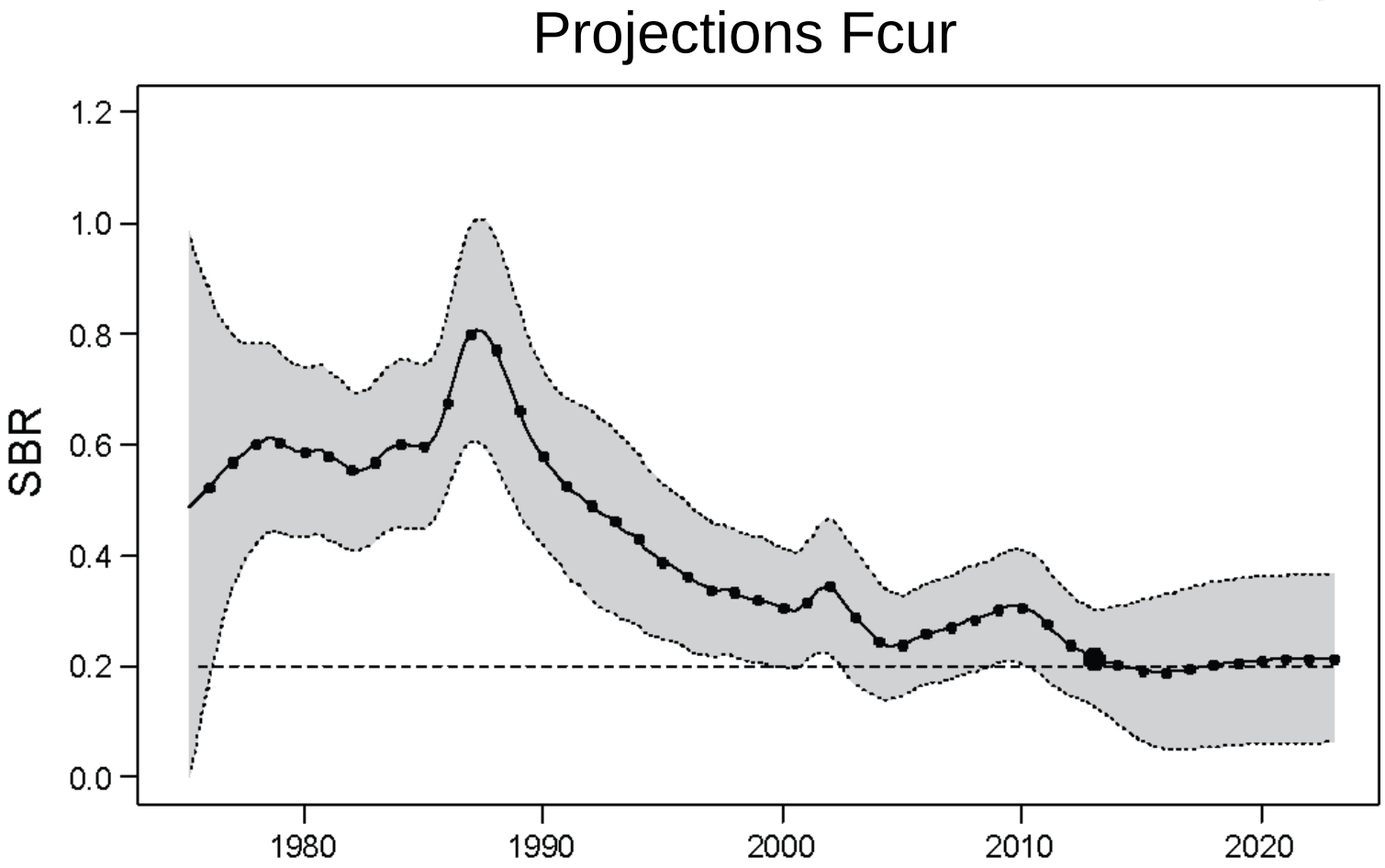
Forward projections

- Projection period: 10 years (2013-2022)
- Evaluate:
  - Catches (surface and longline fisheries)
  - Spawning Biomass Ratio (SBR)
- Three exploitation scenarios:
  - Status quo (F_{cur}): 3-year F average (2010-2012)
  - F_{MSY}
  - No IATTC tuna conservation resolutions (2004-2012)

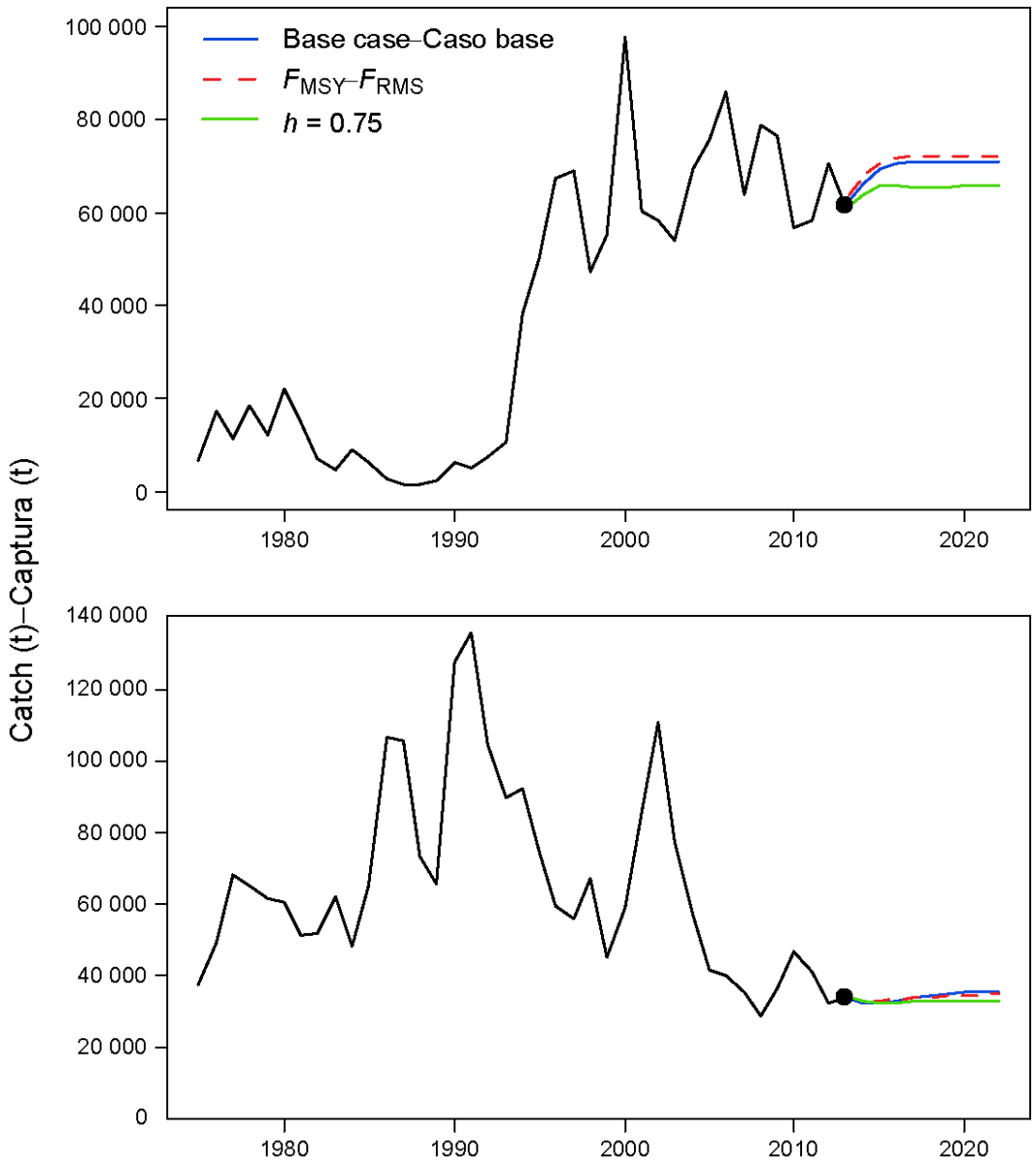
Spawning Biomass Ratio (SBR)

Projections (base case)



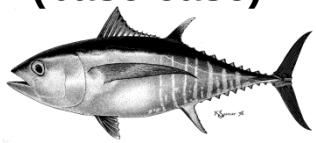


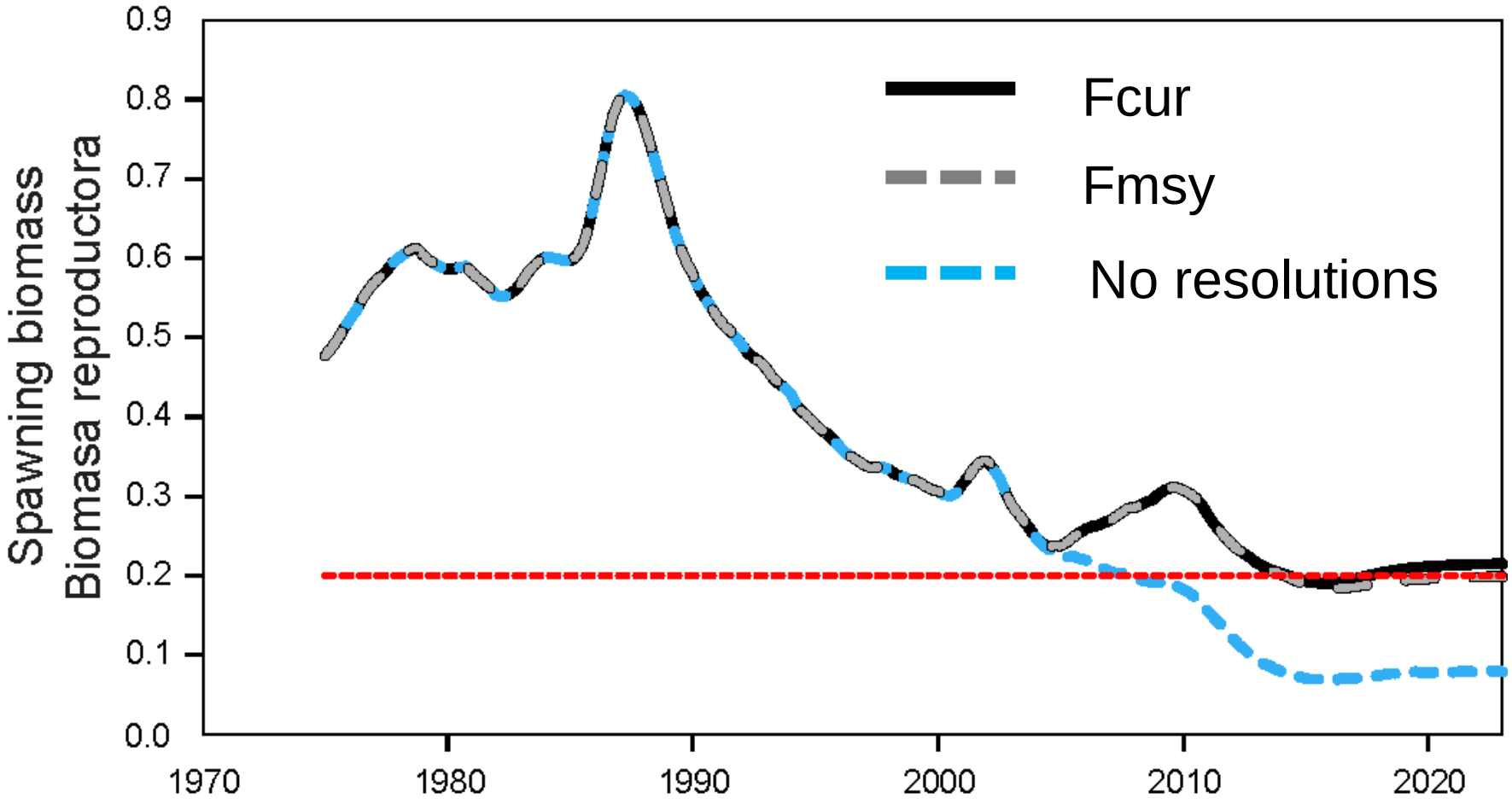
Projected catches



Spawning Biomass Ratio

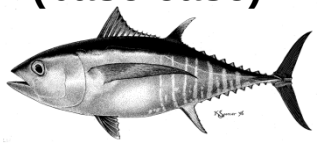
Projections (base case)

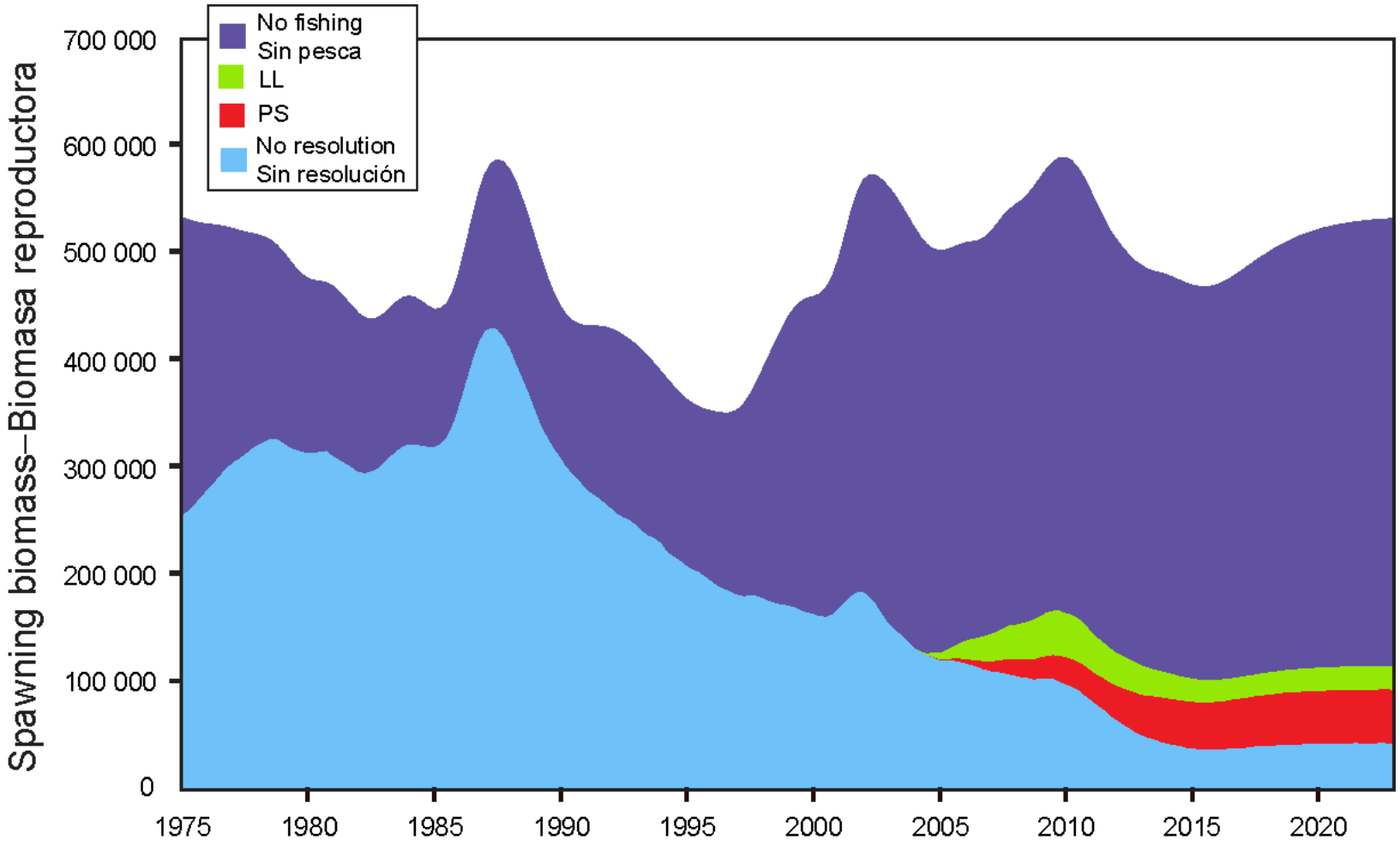




Impact of conservation measures

Projections (base case)





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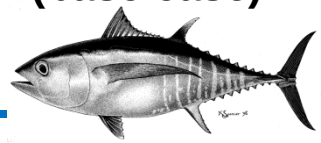
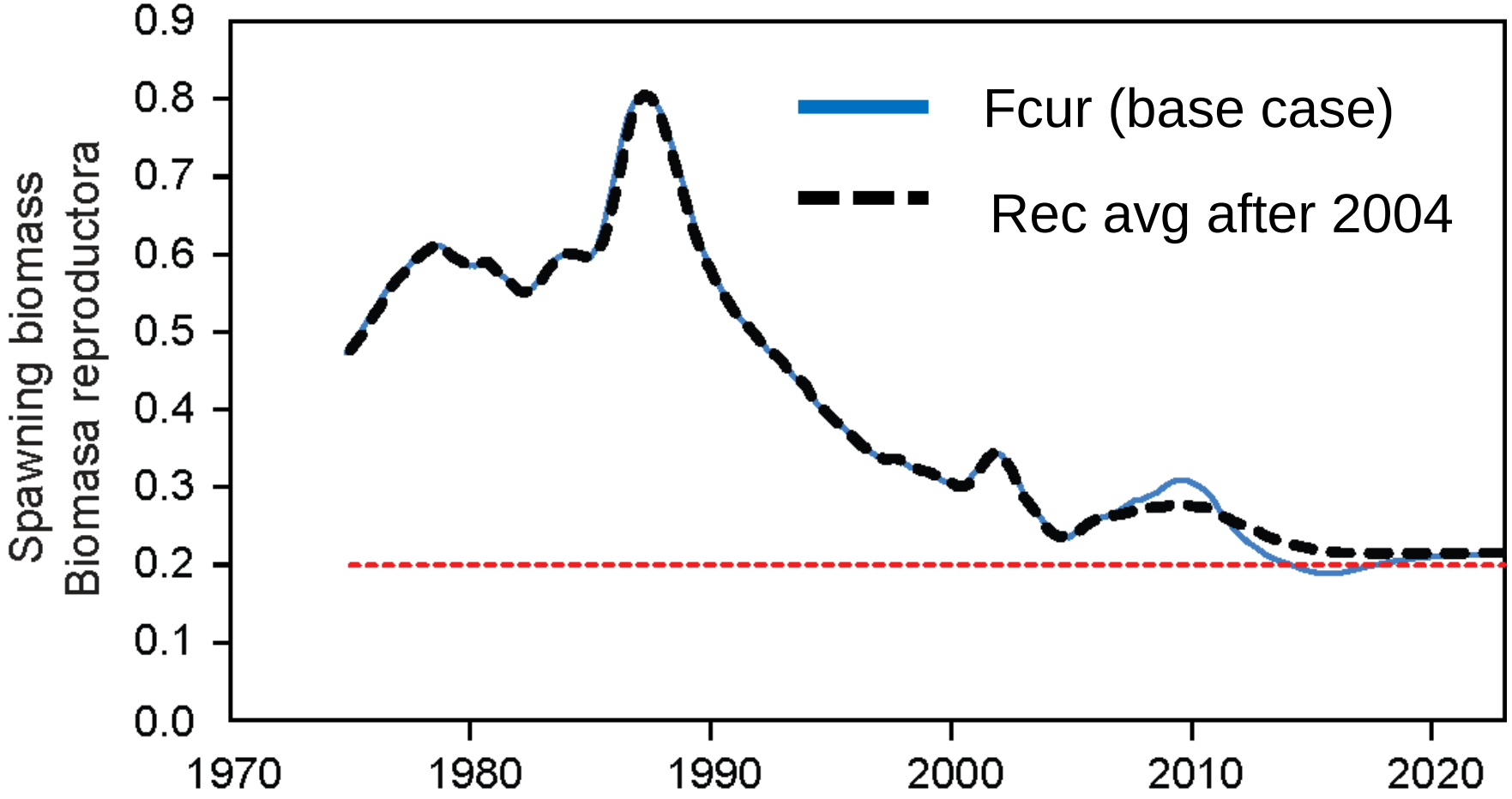
Spawning Biomass Ratio (SBR)

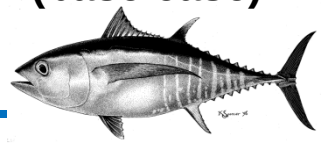
Stock status (base case)



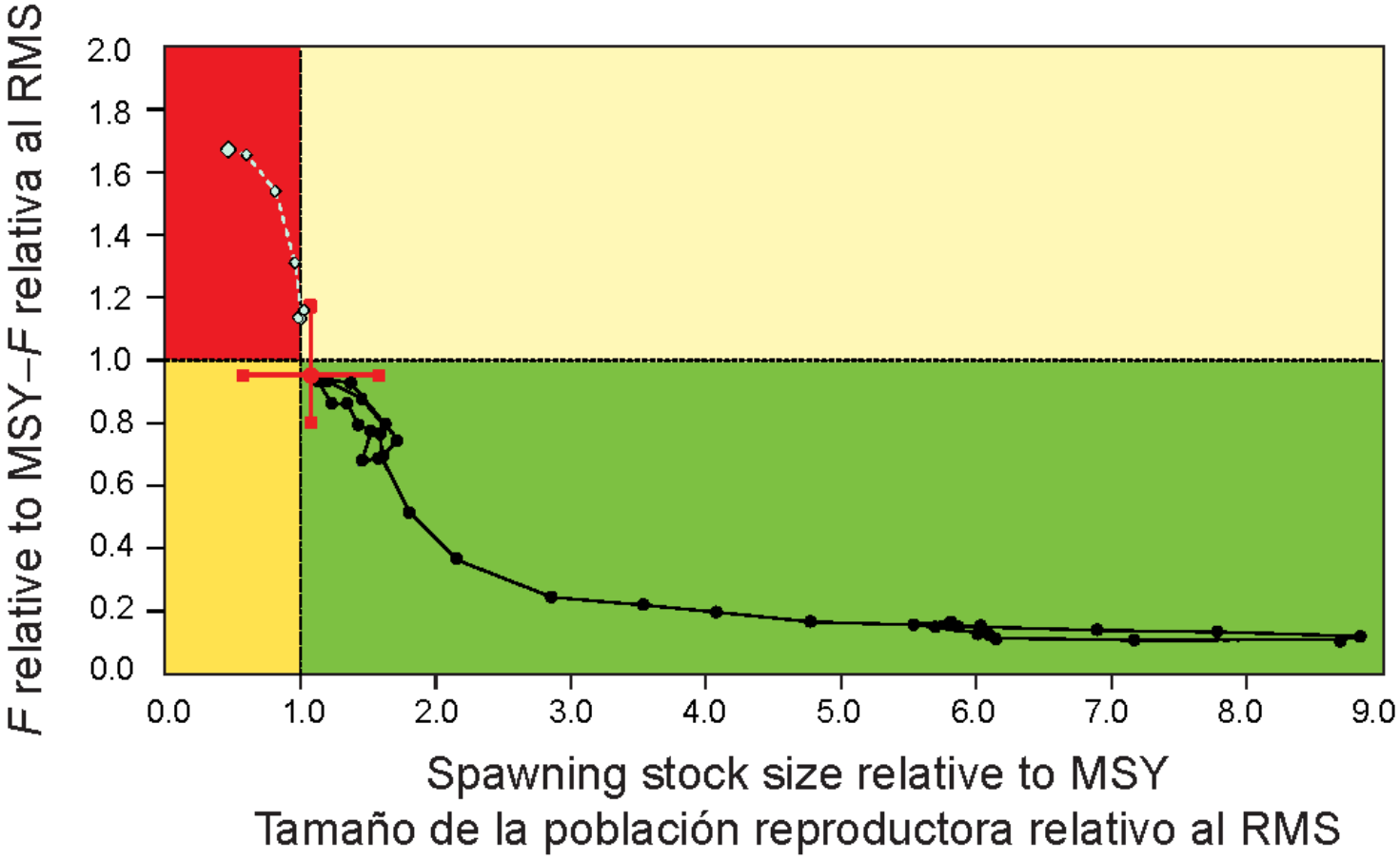


Target Kobe plots

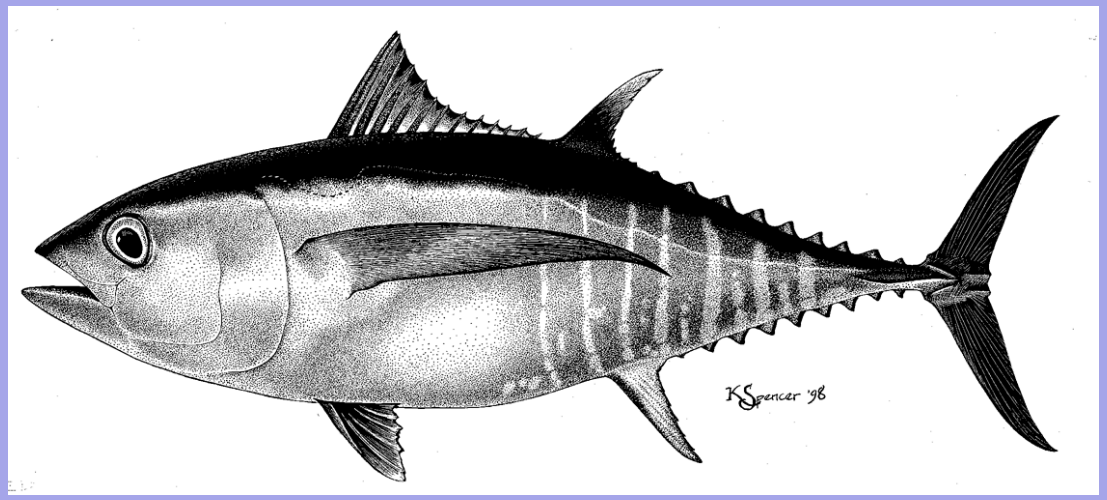
Stock status (base case)



Effect of no IATTC tuna conservation resolutions



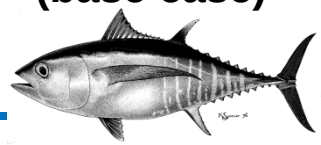
CIAT IATTC

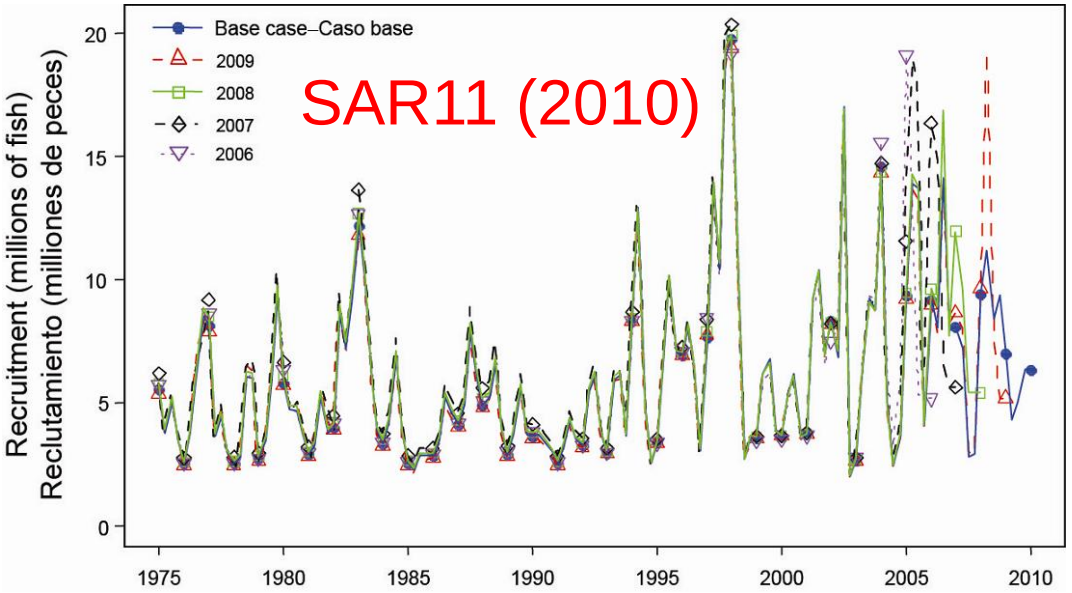


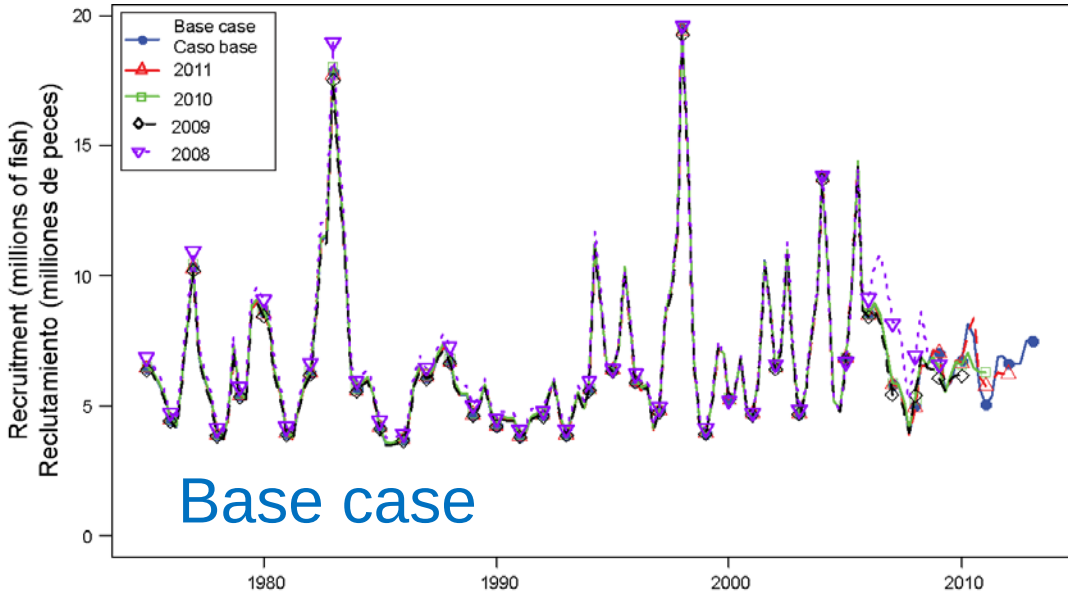
Retrospective analysis

Recruitment - retrospective

Retrospective (base case)

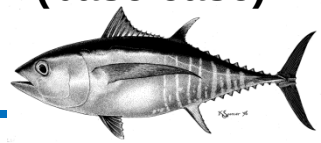


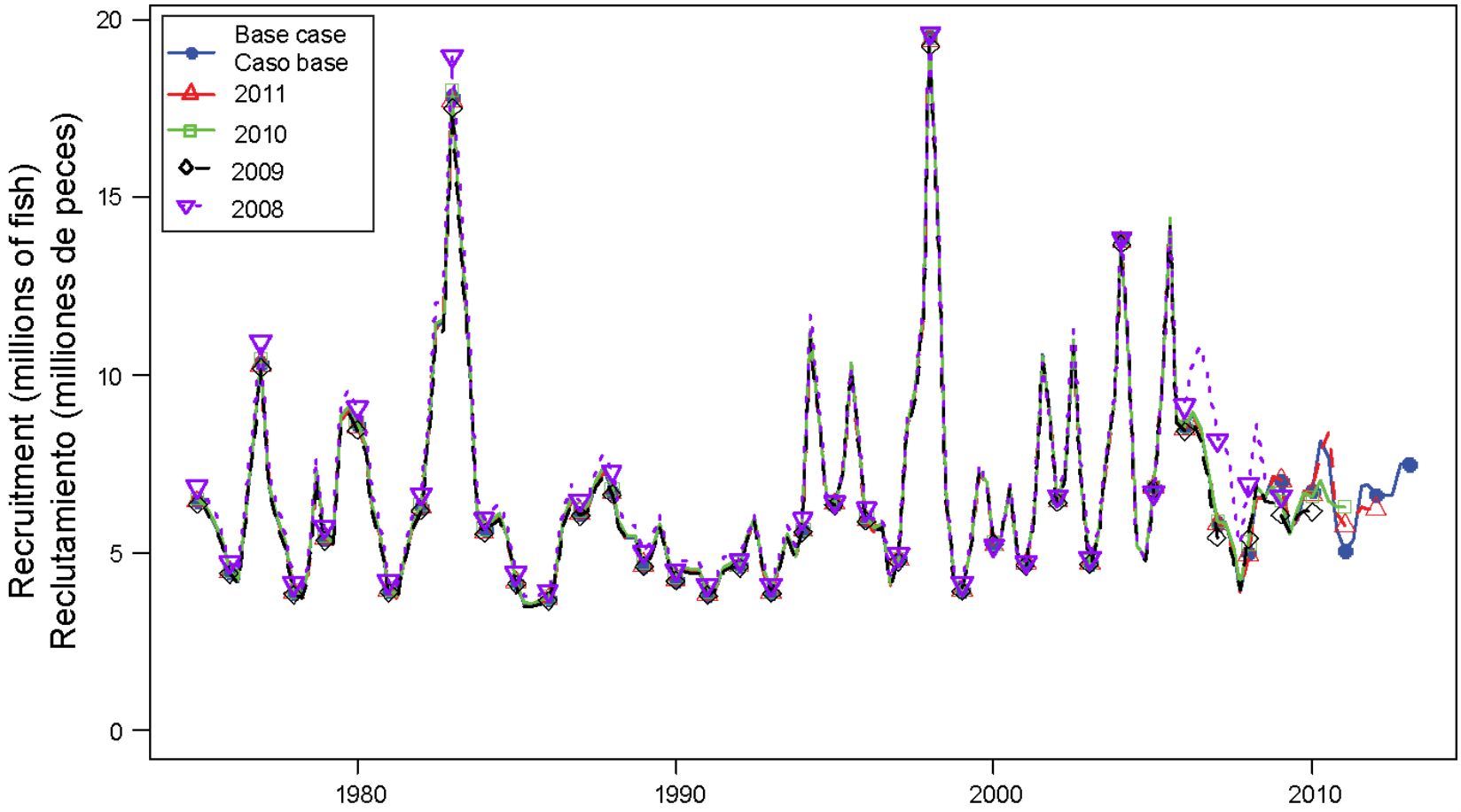




Recruitment - retrospective

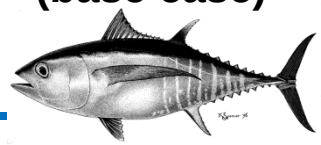
Retrospective (base case)

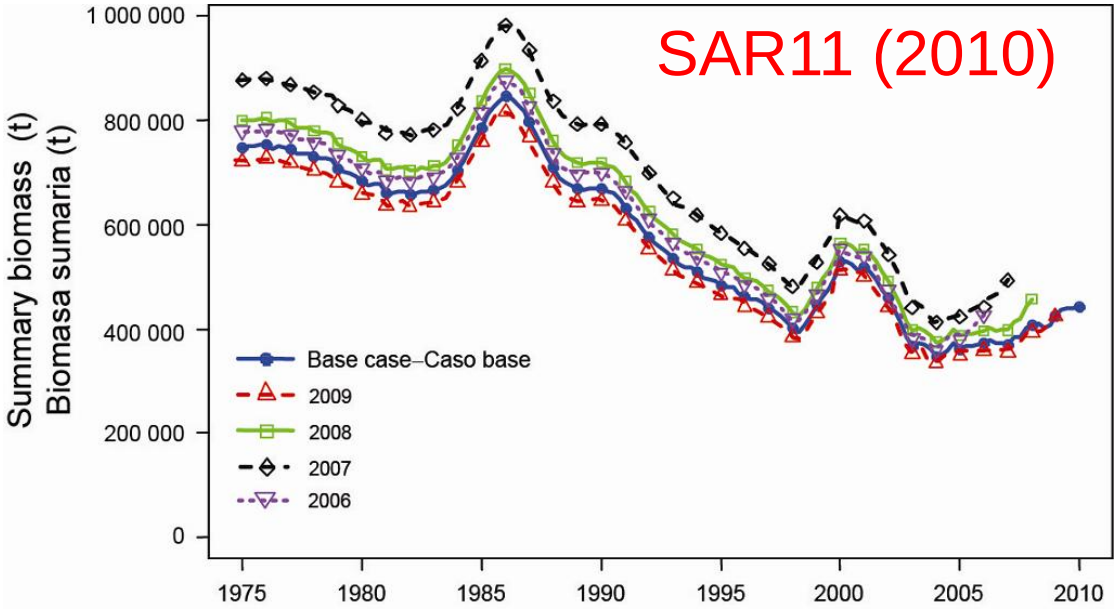


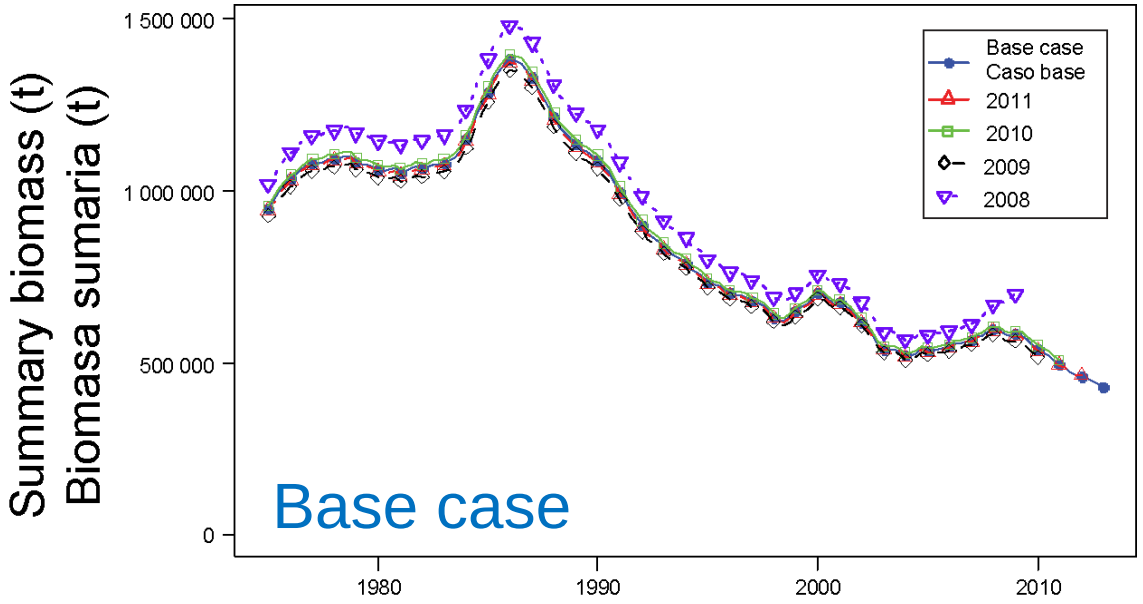


Biomasses - retrospective

Retrospective (base case)

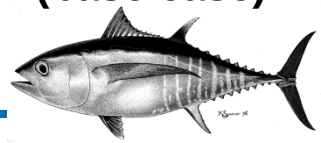


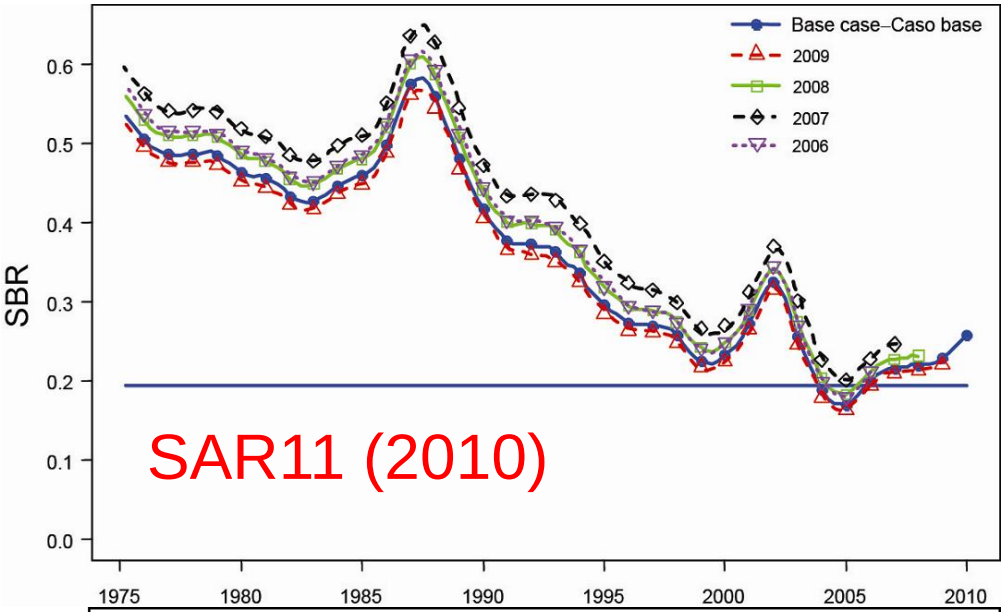


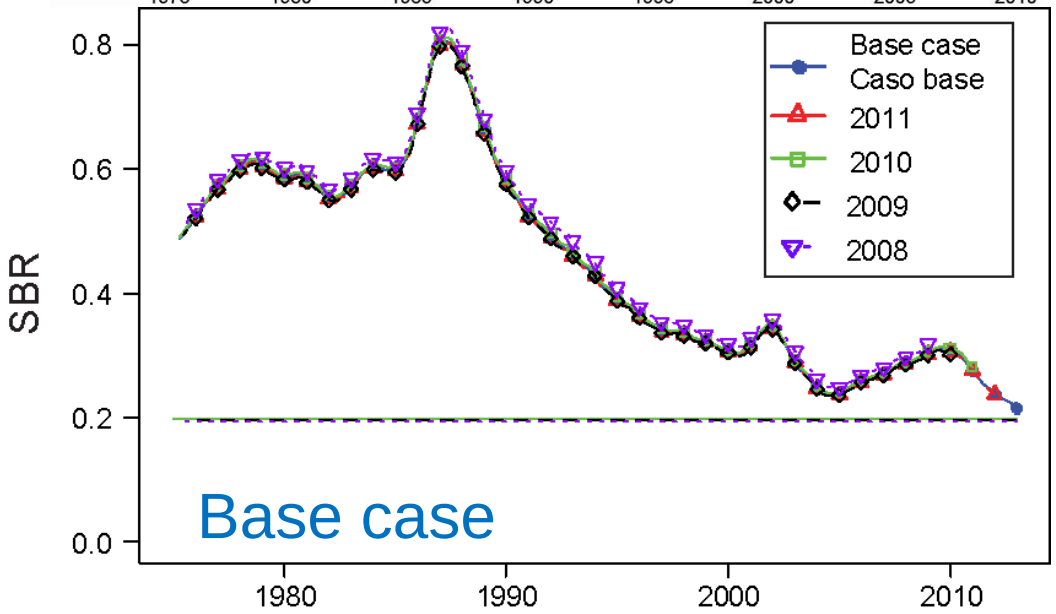


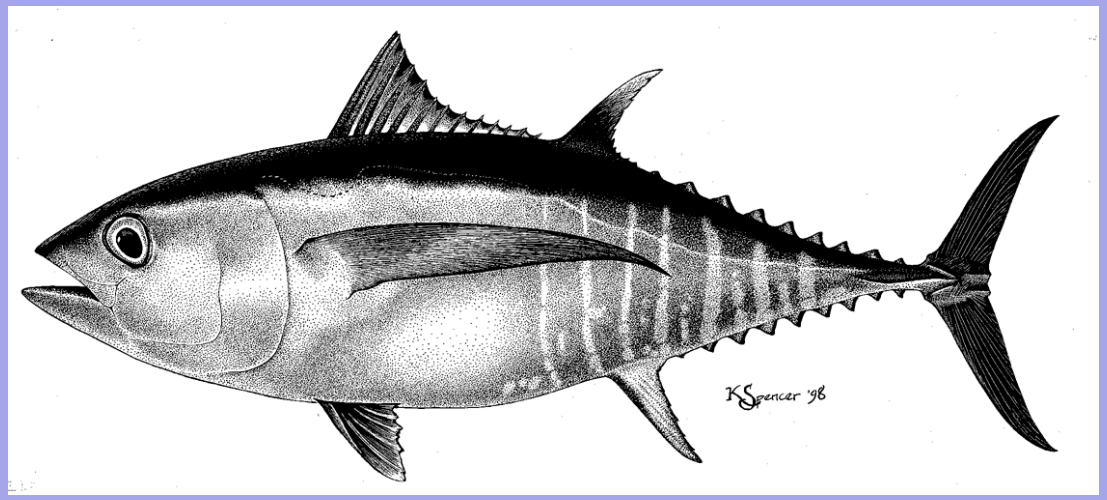
Biomasses - retrospective

Retrospective (base case)





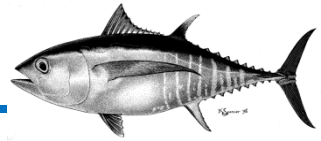


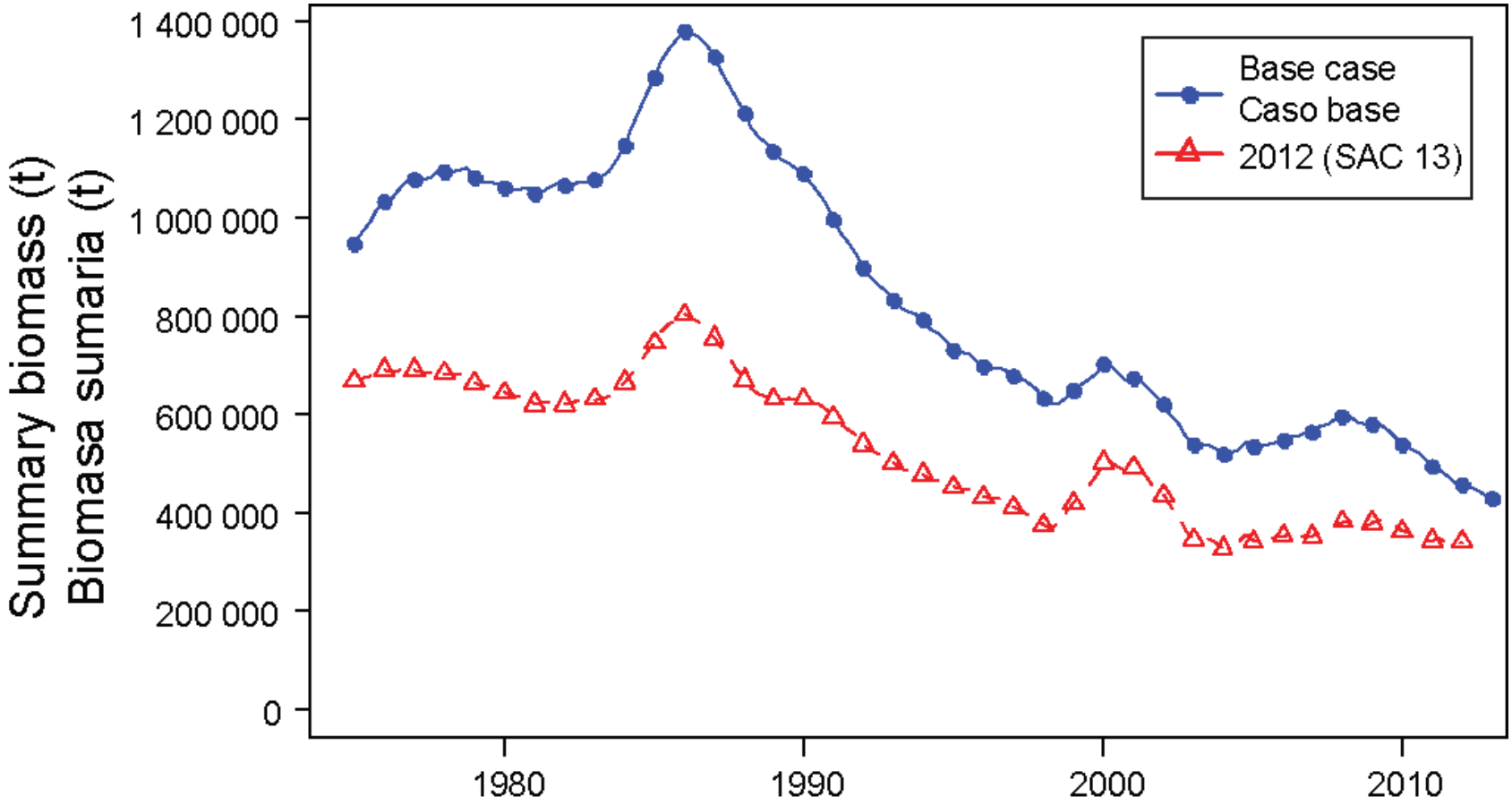


Comparisons to previous assessment (SAR11)

Summary biomass

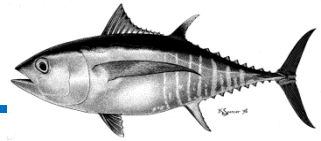
Comparison to SAR10

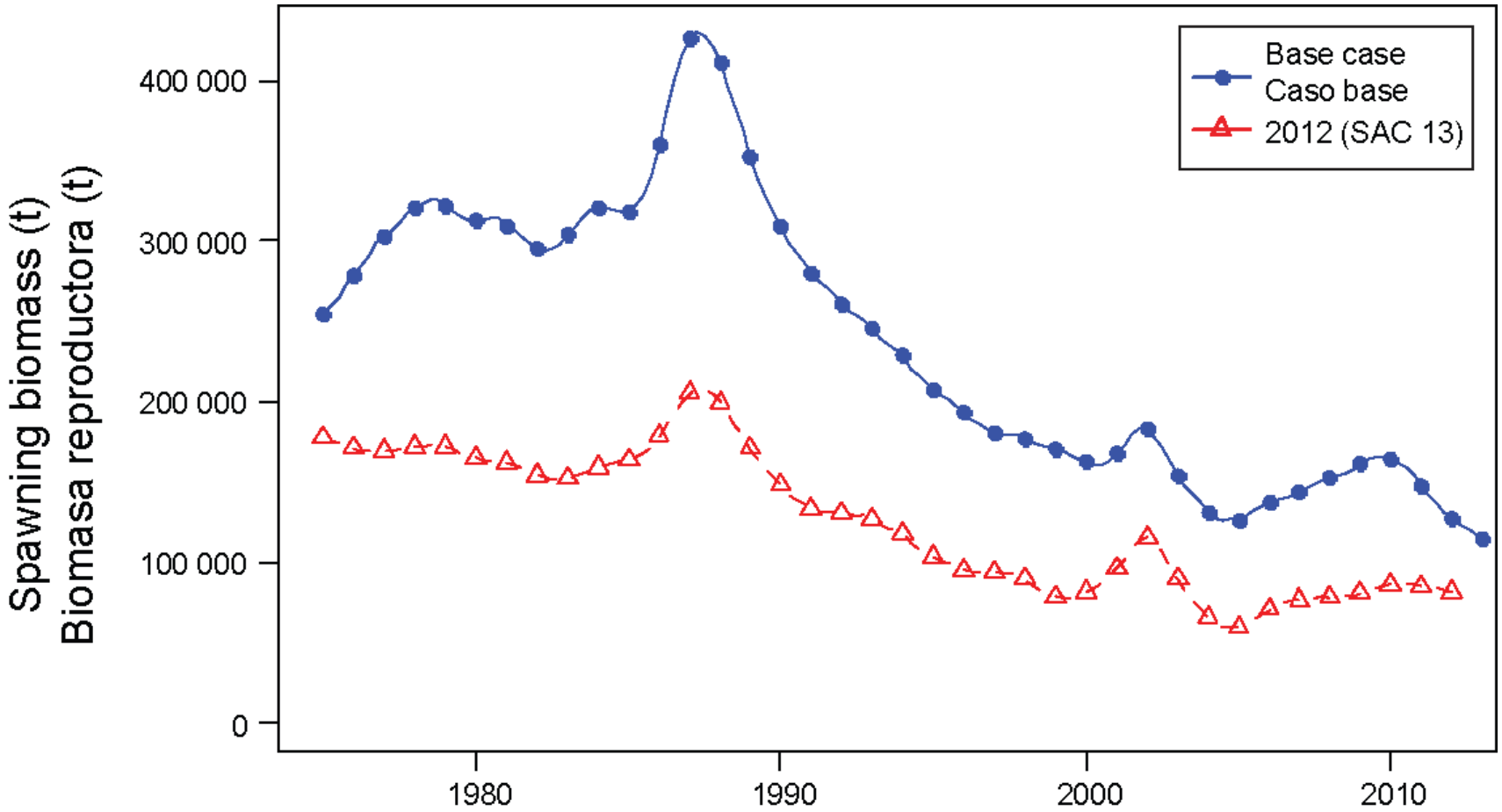




Spawning biomass

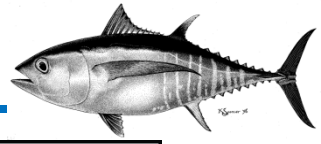
Comparison to SAR10

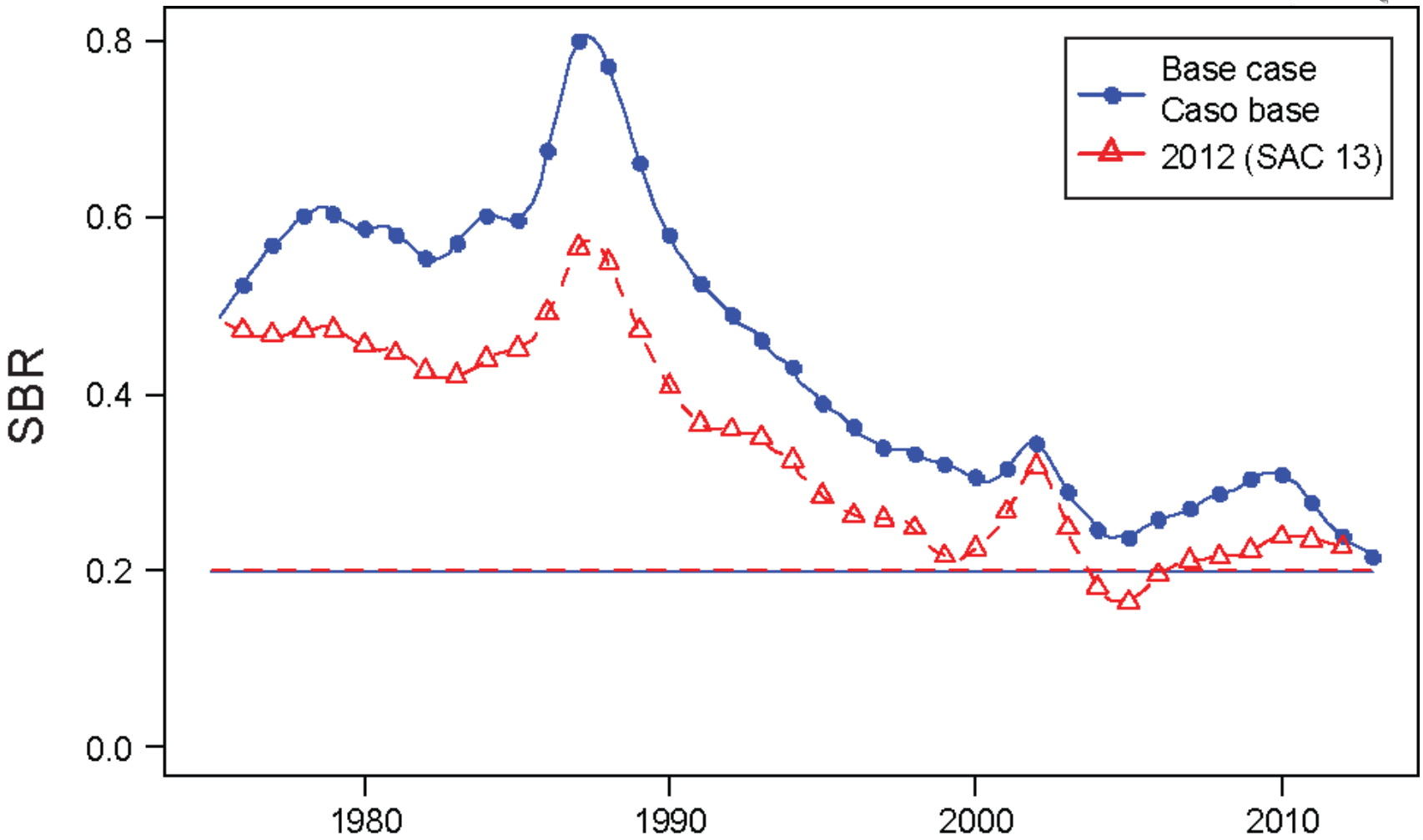




Spawning biomass ratio

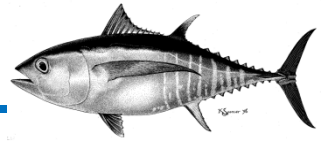
Comparison to SAR10

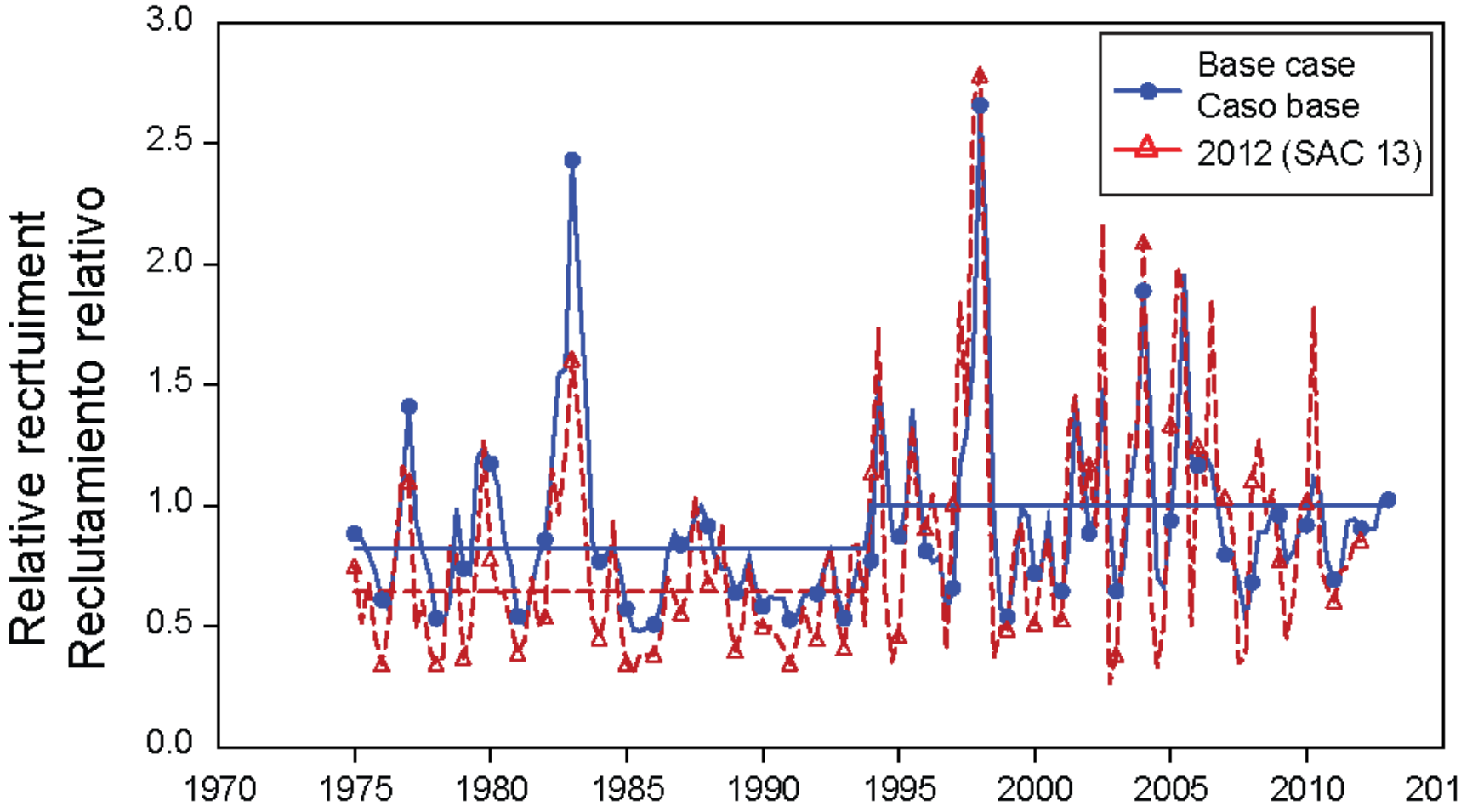




Recruitment

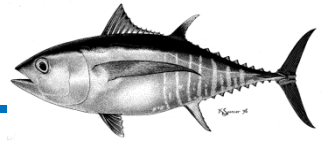
Comparison to SAR10

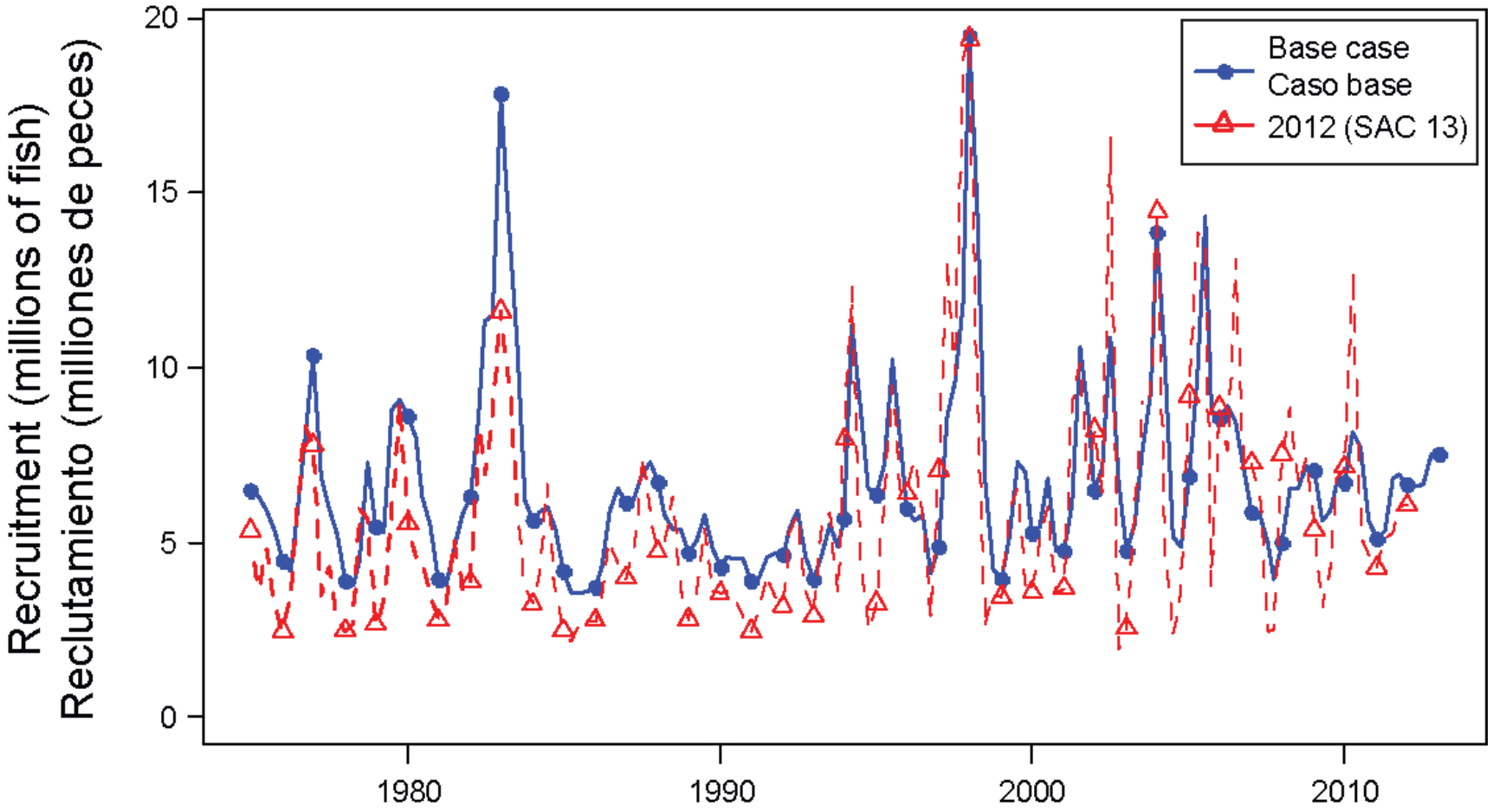




Recruitment

Comparison to SAR10





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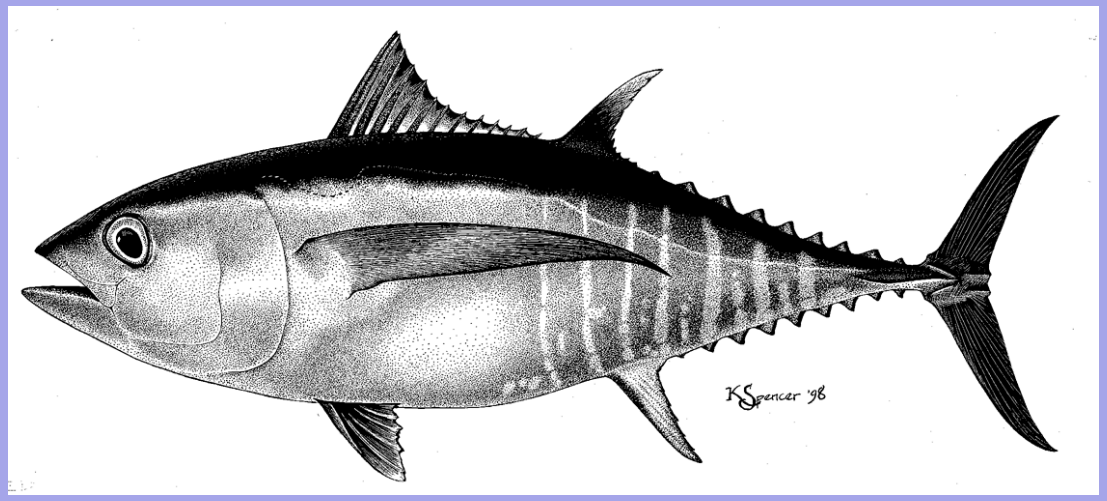
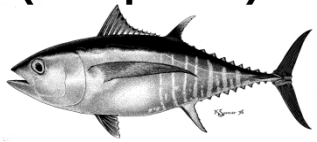


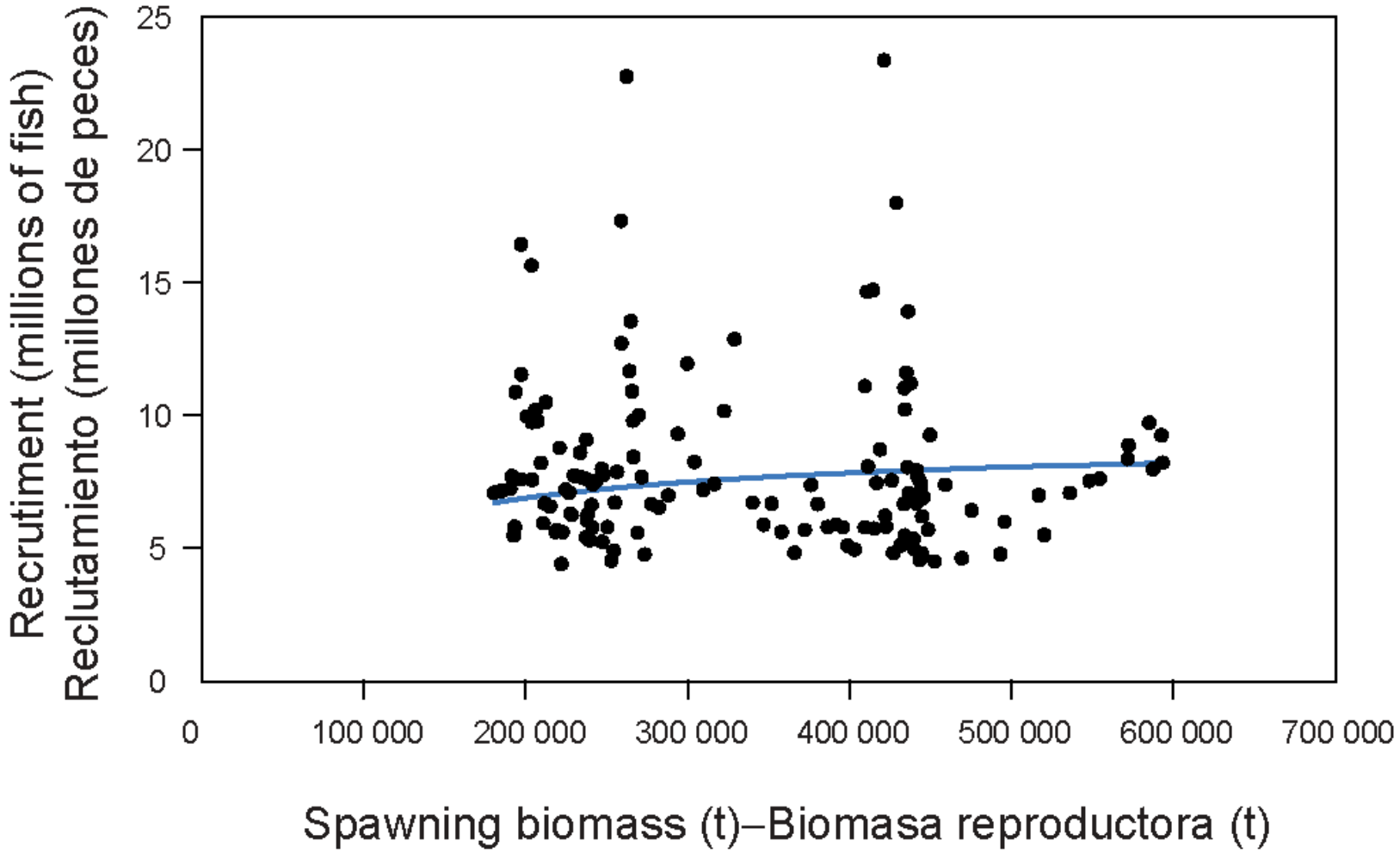
Sensitivity analyses

- Steepness of SR relationship (Appendix A)
- Adult natural mortality (Appendix B)
- Sensitivity analysis to the weighting assigned to the size composition data (Appendix C)

Spawner-recruitment curve

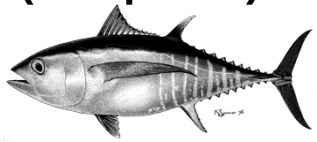
Sensitivities (Steepness)

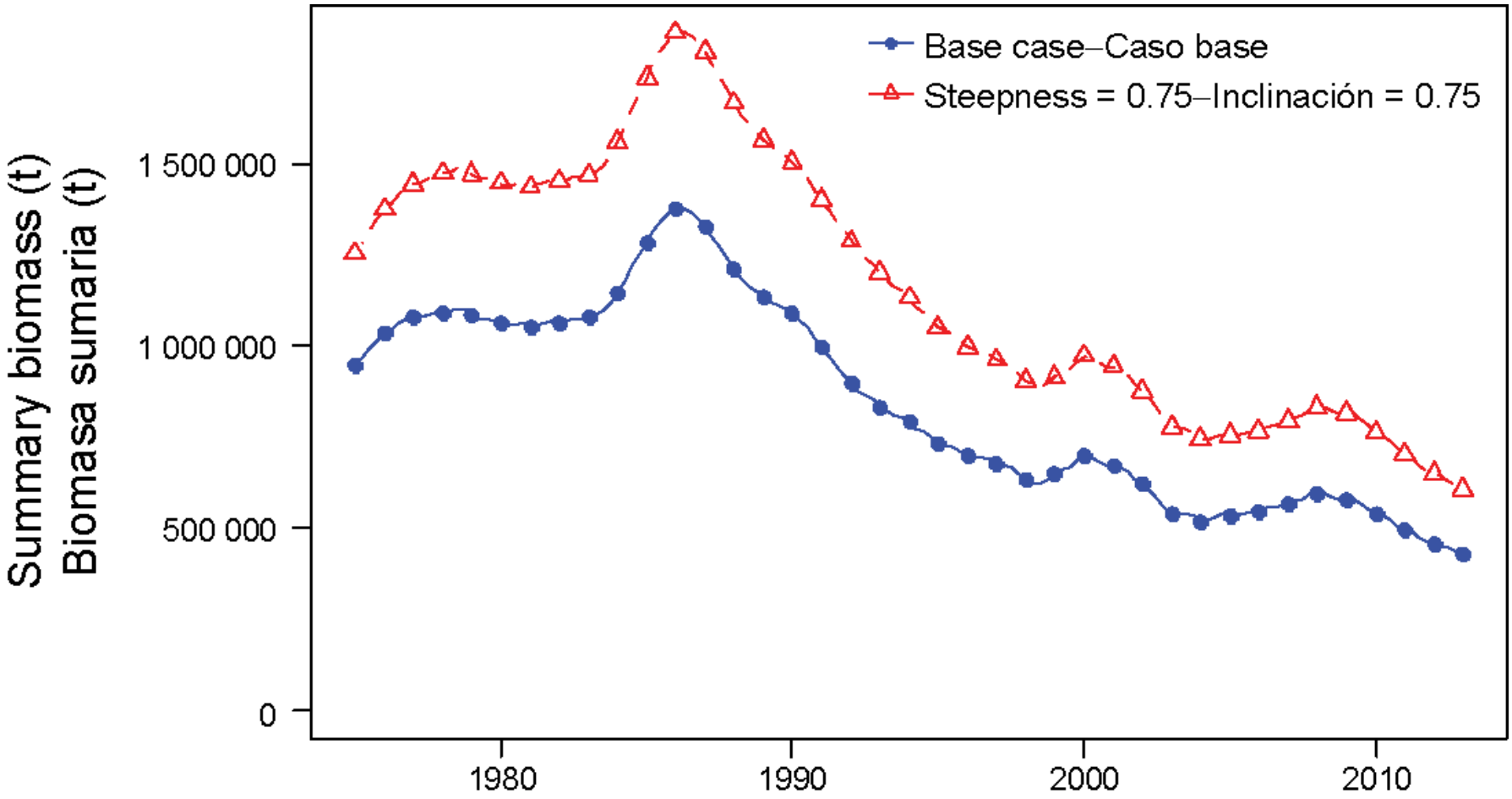




Summary biomass

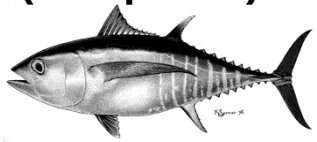
Sensitivities (Steepness)

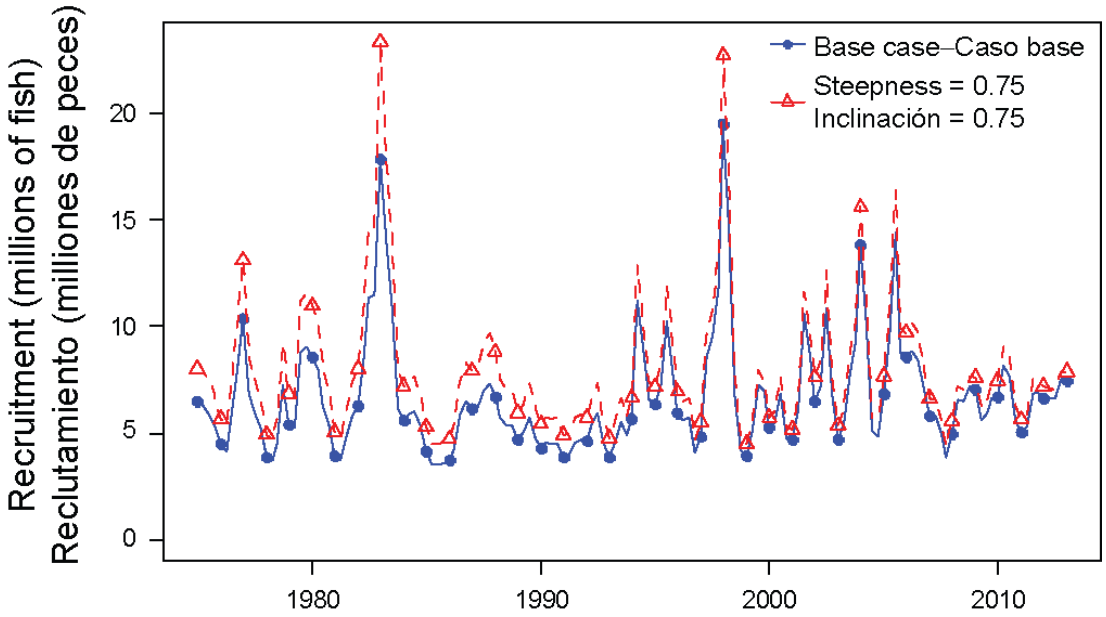


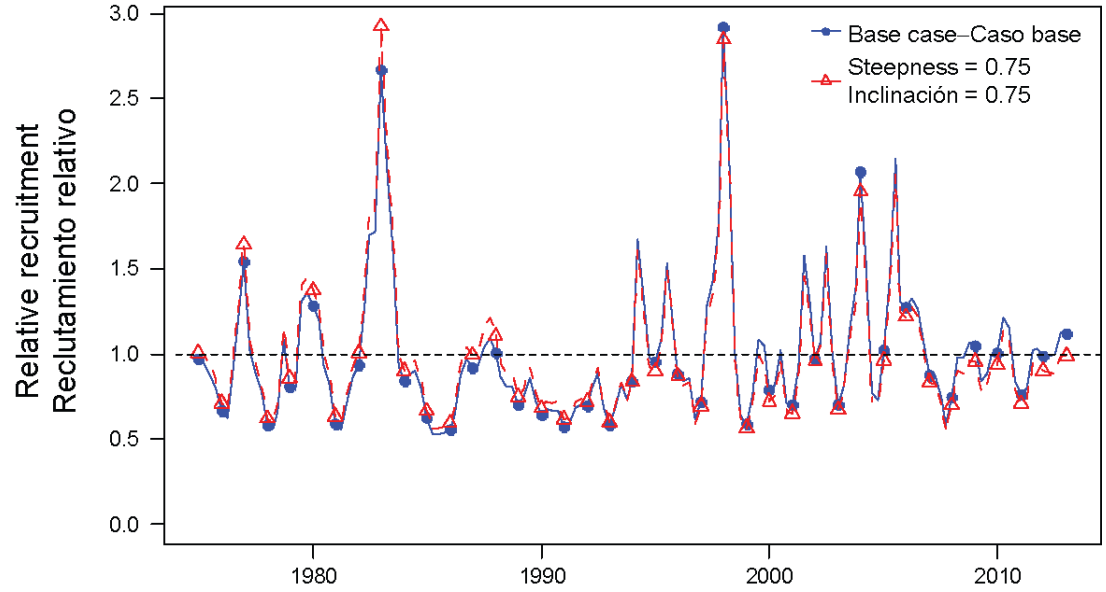


Recruitment

Sensitivities (Steepness)

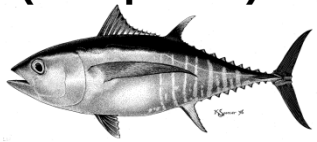


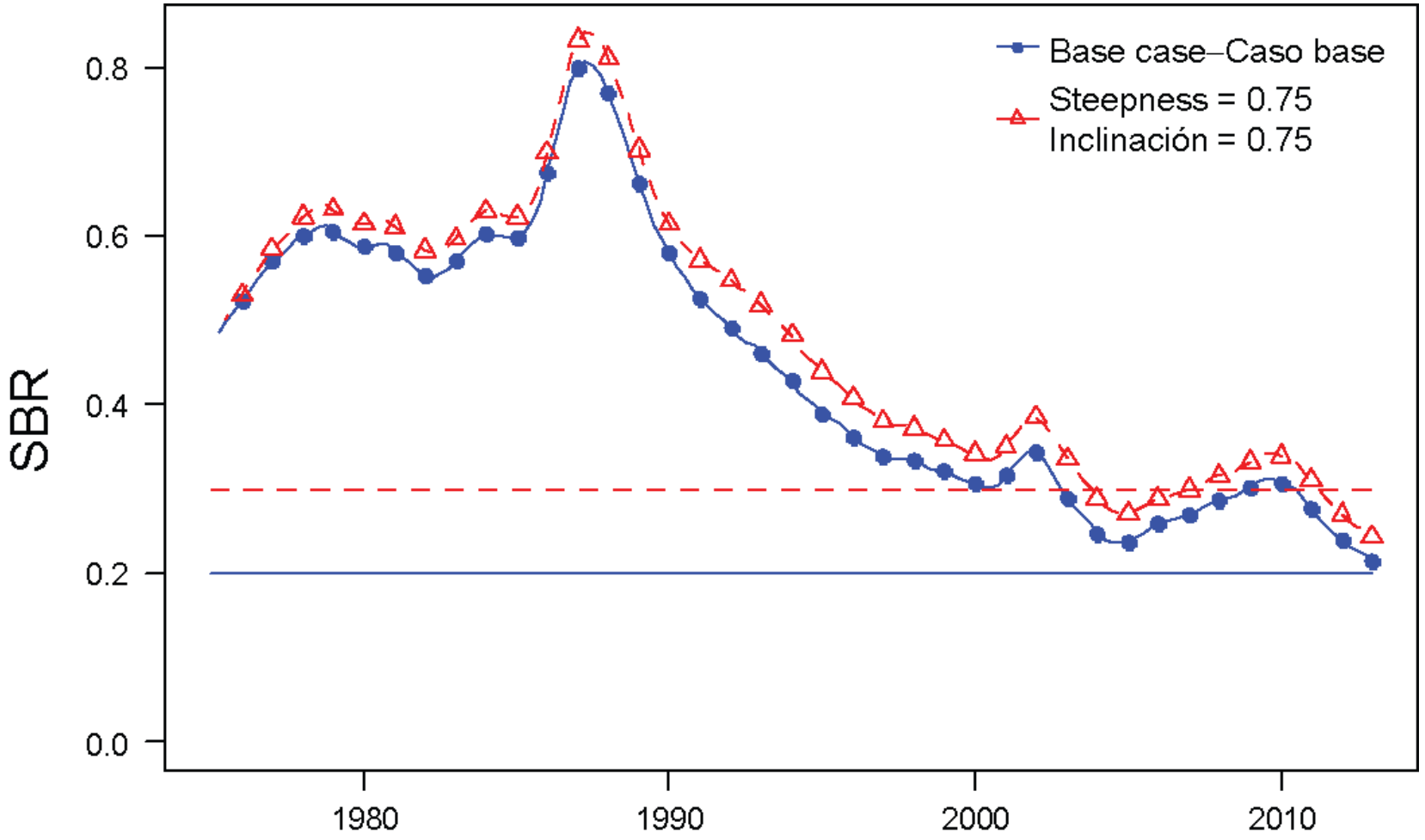




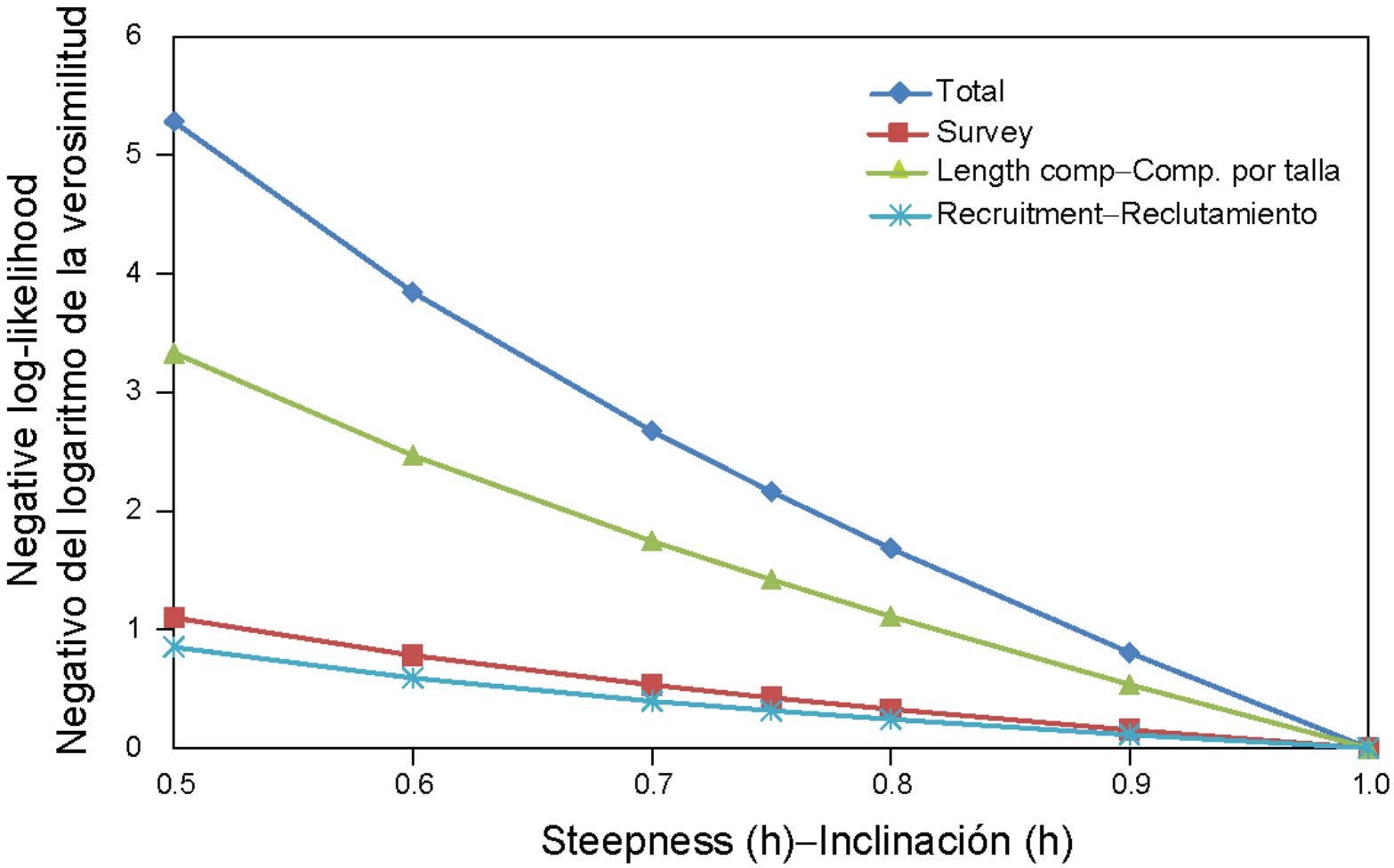
Spawning biomass ratio

Sensitivities (Steepness)



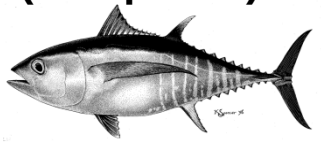


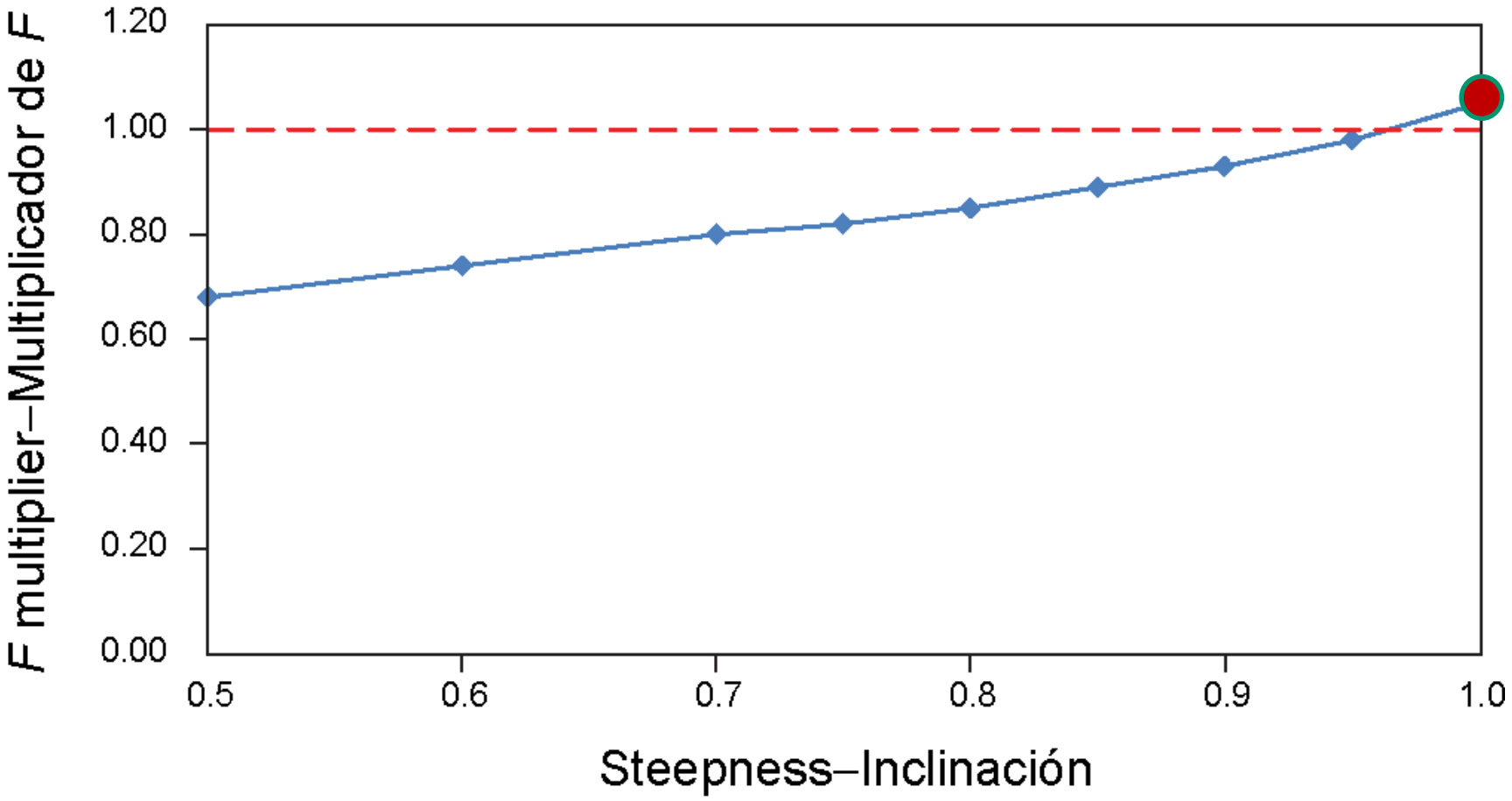
Likelihood profile on steepness



F multiplier and steepness

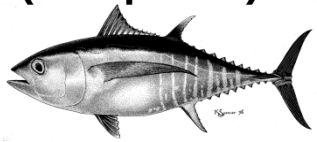
Sensitivities (Steepness)





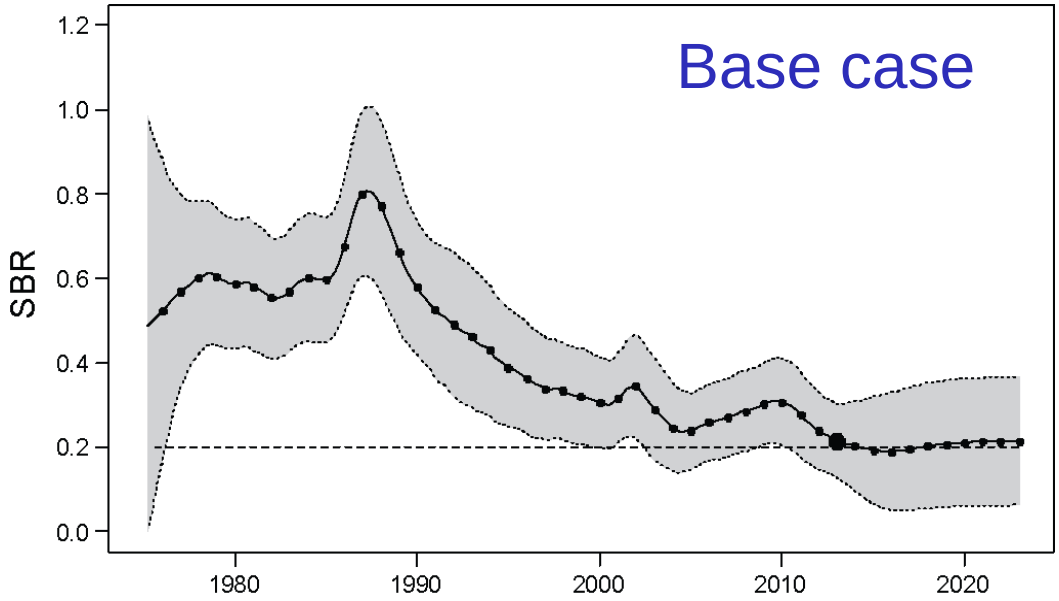
Management quantities

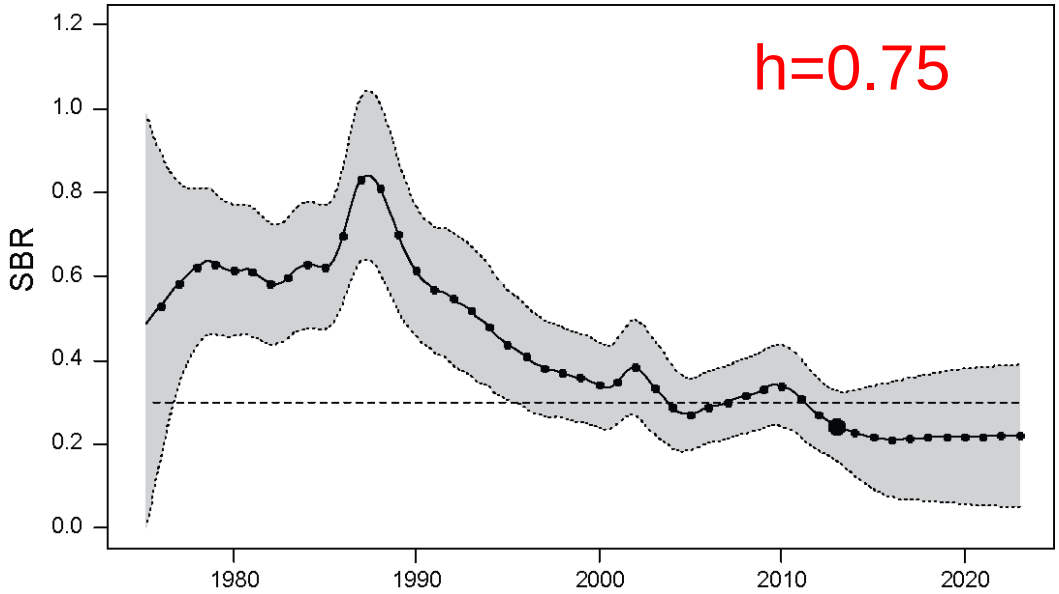
Sensitivities (Steepness)



	Base case–Caso base (h=1)	h = 0.9	h = 0.8	h = 0.75	h = 0.7	h = 0.6	h = 0.5
MSY-RMS	106,706	104,468	102,782	101,994	101,199	99,483	97,415
B_{MSY}- B_{RMS}	418,468	547,941	679,829	754,430	838,483	1,051,330	1,375,260
S_{MSY}- S_{RMS}	105,969	146,270	187,294	210,470	236,561	302,550	402,818
B_{MSY}/B_0- B_{RMS}/B_0	0.24	0.28	0.32	0.33	0.34	0.37	0.39
S_{MSY}/S_0- S_{RMS}/S_0	0.20	0.25	0.28	0.30	0.31	0.34	0.38
C_{recent}/MSY- C_{recent}/RMS	0.97	0.99	1.00	1.01	1.02	1.04	1.06
B_{recent}/B_{MSY}- B_{recent}/B_{RMS}	1.02	0.90	0.83	0.80	0.78	0.74	0.70
S_{recent}/S_{MSY}-S_{recent}/S_{RMS}	1.08	0.92	0.84	0.81	0.79	0.74	0.70
F multiplier- Multiplicador de F	1.05	0.93	0.85	0.82	0.80	0.74	0.68

Spawning biomass ratio





CIAT
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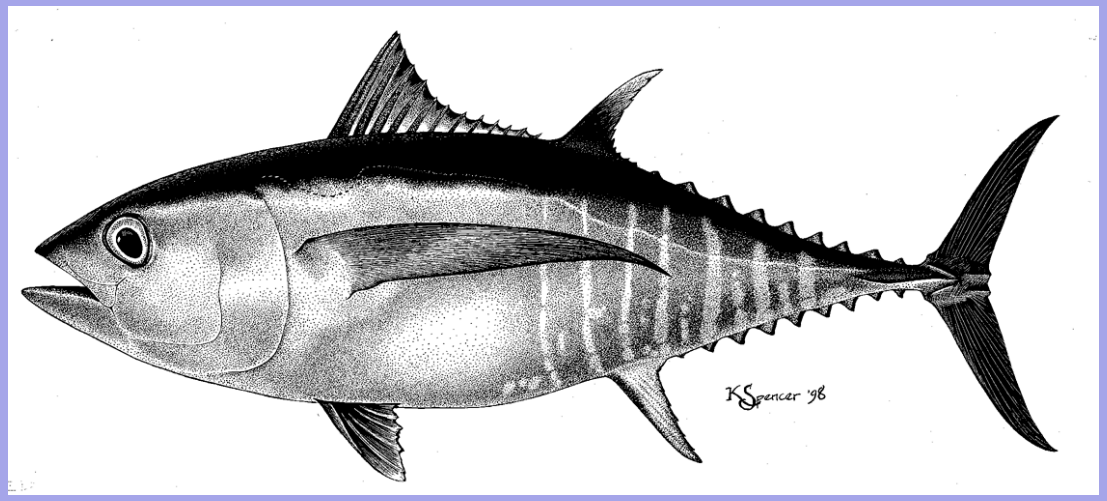
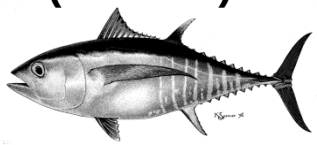


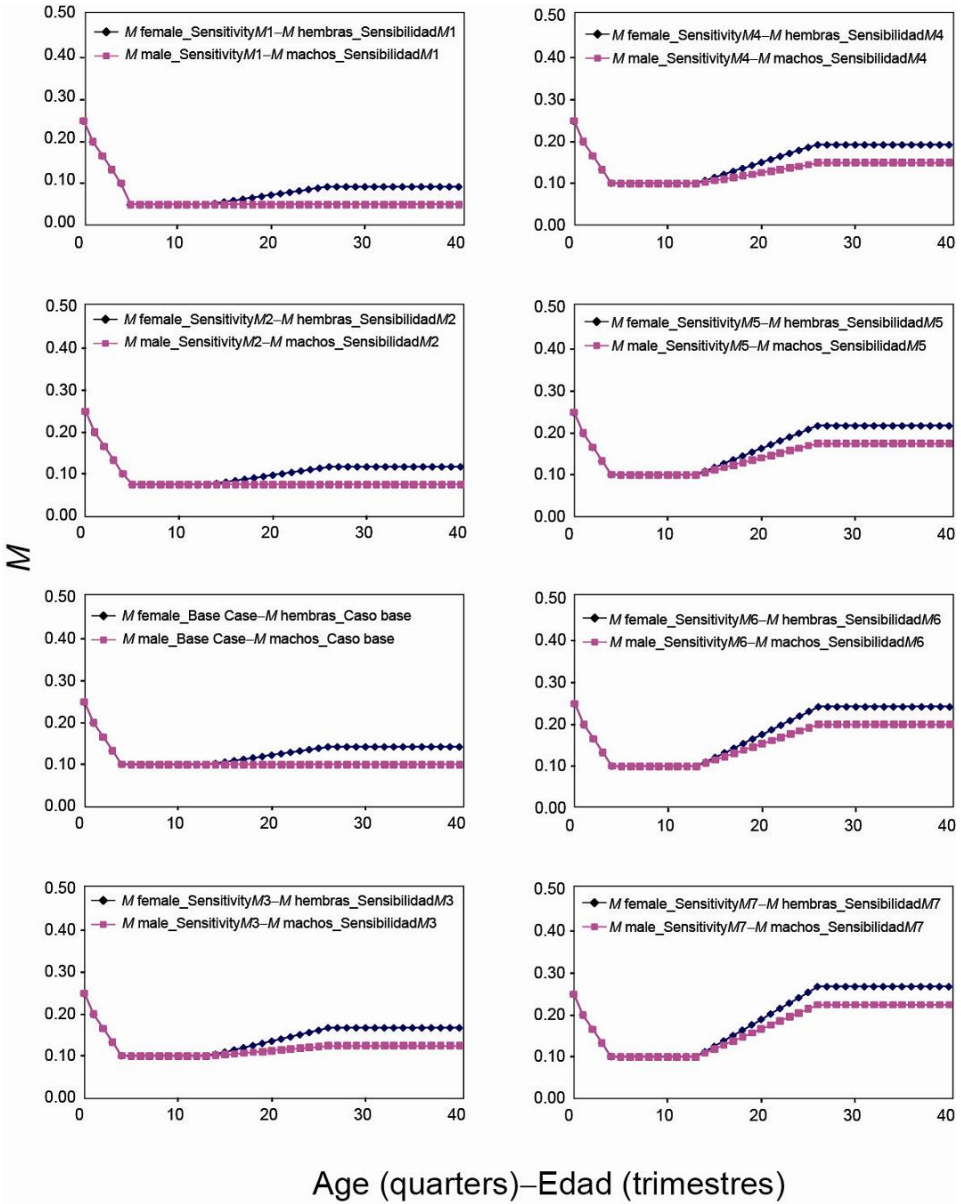
Sensitivity analyses

- Steepness of SR relationship (Appendix A)
- Adult natural mortality (Appendix B)
- Sensitivity analysis to the weighting assigned to the size composition data (Appendix C)

Natural mortality M schedules

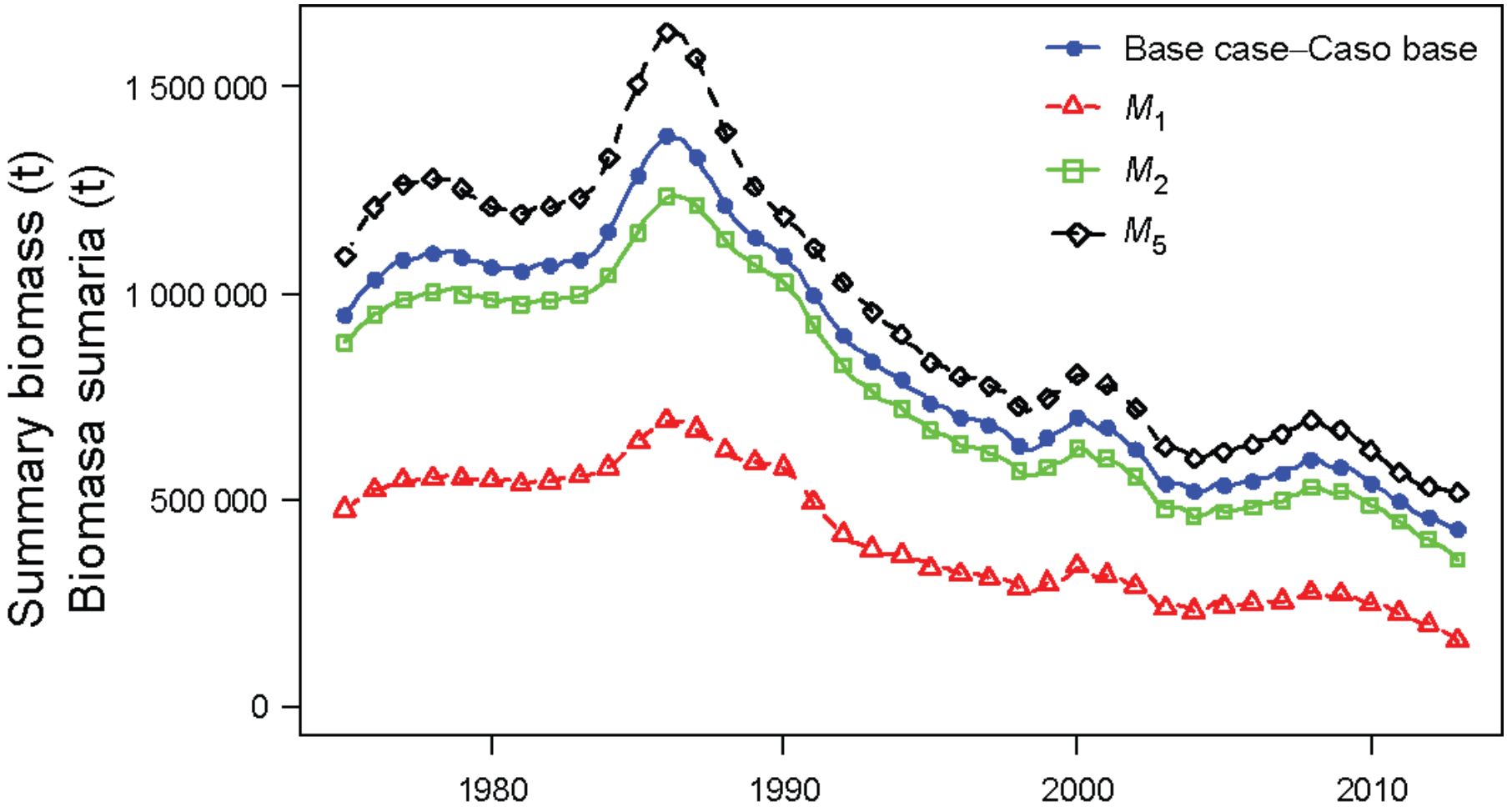
Sensitivities (Adult *M*)





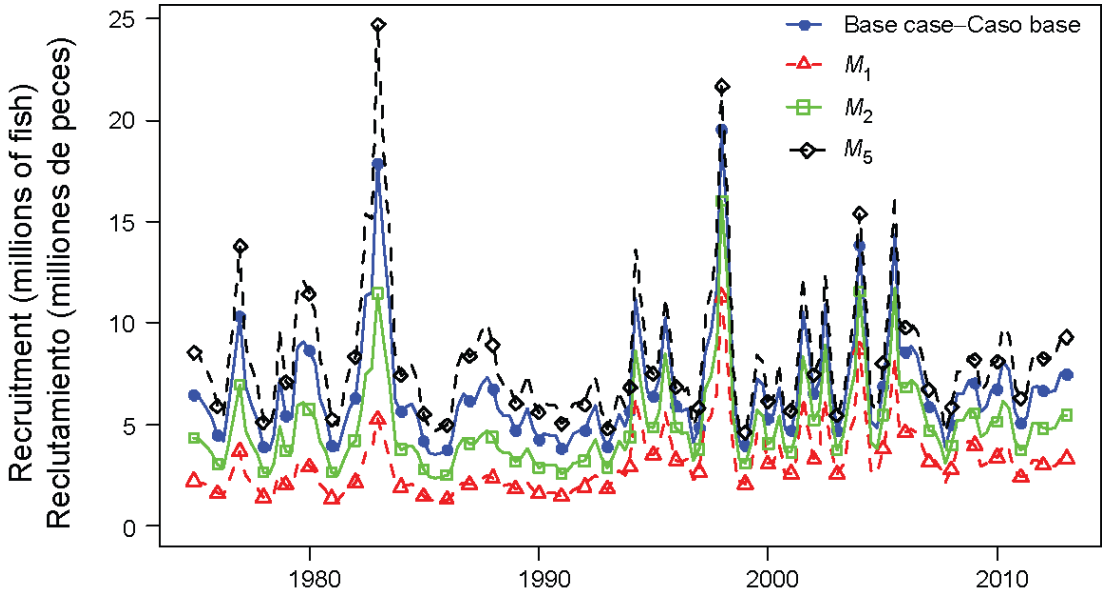
Summary biomass

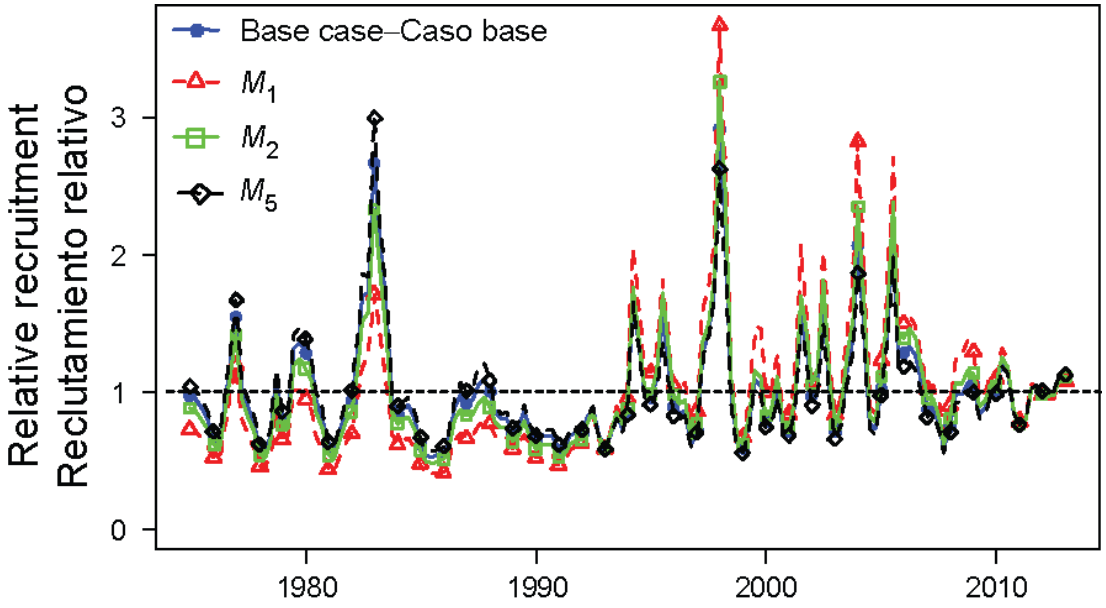
Sensitivities (Adult *M*)



Recruitment

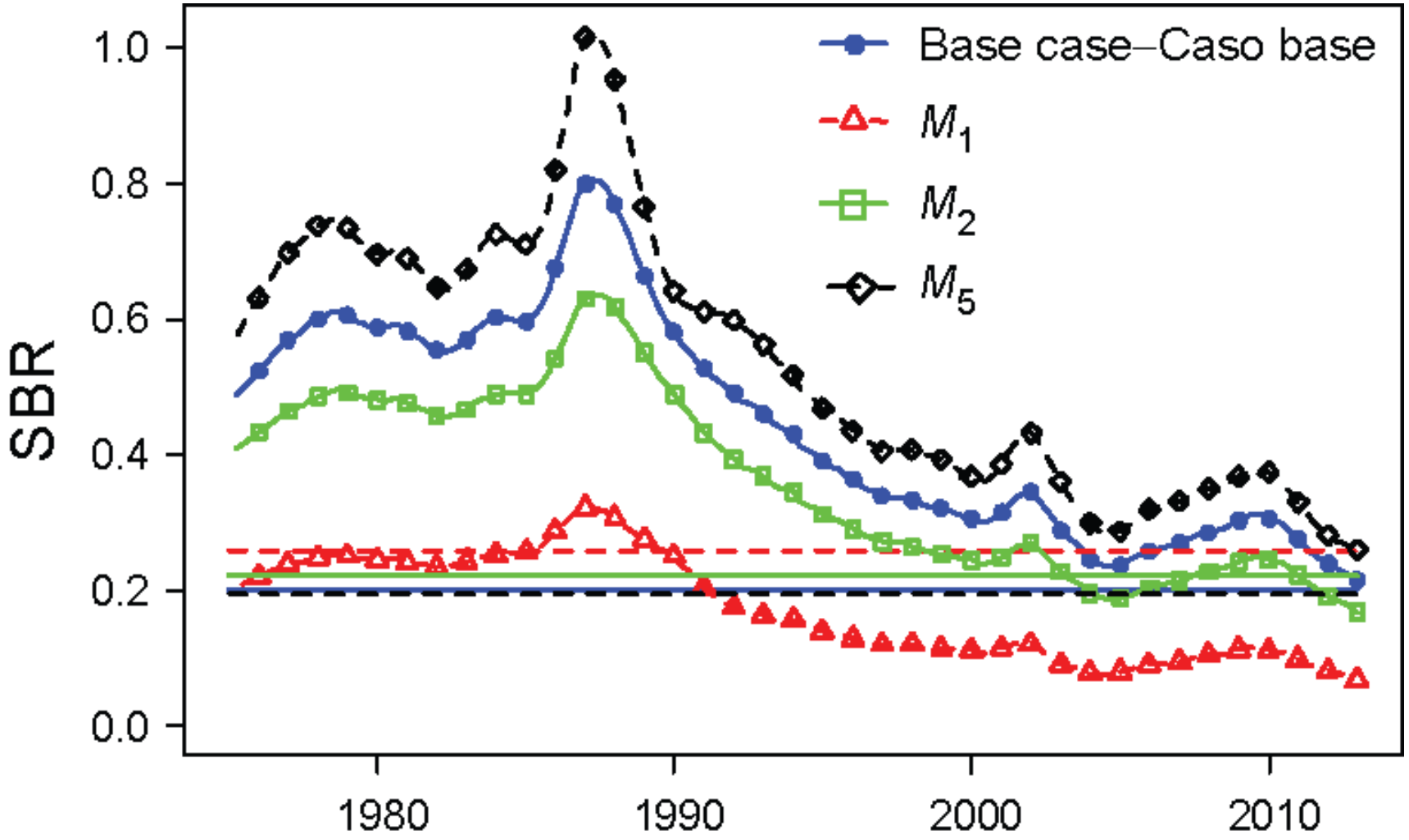
Sensitivities (Adult *M*)



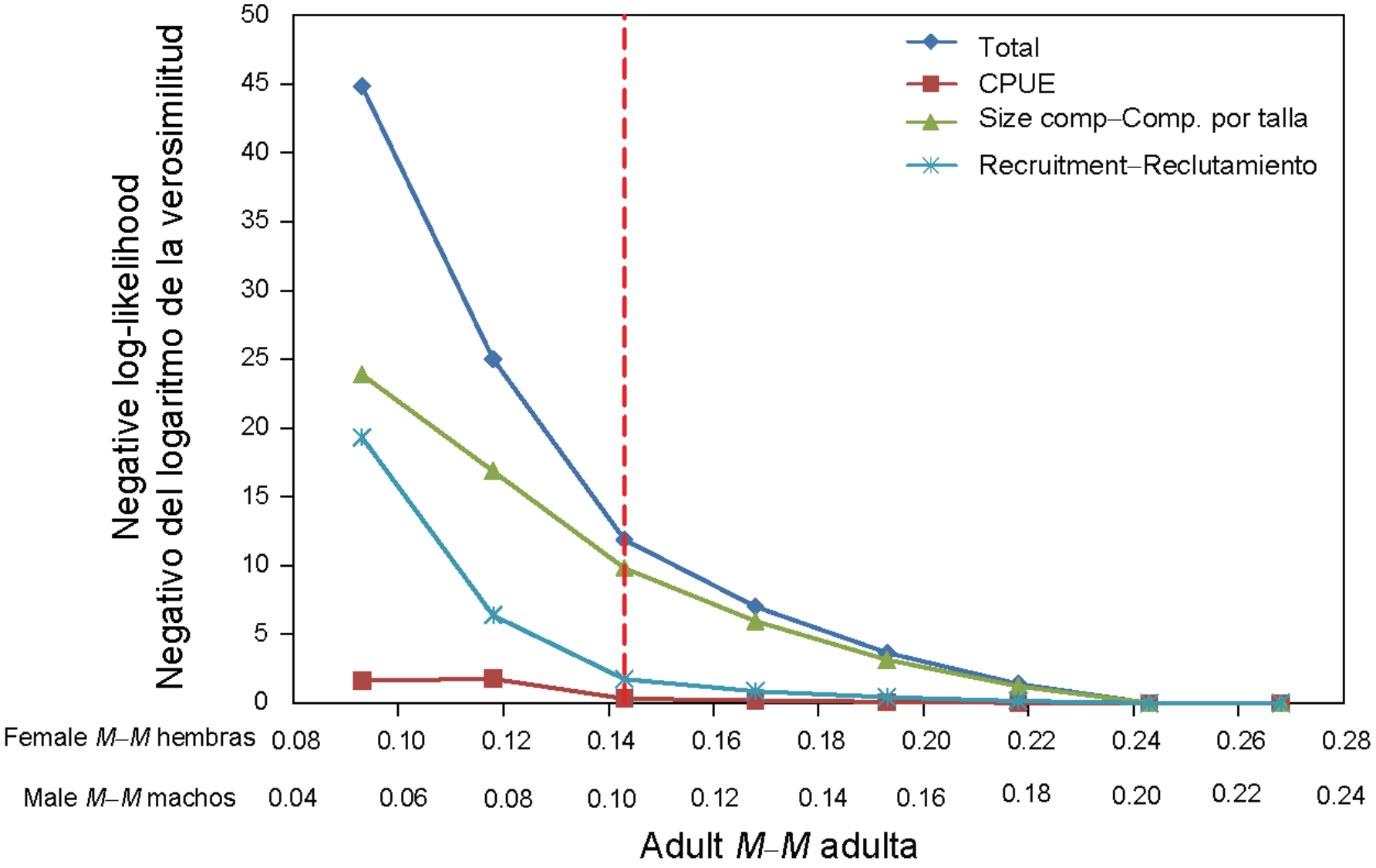


Spawning biomass ratio

Sensitivities (Adult *M*)

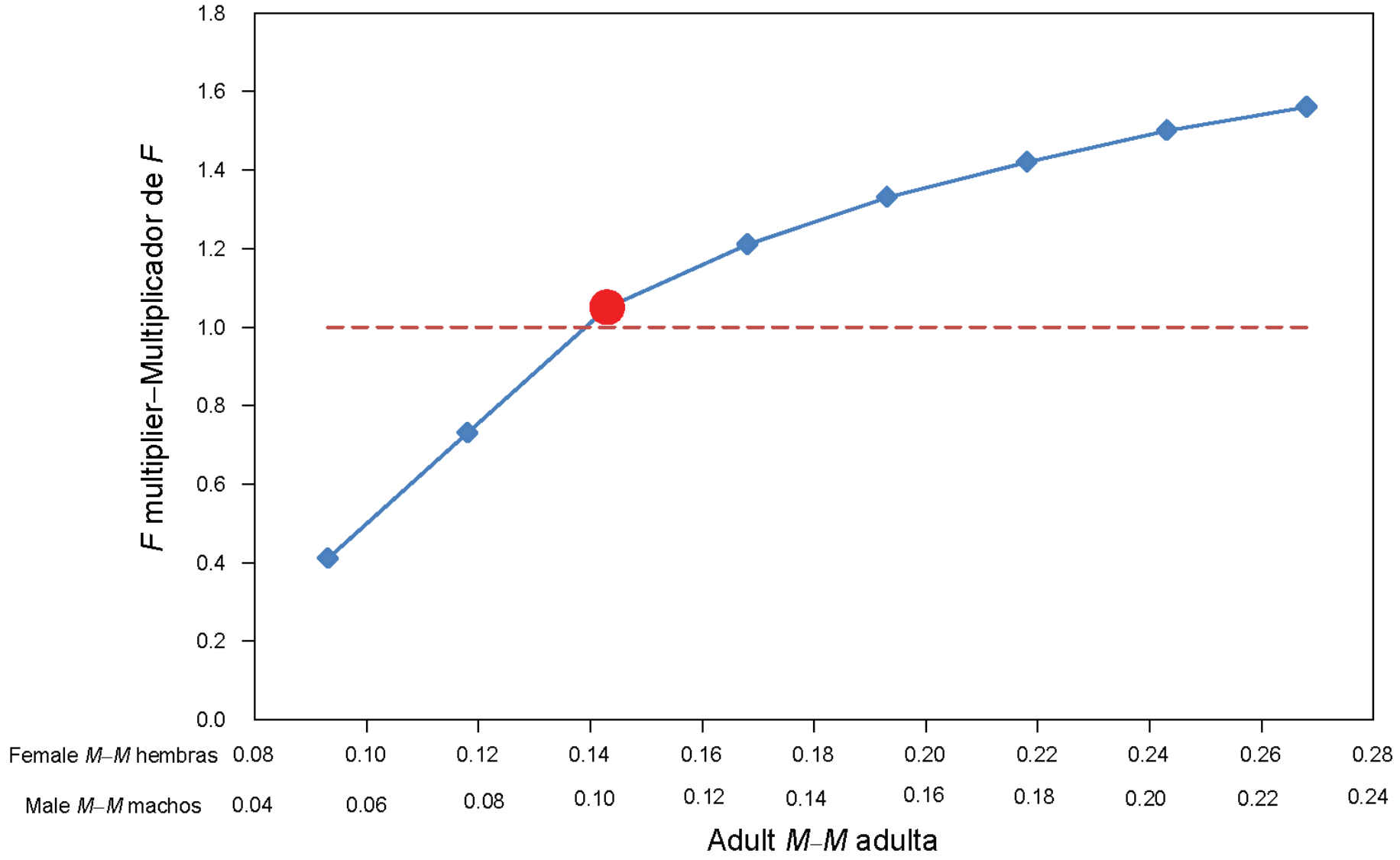


Likelihood profile on adult *M*



F multiplier on adult *M*

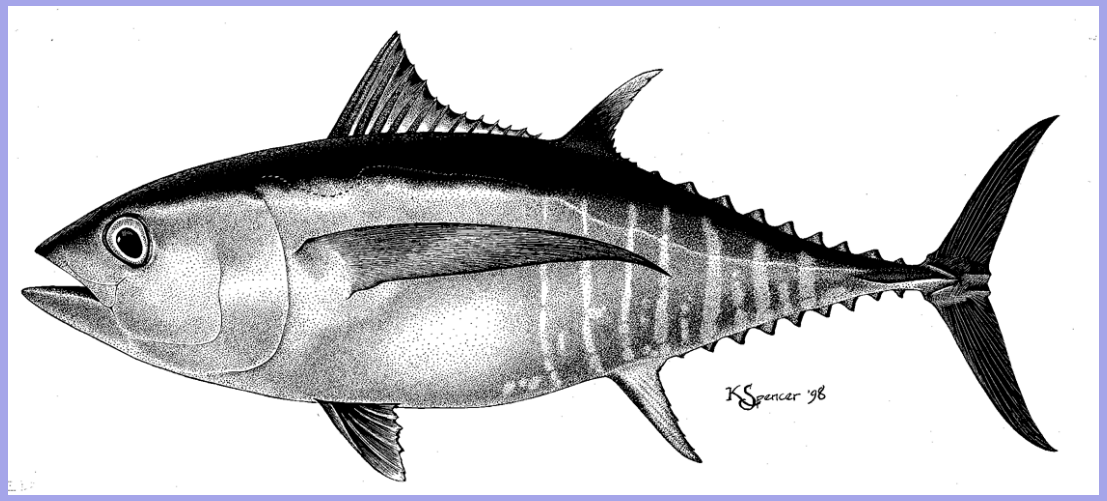
Sensitivities (Adult *M*)



Management quantities

Sensitivities (Adult *M*)

	M1	M2	Base case	M3	M4	M5	M6	M7
Female M	0.09	0.12	0.14	0.17	0.19	0.22	0.24	0.27
Male M	0.05	0.08	0.10	0.13	0.15	0.18	0.20	0.23
MSY-RMS	100,282	94,542	106,706	112,840	117,782	121,804	124,890	127,458
B_{MSY}- B_{RMS}	561,929	487,368	418,468	419,145	416,585	413,296	410,355	407,473
S_{MSY}- S_{RMS}	168,599	138,347	105,969	103,381	99,086	95,869	92,700	89,789
B_{MSY}/B_0- B_{RMS}/B_0	0.27	0.25	0.24	0.24	0.25	0.25	0.25	0.25
S_{MSY}/S_0- S_{RMS}/S_0	0.26	0.22	0.2	0.2	0.2	0.2	0.2	0.2
C_{recent}/MSY-C_{recent}/RMS	1.03	1.09	0.97	0.91	0.87	0.85	0.82	0.81
B_{recent}/B_{MSY}-B_{recent}/B_{RMS}	0.29	0.73	1.02	1.13	1.2	1.25	1.29	1.31
S_{recent}/S_{MSY}-S_{recent}/S_{RMS}	0.26	0.76	1.08	1.2	1.28	1.33	1.37	1.4
F multiplier-Multiplicador de *F*	0.41	0.73	1.05	1.21	1.33	1.42	1.5	1.56

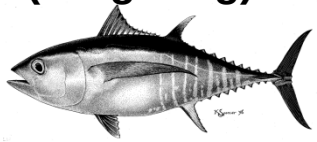


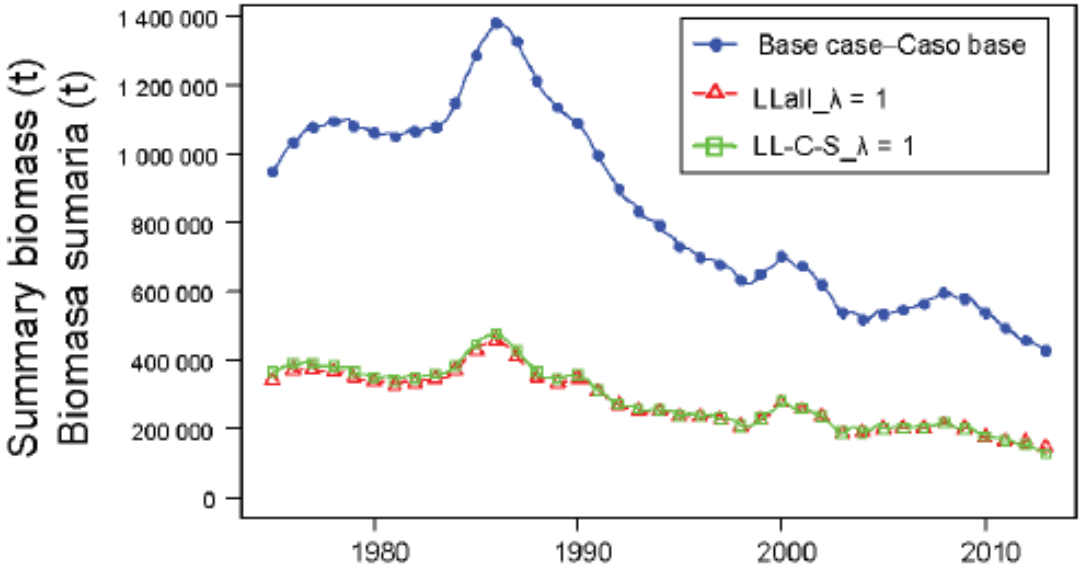
Sensitivity analyses

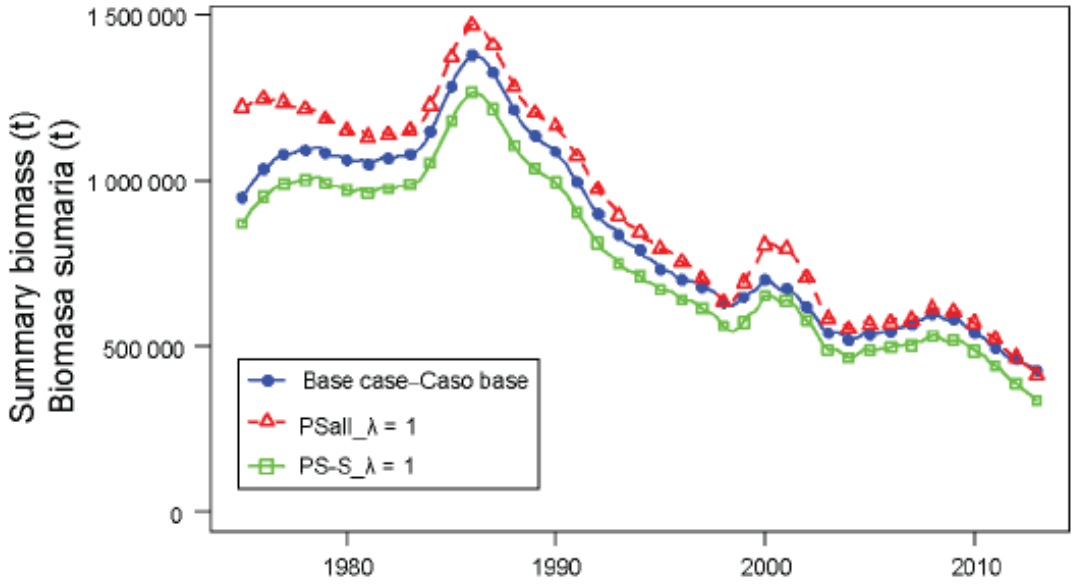
- Steepness of SR relationship (Appendix A)
- Adult natural mortality (Appendix B)
- Sensitivity analysis to the weighting assigned to the size composition data (Appendix C)

Summary biomass

Sensitivities (weighting)

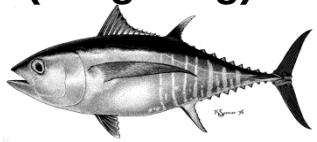


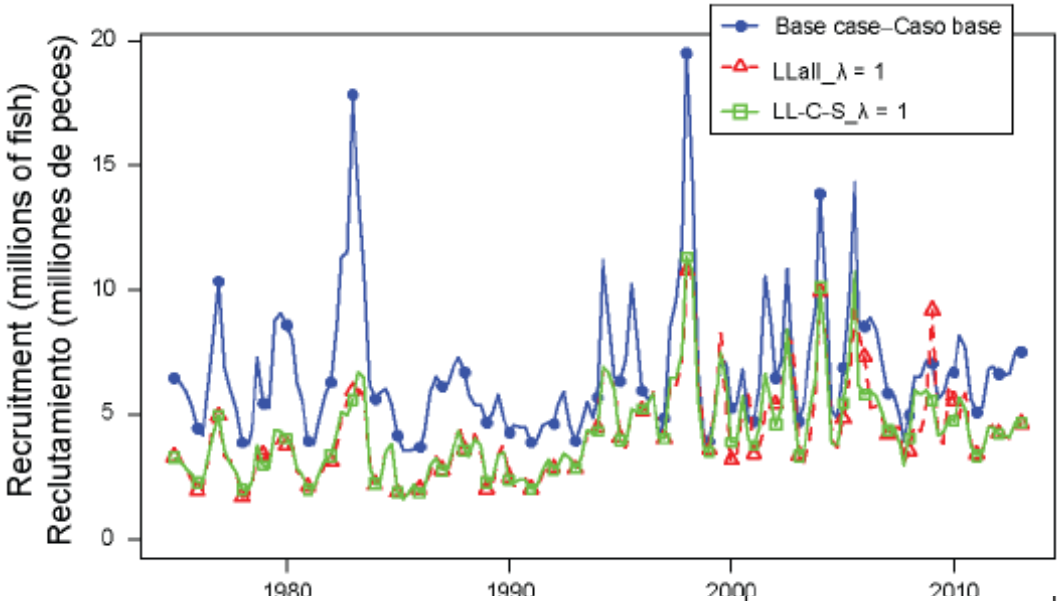


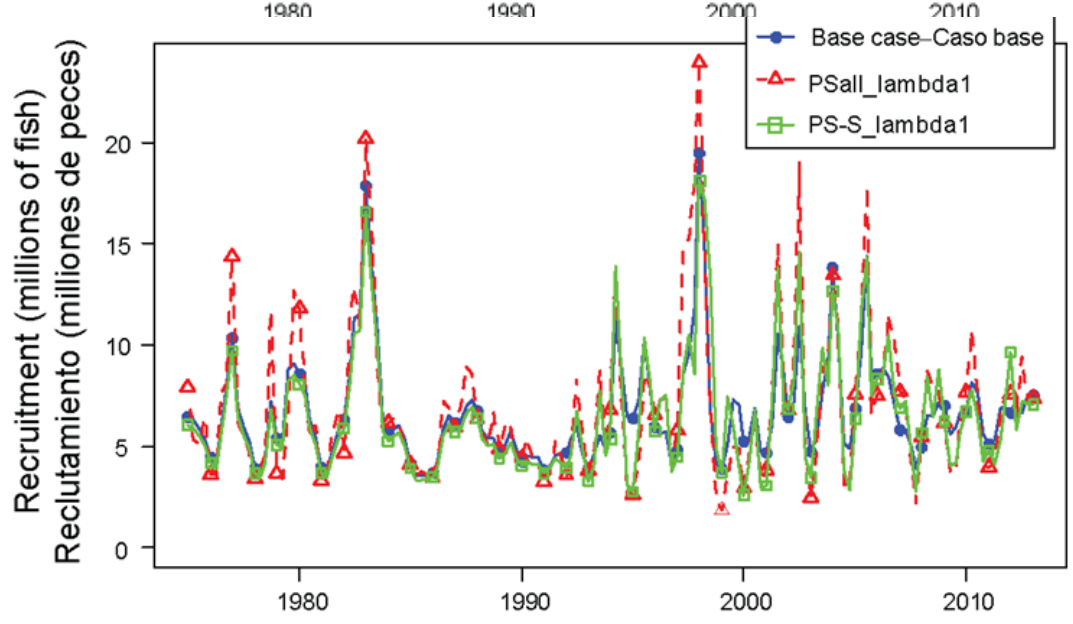


Recruitment

Sensitivities (weighting)

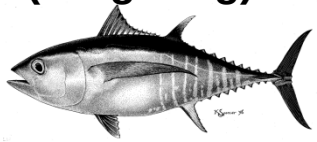


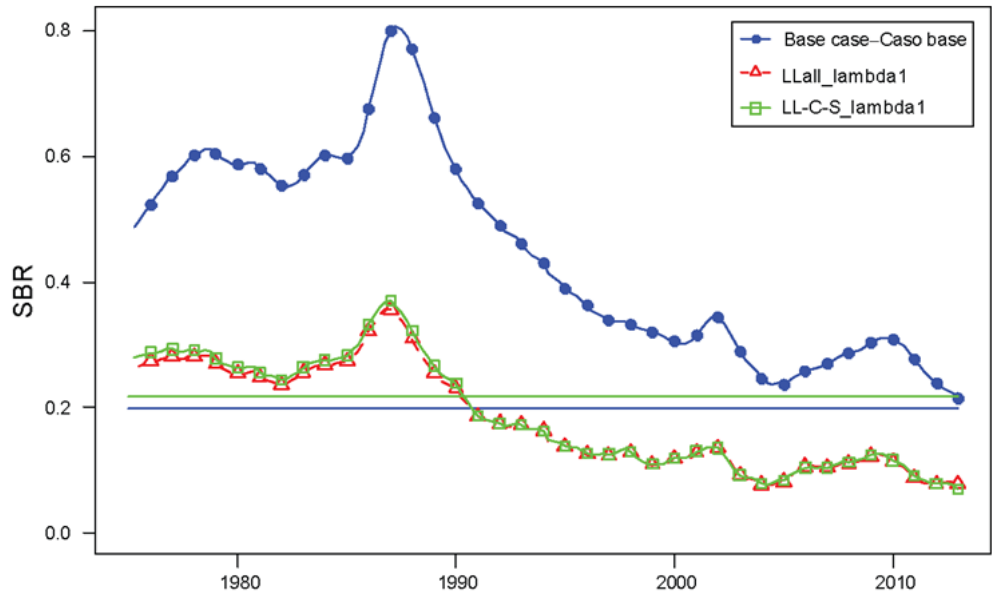


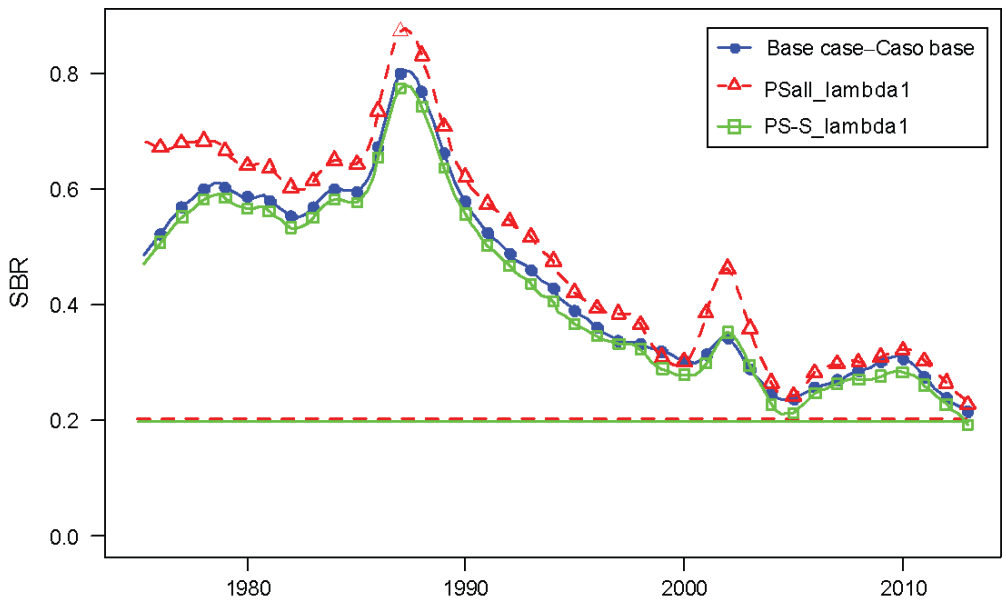


Spawning biomass ratio

Sensitivities (weighting)

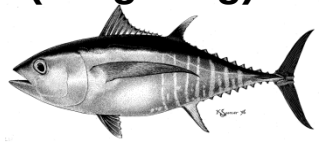


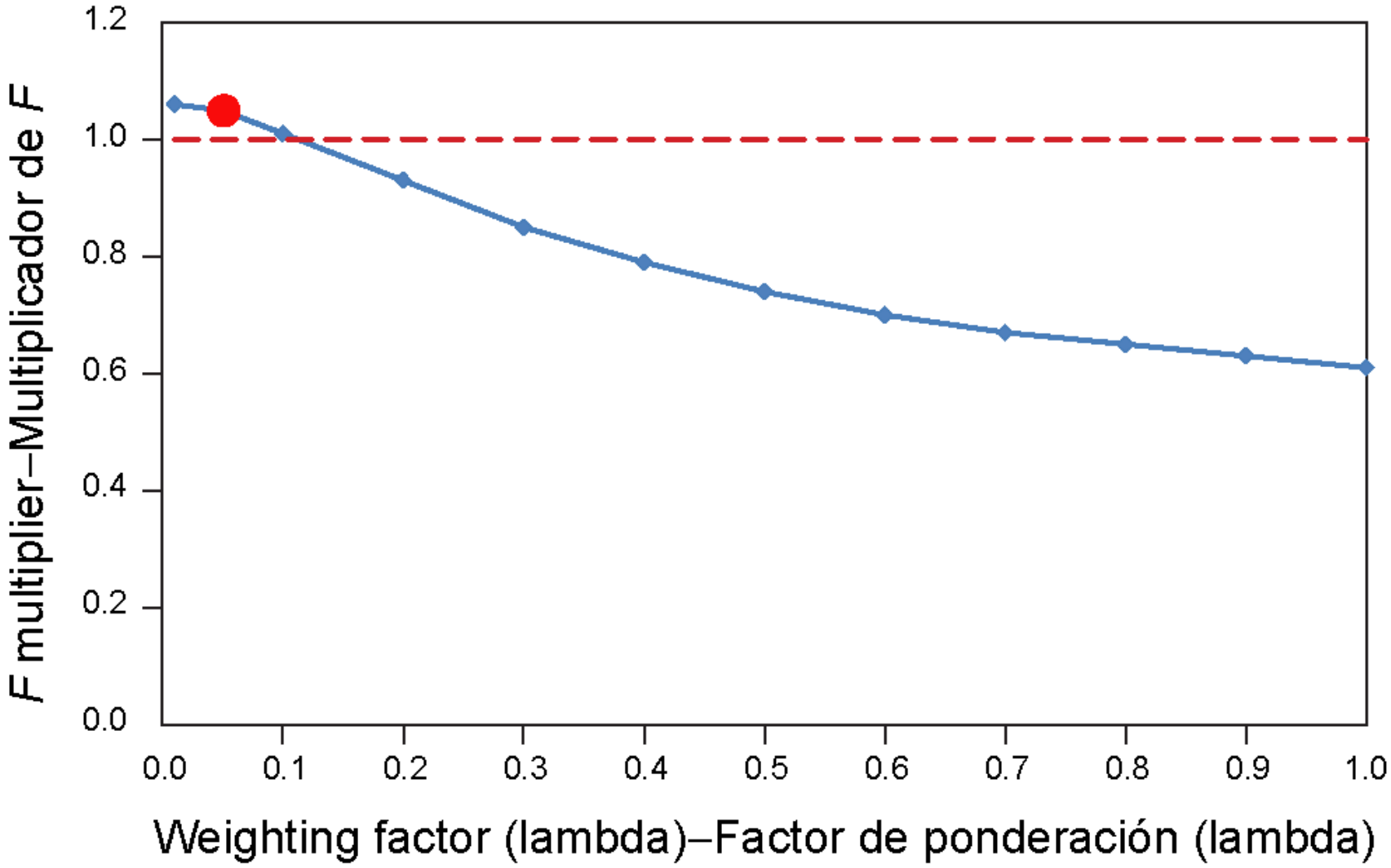




Length comp weighting

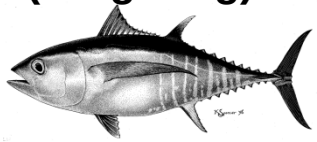
Sensitivities (weighting)



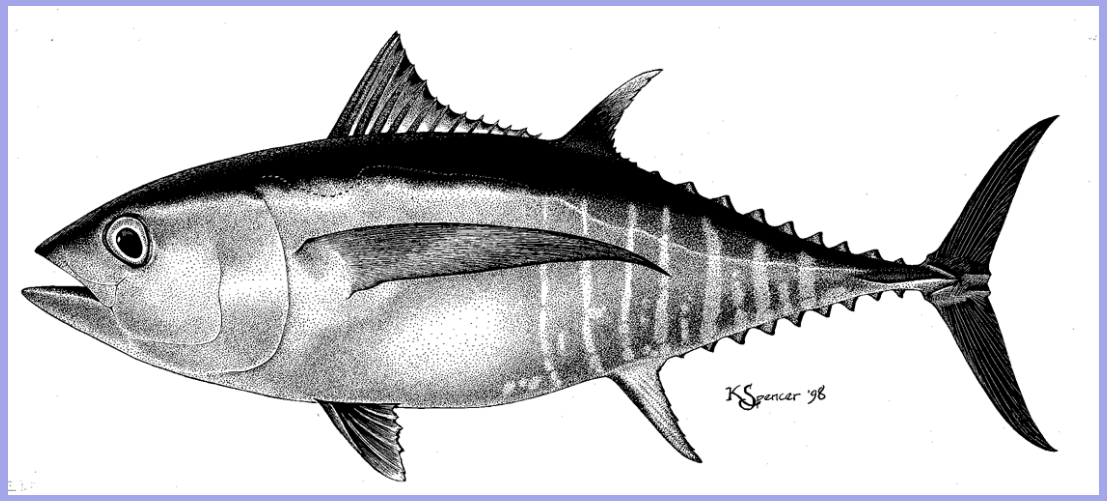


Management quantities

Sensitivities (weighting)



	Base case	PS-all $\lambda = 0.05$			LL-all $\lambda = 0.05$	
	All $\lambda = 0.05$	LL-all $\lambda = 1$	LL 14-17 $\lambda = 1$	PS-all $\lambda = 1$	PS-S	1
MSY-RMS	106,706	99,124	98,180	97,018	95,334	
B_{MSY}- B_{RMS}	418,468	312,484	313,793	409,722	388,362	
S_{MSY}- S_{RMS}	105,969	71,818	72,708	106,472	99,877	
B_{MSY}/B_0- B_{RMS}/B_0	0.24	0.29	0.29	0.24	0.24	
S_{MSY}/S_0- S_{RMS}/S_0	0.20	0.22	0.22	0.20	0.20	
C_{recent}/MSY- C_{recent}/RMS	0.97	1.04	1.05	1.06	1.08	
B_{recent}/B_{MSY}- B_{recent}/B_{RMS}	1.02	0.47	0.41	1.01	0.86	
S_{recent}/S_{MSY}-S_{recent}/S_{RMS}	1.08	0.36	0.32	1.12	0.97	
F multiplier- Multiplicador de F	1.05	0.54	0.51	0.95	0.85	

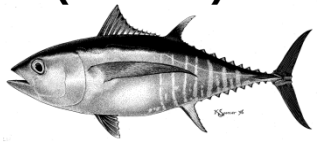


Sensitivity analyses

- Overall results

Management quantities

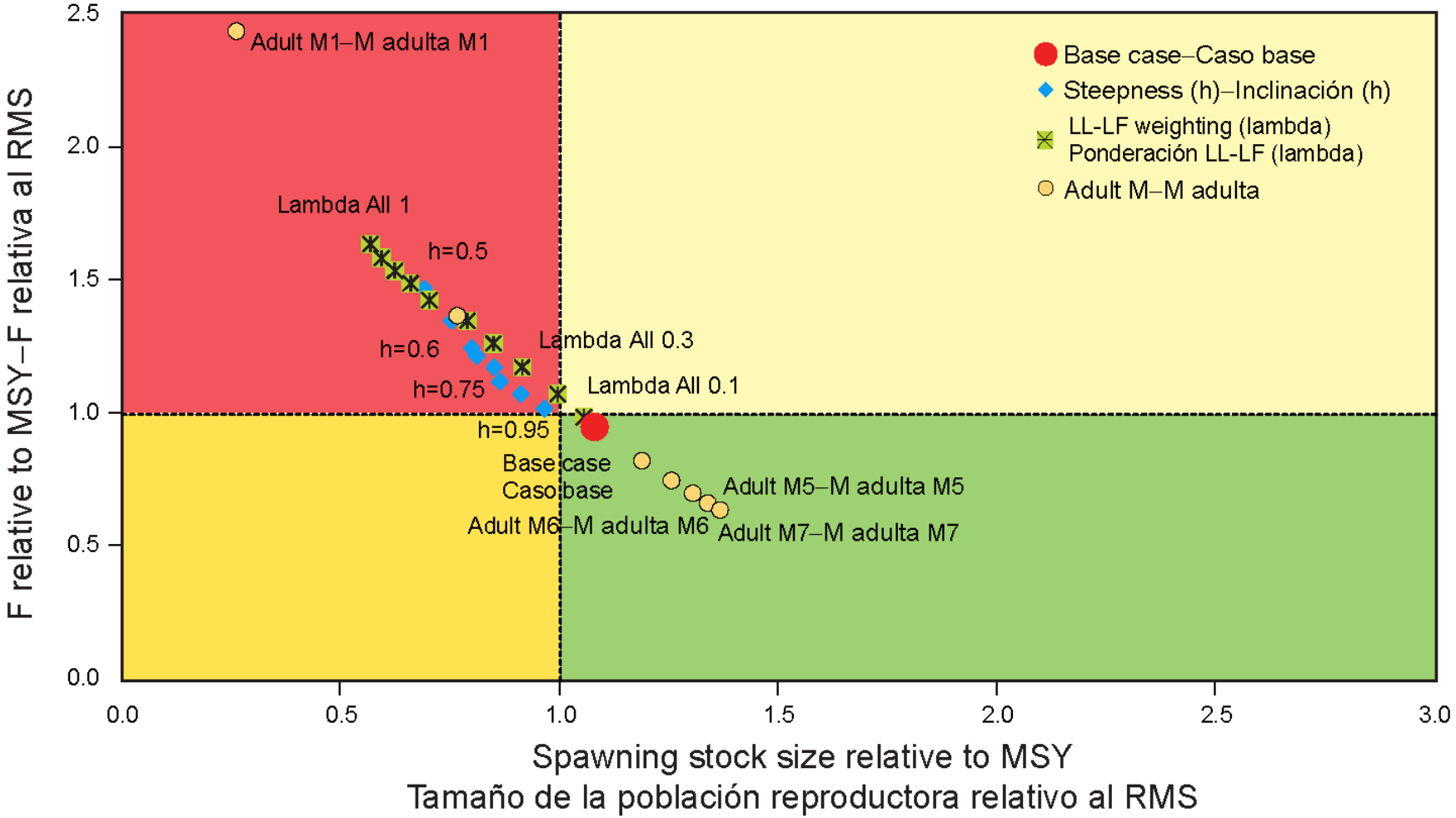
Sensitivities (Overall)

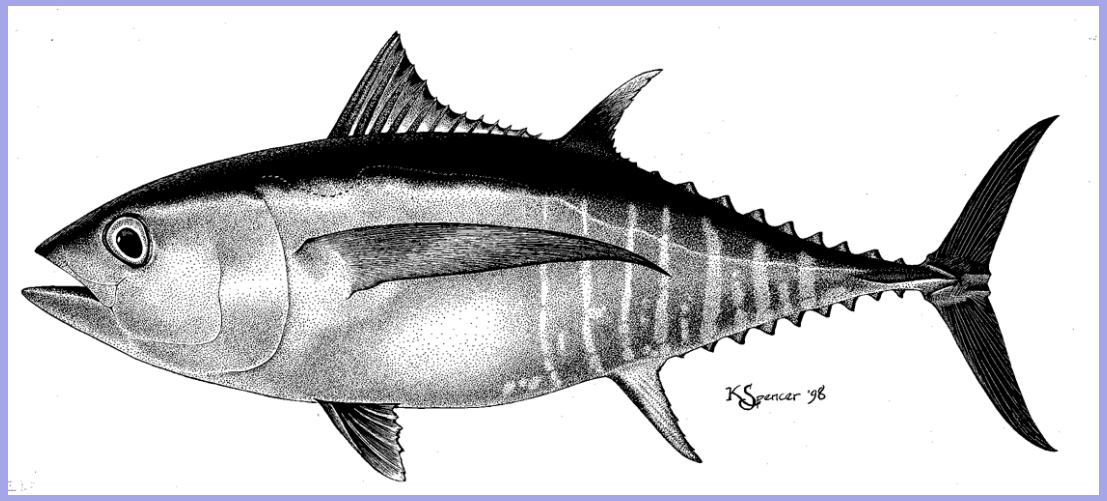


	Appendix-Anexo							
	A	B		C				
	Base case-Caso base	$h = 0.75$	Adult M-M adulto		$\lambda = 1$			PS-S
			Sens $M1$	Sens $M5$	LL All-Todas	LL 14-17	PS All-Todas	2
MSY-RMS	106,706	101,994	100,282	121,804	99,124	98,180	97,018	95,334
B_{MSY}- B_{RMS}	418,468	754,430	561,929	413,296	312,484	313,793	409,722	388,362
S_{MSY}- S_{RMS}	105,969	210,470	168,599	95,869	71,818	72,708	106,472	99,877
B_{MSY}/B_0- B_{RMS}/B_0	0.24	0.33	0.27	0.25	0.29	0.29	0.24	0.24
S_{MSY}/S_0- S_{RMS}/S_0	0.20	0.30	0.26	0.20	0.22	0.22	0.20	0.20
C_{recent}/MSY- C_{recent}/RMS	0.97	1.01	1.03	0.85	1.04	1.05	1.06	1.08
B_{recent}/B_{MSY}- B_{recent}/B_{RMS}	1.02	0.80	0.29	1.25	0.47	0.41	1.01	0.86
S_{recent}/S_{MSY}-S_{recent}/S_{RMS}	1.08	0.81	0.26	1.33	0.36	0.32	1.12	0.97
F multiplier-Multiplicador de F	1.05	0.82	0.41	1.42	0.54	0.51	0.95	0.85

Model uncertainty

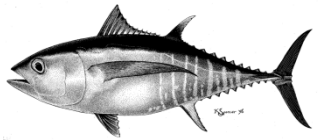
Sensitivities (Overall)



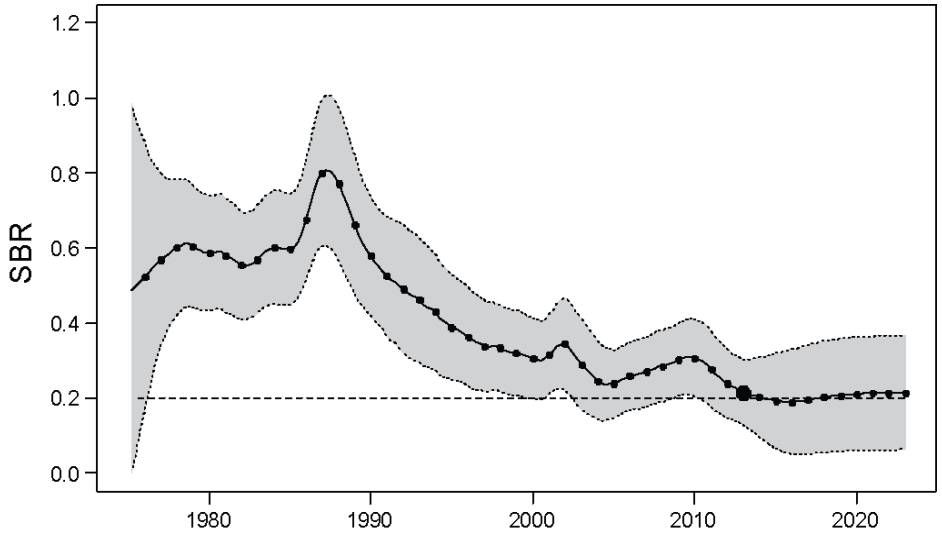


Summary

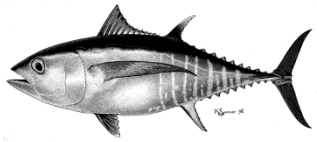
Summary: key results



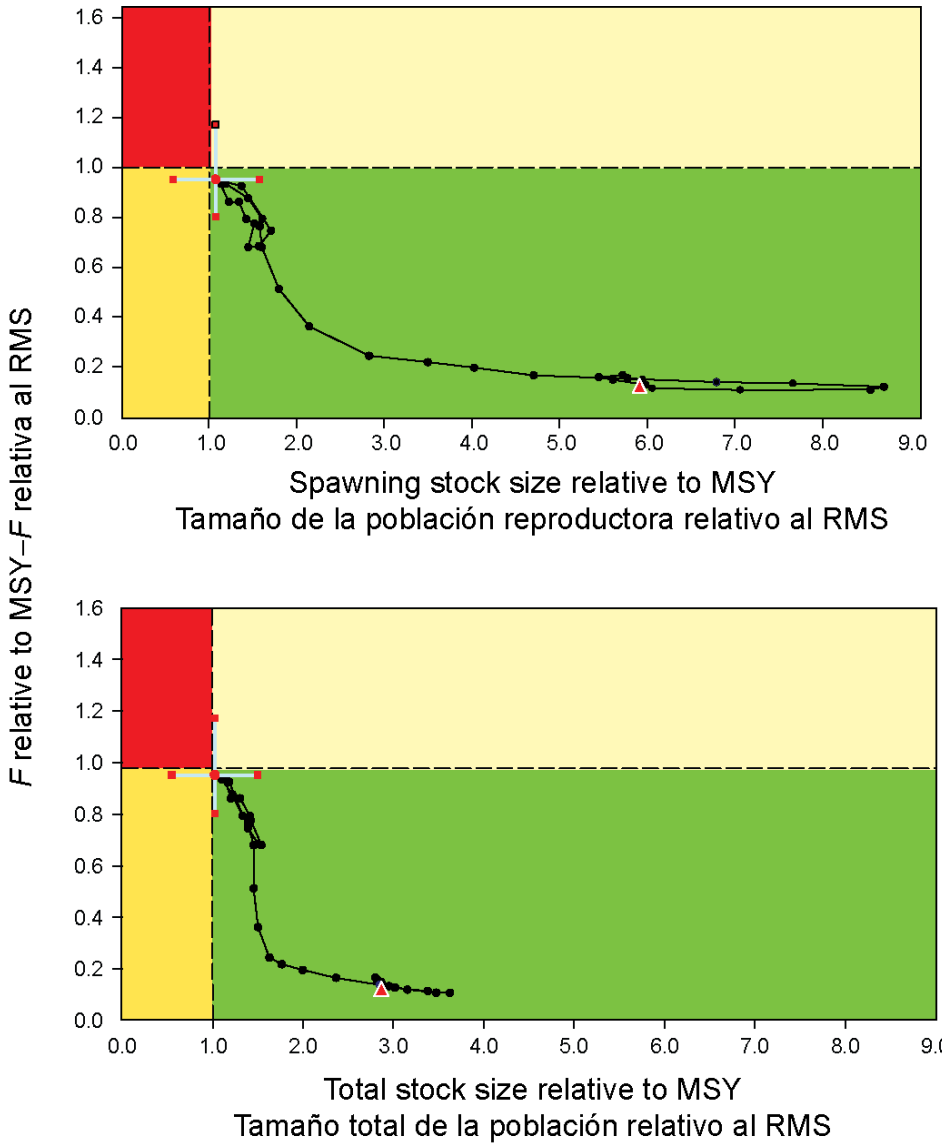
- Recovery trend since 2004 coinciding with beginning of IATTC tuna conservation resolutions
- But this recovery was not sustained since 2010 and biomasses were reduced to lowest historic levels at the start of 2013
- The recent decline may be related to series of below average recruitments coinciding with strong La Nina events (since 2007)
- However, at current fishing mortality levels, and average recruitment, SBR is predicted to stabilize at about SBR at MSY



Summary: key results (cont.)

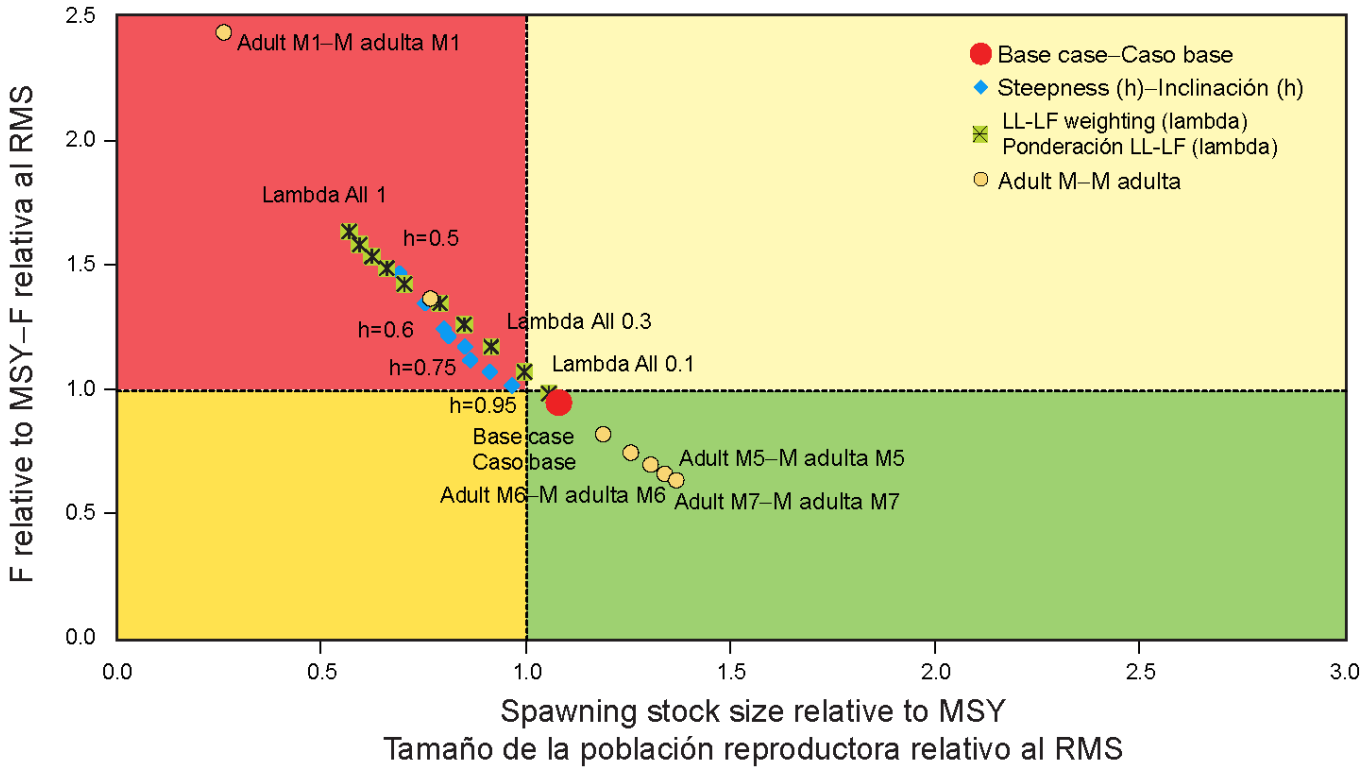


- The recent fishing mortality rates are estimated to be below the level corresponding to MSY ($F_{recent} < F_{MSY}$)
- The recent levels of spawning biomass are estimated to be above the MSY level ($S_{recent} > S_{MSY}$)
- But the recent estimates are uncertain (low precision)

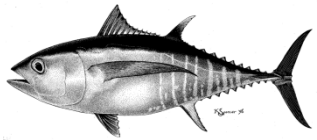


Summary: key results (cont.)

- However, these interpretations are highly sensitive about the following assumptions:
  - Steepness of stock-recruitment relationship
  - Adult natural mortality levels
  - Weighting assigned to the size composition data



Plausible Sensitivities and Uncertainties



- Results are more **pessimistic** with:
  - The inclusion of a stock-recruitment relationship
  - Lower rates of adult natural mortality (*M*)
  - Up-weighting the size composition data (LL in particular)
  - Higher L_2

- Results are more **optimistic** with:
  - Higher rates of adult natural mortality (*M*)
  - Lower L_2

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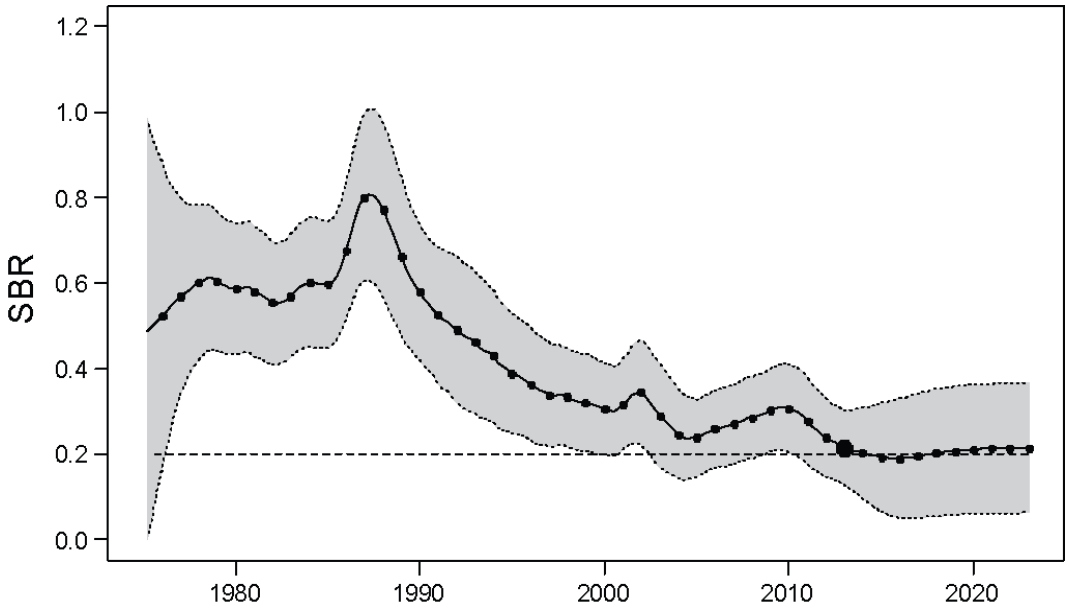
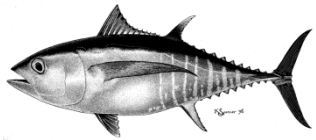
What is robust

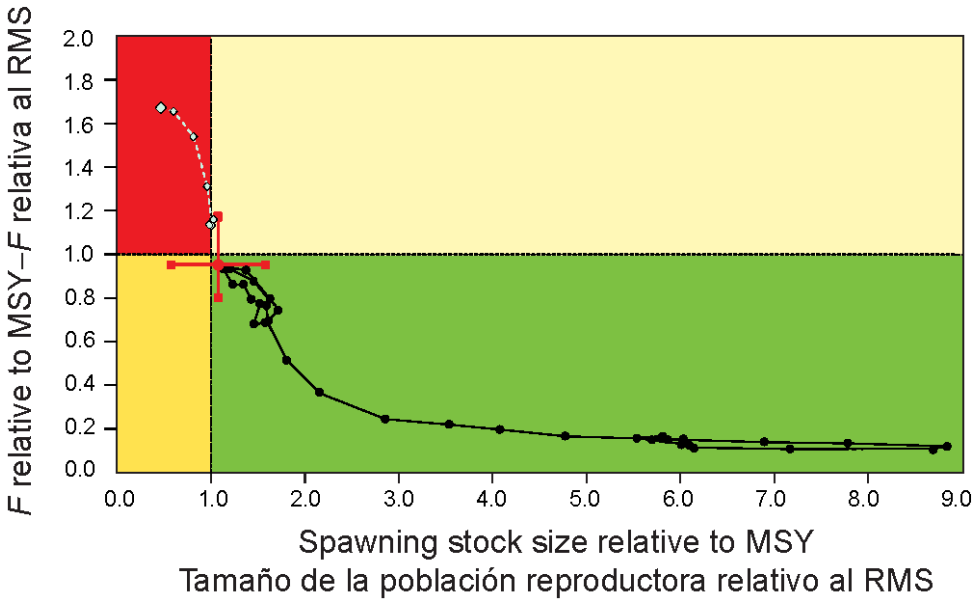
- Relative trend
- Recent decline in biomasses
- Lower biomass compared to historic levels

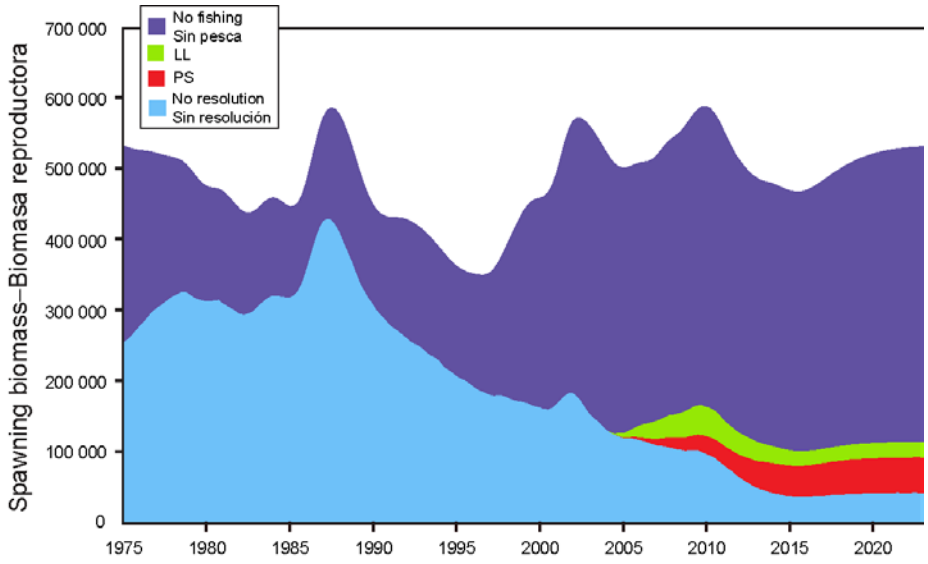


Summary: key results (cont.)

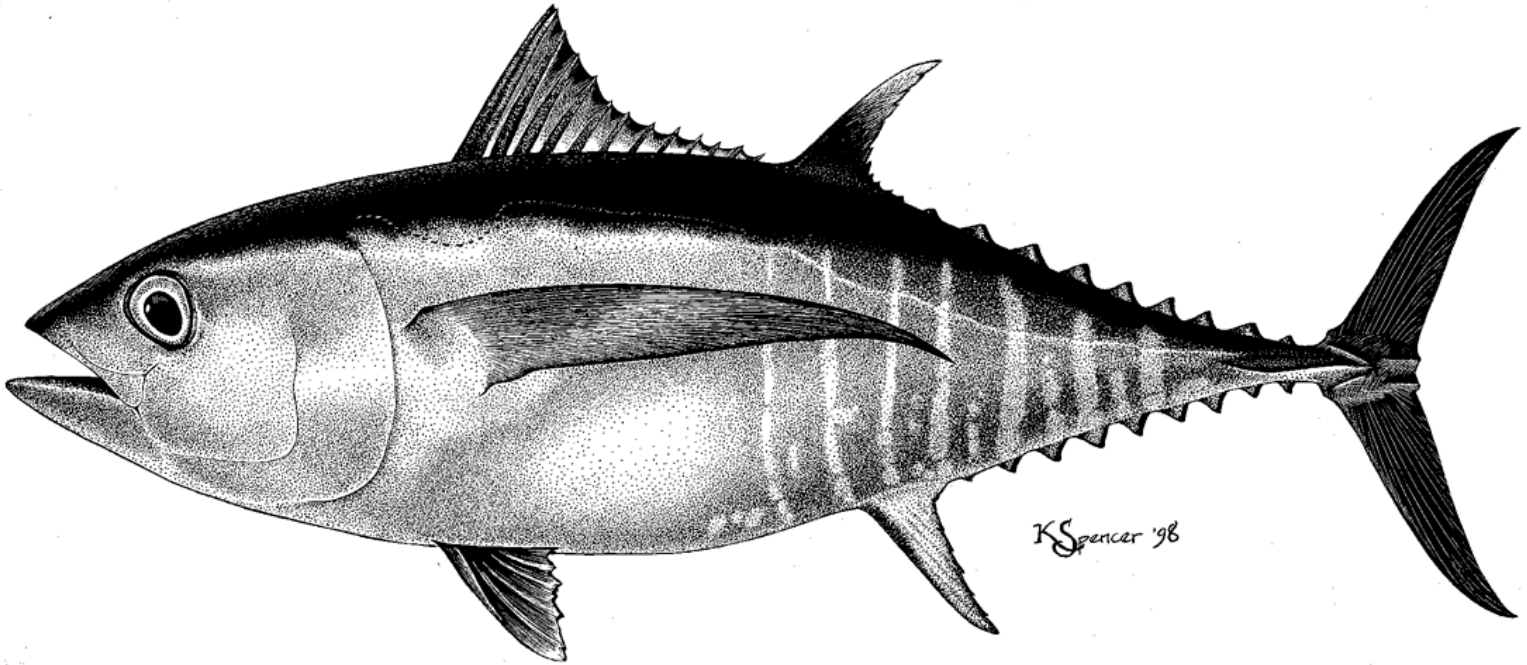


- IATTC Tuna Conservation resolutions produced benefits (2004-2012)



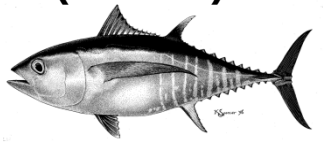


Questions?



Likelihoods

Sensitivities (Overall)



		Appendix-Anexo						
		A	B		C			
Data Datos	Base case Caso base	$h = 0.75$	Adult *M*-*M* adulto		$\lambda = 1$			
			Sens *M*1	Sens *M*5	LL All-Todas	LL 14-17	PS All-Todas	LL 2
CPUE								
1	195.84	195.156	191.852	196.099	192.452	192.688	193.958	195.94
2	-44.5238	-44.2195	-42.9116	-44.1636	-45.0213	-44.6798	-42.2471	-44.3206
3	6.13	6.06965	7.26421	8.30431	8.73637	6.91472	8.30835	4.91525
4	212.75	211.7	217.657	212.022	217.036	216.482	213.66	216.769
5	6.90	7.96826	12.2763	5.51157	8.96672	10.0219	11.433	11.0729
12	56.04	57.3324	51.7447	57.1805	57.0969	50.7934	65.1018	56.0167
13	164.45	168.757	150.042	161.369	148.791	154.081	267.705	216.091
14	-67.60	-67.6281	-67.34	-67.6288	-63.3868	-63.202	-66.7725	-67.5925
15	-66.62	-66.4128	-66.01	-66.8958	-57.2769	-58.7199	-50.6992	-55.2851
16	-98.09	-98.1472	-97.67	-98.0399	-94.6007	-94.6036	-97.8979	-98.0853
17	-131.43	-131.139	-131.43	-131.505	-128.296	-128.197	-123.58	-130.666
18	17.80	17.2513	16.25	17.6372	16.9751	20.9719	13.4457	17.5684
19	172.00	169.689	191.80	169.001	197.656	186.622	172.701	174.137
Total	**-363.751**	**-363.327**	**-362.444**	**-364.070**	**-343.560**	**-344.723**	**-338.950**	**-351.629**
Size compositions – Composición por talla								
1	55.0732	55.05	55.1812	54.93	56.4414	56.27	159.095	55.0937
2	25.1443	25.12	28.3671	25.47	27.8636	26.52	299.884	279.032
3	41.7469	41.79	43.5306	41.62	45.6855	43.25	328.801	43.2651
4	43.3528	43.16	43.30	43.19	45.5335	45.08	77.3006	44.1171
5	27.8305	27.76	32.00	27.87	32.7235	29.78	203.996	26.8177
6	38.1199	38.17	38.25	38.17	38.4488	38.24	124.149	38.1183
7	55.7242	55.43	55.61	55.68	59.8478	59.14	131.071	55.7707
12	12.6024	12.61	12.66	12.60	31.5795	13.01	13.7197	12.6066
13	25.8381	25.70	26.01	25.60	61.4318	25.51	27.8317	27.3964
14	24.6072	24.60	24.82	24.62	34.0475	33.27	23.2526	24.6
15	35.8985	37.19	37.69	31.21	49.2388	48.95	41.4491	36.1078
16	16.233	16.34	16.03	16.34	40.5502	40.44	16.7004	16.2187
17	19.8067	20.57	22.31	16.08	120.932	122.08	23.0363	19.4529
18	19.6126	19.61	19.65	19.60	53.4593	19.26	19.5067	19.6119
19	29.5176	29.44	29.77	29.54	60.7296	30.62	30.1652	28.936
Total	471.108	472.529	485.188	462.523	758.513	631.422	1519.958	727.145
Recruitment-Reclutamiento								
	-55.0666	-54.7508	-37.4801	-56.6466	-42.2957	-42.2957	-27.6621	-43.0154
Total	52.290	54.451	85.264	41.807	372.657	244.404	1153.347	332.501

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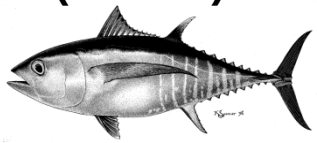
Average effective sample sizes

Sensitivities (Overall)



Data Datos	Base case Caso base	Appendix-Anexo A $h = 0.75$	B Adult *M*-*M* adulto Sens *M*1	B Adult *M*-*M* adulto Sens *M*5	C $\lambda = 1$ LL All-Todas	C $\lambda = 1$ LL 14-17	C $\lambda = 1$ PS All-Todas	C $\lambda = 1$ LL 2
1	19.91	19.92	20.00	19.97	19.16	19.25	21.42	19.93
2	66.30	66.44	54.63	66.79	56.13	60.93	77.24	78.29
3	54.77	55.11	47.20	55.27	50.31	54.92	67.06	58.23
4	6.49	6.61	6.44	6.53	5.99	6.11	6.98	6.59
5	49.29	49.74	35.29	50.46	37.23	40.26	59.25	52.68
6	19.84	19.86	20.20	19.78	19.47	19.12	30.15	19.84
7	14.25	14.03	14.38	14.06	14.55	14.65	14.08	14.06
12	73.37	73.58	73.04	73.65	71.75	68.71	67.02	73.27
13	44.43	44.96	41.65	44.97	48.67	42.11	40.52	42.21
14	69.91	69.82	70.95	70.22	101.13	112.09	76.22	70.00
15	243.30	109.62	58.02	85.04	97.40	103.80	34.35	156.76
16	158.32	157.29	165.03	156.23	197.21	198.38	157.77	158.88
17	114.08	100.90	101.35	183.07	173.96	173.52	86.95	114.40
18	86.96	86.84	86.86	87.34	90.48	87.57	86.07	86.95
19	76.12	76.48	74.56	76.01	81.95	66.08	74.32	78.48
Average-Promedio	73.16	63.41	57.97	67.29	71.03	71.17	59.96	68.70