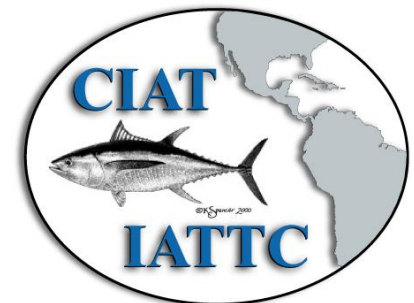
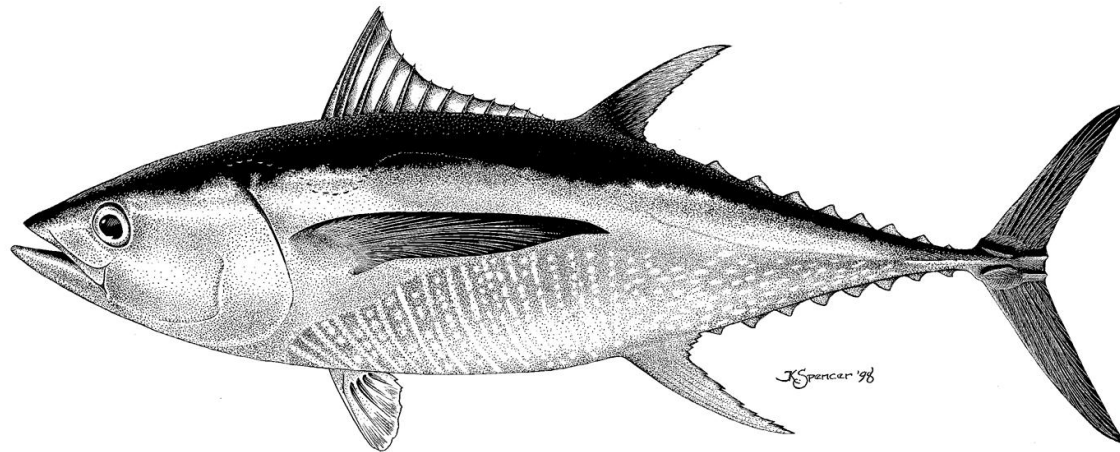
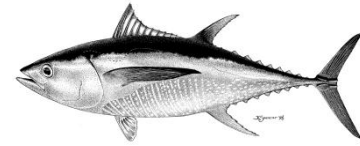


STATUS OF YELLOWFIN TUNA IN THE EASTERN PACIFIC OCEAN IN 2010

January 1975 – December 2010



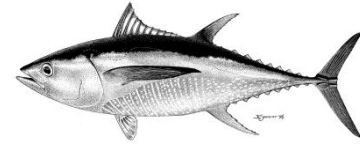
Outline



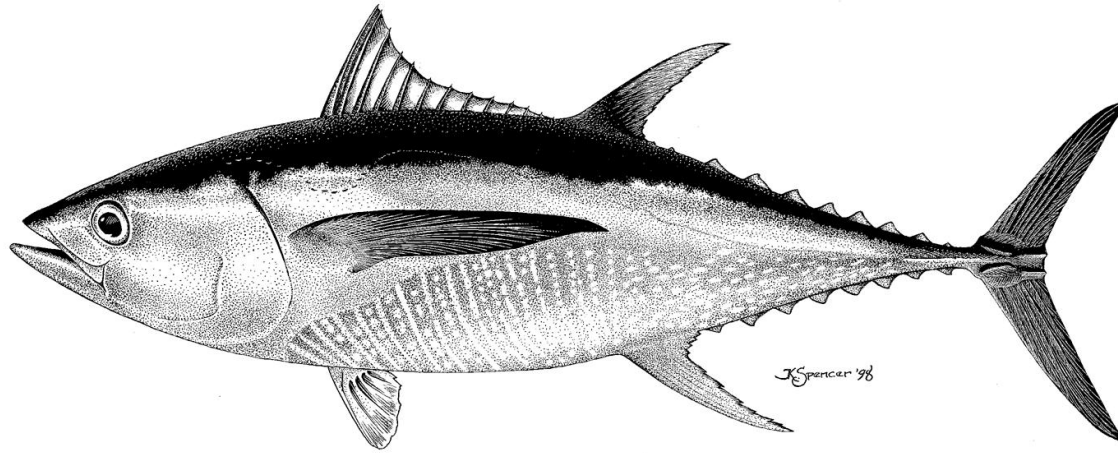
- Stock assessment (base case model)
 - Methodology (Stock Synthesis)
 - Fishery data
 - Model assumptions
 - Results (fishing mortality, recruitment, biomasses, others)
 - Retrospective analysis
 - Comparison to previous assessment (SAC1)
 - Stock status (base case)
 - Simulations (projections with *status quo* and F_{MSY})
- Sensitivity analyses
- Summary conclusions



Overview of assessment model

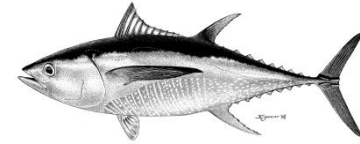


- Age-structured, statistical, catch-at-length model (Stock Synthesis – version 3.20b)
- Integrated analysis
- Same type of model as MULTIFAN-CL, A-SCALA and CASAL



Fishery data

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



New or updated data

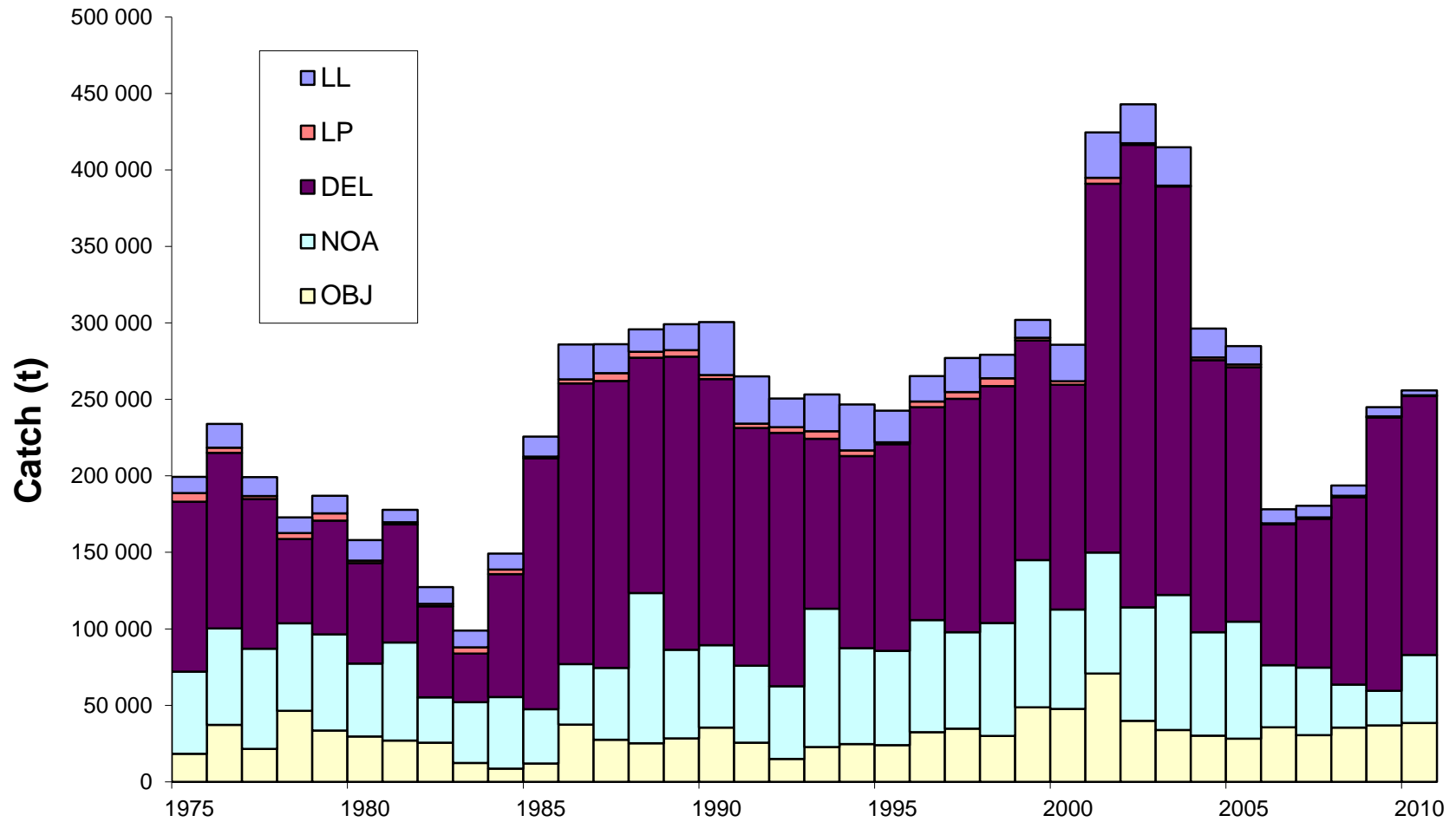
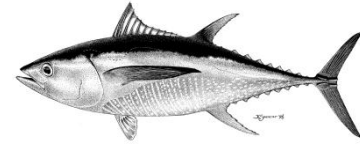
- Surface fisheries

- Catch, CPUE and size-frequency data updated to include new data for 2010 and revised data for earlier years

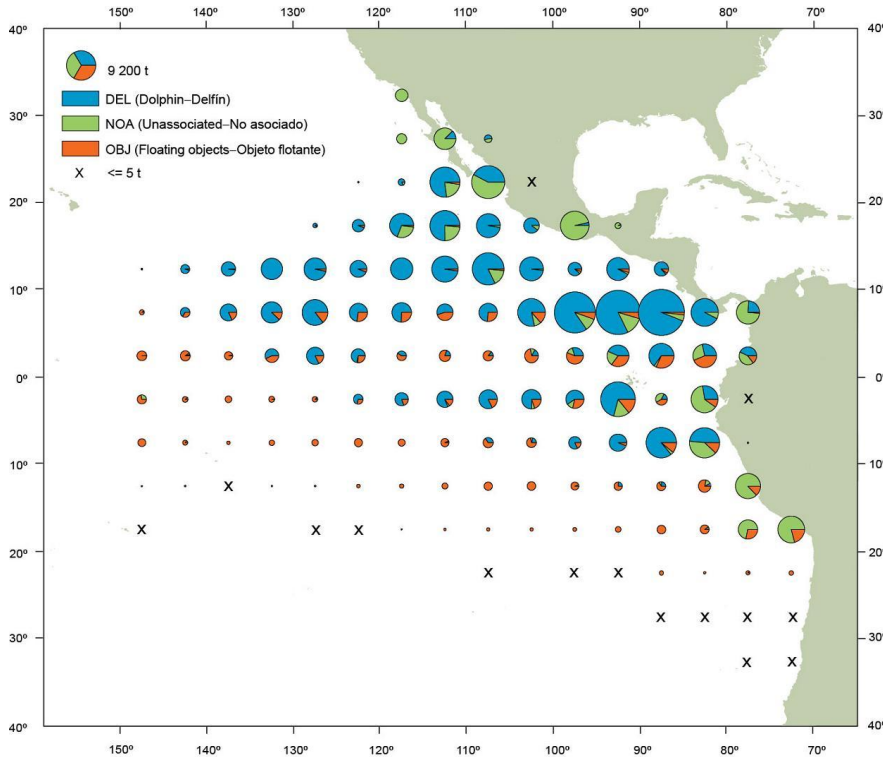
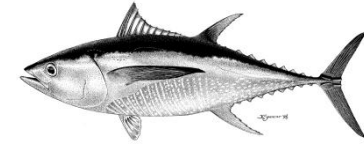
- Longline fisheries

- New or updated longline catch data: French Polynesia (2009), Japan (2008-2010), Korea (2009) and USA (2008-2009)
- New or updated CPUE data available for Japan (2008-2010)
- New or updated longline size-frequency data available for Japan (2007-2009)

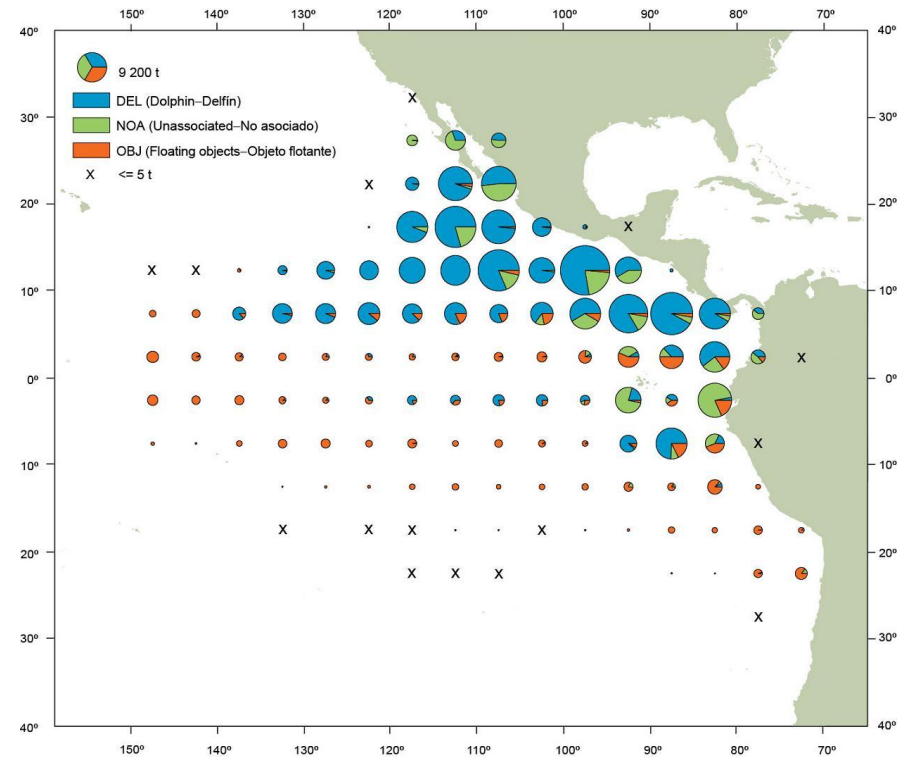
Total catches



Spatial distribution of PS catches

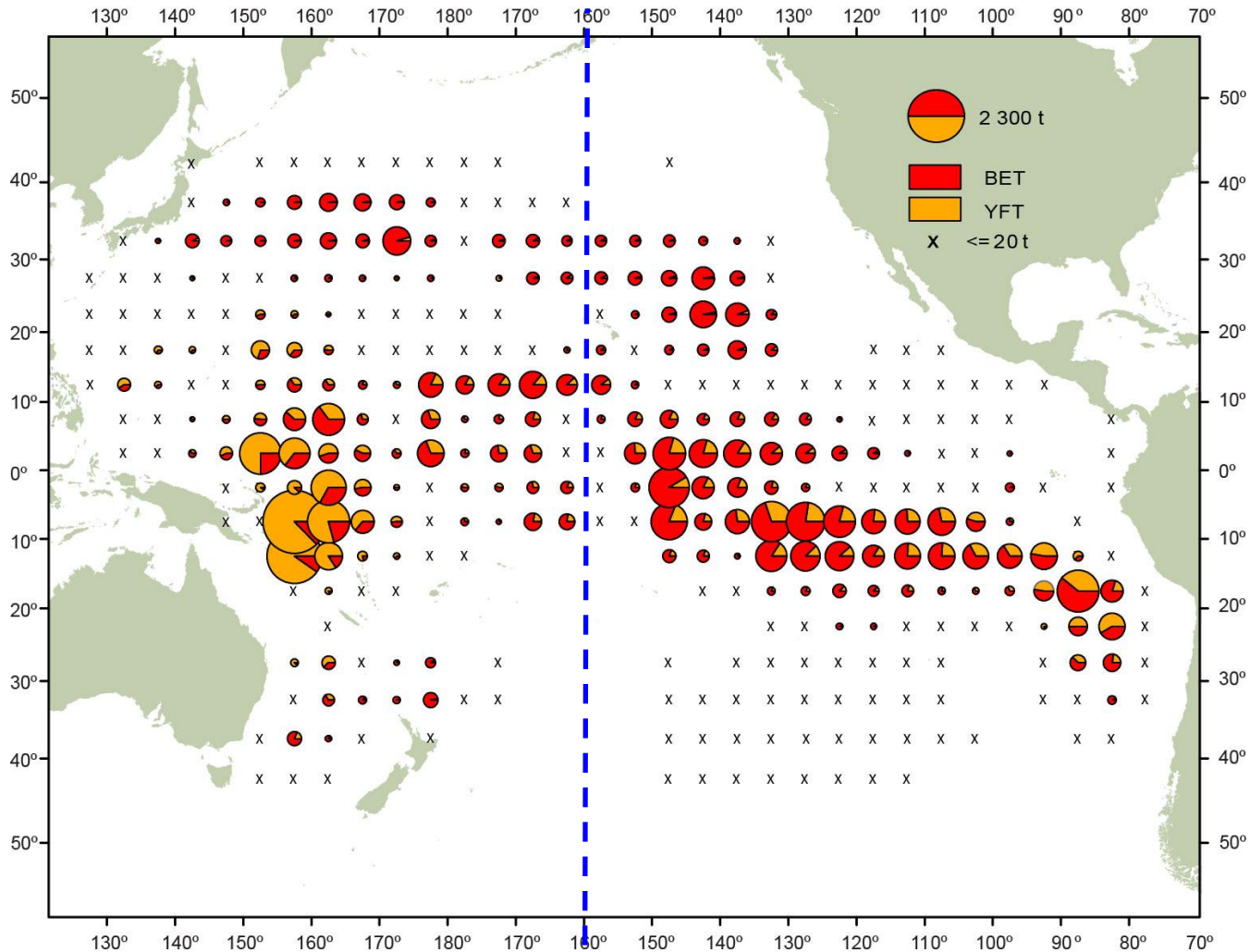
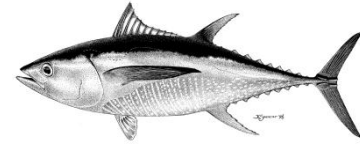


Average annual distribution of YFT PS catches, 2005-2009



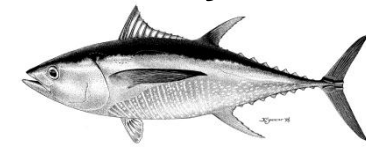
Annual distribution of YFT PS catches, 2010

Spatial distribution of LL catches



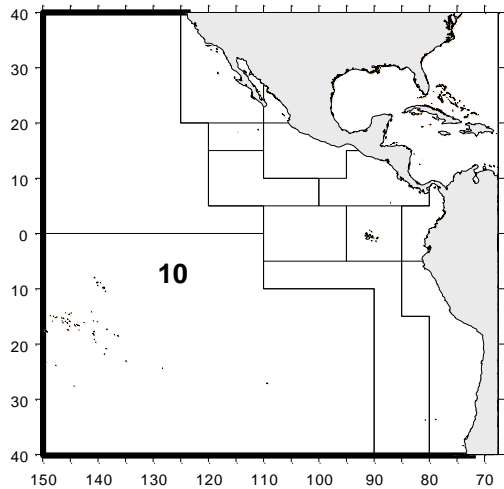
Average annual LL catch, 2005-2009



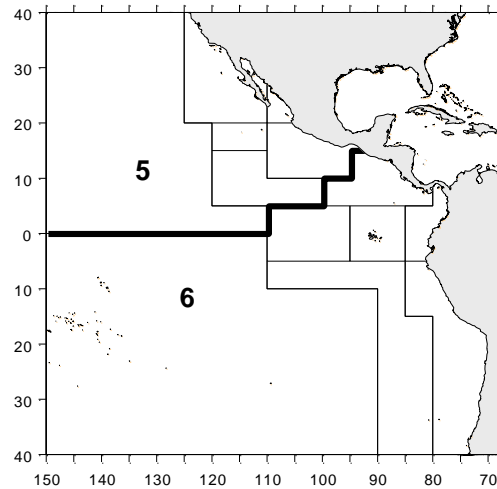


YFT fishery definitions

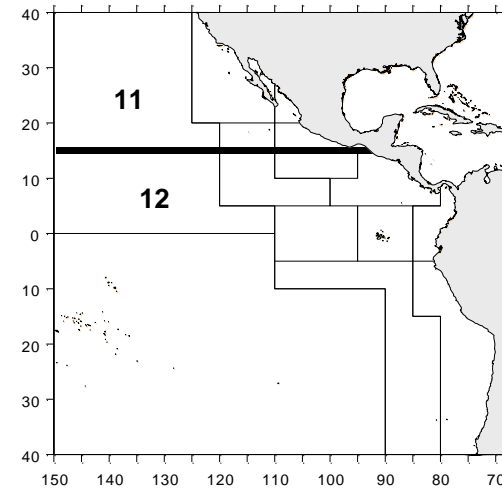
Baitboat



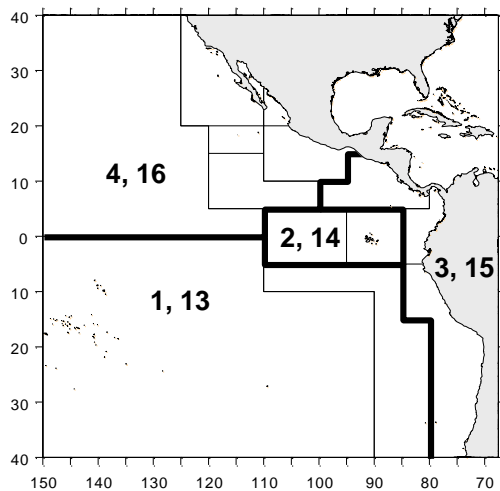
Unassociated



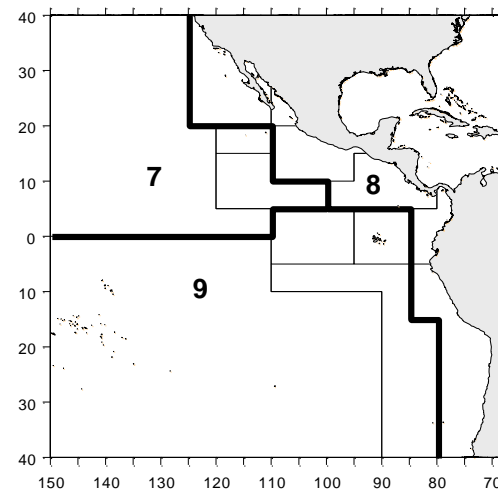
Longline



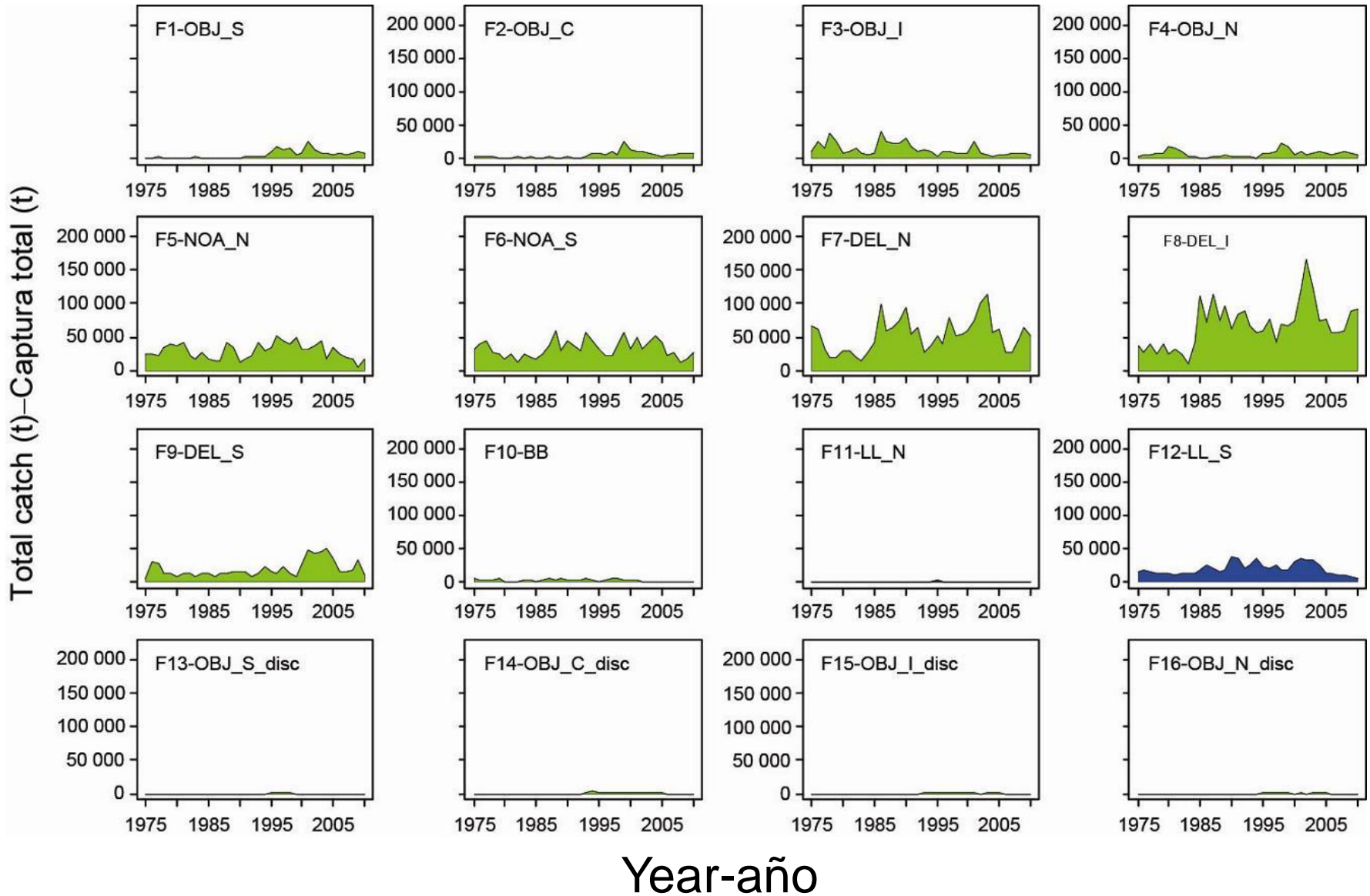
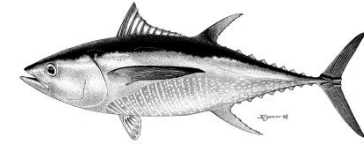
Floating Objects

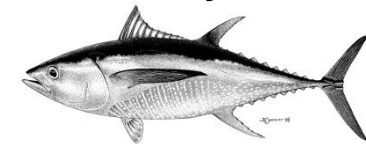


Dolphin

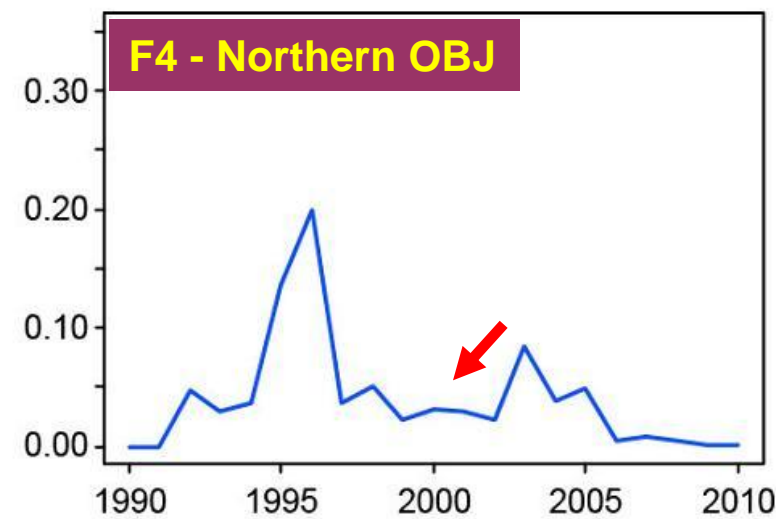
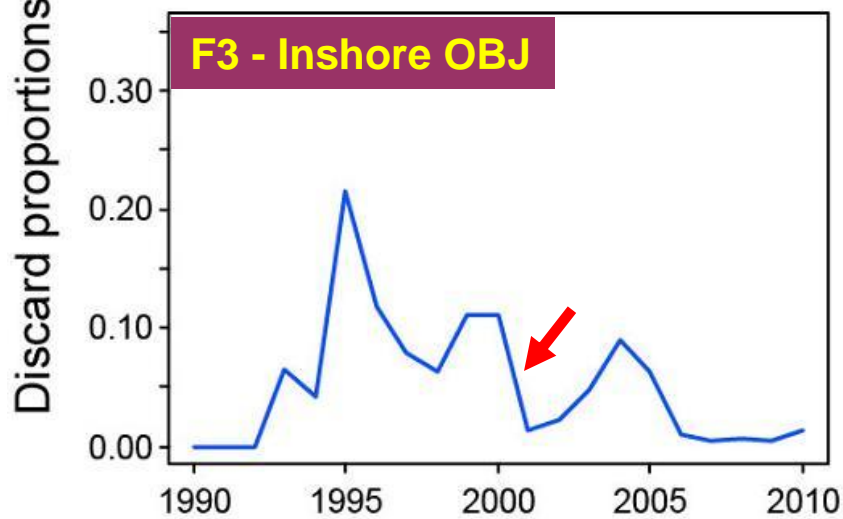
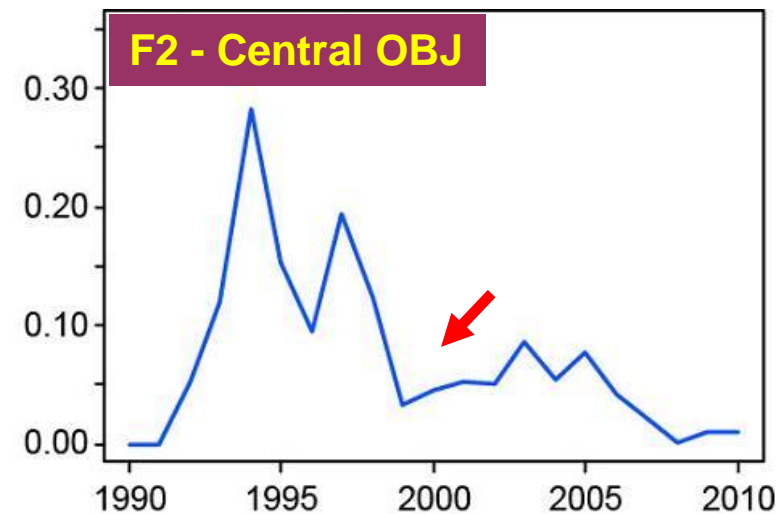
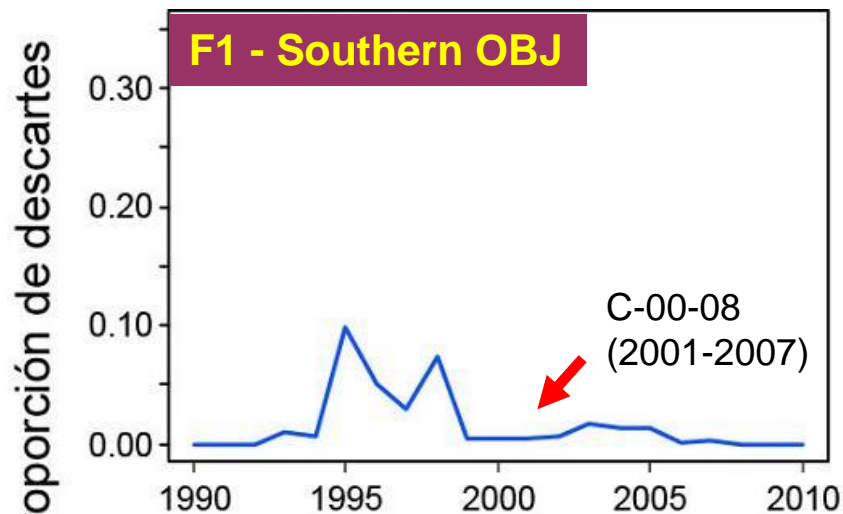


Annual catches by fishery



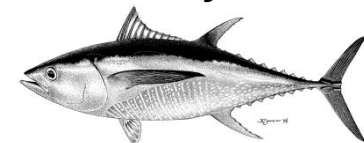


Discards

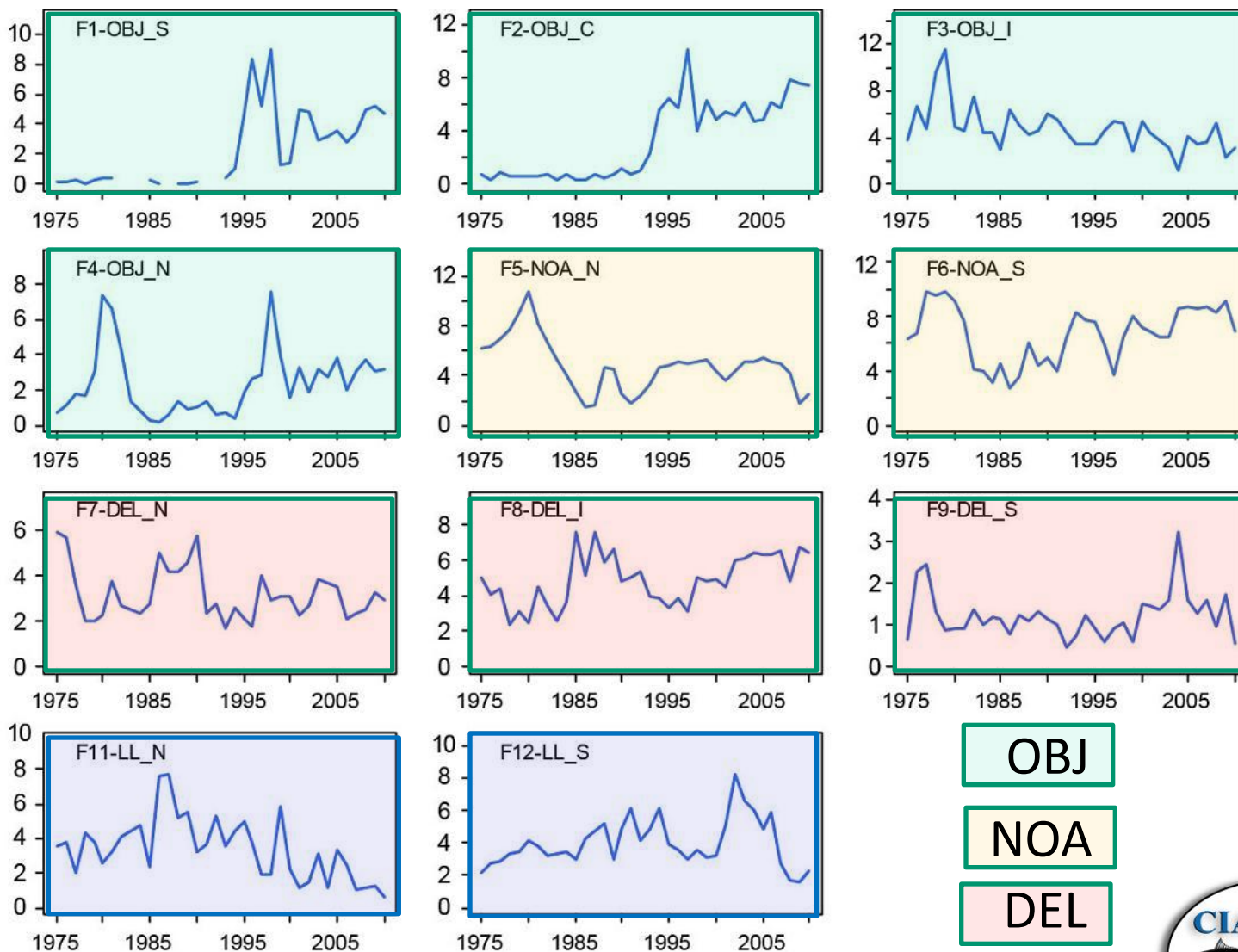


Year-año

Fishing effort

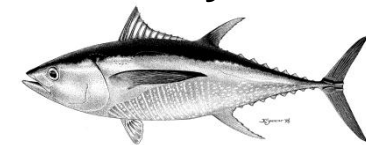


Thousands of days and standardized numbers of hooks
Miles de días e número de anzuelos estandarizados

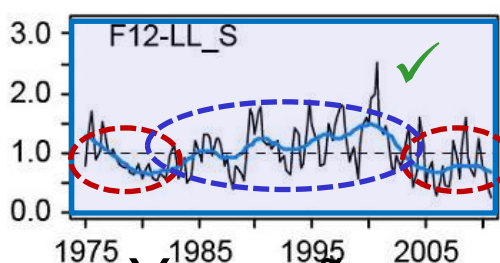
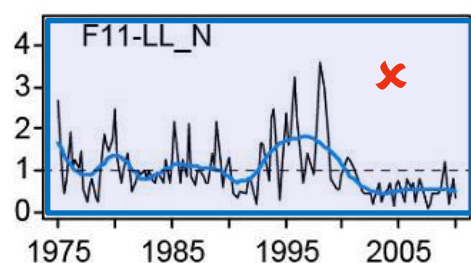
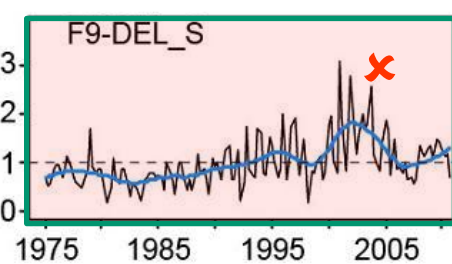
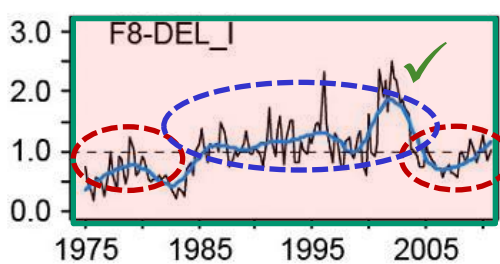
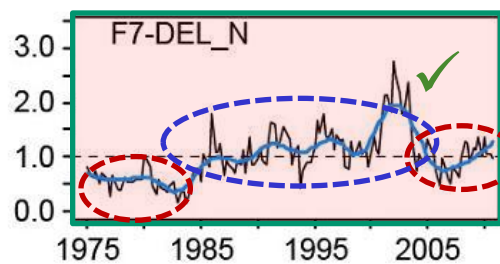
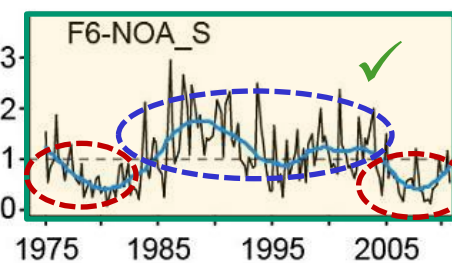
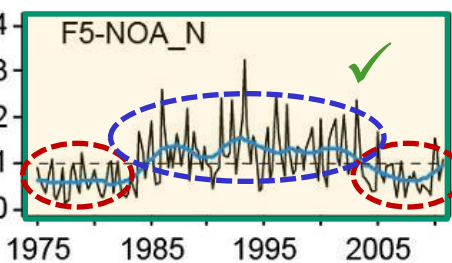
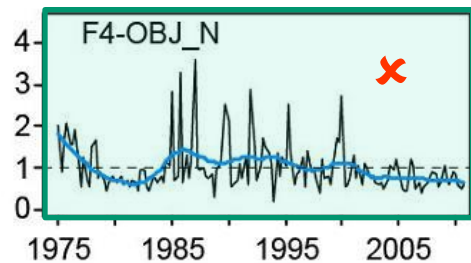
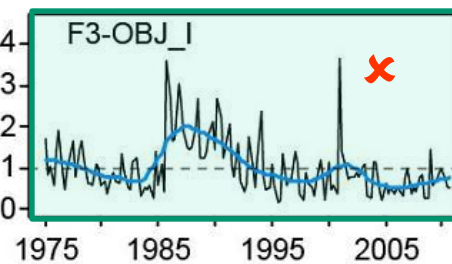
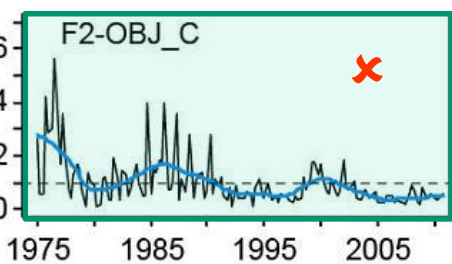
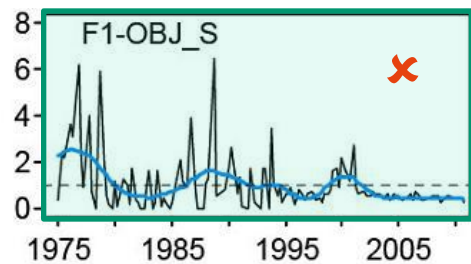


Year-año

Catch-per-unit effort (CPUE)



Scaled CPUE-CPUE escalada

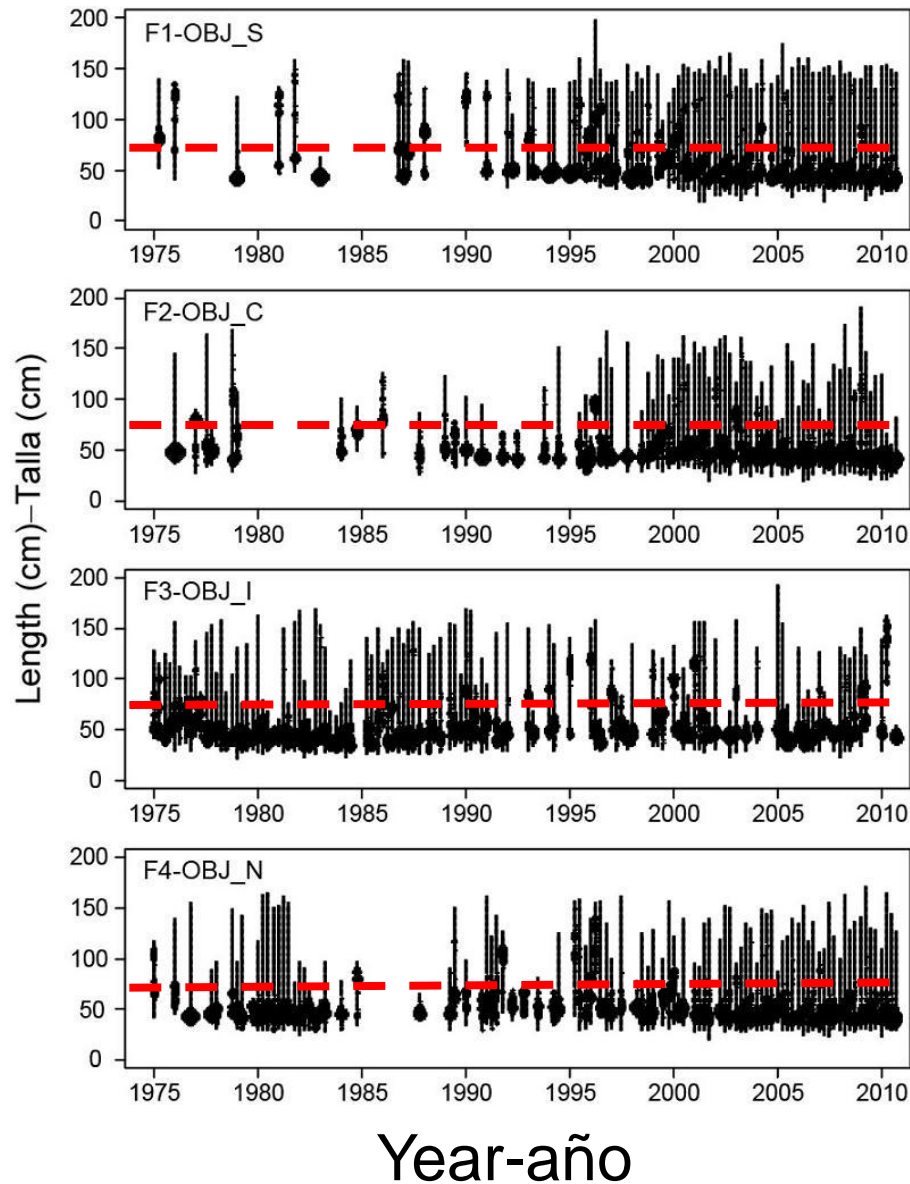
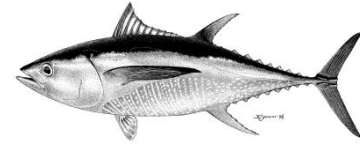


Year-ano

- OBJ
- NOA
- DEL
- LL

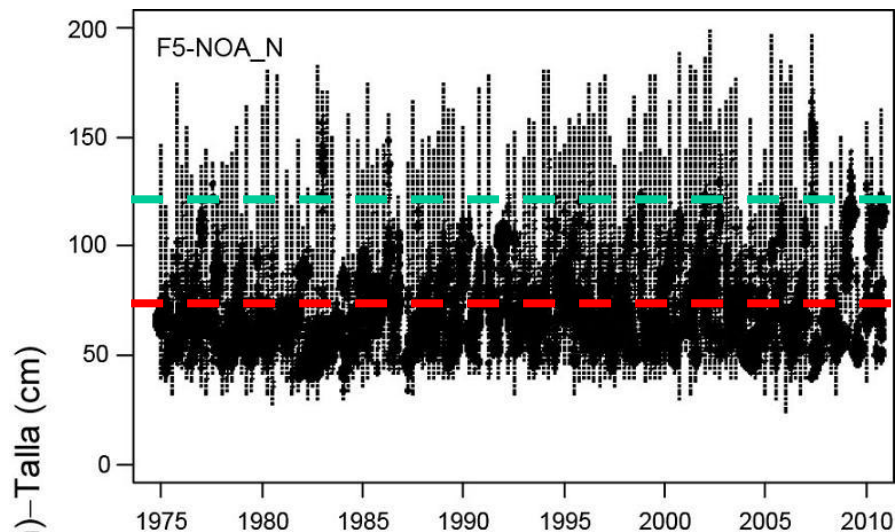
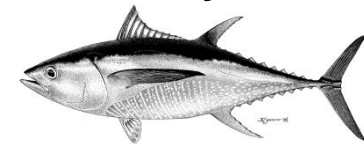


Size compositions – OBJ fisheries



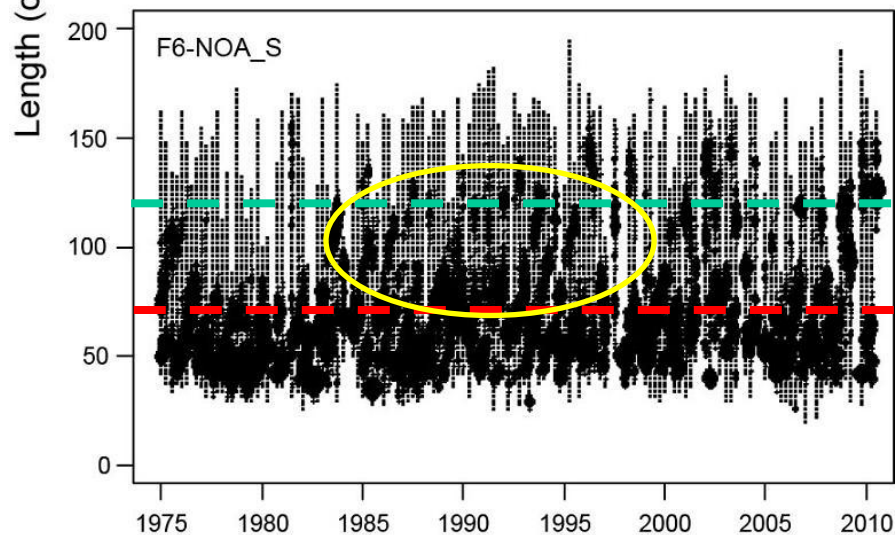
Small

Size compositions – NOA fisheries



Medium

Small



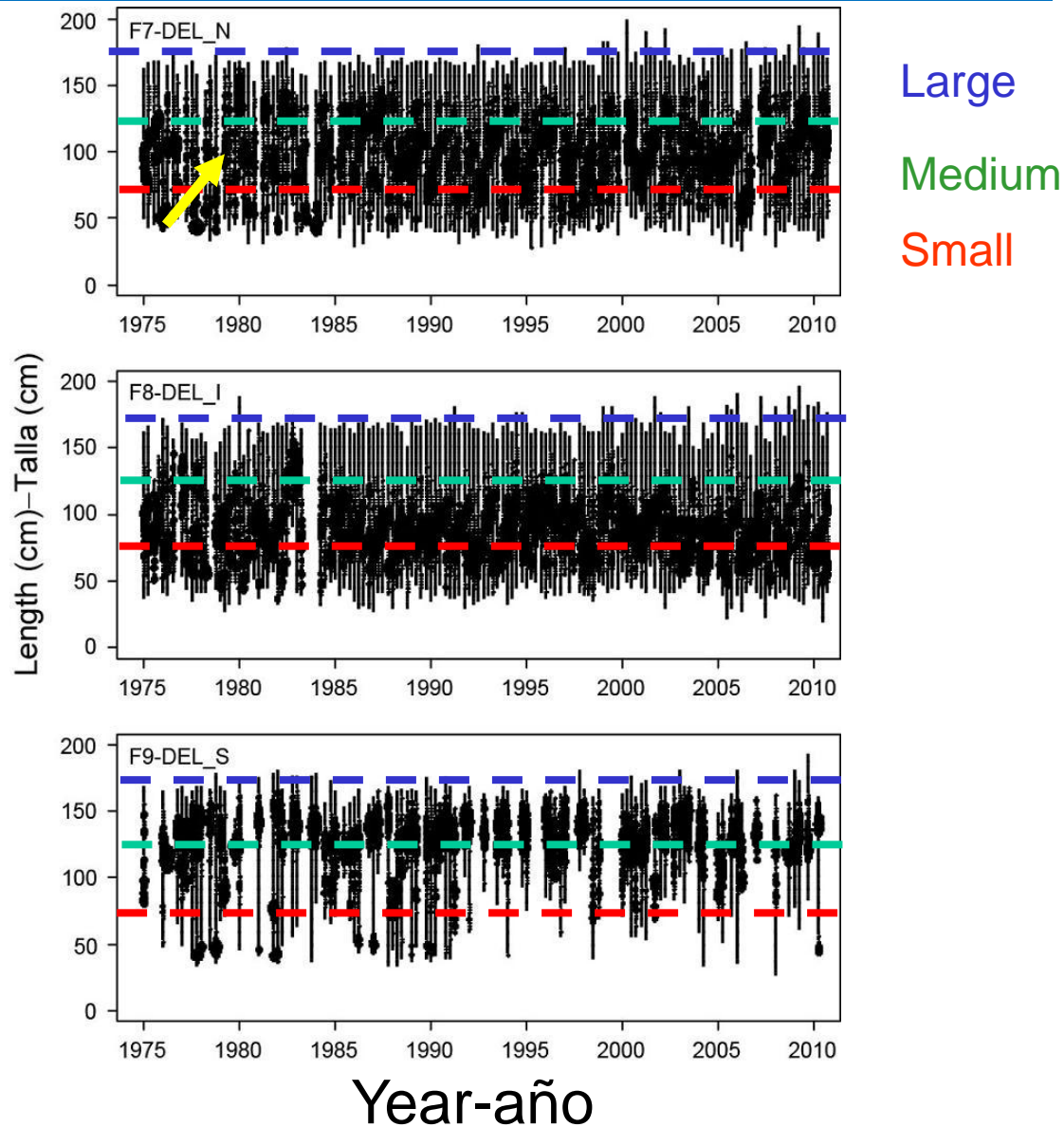
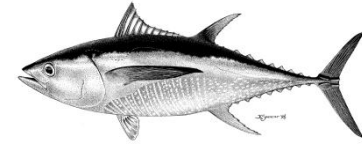
Medium

Small

Year-año

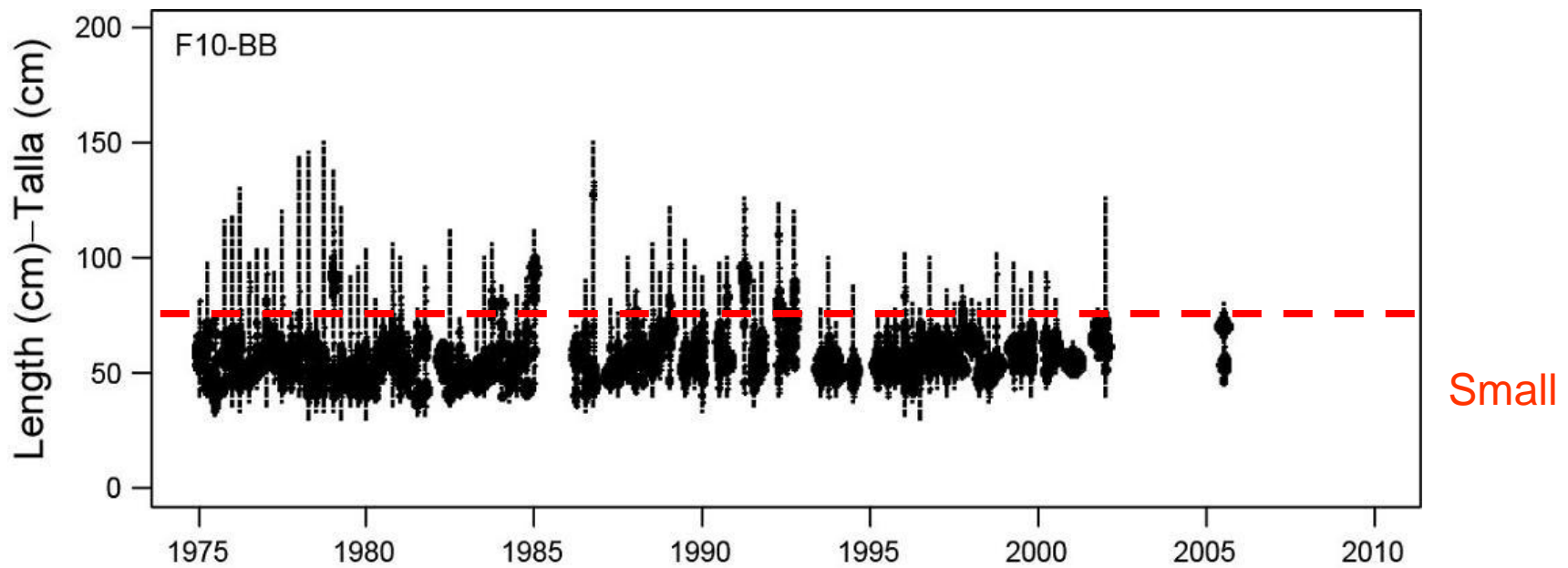
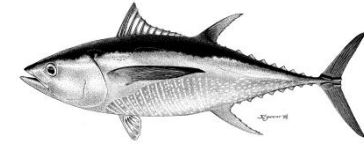


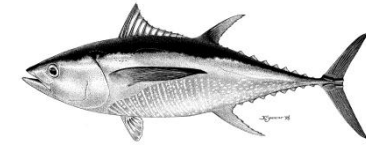
Size compositions – DEL fisheries



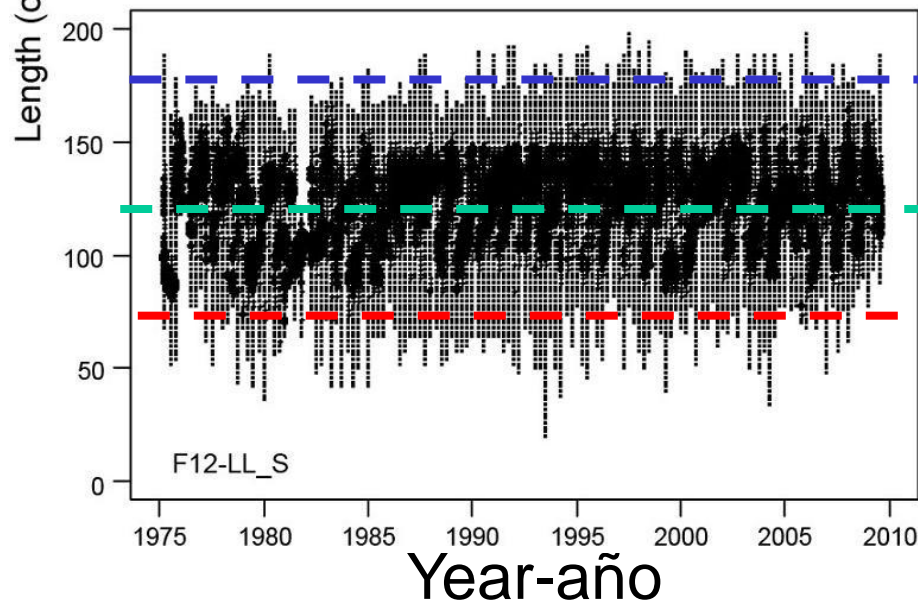
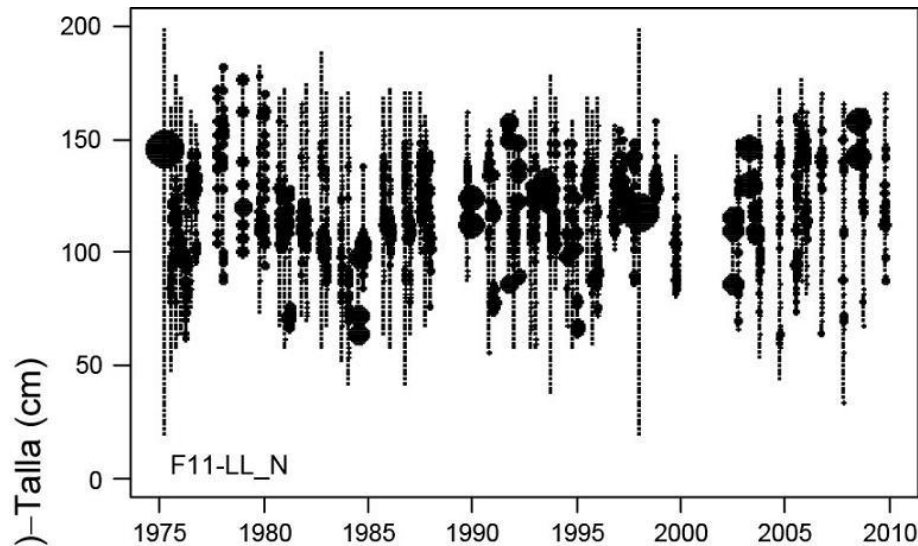
Size compositions – BB fishery

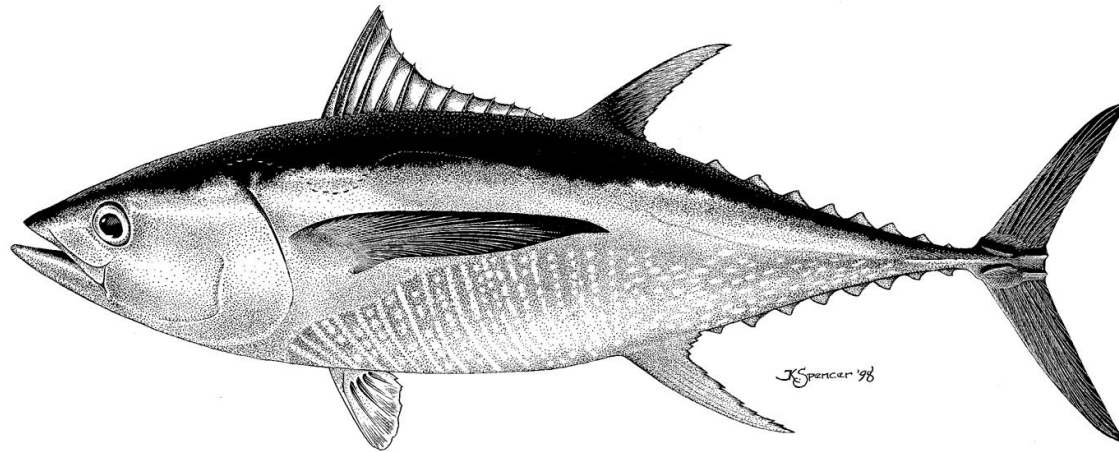
Fishery data





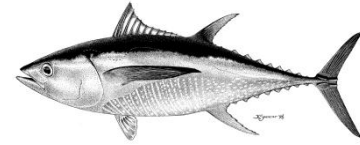
Size compositions – LL fisheries





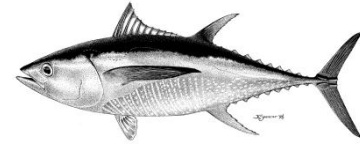
Model assumptions (base case)

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



YFT stock structure

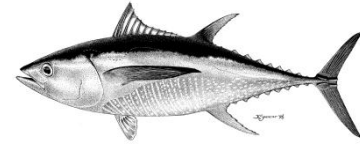
- Minimal net movement of fish between the EPO and WCPO
- Single stock of YFT in EPO



Stock-recruitment relationship

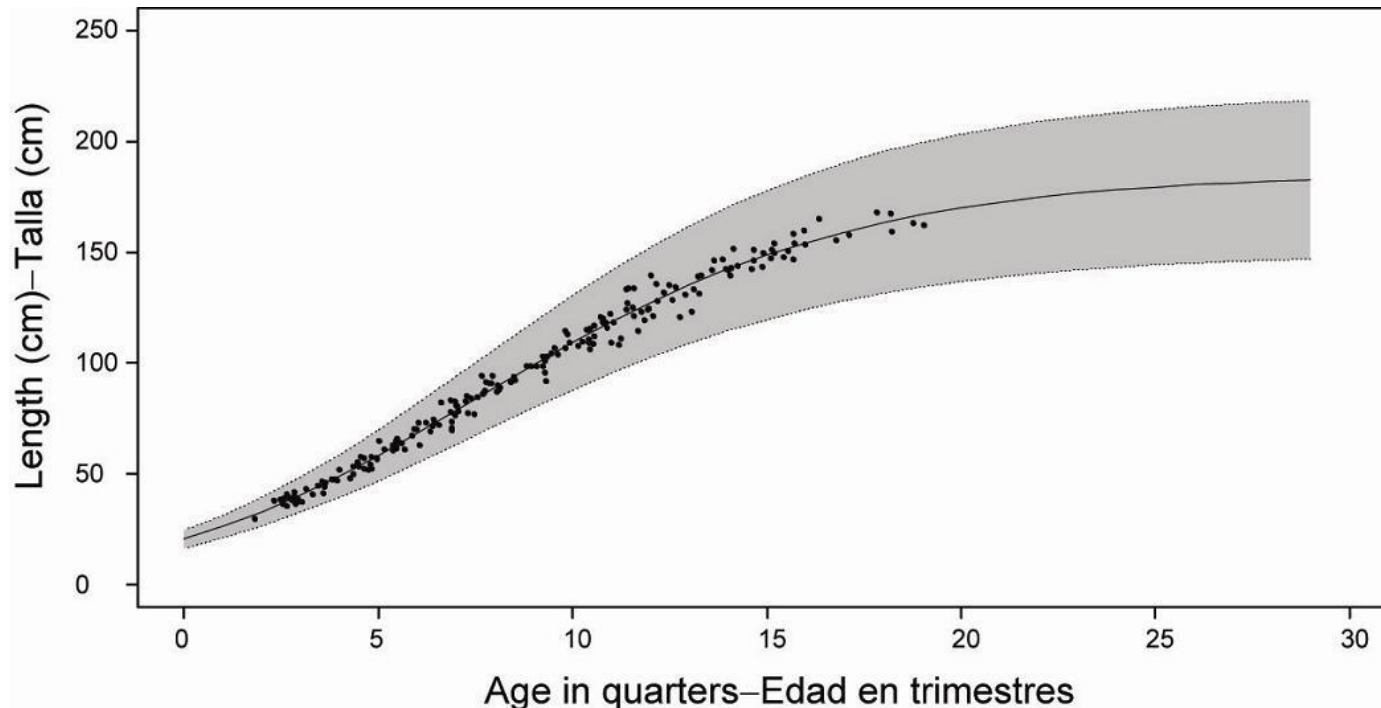
- Beverton-Holt relationship
- No S-R relationship (steepness = 1)
- Sensitivity analysis ([Appendix A](#))
 - Steepness = 0.75
 - Likelihood profile on steepness (0.6, 0.7, 0.8, 0.9, 1.0)

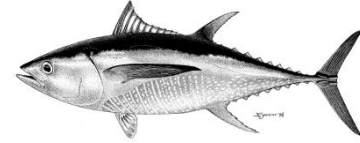
Steepness (h): Fraction of R_0 that is produced if SSB is reduced to 20% of S_0



Age and growth

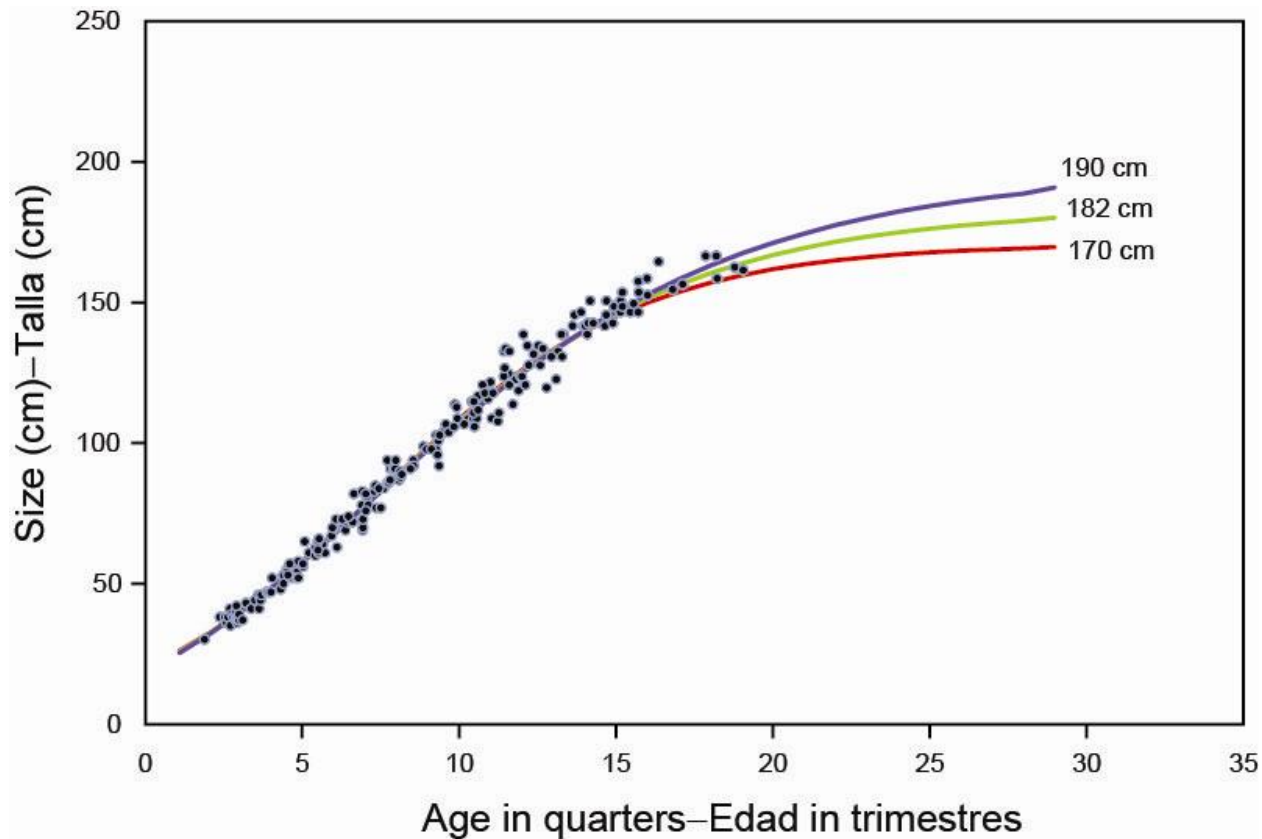
- Richards growth curve
 - Growth parameters fixed (Maunder and Aires-da-Silva, 2009)
 - L_2 fixed at 182.3 cm
 - Variability of length-at-age (LSD) fixed

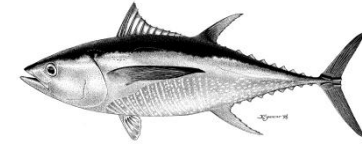




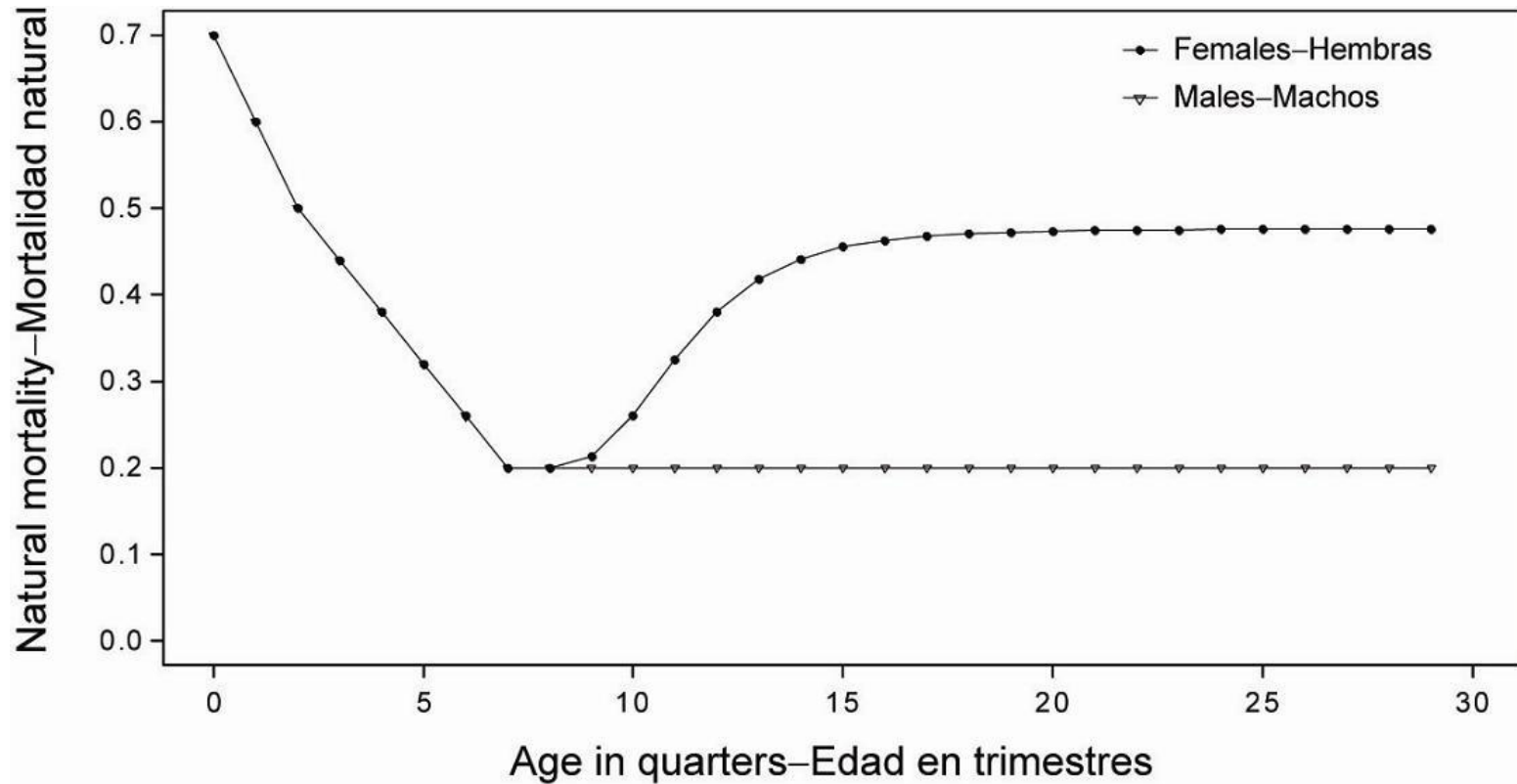
Growth - sensitivities

- Sensitivity analysis to fixed value of L_2 (Appendix B)



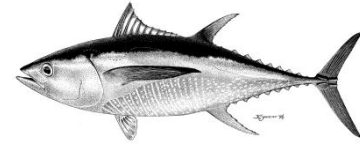


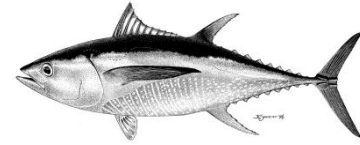
Natural mortality (M)



Relative fecundity

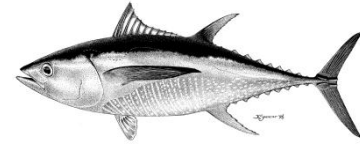
Assumptions





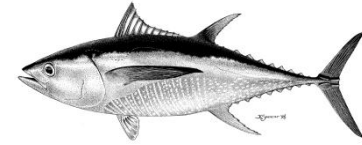
Fixed parameters

- Mean length at age
- Params of a linear model relating the CV of LLA to age
- Sex and age-specific natural mortality-rates (M)
- Sex ratio at age 0 (=0.5)
- Age-specific fecundity at age
- CV of LL-S CPUE (CV=0.2), Sensitivity analysis fitting to DEL-N CPUE as main index (CV=0.2) (Appendix C)
- Selectivity curves for discard fisheries
- Steepness (h) of S-R relationship ($h=1$)



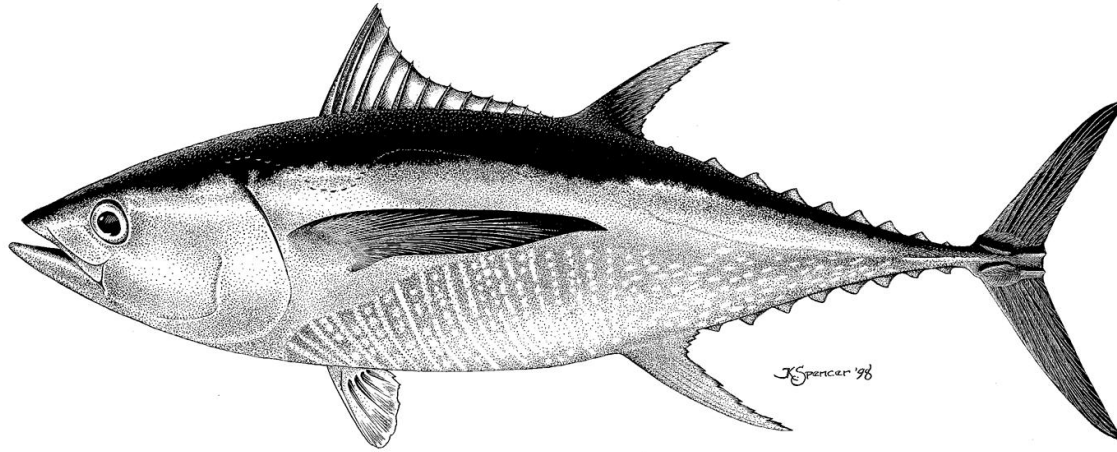
Estimated parameters

- Recruitment in every quarter from 1975 to 2011 (average recruitment and temporal recruitment anomalies)
- Catchability coefficients for the 5 CPUE time series (NOA-N, NOA-S, DEL-N, DEL-I, LL-S)
- CV for 4 CPUE indices (NOA, DEL)
- Selectivity curves for 11 of the 16 fisheries (F9 DEL-S mirrors F12 LL-S)
- Logistic selectivity for LL-S and DEL-S, and dome-shape for all other fisheries (except discards)
- Initial population age-structure



Changes from early assessment (SAC1)

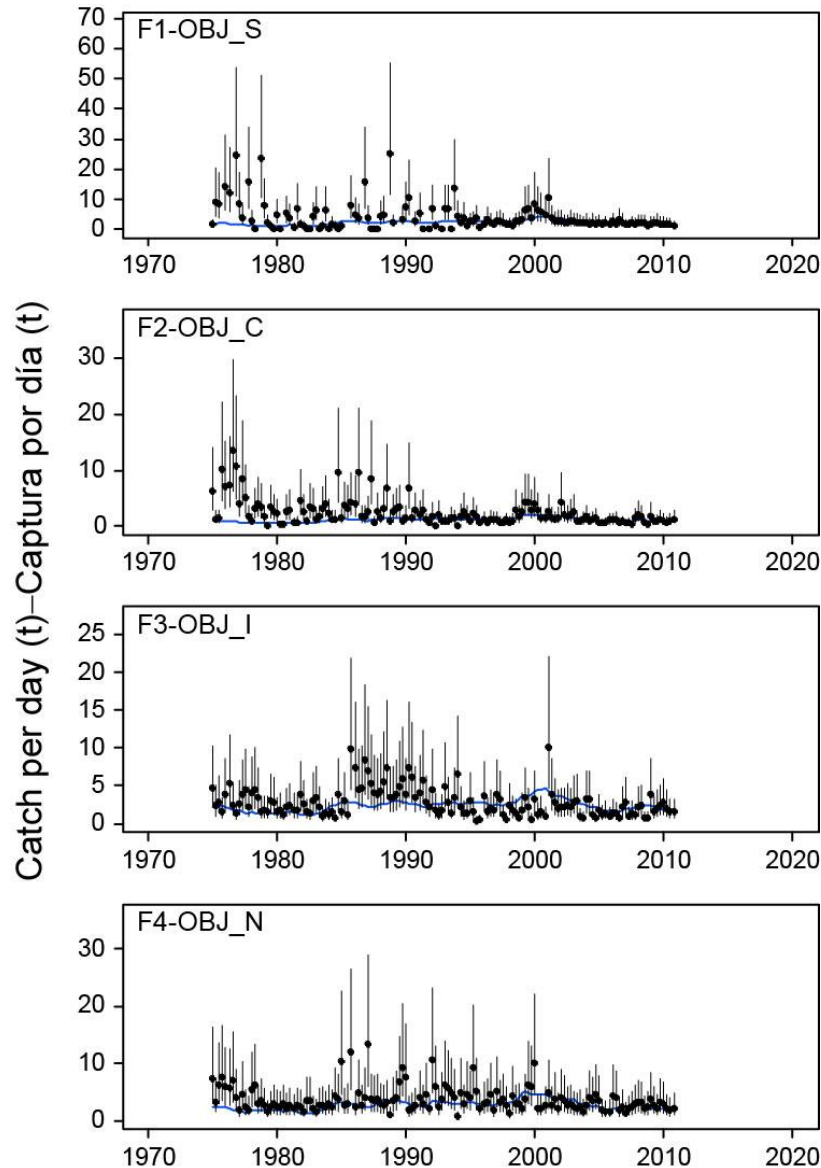
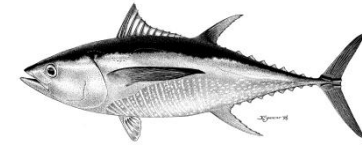
- Fishery definitions: **No changes**
- Growth modeling: **No changes**
- Data weighting: the CV of the southern LL-S fishery is fixed (0.2) rather than estimated
- Modeling of selectivity:
 - Sharing of selectivities minimized (DEL-S/LL-S only)
 - No sharing of PL/OBJ-I and LL-N/LL-S



Results (base case)

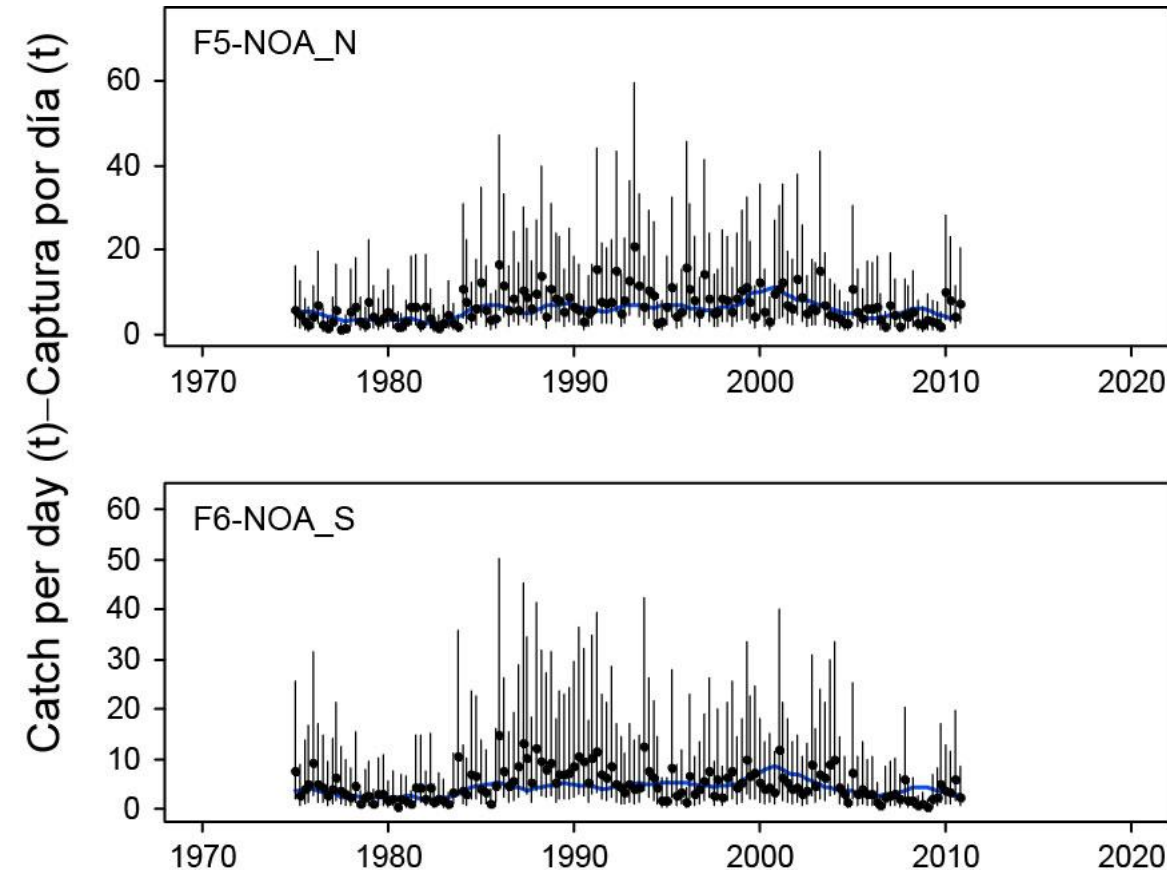
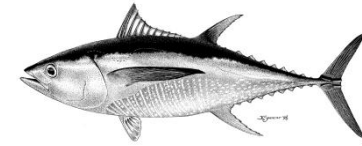
- Model fits (CPUE and size compositions)
- Fishing mortality
- Selectivity
- Recruitment
- Biomass

Fit to CPUE – OBJ fisheries



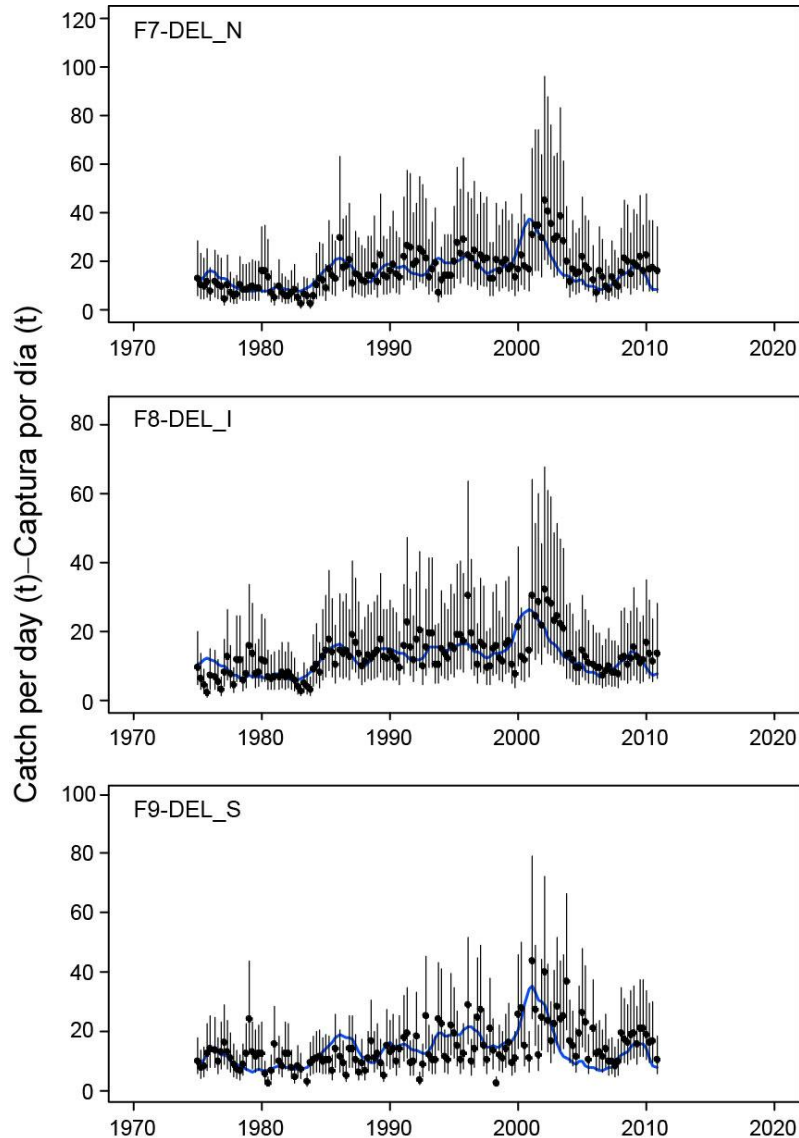
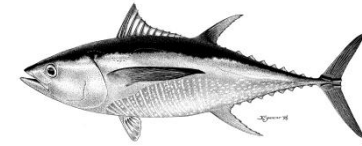
Fishery	CV	Used
F1-OBJ_S	0.35	No
F2-OBJ_C	0.41	No
F3-OBJ_I	0.69	No
F4-OBJ_N	0.41	No
F5-NOA_N	0.54	Yes
F6-NOA_S	0.62	Yes
F7-DEL_N	0.39	Yes
F8-DEL_I	0.38	Yes
F9-DEL_S	0.50	No
F10-BB	0.00	No
F11-LL_N	0.75	No
F12-LL_S	0.36	Yes

Fit to CPUE – NOA fisheries



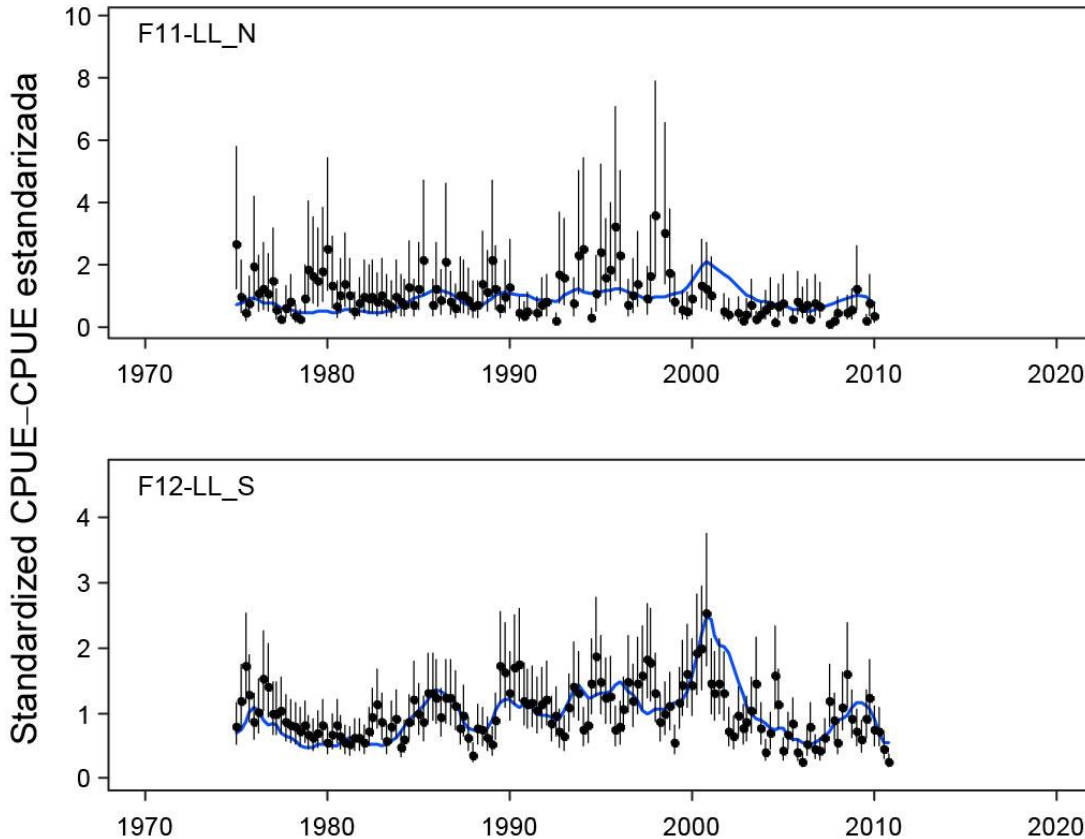
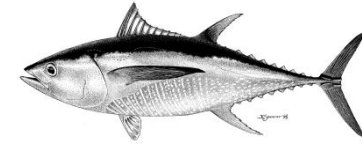
Fishery	CV	Used
F1-OBJ_S	0.35	No
F2-OBJ_C	0.41	No
F3-OBJ_I	0.69	No
F4-OBJ_N	0.41	No
F5-NOA_N	0.54	Yes
F6-NOA_S	0.62	Yes
F7-DEL_N	0.39	Yes
F8-DEL_I	0.38	Yes
F9-DEL_S	0.50	No
F10-BB	0.00	No
F11-LL_N	0.75	No
F12-LL_S	0.36	Yes

Fit to CPUE – DEL fisheries



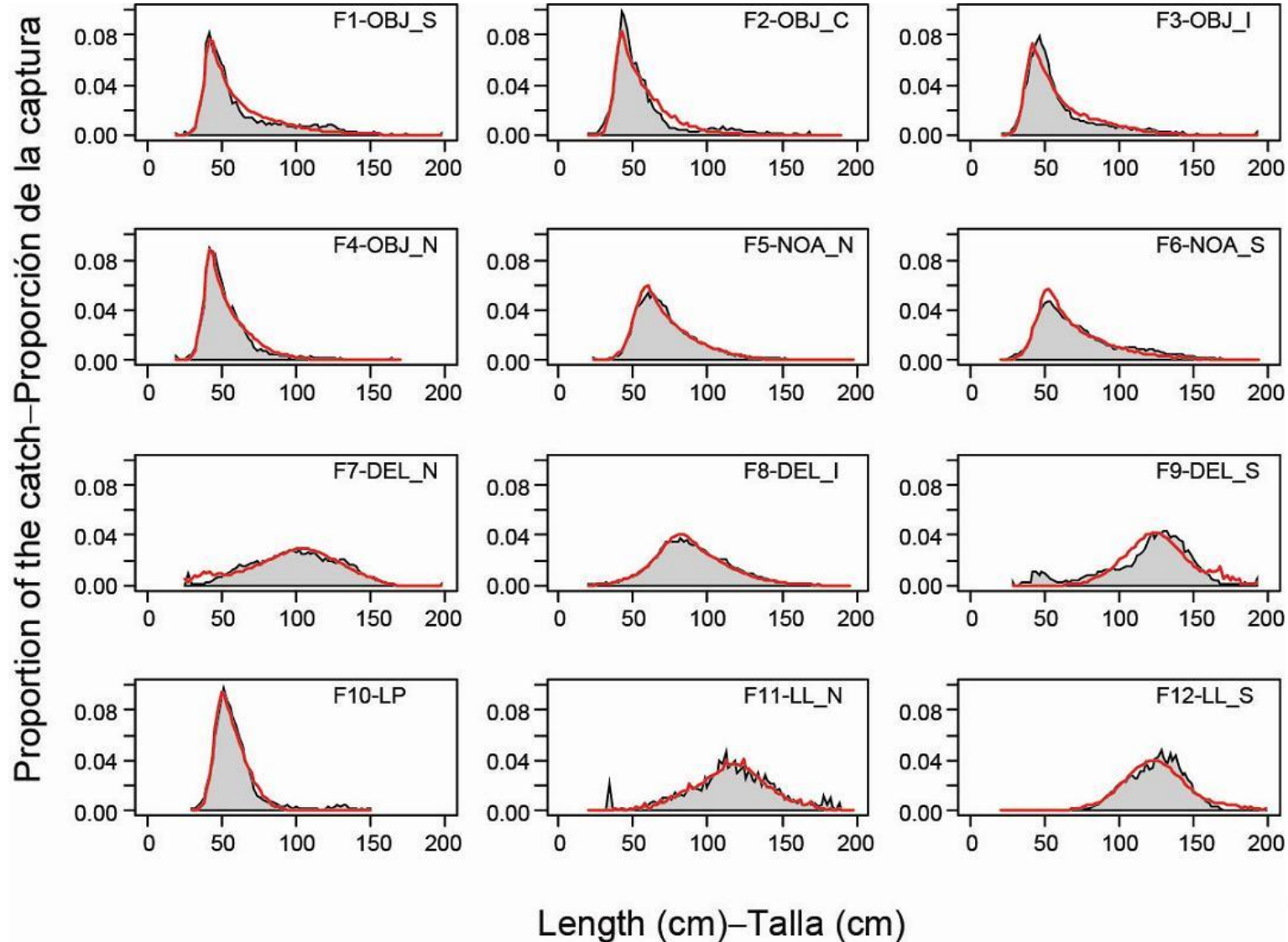
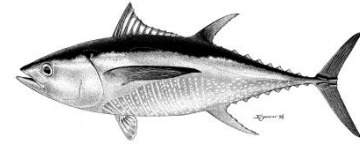
Fishery	CV	Used
F1-OBJ_S	0.35	No
F2-OBJ_C	0.41	No
F3-OBJ_I	0.69	No
F4-OBJ_N	0.41	No
F5-NOA_N	0.54	Yes
F6-NOA_S	0.62	Yes
F7-DEL_N	0.39	Yes
F8-DEL_I	0.38	Yes
F9-DEL_S	0.50	No
F10-BB	0.00	No
F11-LL_N	0.75	No
F12-LL_S	0.36	Yes

Fit to CPUE – LL fisheries

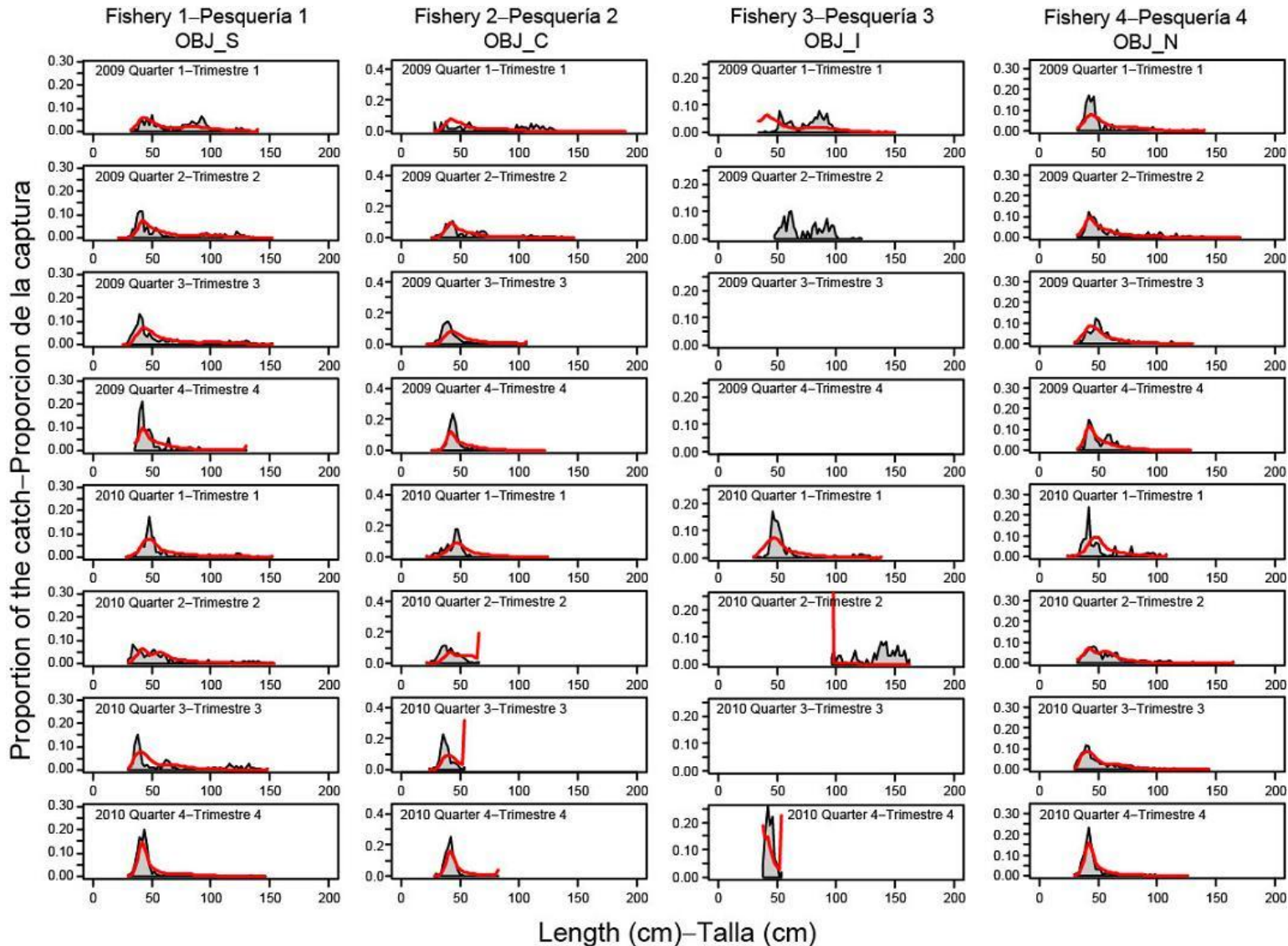
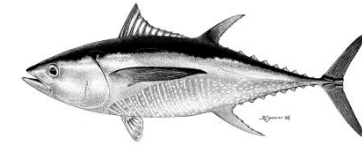


Fishery	CV	Used
F1-OBJ_S	0.35	No
F2-OBJ_C	0.41	No
F3-OBJ_I	0.69	No
F4-OBJ_N	0.41	No
F5-NOA_N	0.54	Yes
F6-NOA_S	0.62	Yes
F7-DEL_N	0.39	Yes
F8-DEL_I	0.38	Yes
F9-DEL_S	0.50	No
F10-BB	0.00	No
F11-LL_N	0.75	No
F12-LL_S	0.36	Yes

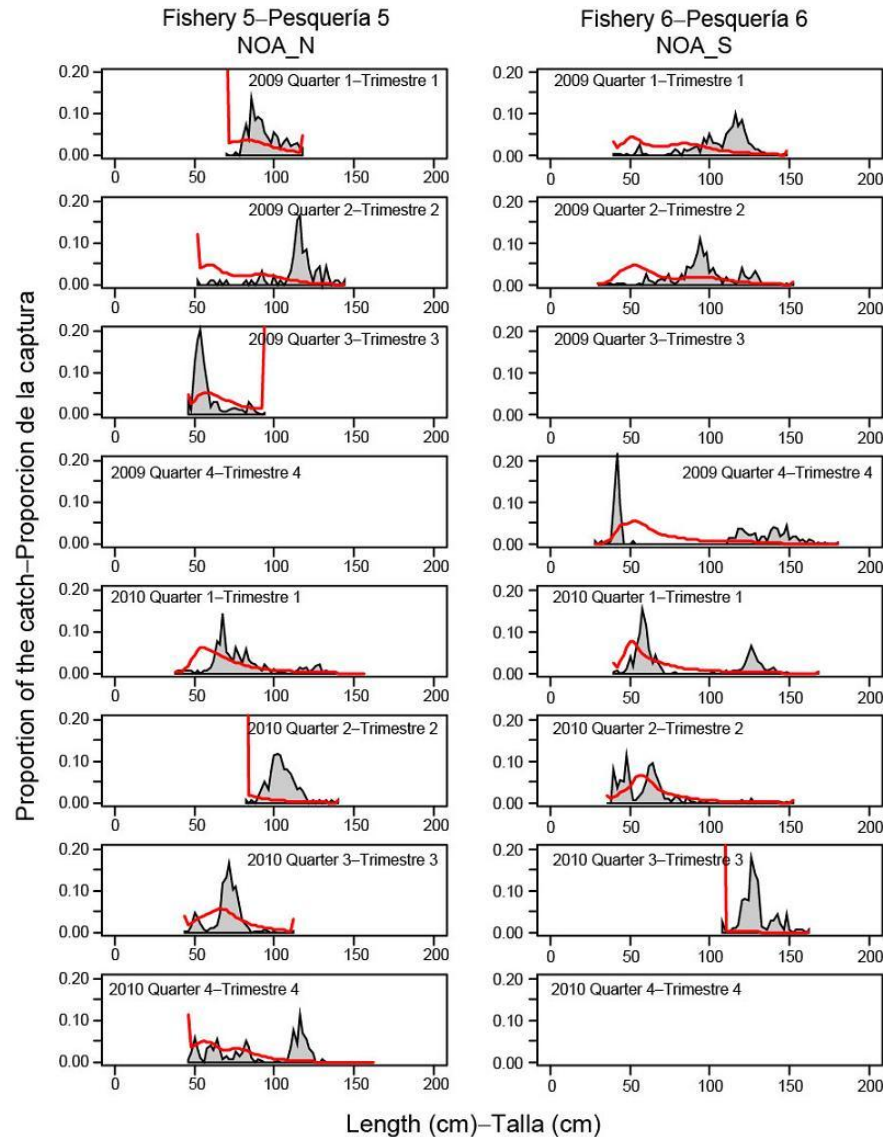
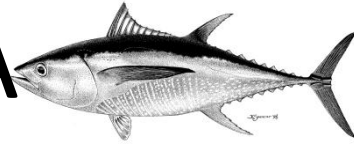
Average fits to size comps.



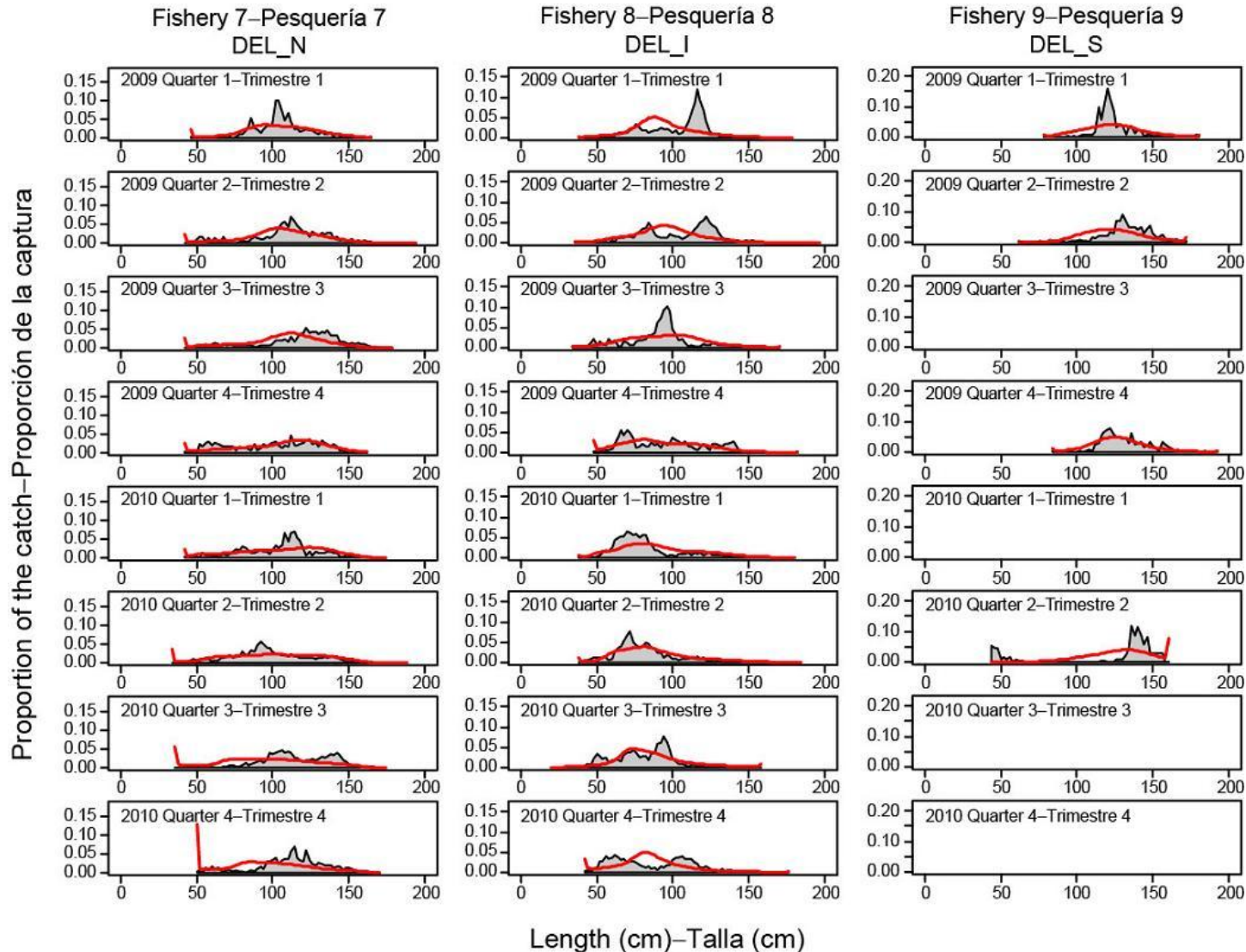
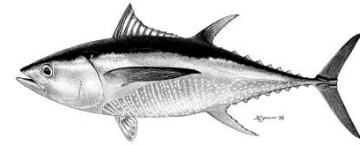
Recent fits to size comps. - OBJ



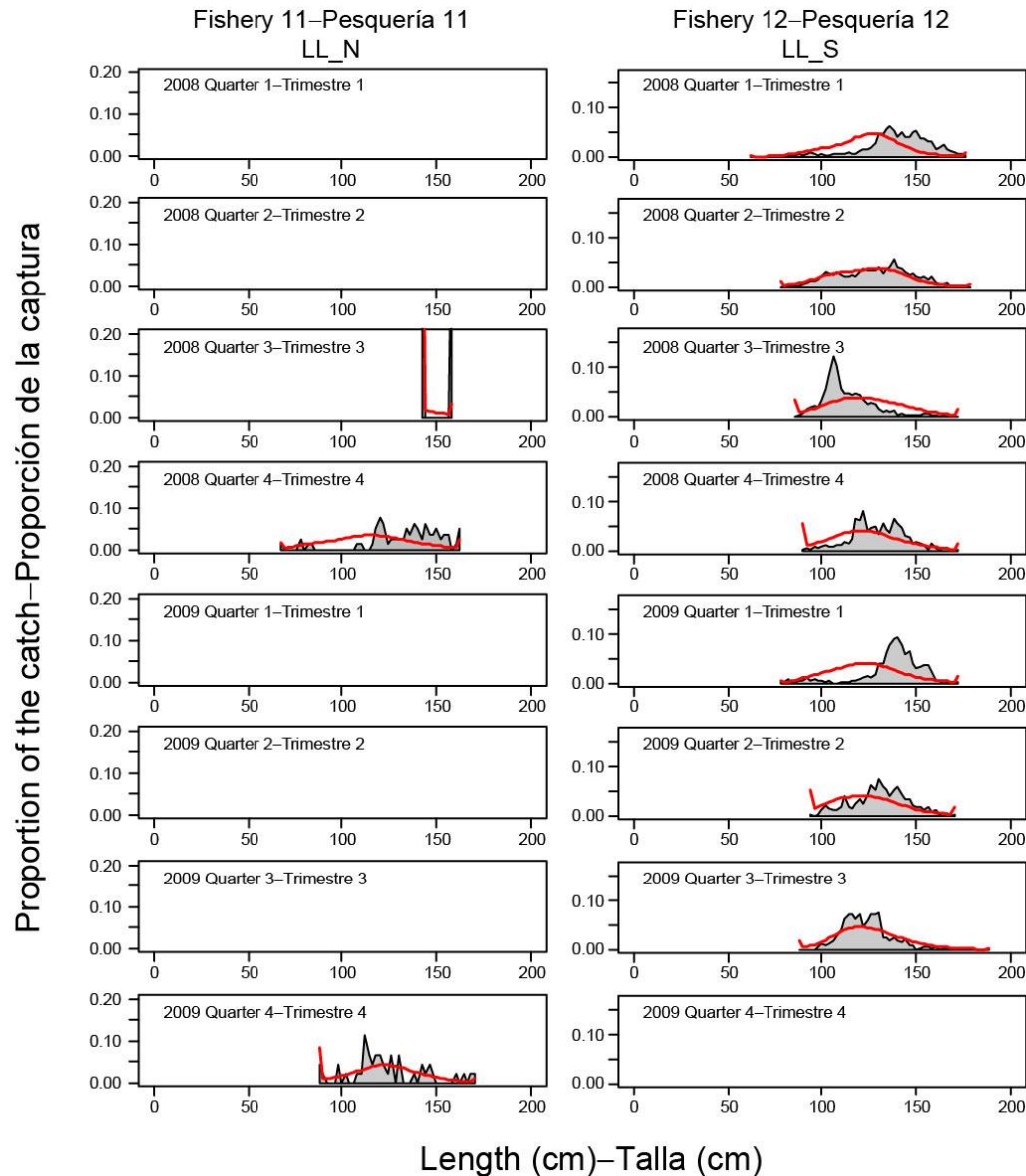
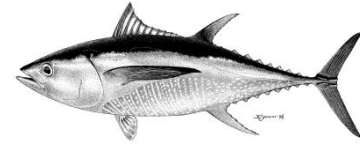
Recent fits to size comps. - NOA



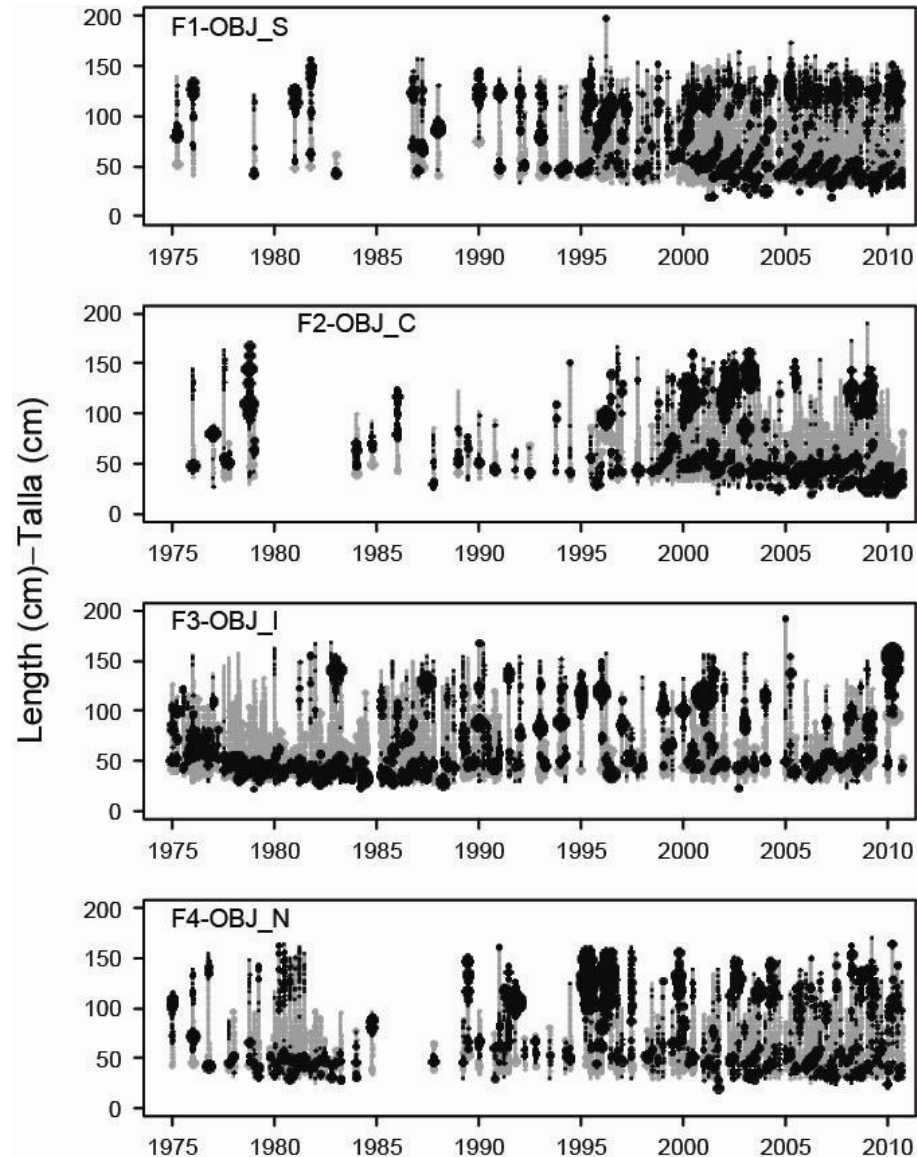
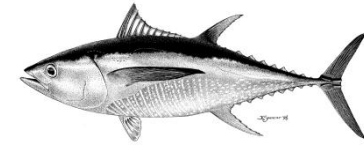
Recent fits to size comps. - DEL



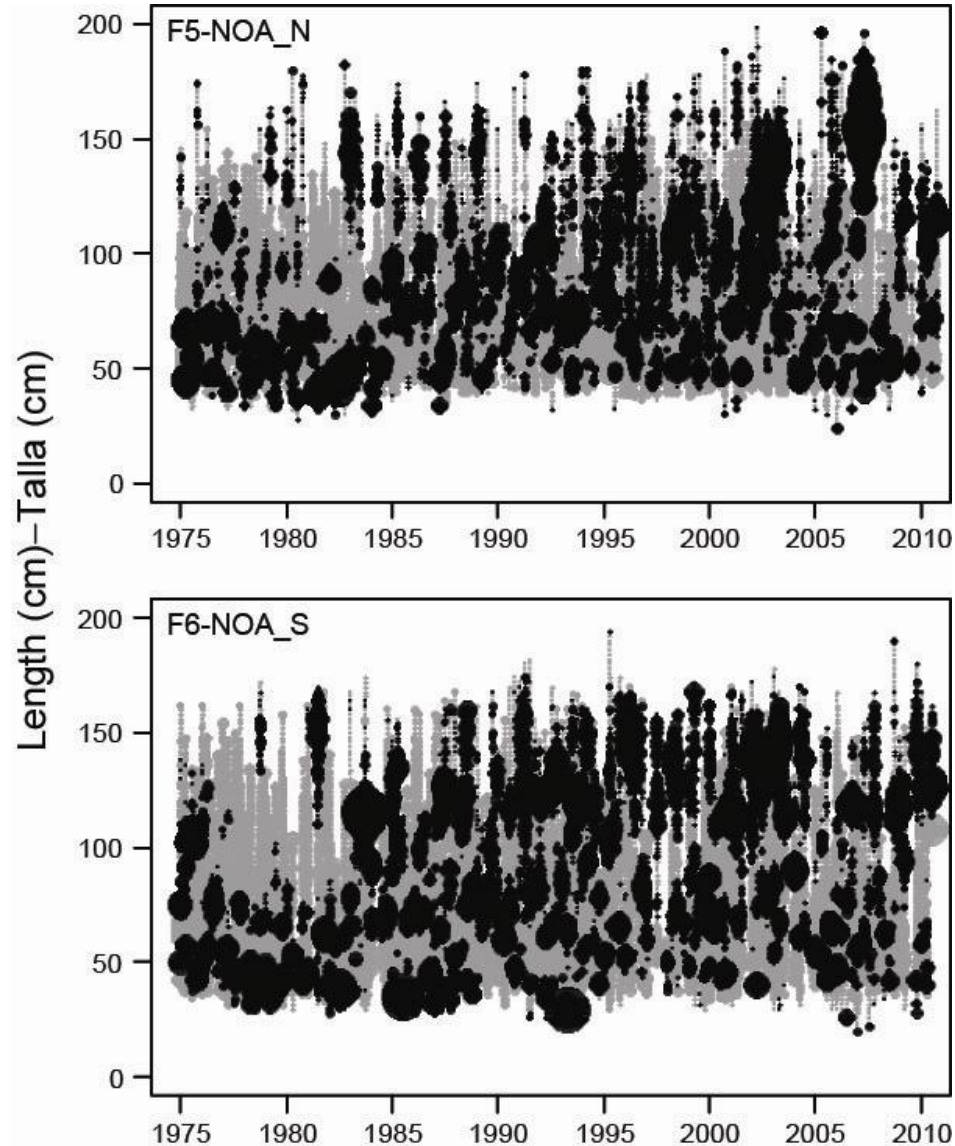
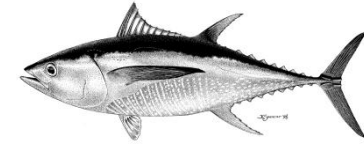
Recent fits to size comps. - LL



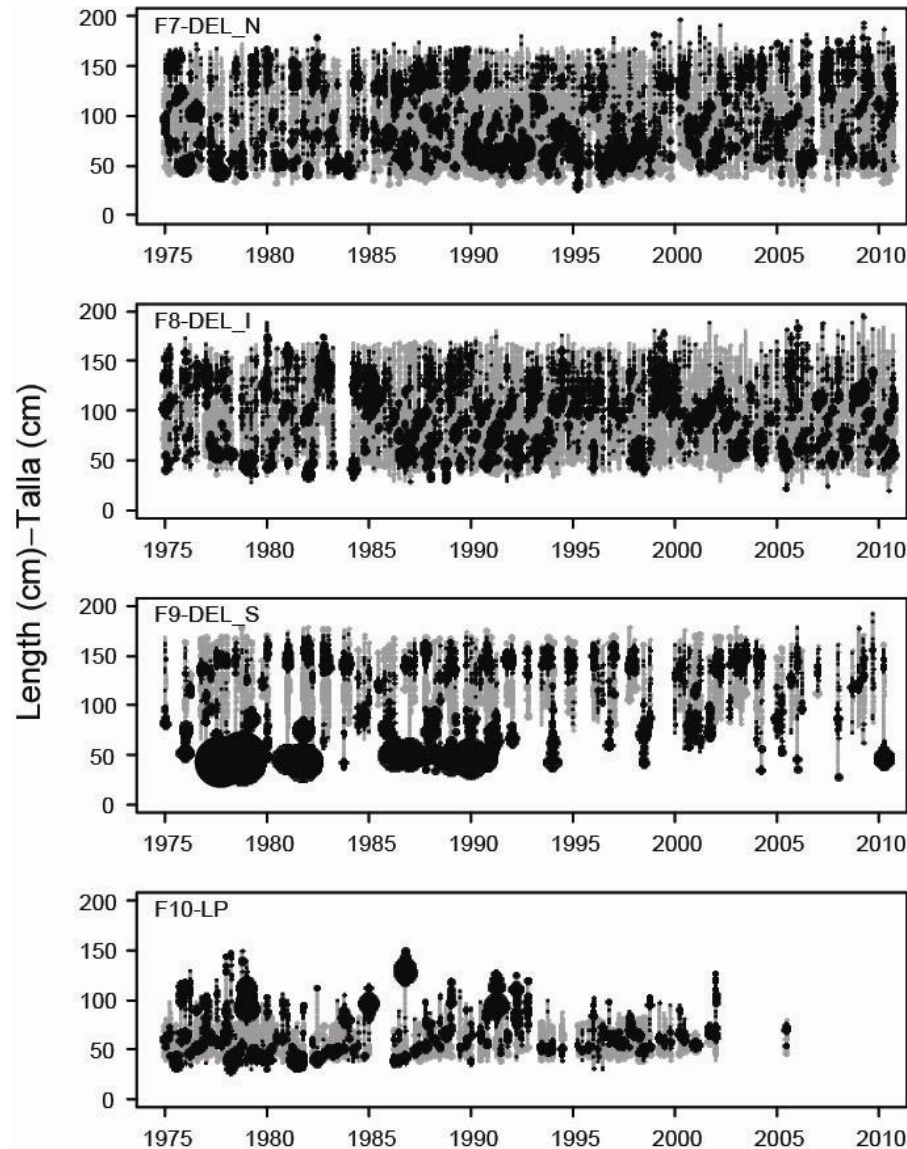
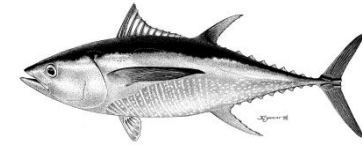
OBJ size comp. residual pattern



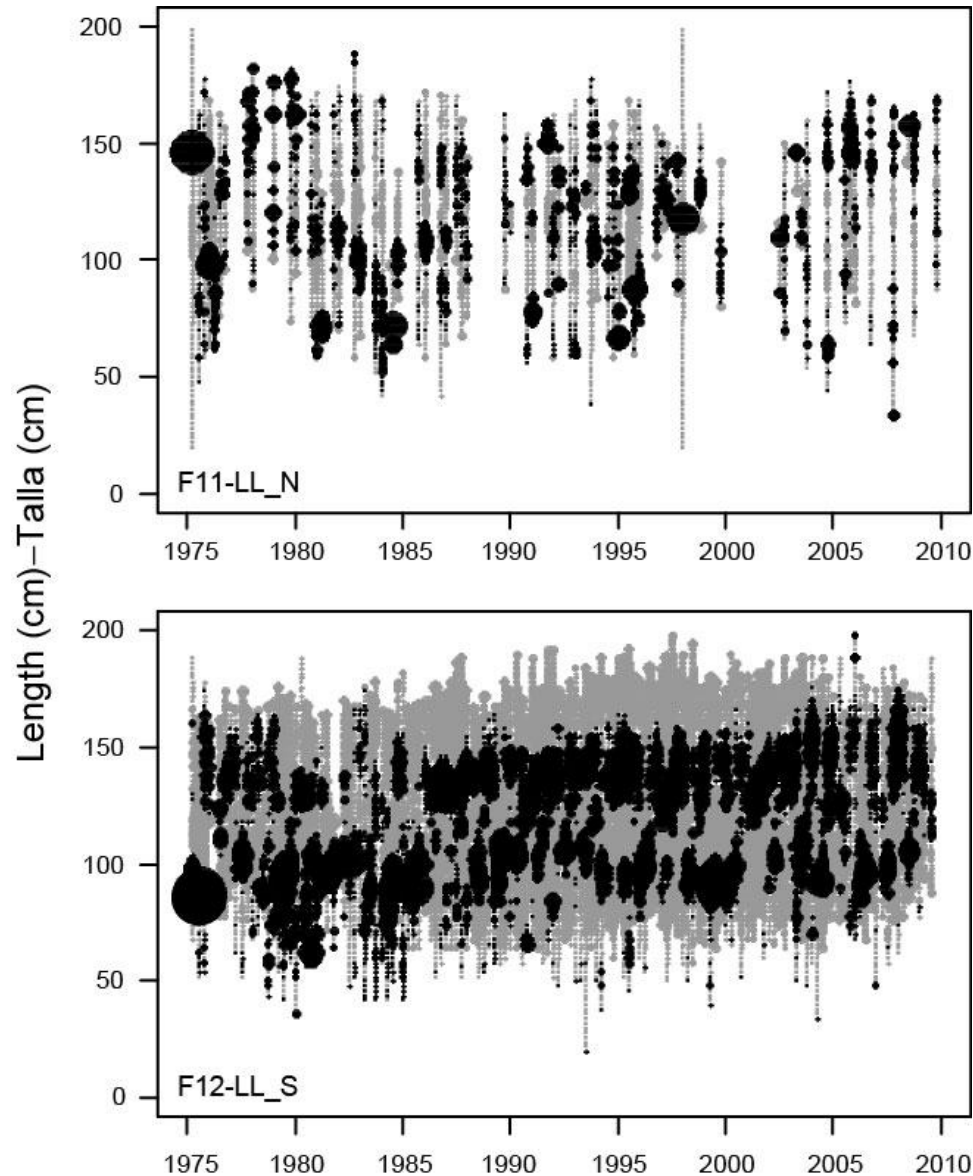
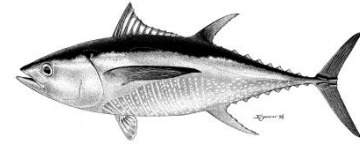
NOA size comp. residual pattern

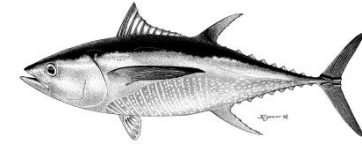


DEL size comp. residual pattern



LL size comp. residual pattern

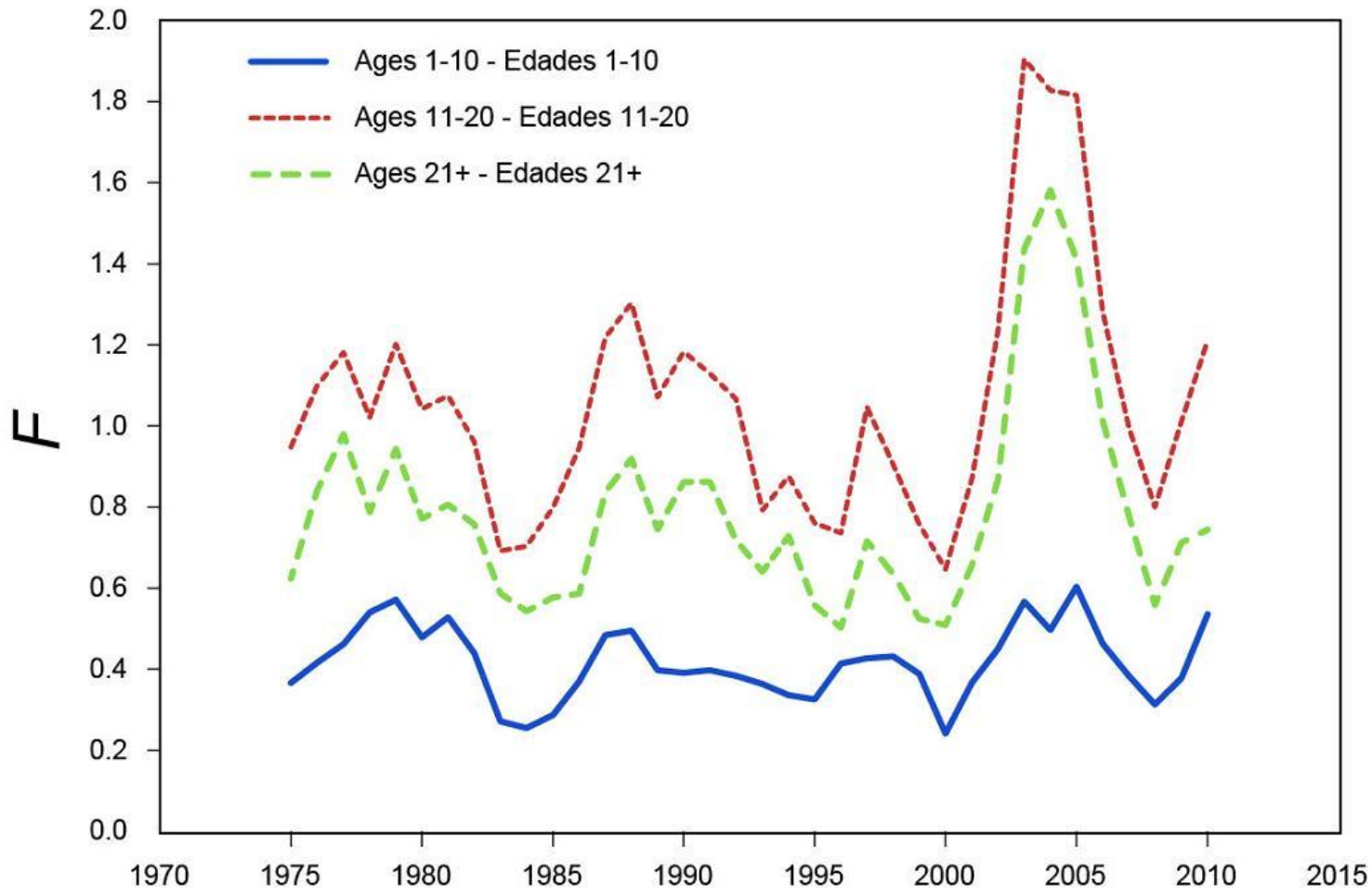
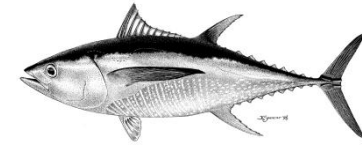




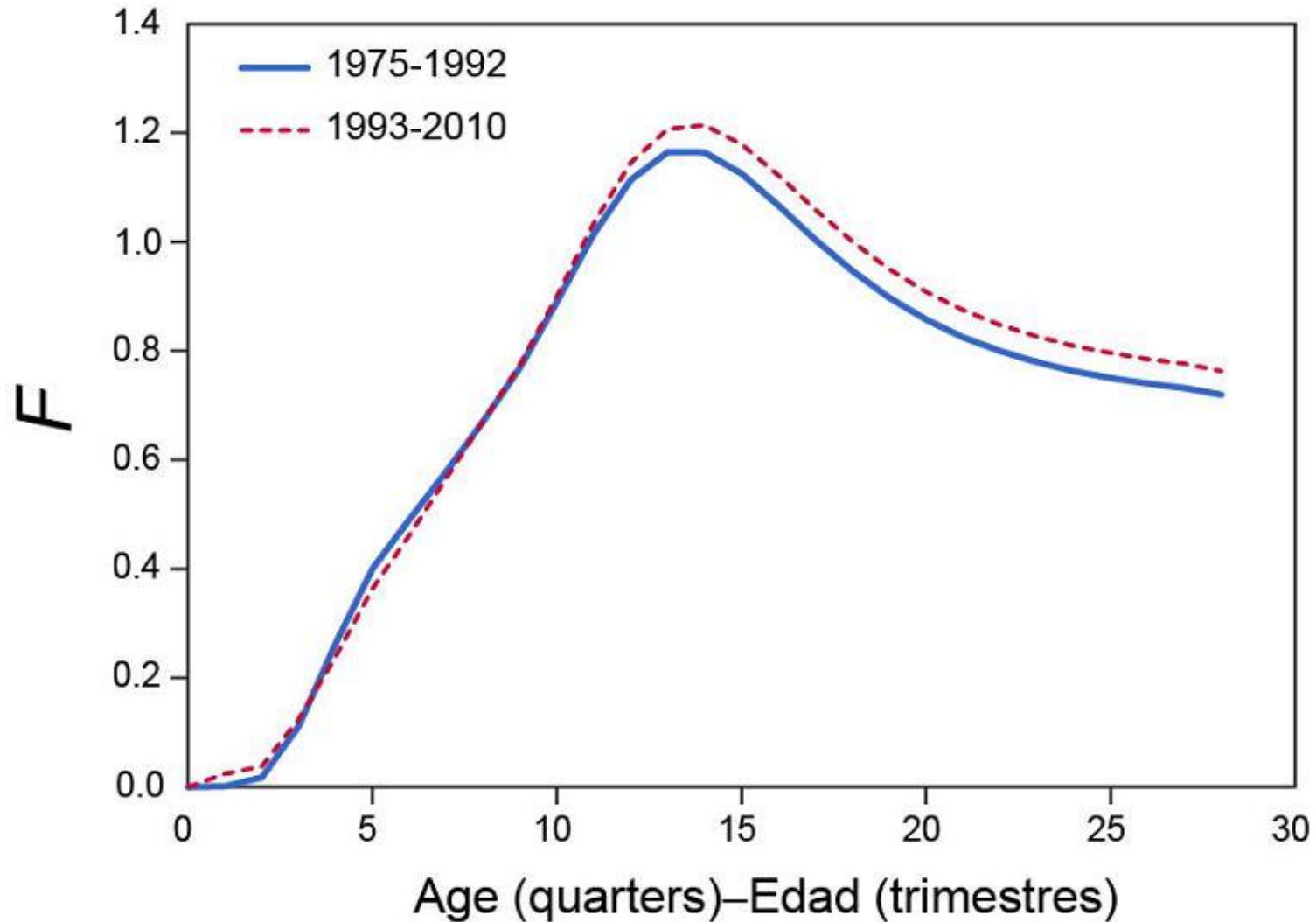
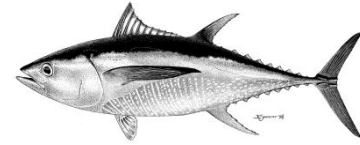
Fit to the size compositions

Fishery	Mean input sample size	Mean effective sample size	Used
F1-OBJ_S	14	33	Yes
F2-OBJ_C	14	28	Yes
F3-OBJ_I	13	23	Yes
F4-OBJ_N	11	57	Yes
F5-NOA_N	23	56	Yes
F6-NOA_S	21	34	Yes
F7-DEL_N	32	120	Yes
F8-DEL_I	30	128	Yes
F9-DEL_S	9	53	No
F10-BB	12	36	Yes
F11-LL_N	2	31	Yes
F12-LL_S	30	105	Yes

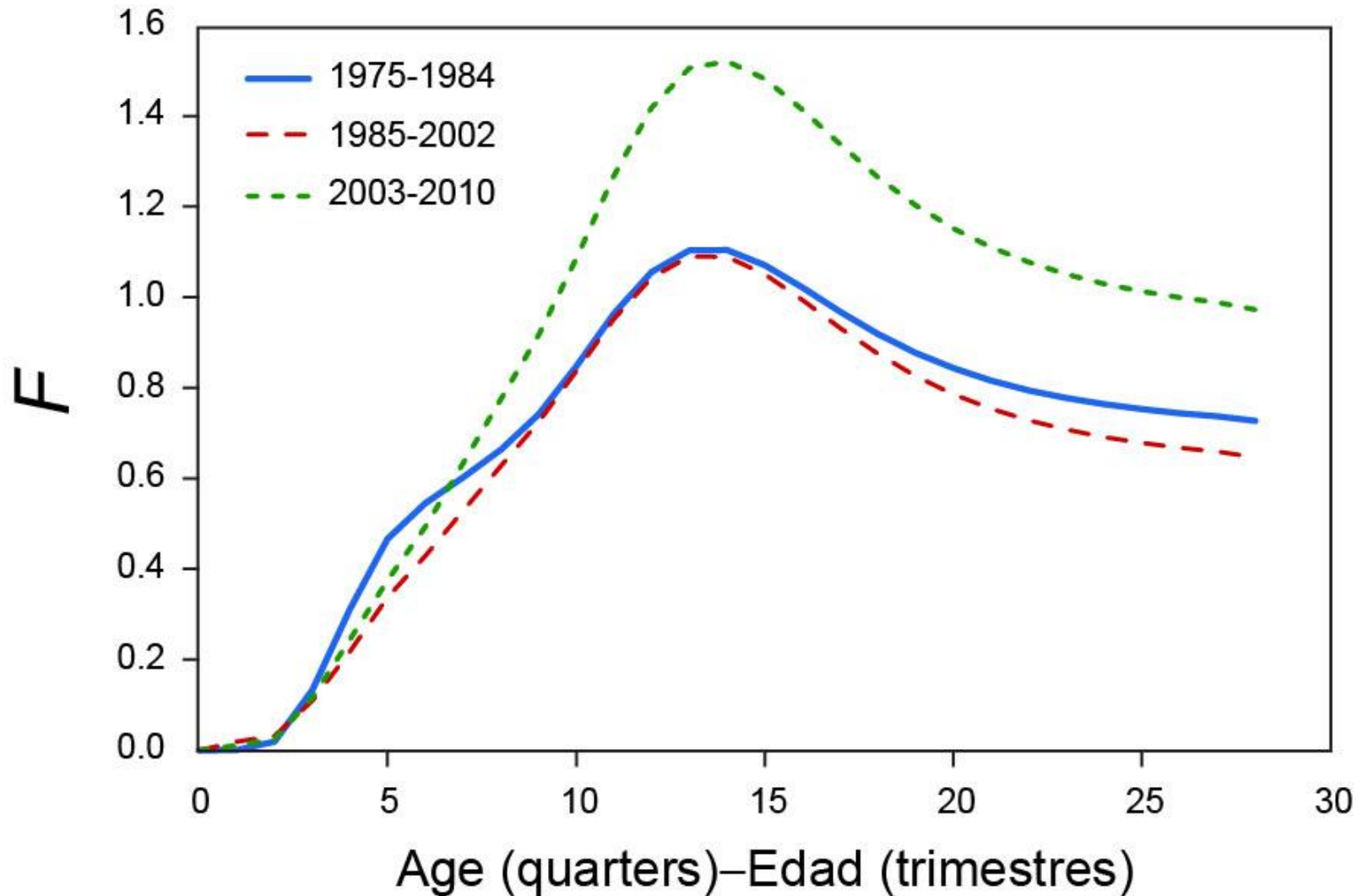
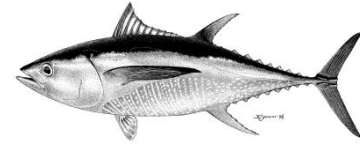
Fishing mortality - annual



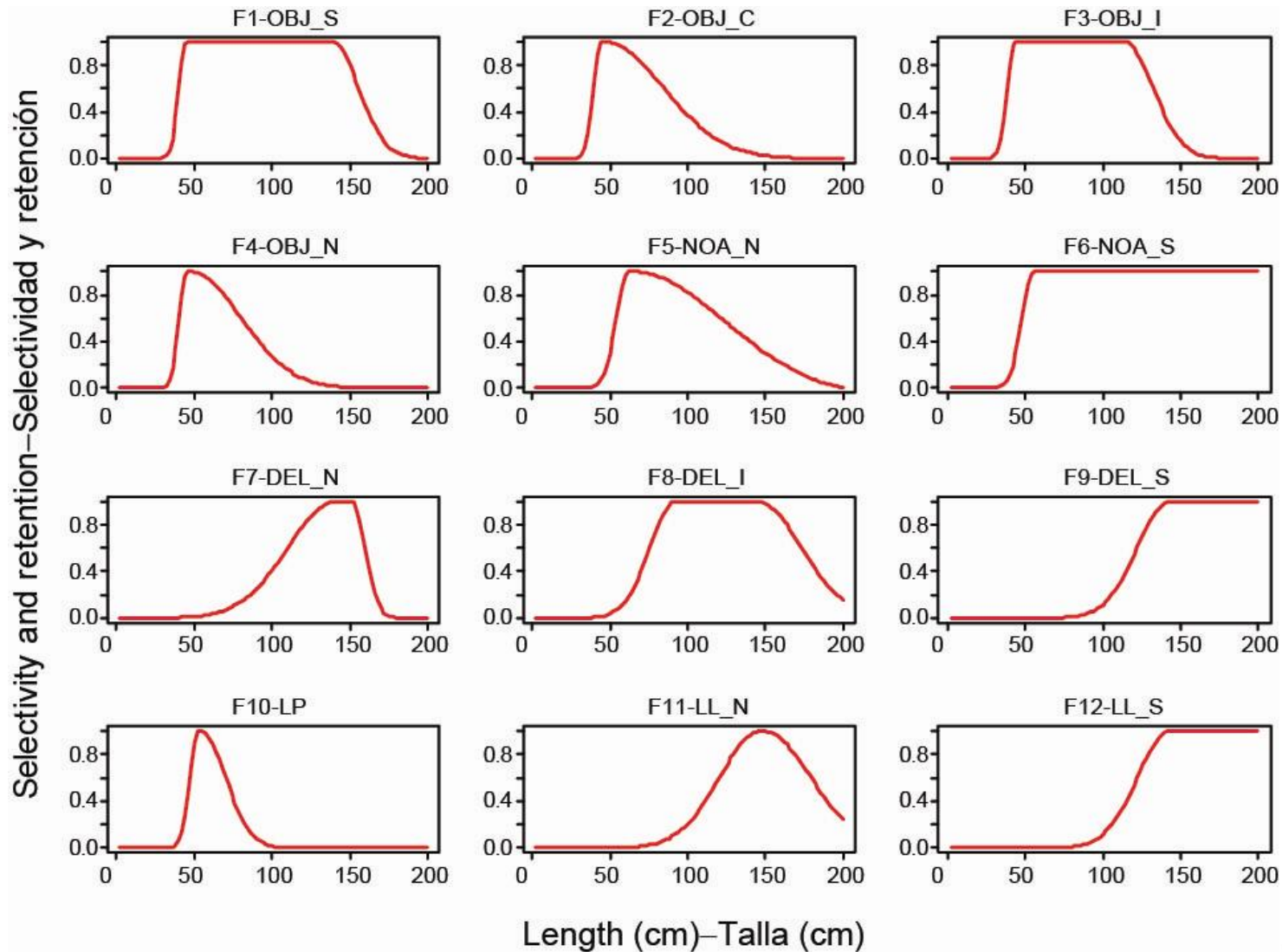
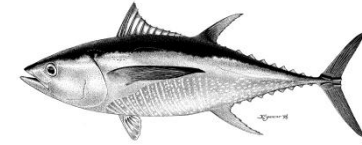
Age-specific fishing mortality



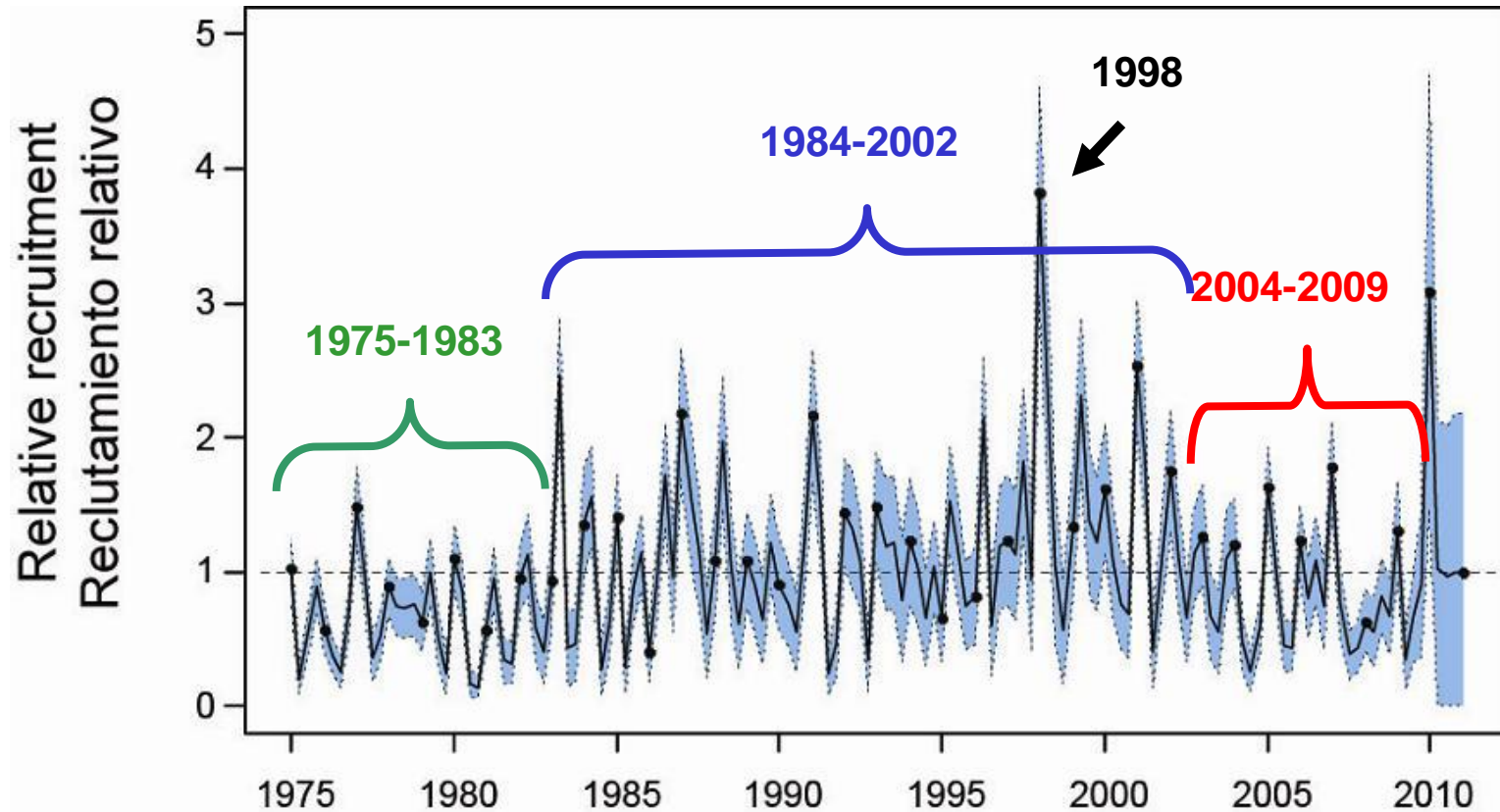
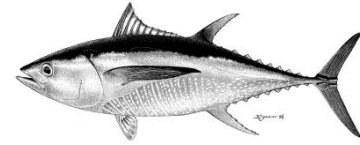
Age-specific fishing mortality



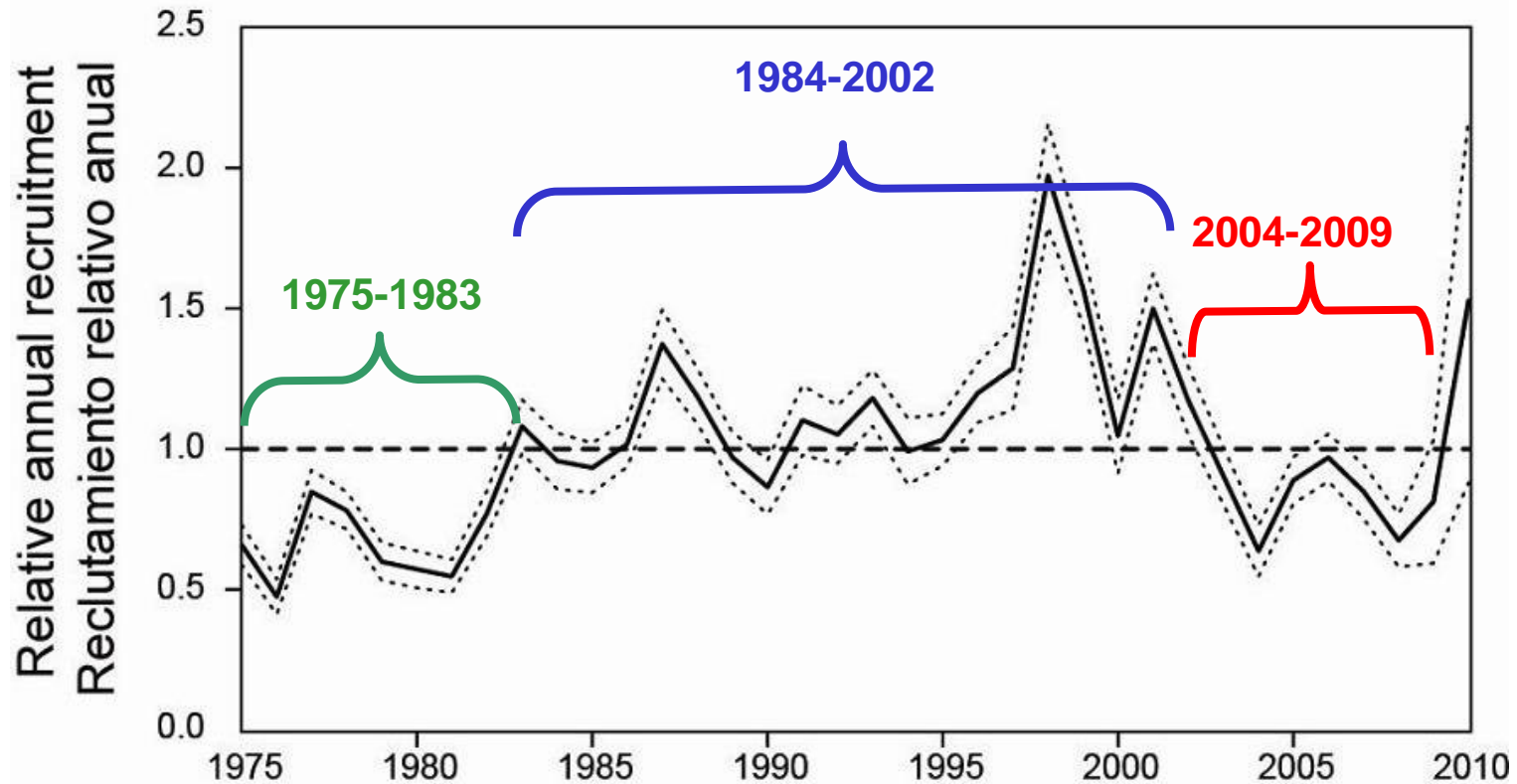
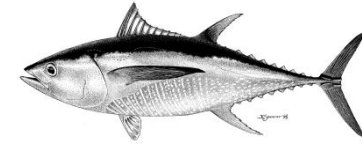
Size selectivity



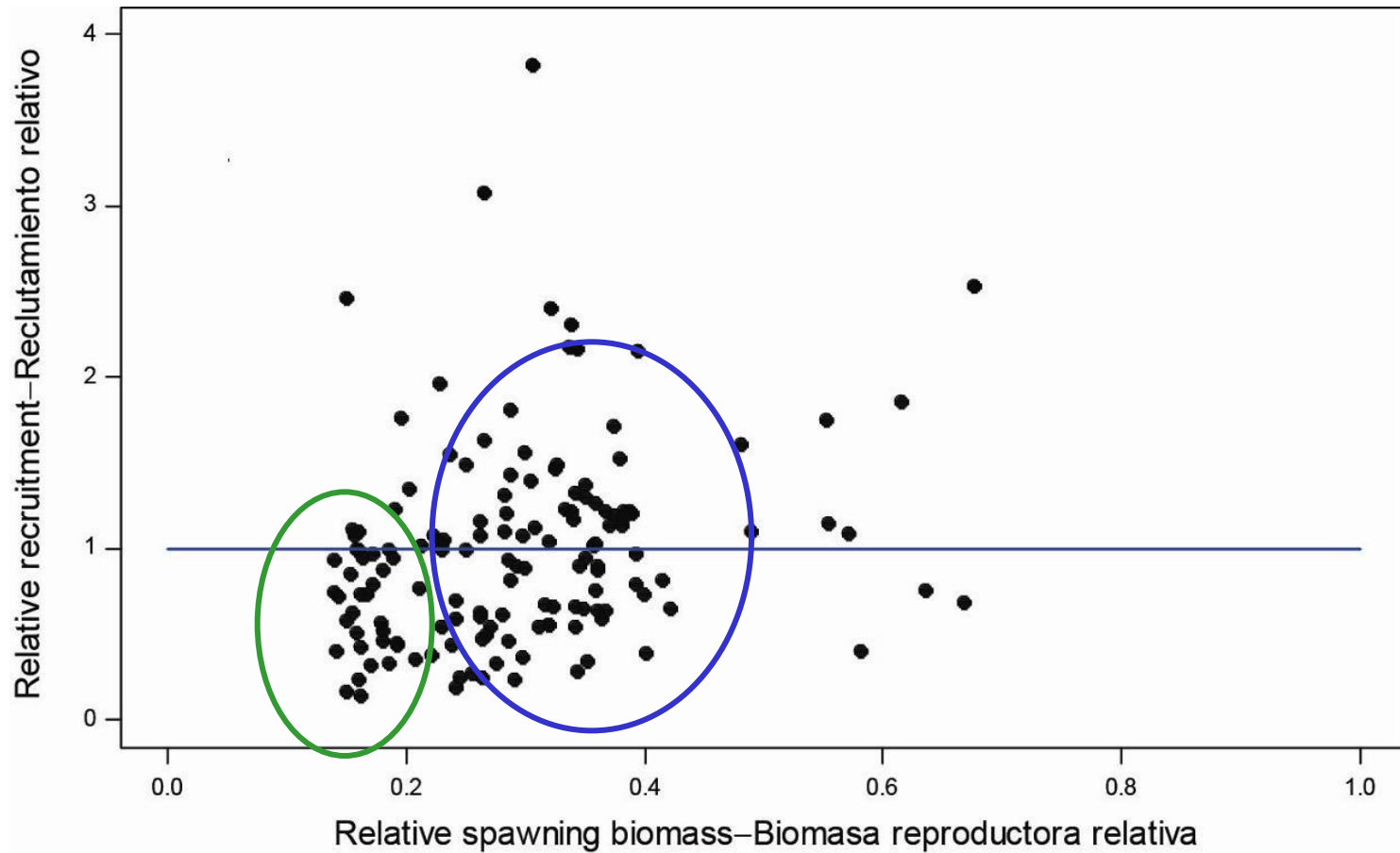
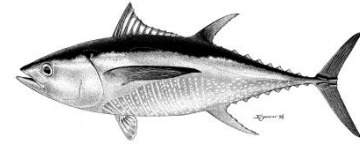
Quarterly recruitment



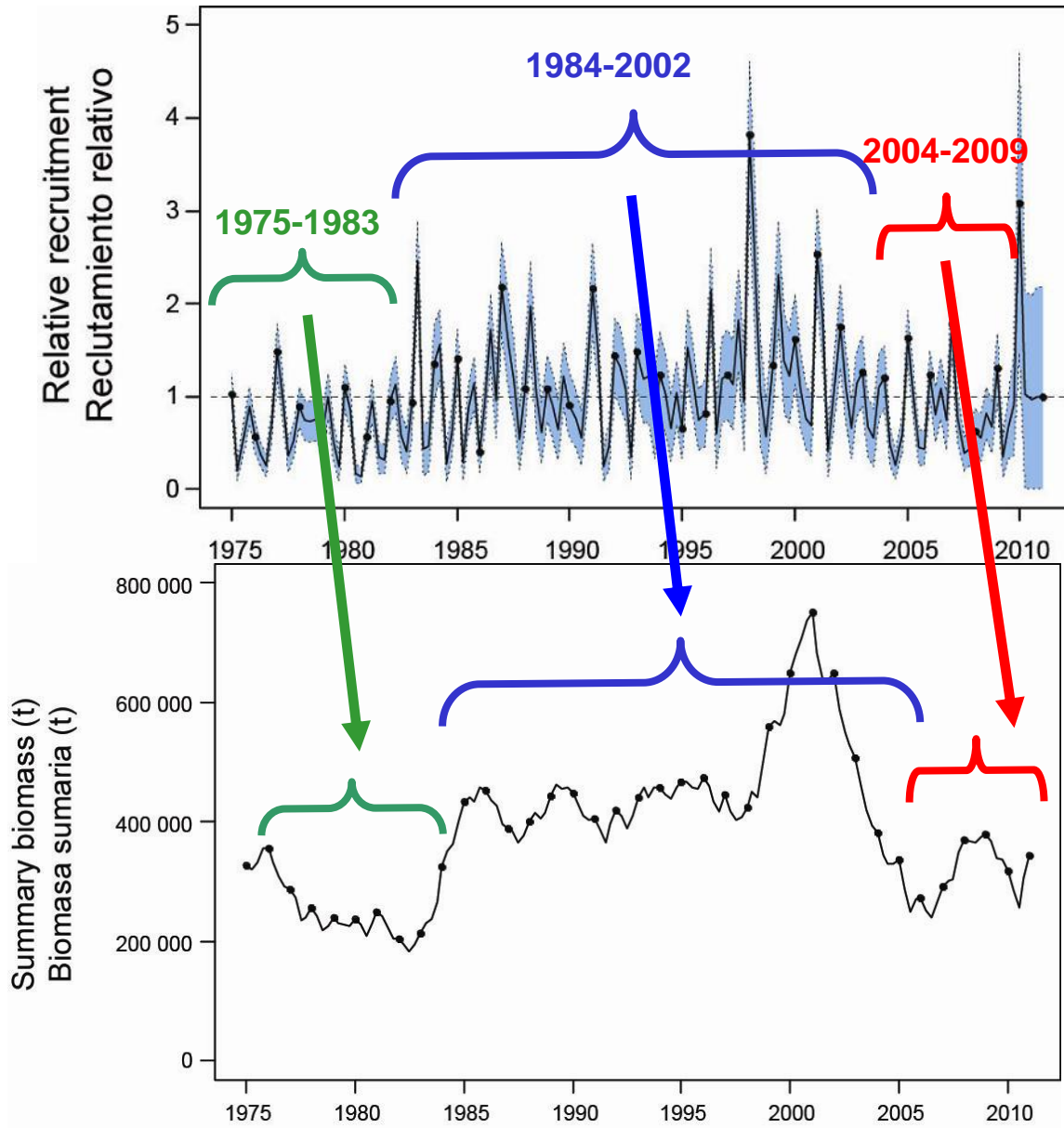
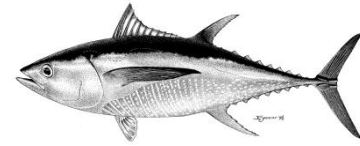
Annual recruitment



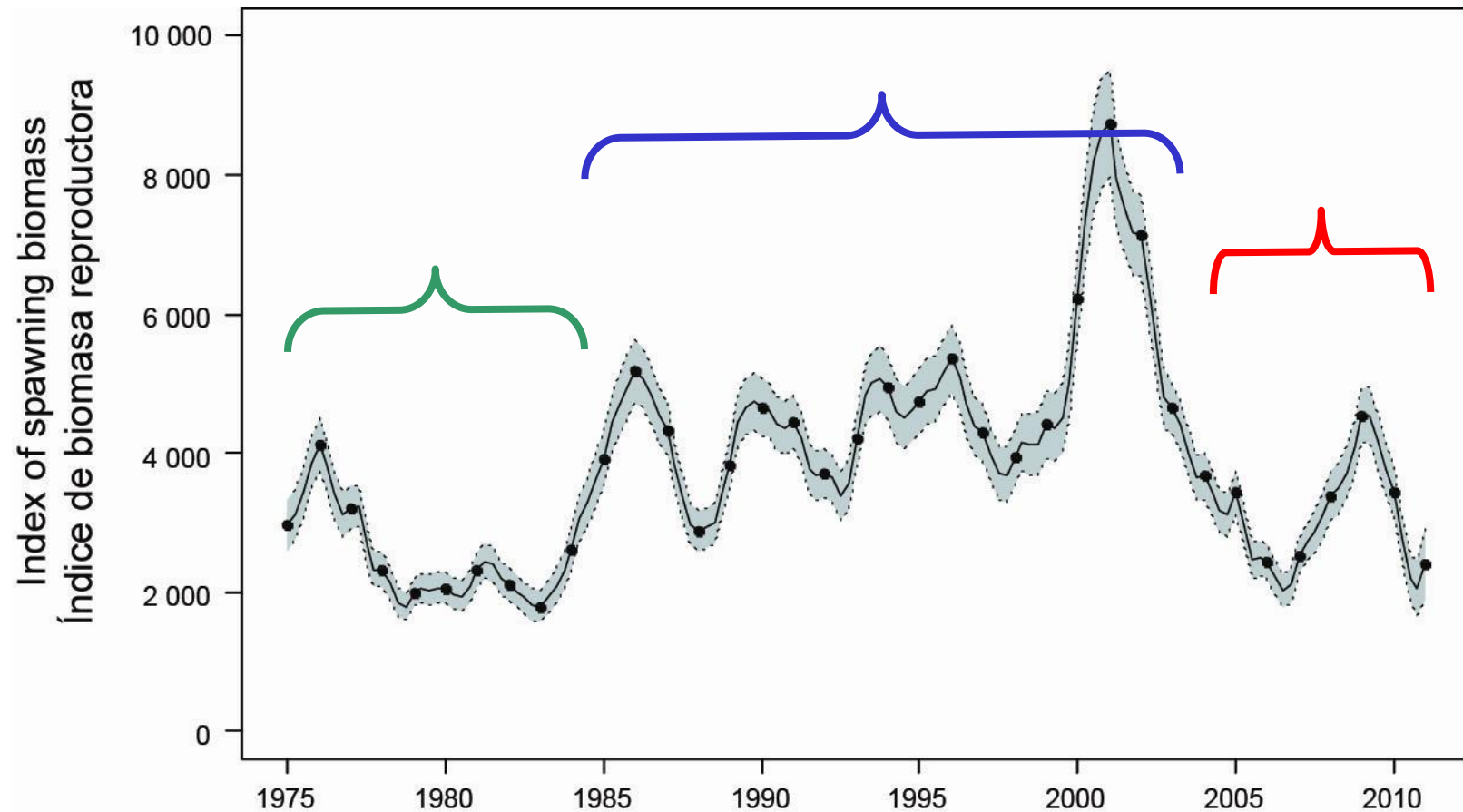
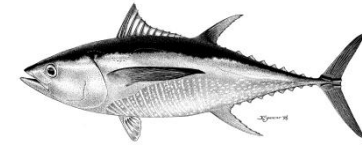
Stock-recruitment



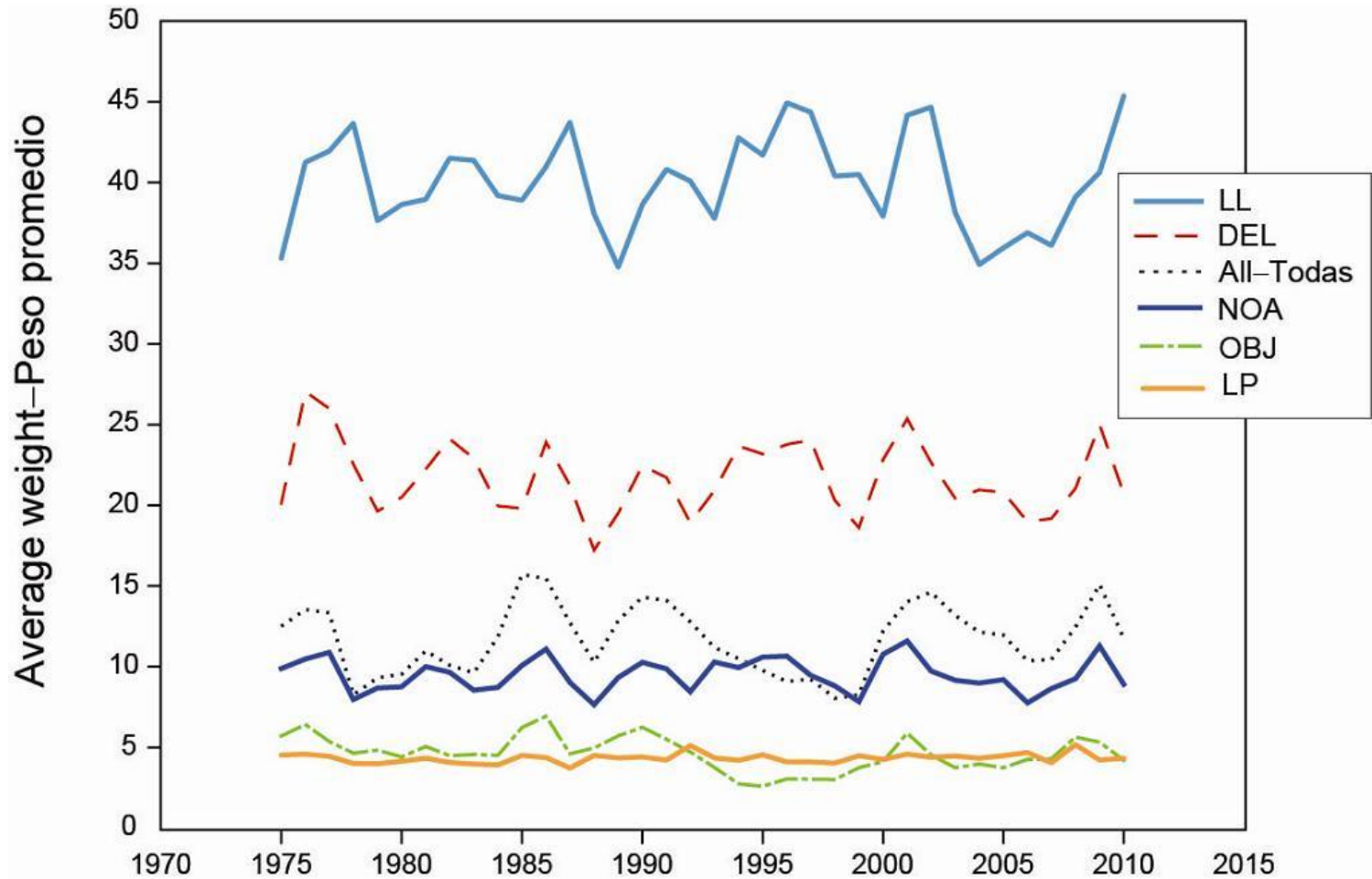
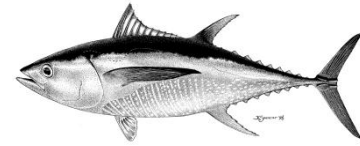
Summary biomass



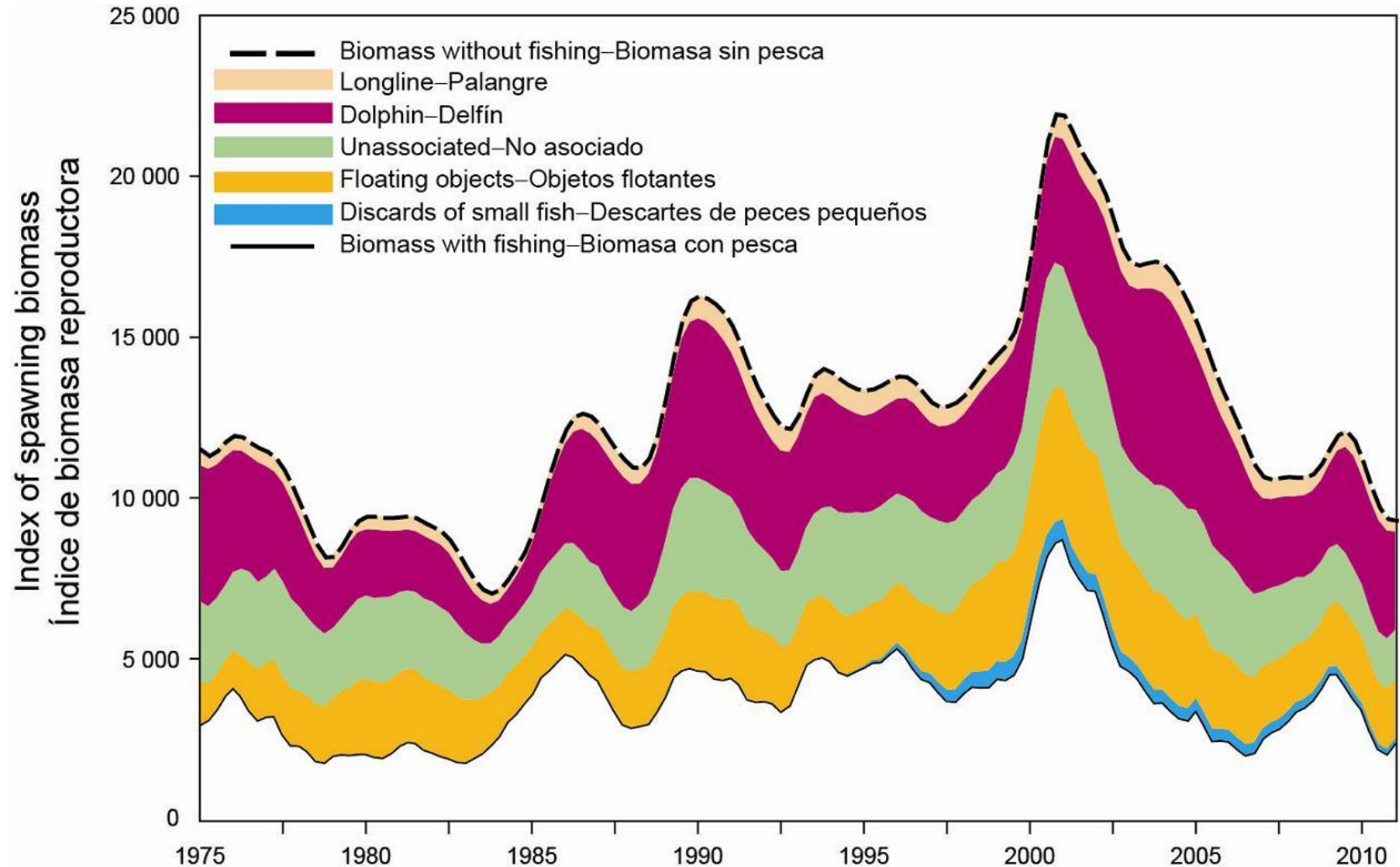
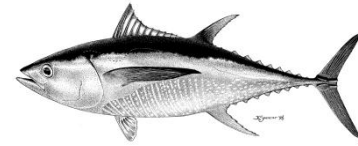
Spawning biomass

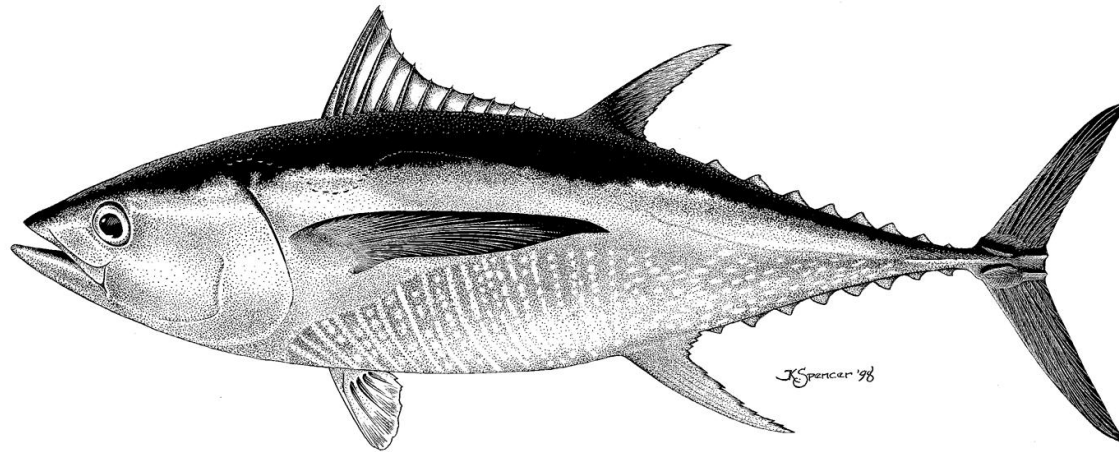


YFT average weight



Fishery impact

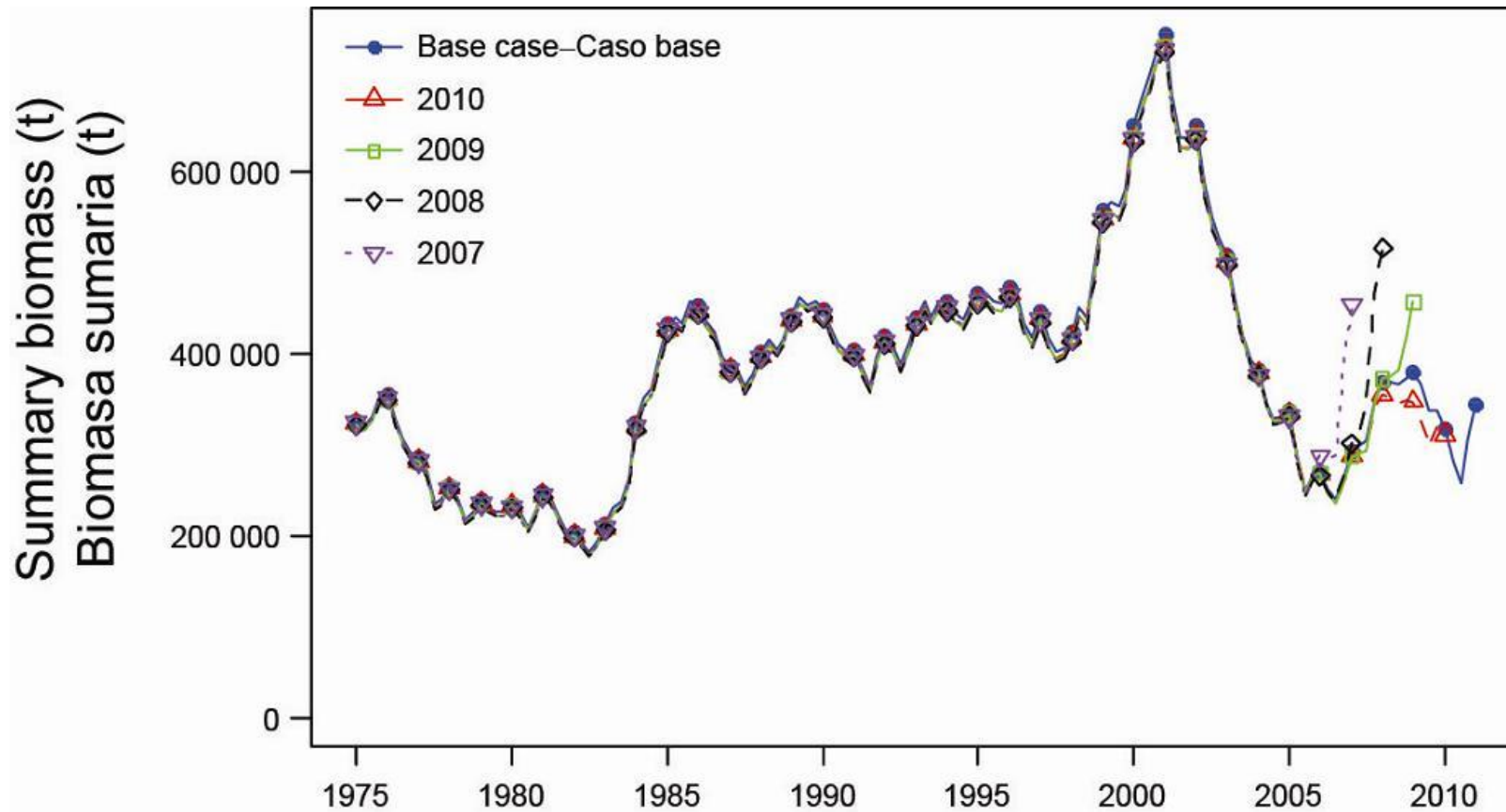
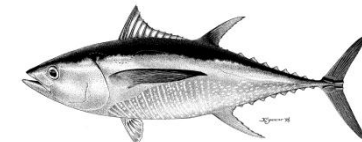




Retrospective analysis

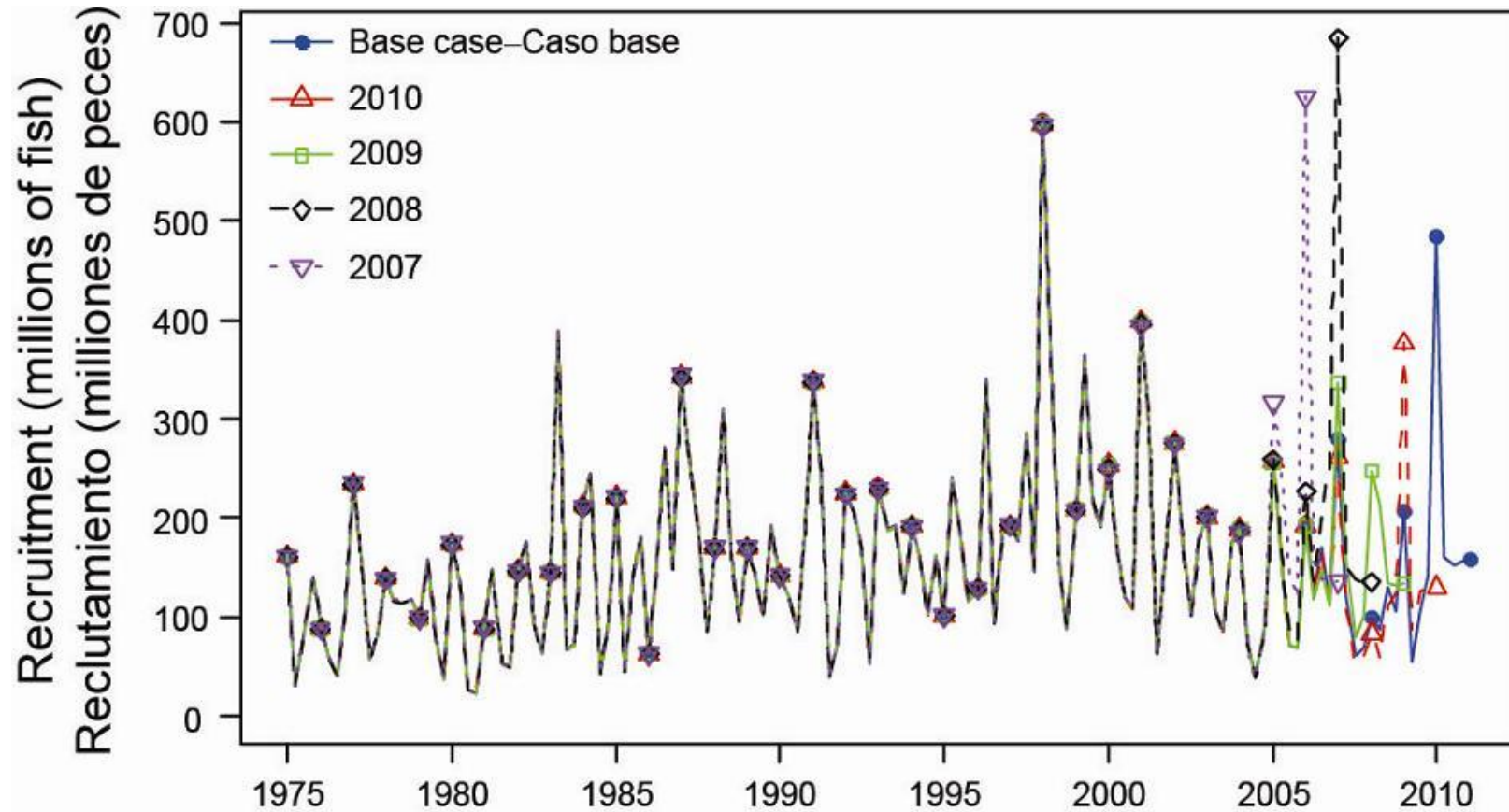
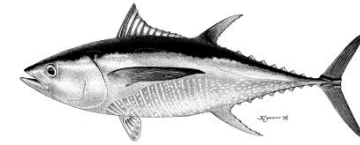
Summary biomass

Retrospective



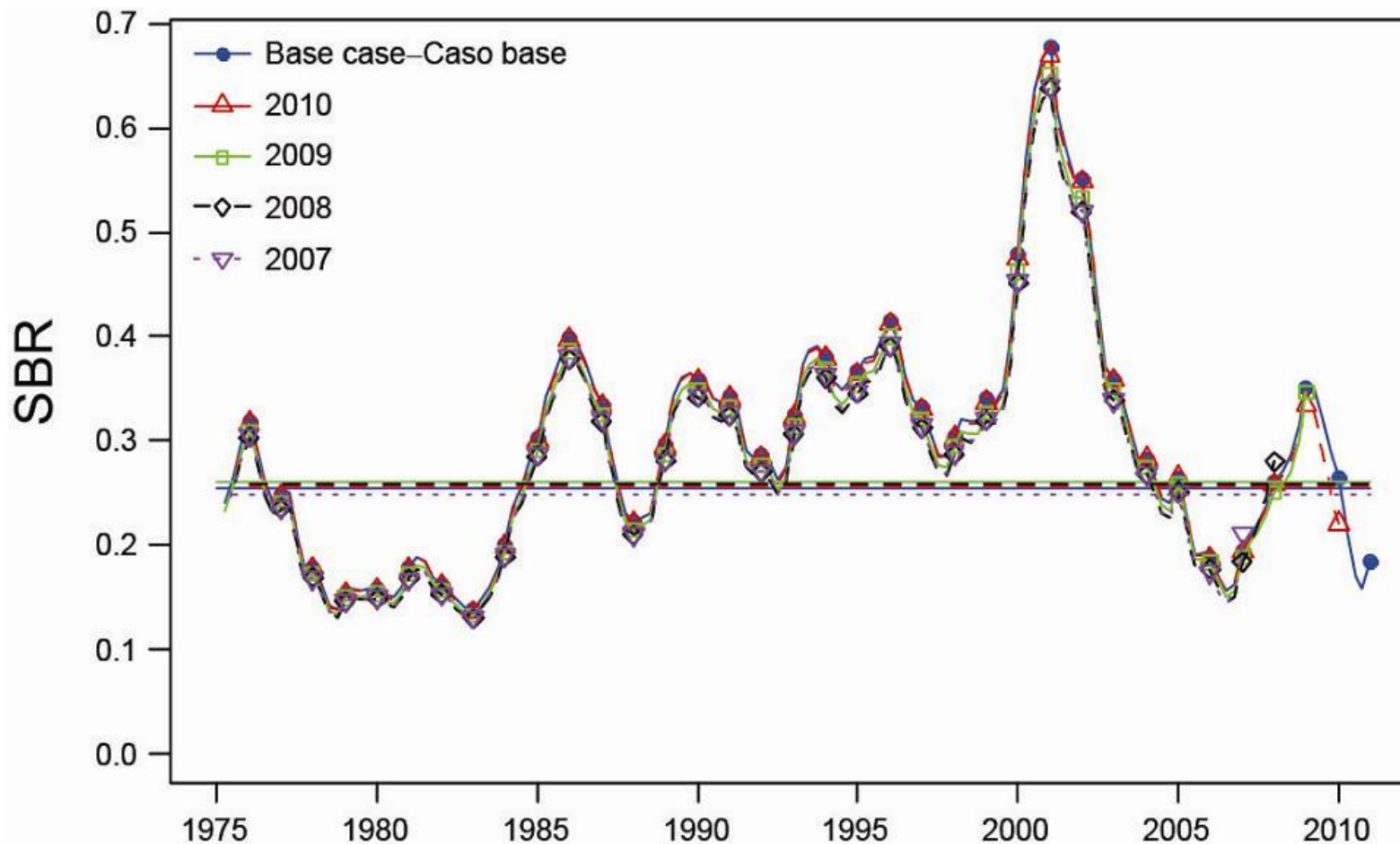
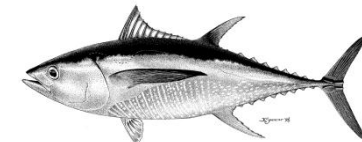
Recruitment

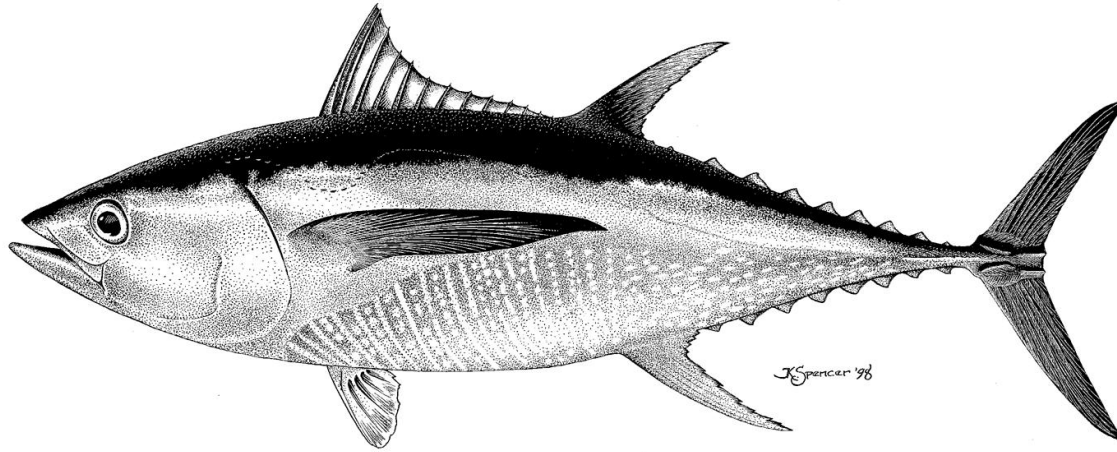
Retrospective



Spawning biomass ratio

Retrospective

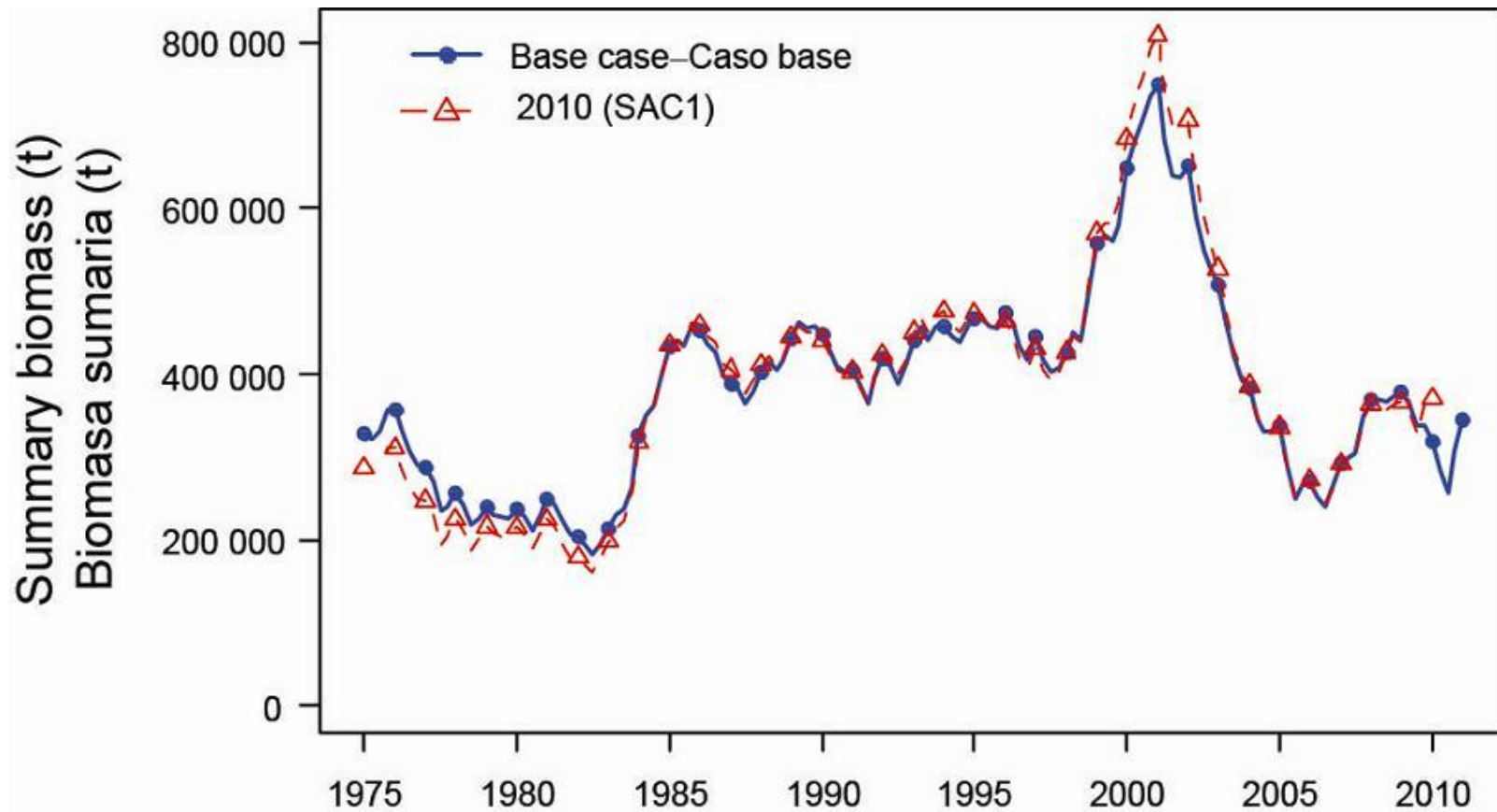
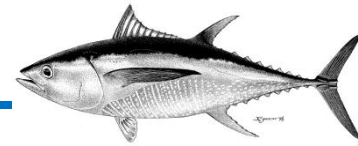




Comparison to previous assessment (SAC1 -2010)

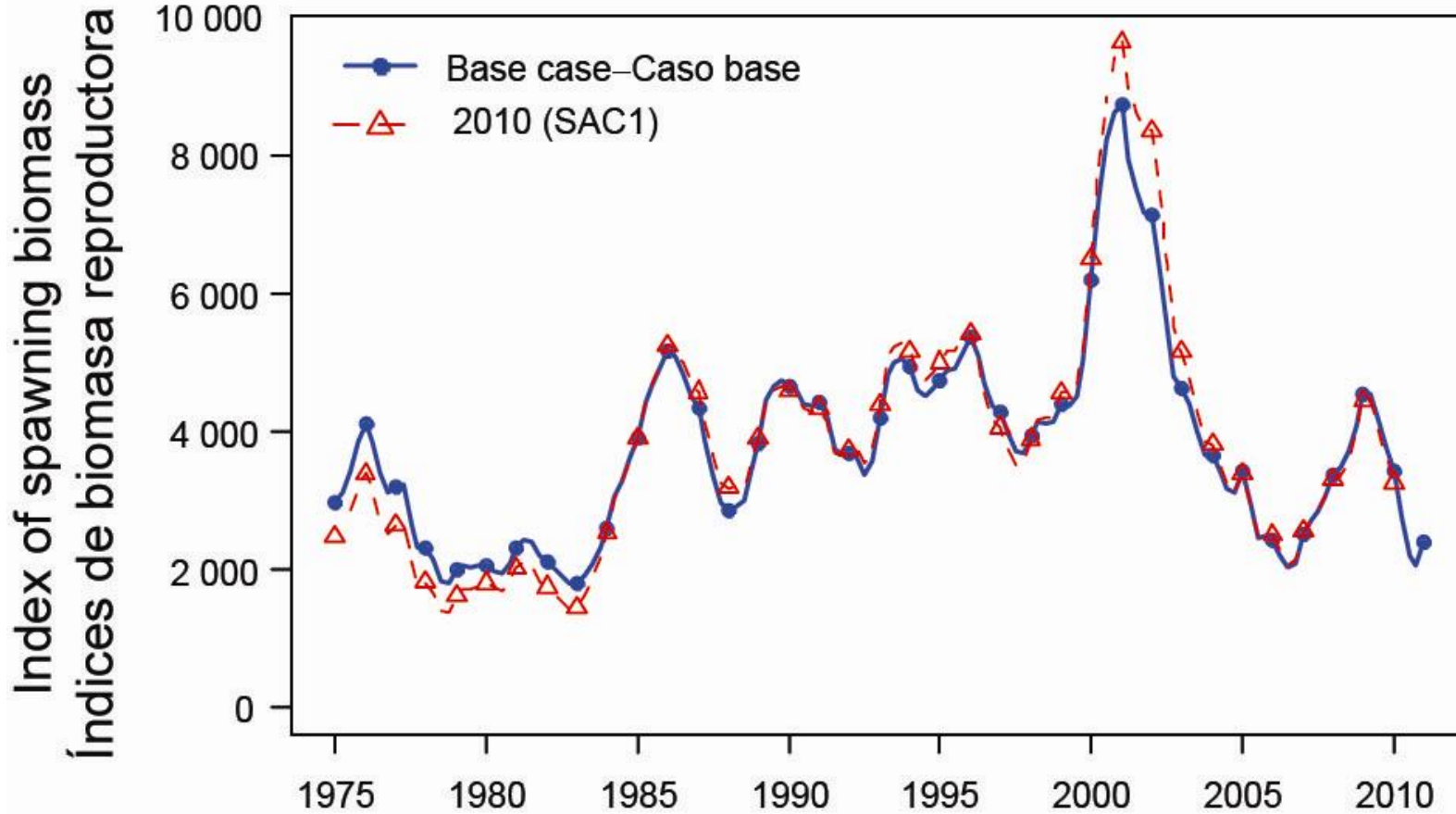
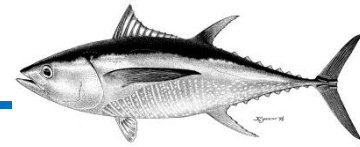
Summary biomass

Comparison
to SAC1



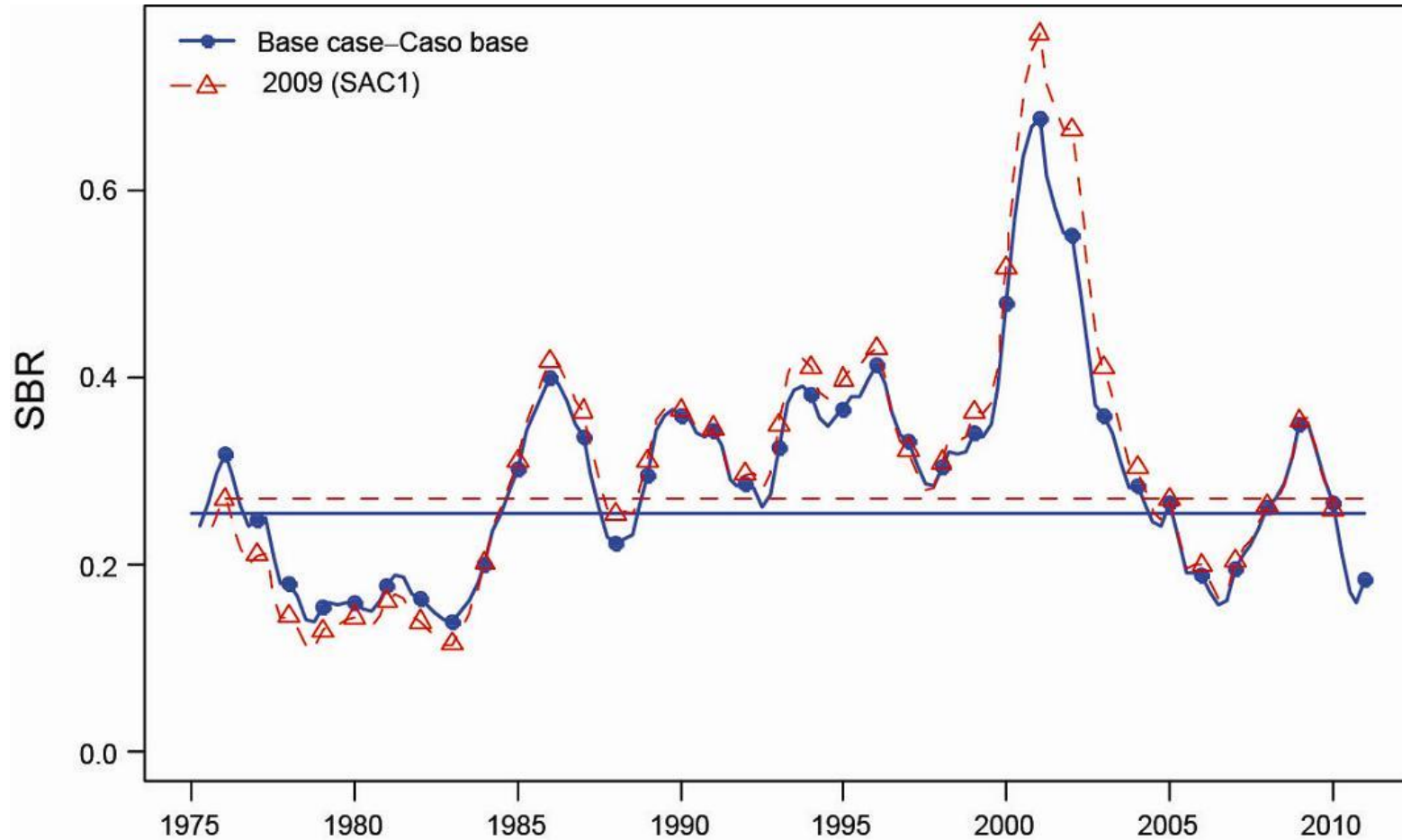
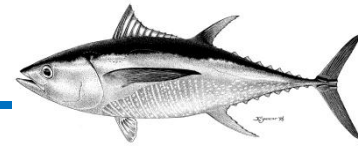
Spawning biomass

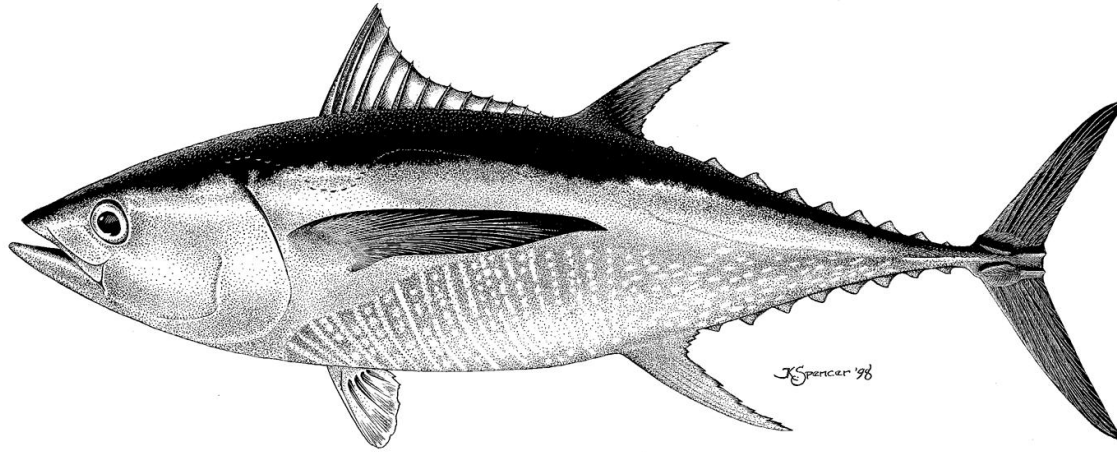
Comparison
to SAC1



Spawning biomass ratio

Comparison
to SAC1



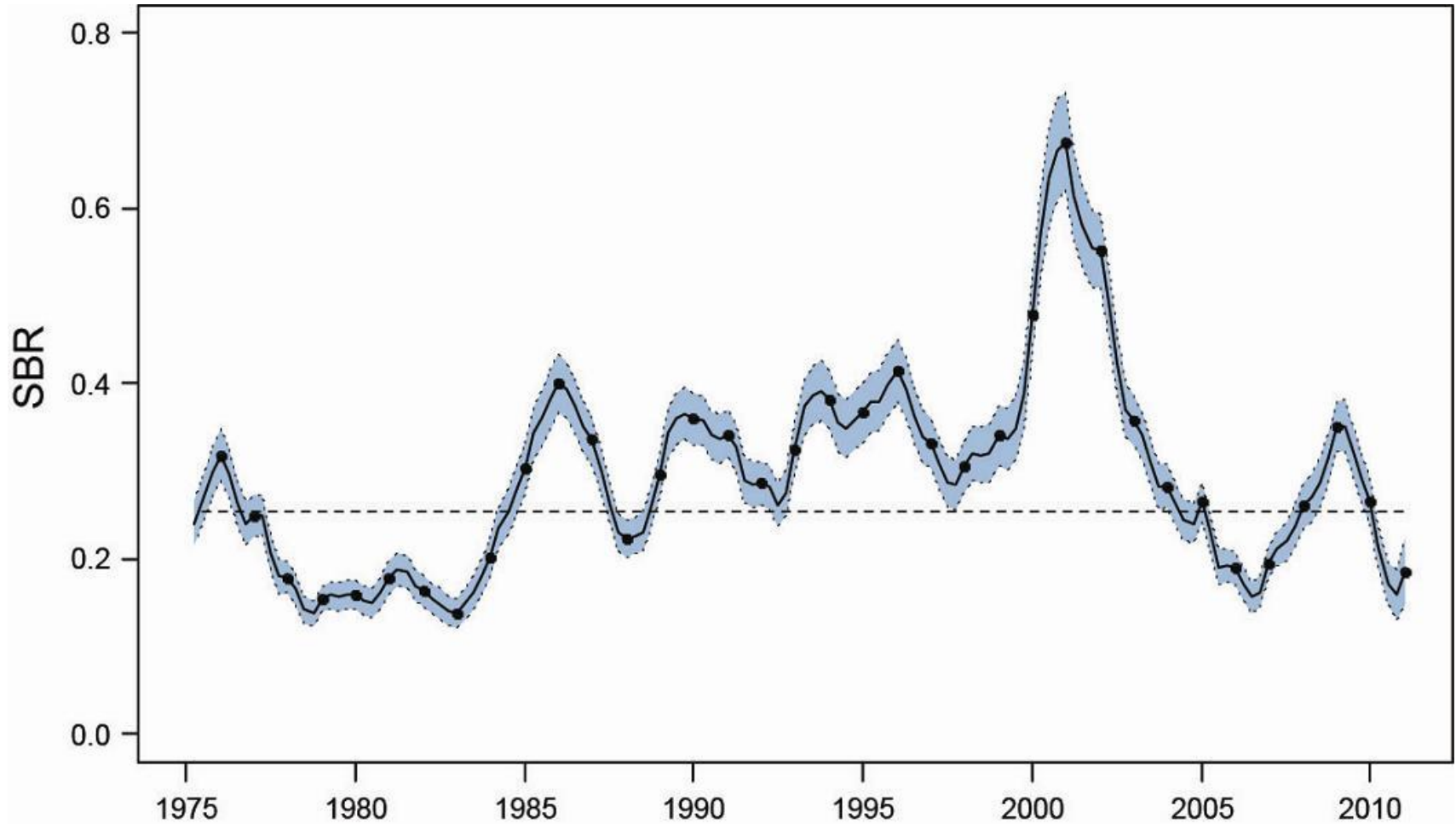
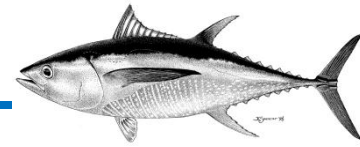


Stock status (base case)

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

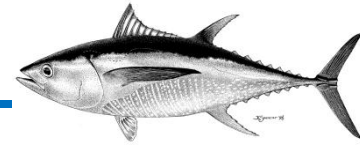
Spawning biomass ratio

Stock status
(base case)



Management quantities

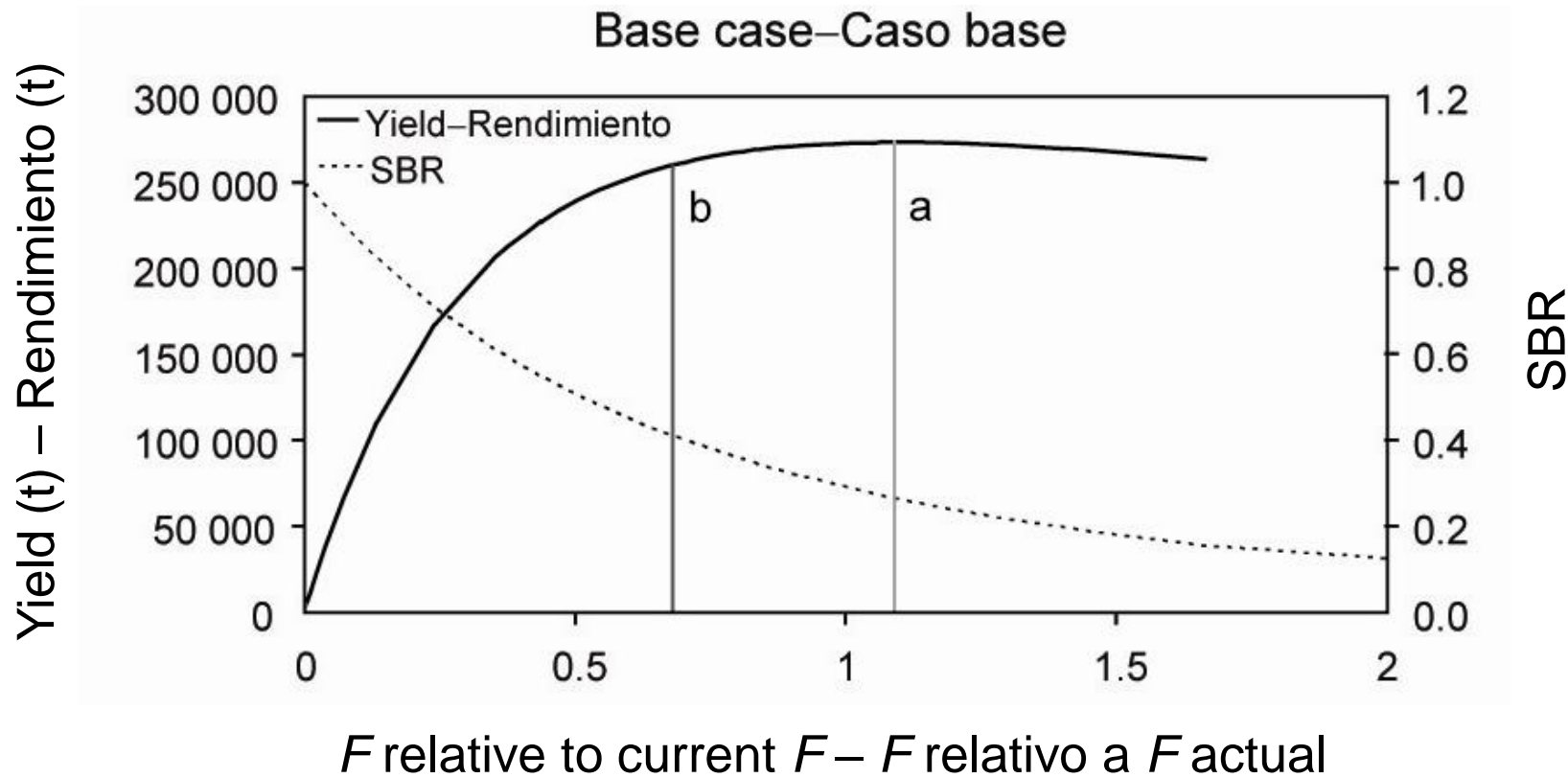
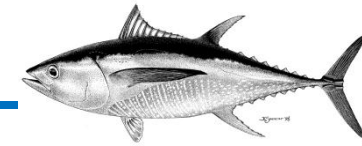
Stock status
(base case)



	F's 2008-2010 Base case	F's 2008-2009
MSY	262,857	263,310
Bmsy	354,958	360,024
Smsy	3,305	3,407
Bmsy/B0	0.31	0.32
Smsy/S0	0.26	0.27
Crecent/MSY	0.88	0.88
Brecent/Bmsy	0.96	0.95
Srecent/Smsy	0.71	0.69
Fmultiplier	1.13	1.29

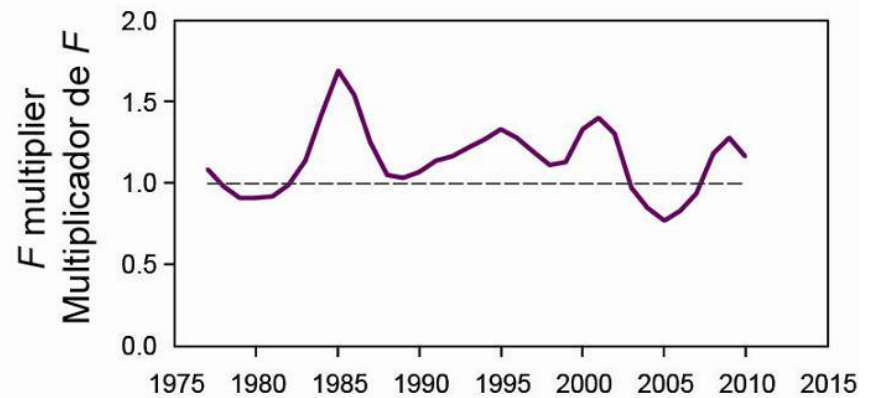
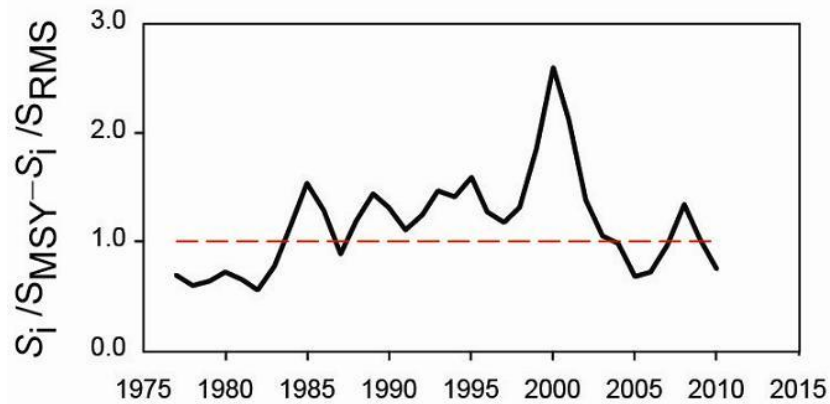
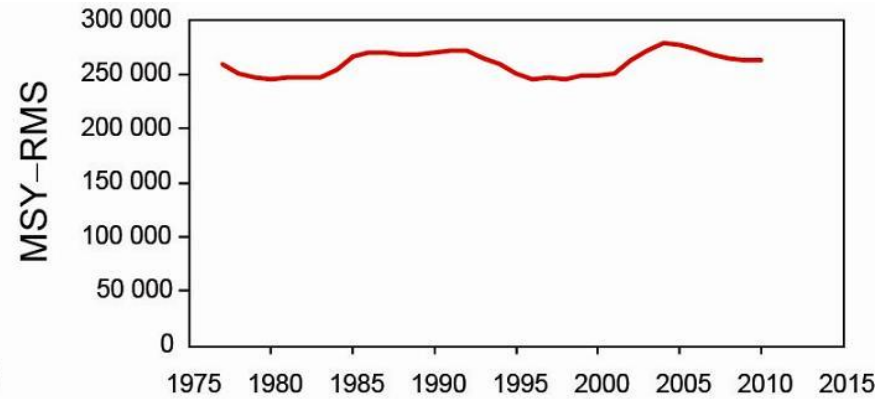
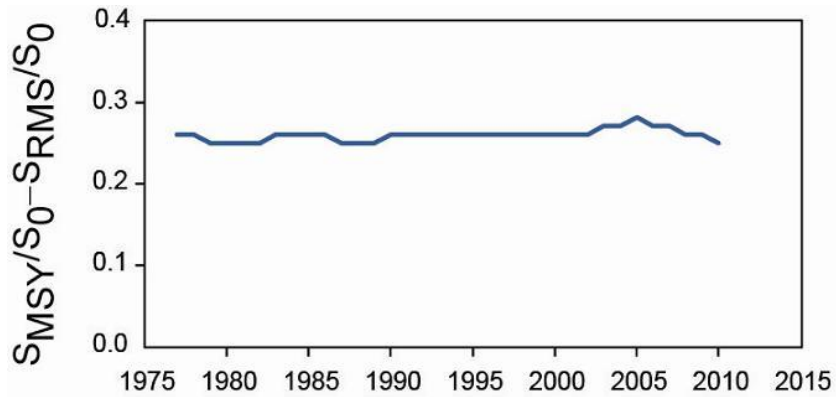
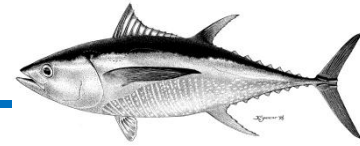
Yield

Stock status
(base case)



Time varying indicators

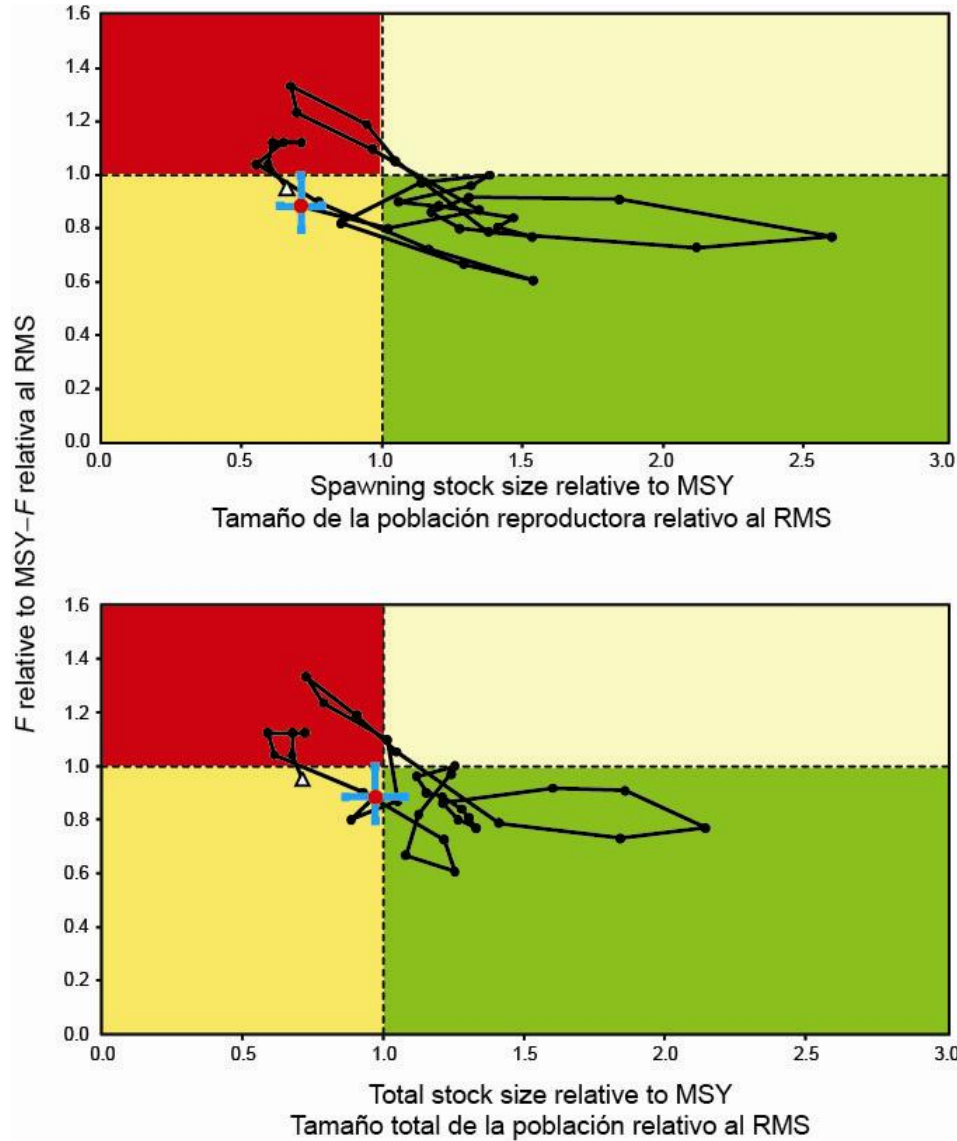
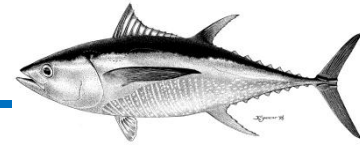
Stock status
(base case)



Year - Año

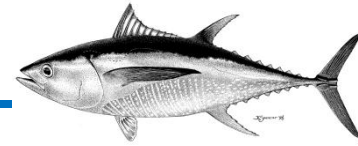
Kobe plot

Stock status
(base case)

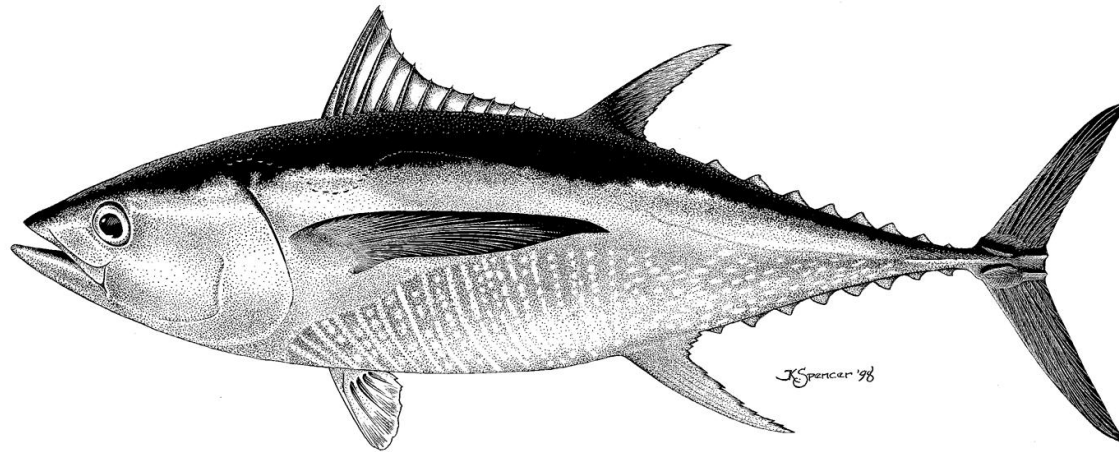


MSY-quantities by fishery

Stock status
(base case)



	All - todas	OBJ	NOA	DEL	LL
MSY	262,857	166,349	221,759	307,523	407,748
Bmsy	354,958	208,259	295,992	363,447	380,574
Smsy	3,305	1,607	2,485	3,139	3,137
Bmsy/B0	0.31	0.18	0.26	0.32	0.33
Smsy/S0	0.26	0.13	0.19	0.24	0.24
Crecent/MSY	0.88	1.39	1.04	0.75	0.57
Brecent/Bmsy	0.96	1.64	1.15	0.94	0.89
Srecent/Smsy	0.71	1.47	0.95	0.75	0.75
Fmultiplier	1.13	8.11	7.79	2.20	138.30

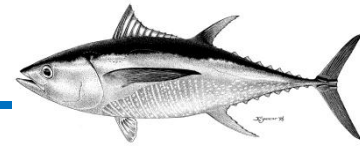


Projection simulations (base case)

- *Status quo* (F_{current}) fishing strategy
- MSY fishing strategy

Forward projections

Projections
(base case)

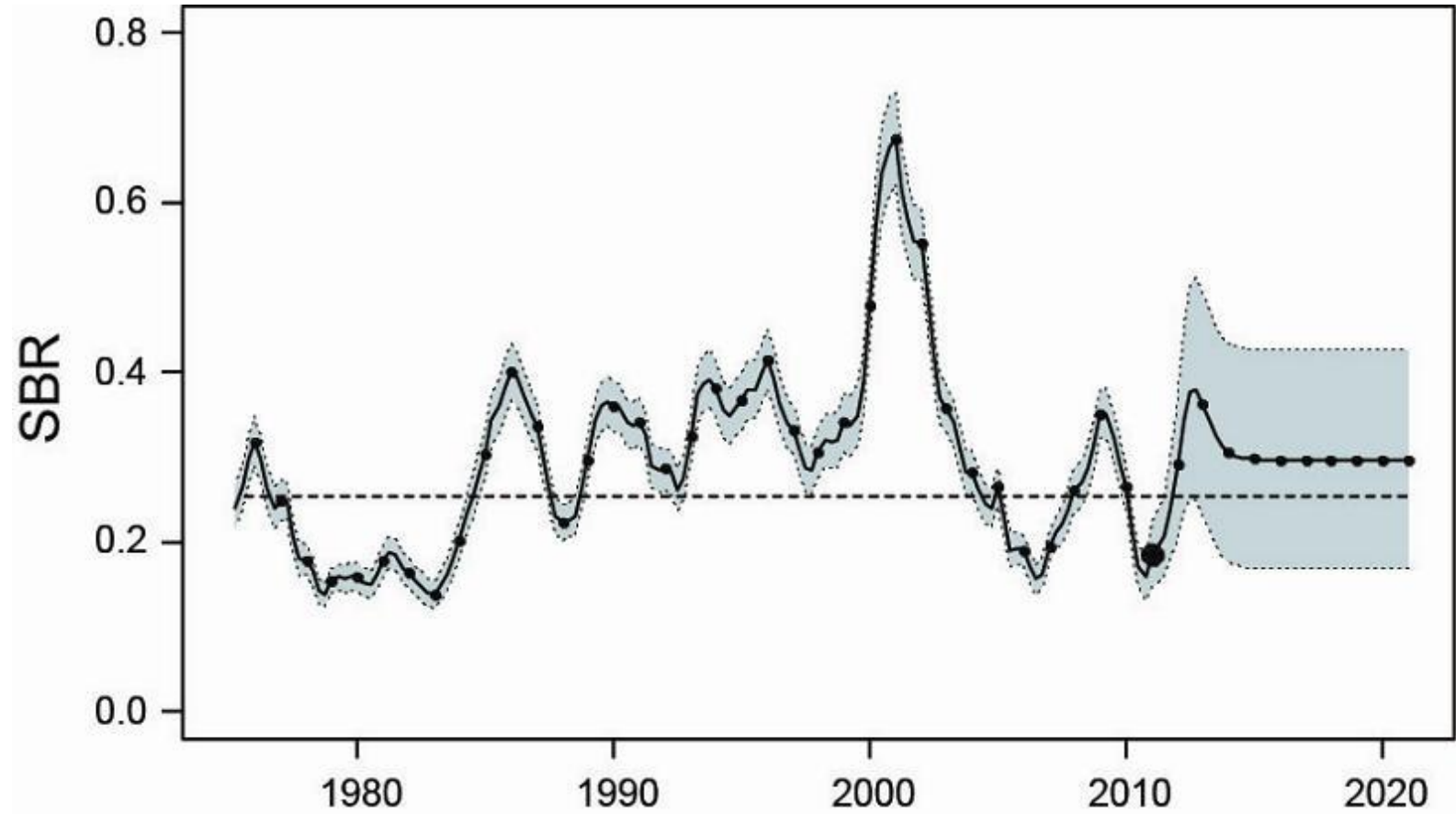
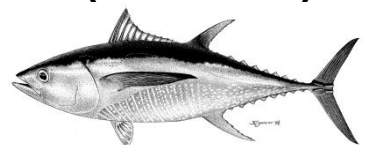


- Projection period: 10 years (2011-2021)
- Evaluate:
 - Catches (surface and longline fisheries)
 - Spawning Biomass Ratio (SBR)
- Three exploitation scenarios:
 - Status quo (F_{cur}): 3-year F average (2008-2010)
 - F_{MSY}



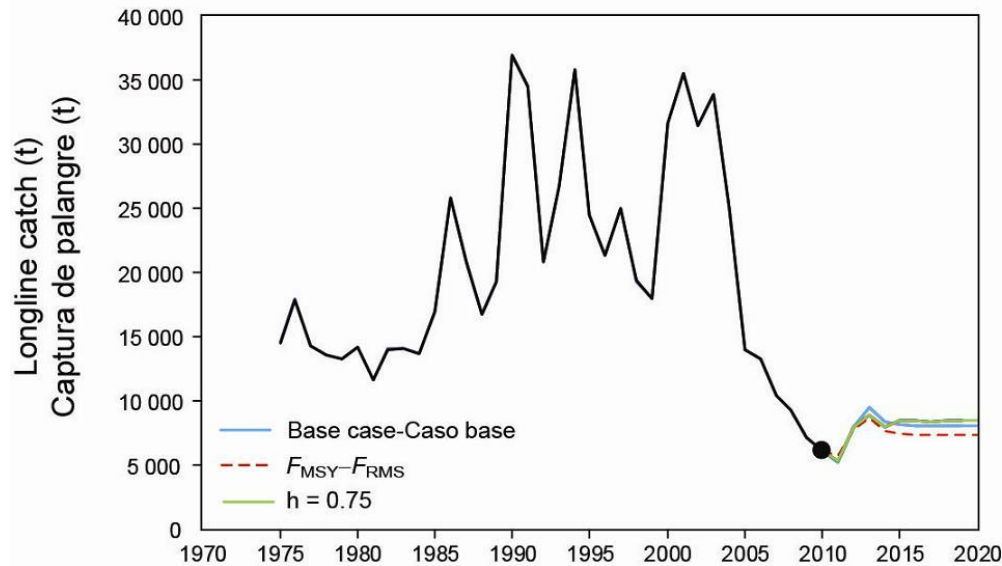
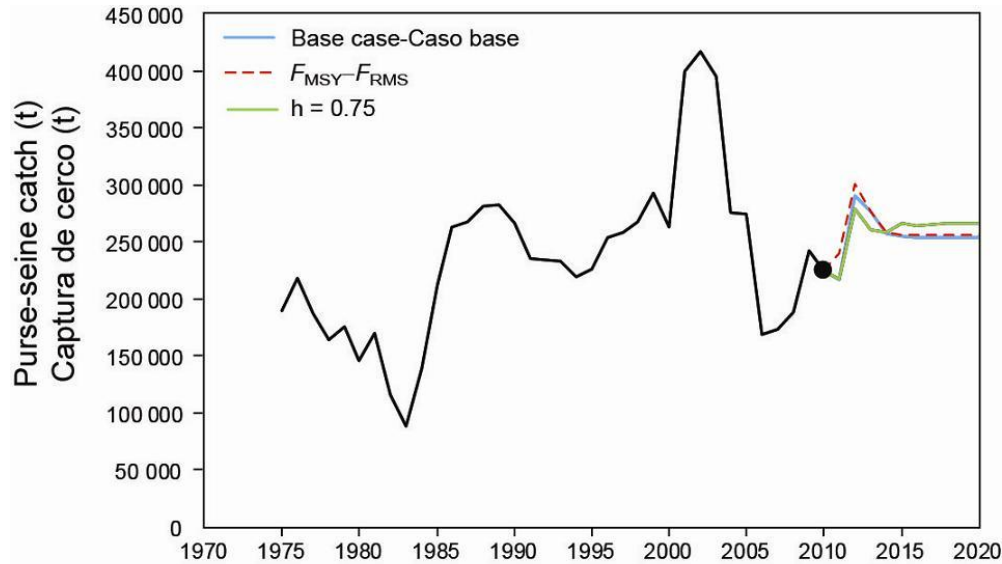
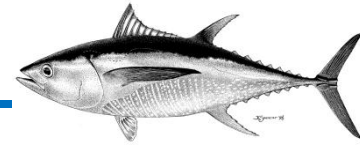
Projected SBR – F_{cur}

Projections
(base case)



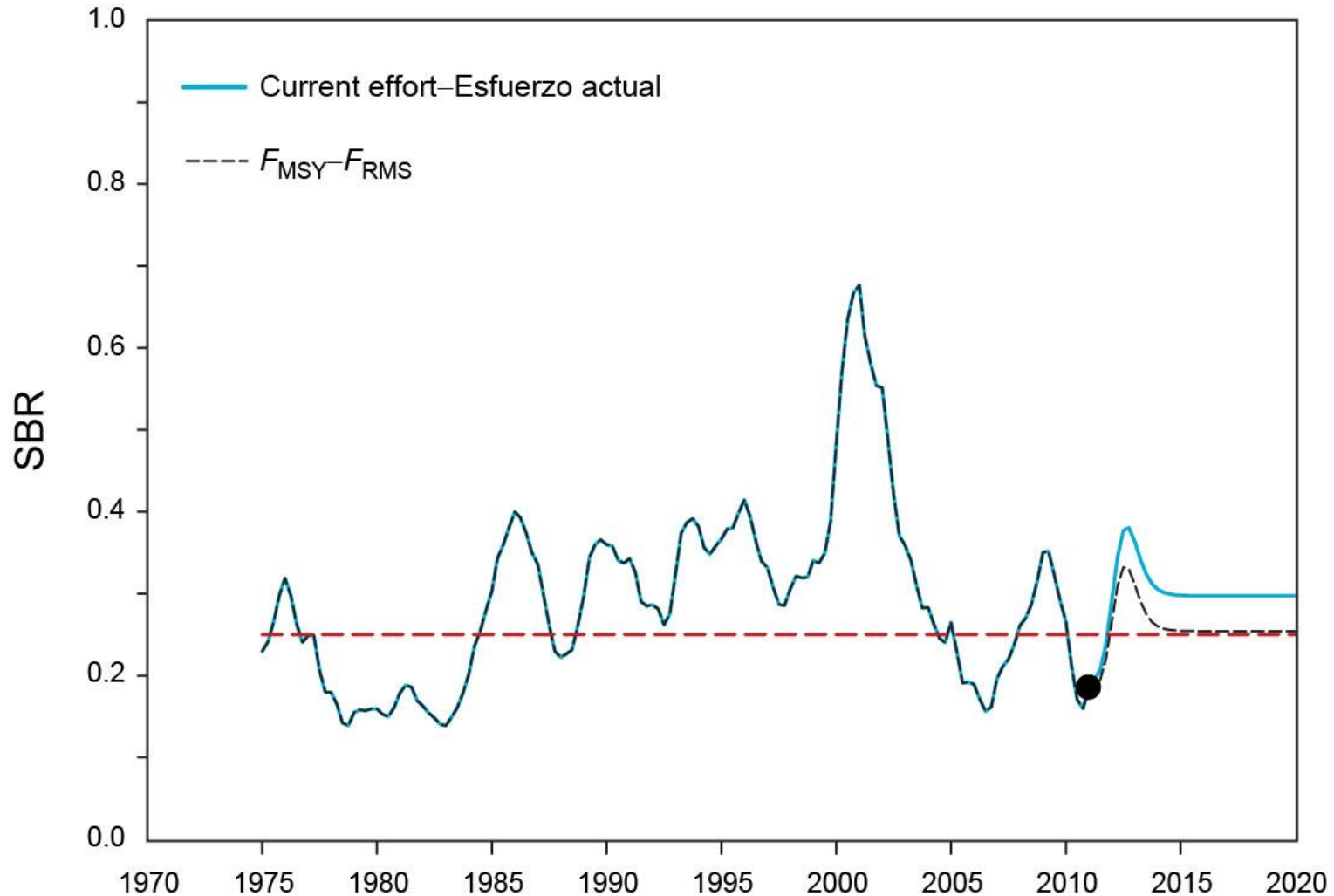
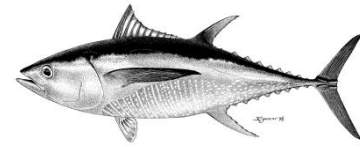
Projected catches – F_{cur} and F_{msy}

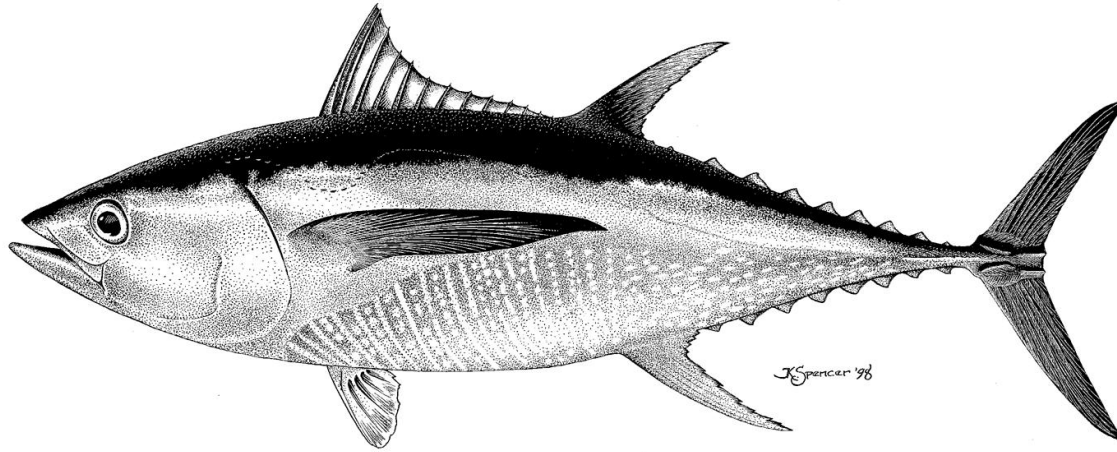
Projections
(base case)



Projected SBR – F_{cur} and F_{msy}

Projections
(base case)



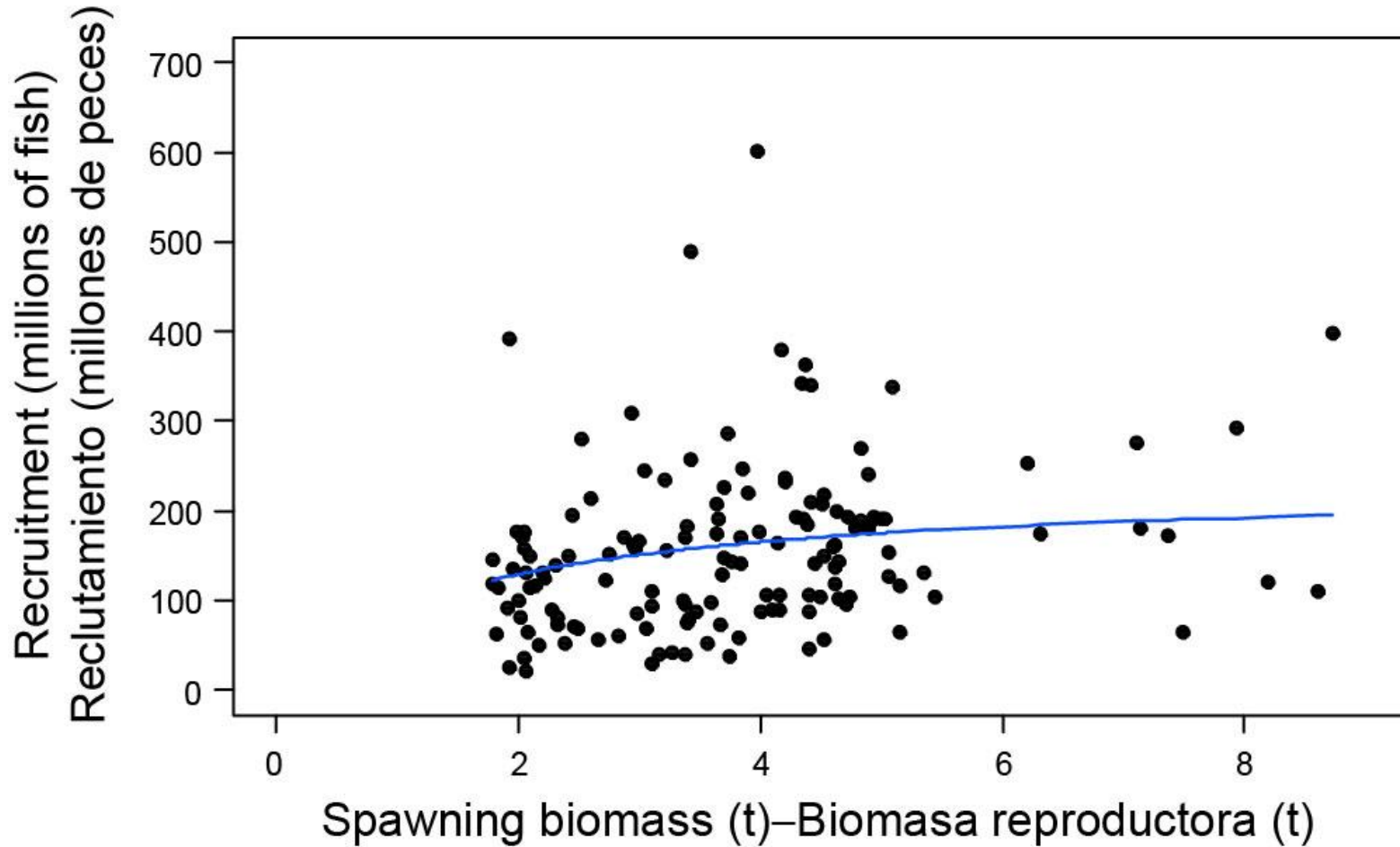
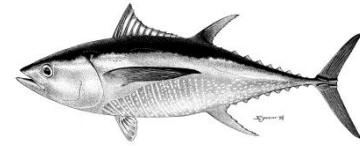


Sensitivity analyses

- Steepness of SR relationship (Appendix A)
- Average size of oldest fish L_2 (Appendix B)
- Fitting to CPUE of DEL-N as main index (Appendix C)

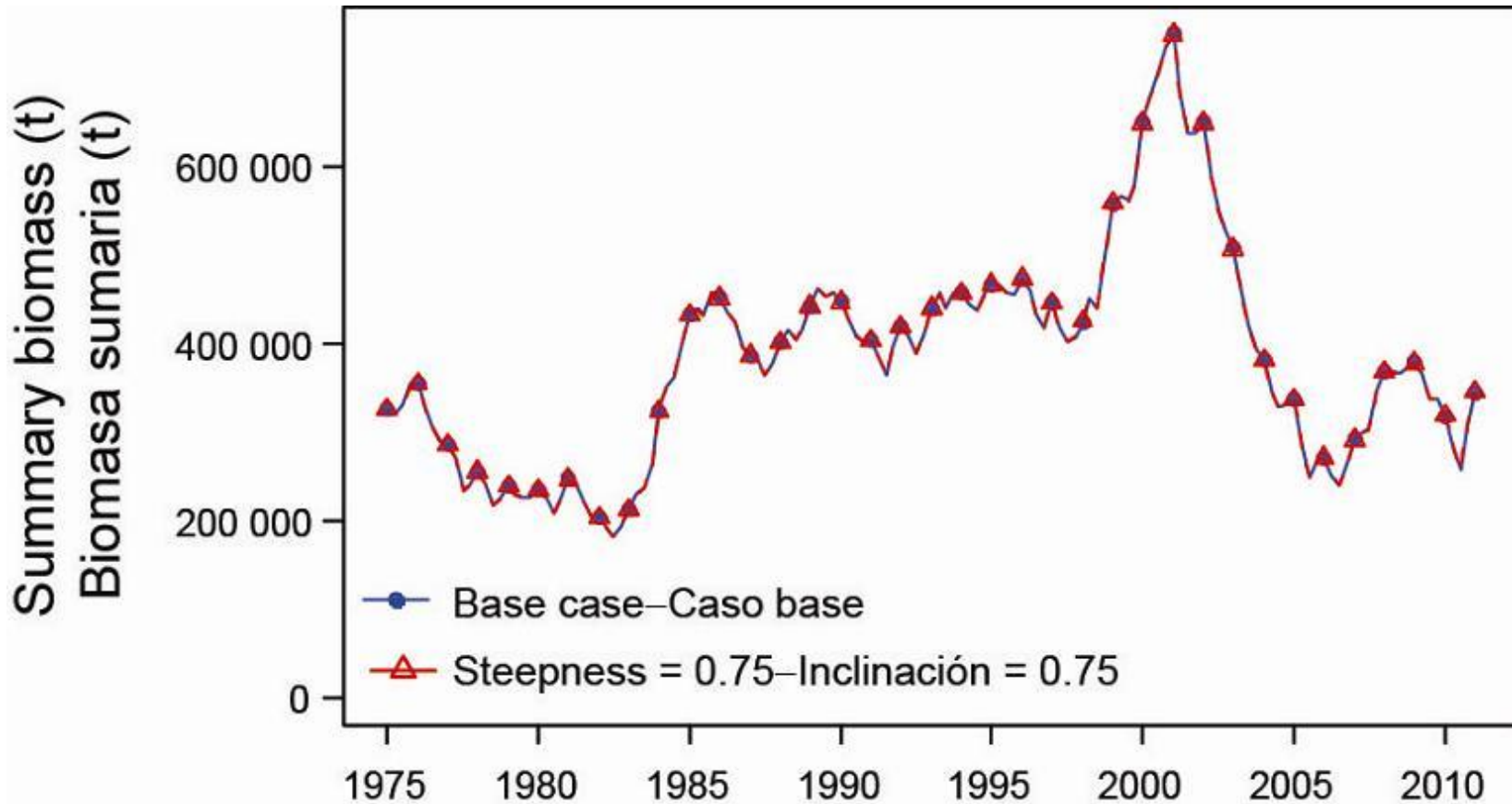
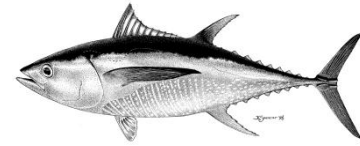
Spawner-recruitment curve

Sensitivities
(Steepness)



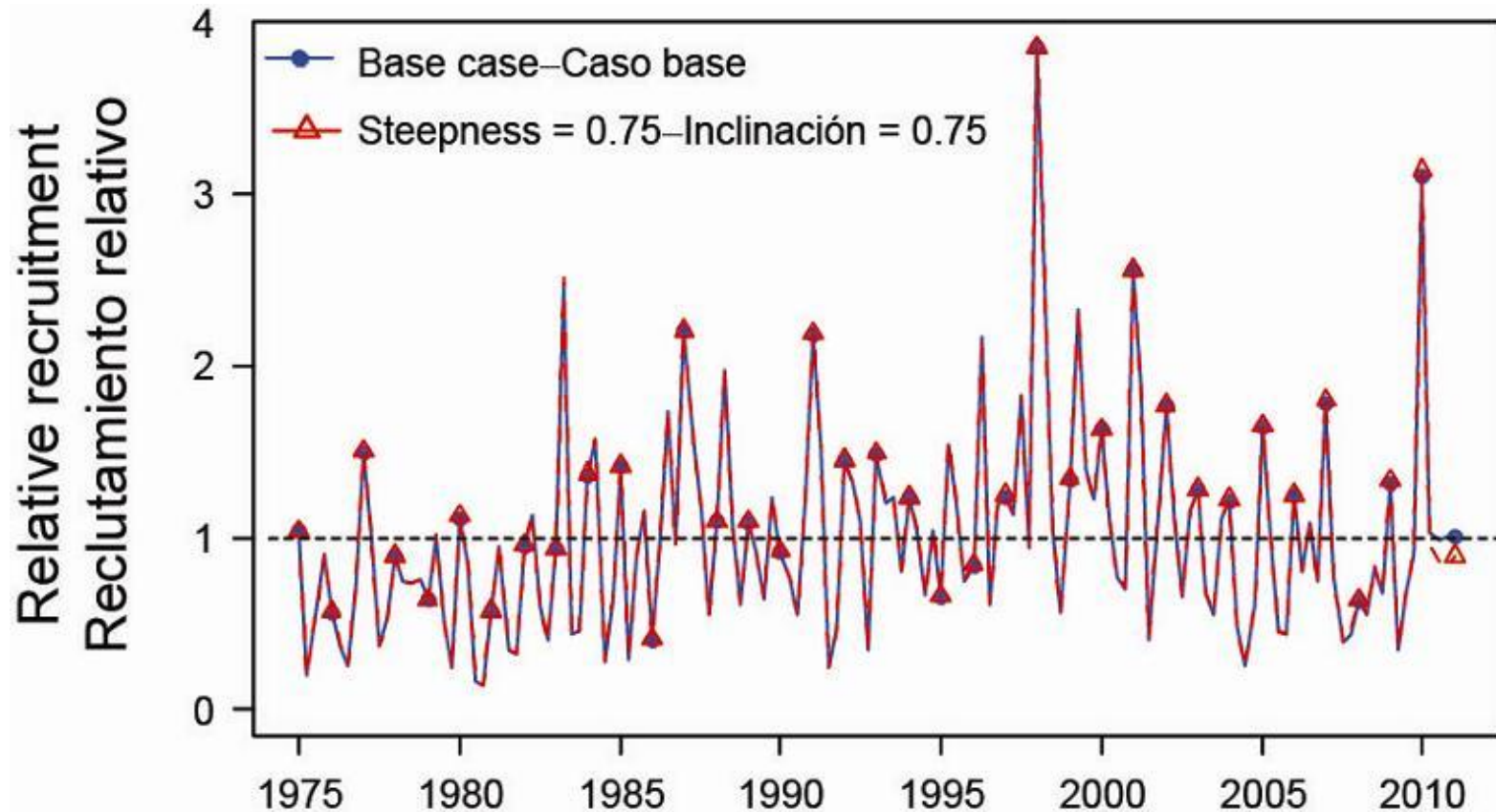
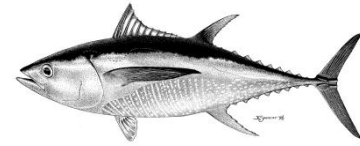
Summary biomass

Sensitivities
(Steepness)



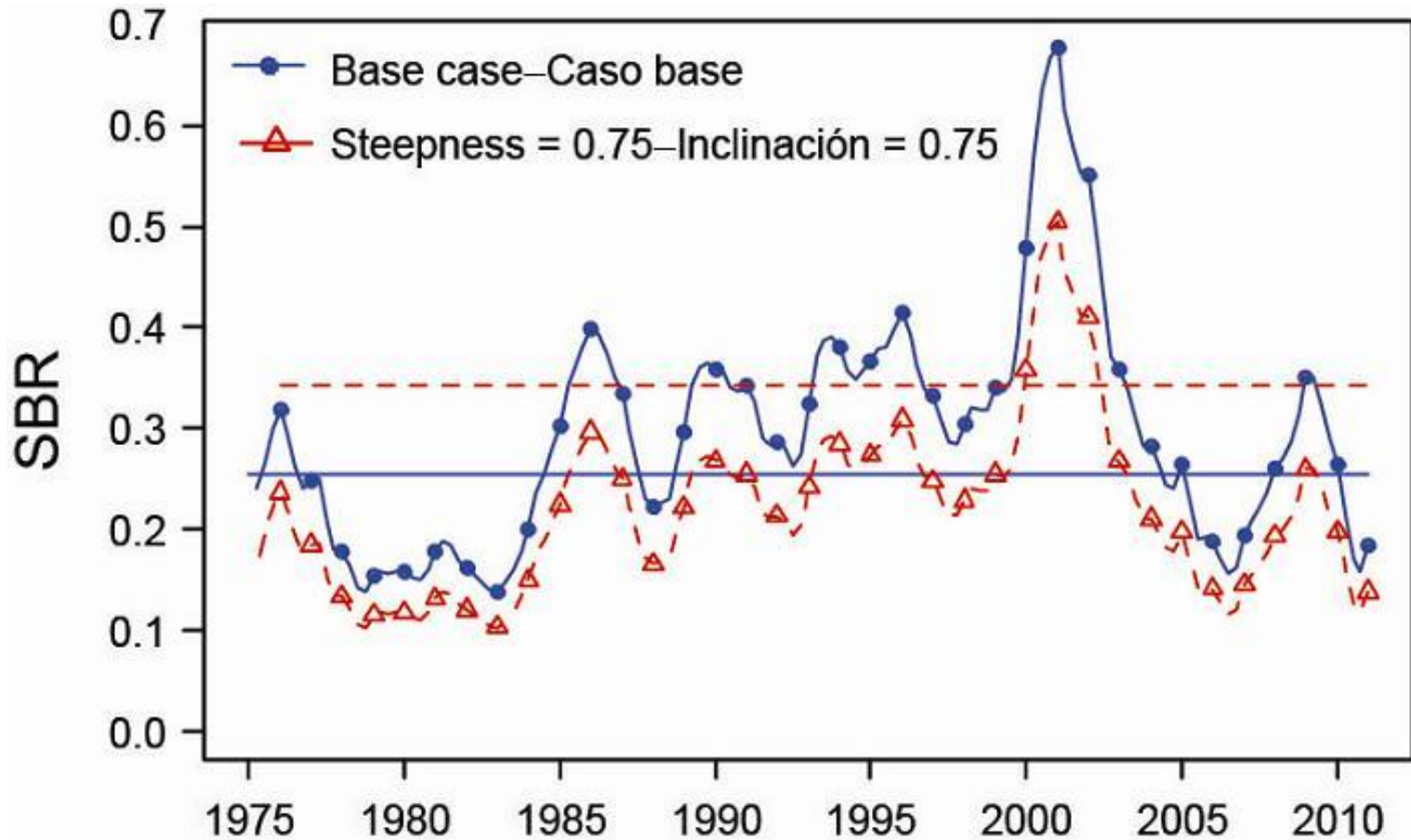
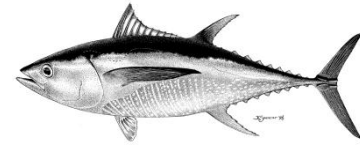
Recruitment

Sensitivities
(Steepness)



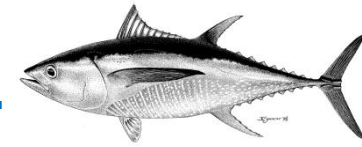
Spawning biomass ratio

Sensitivities
(Steepness)



Management quantities

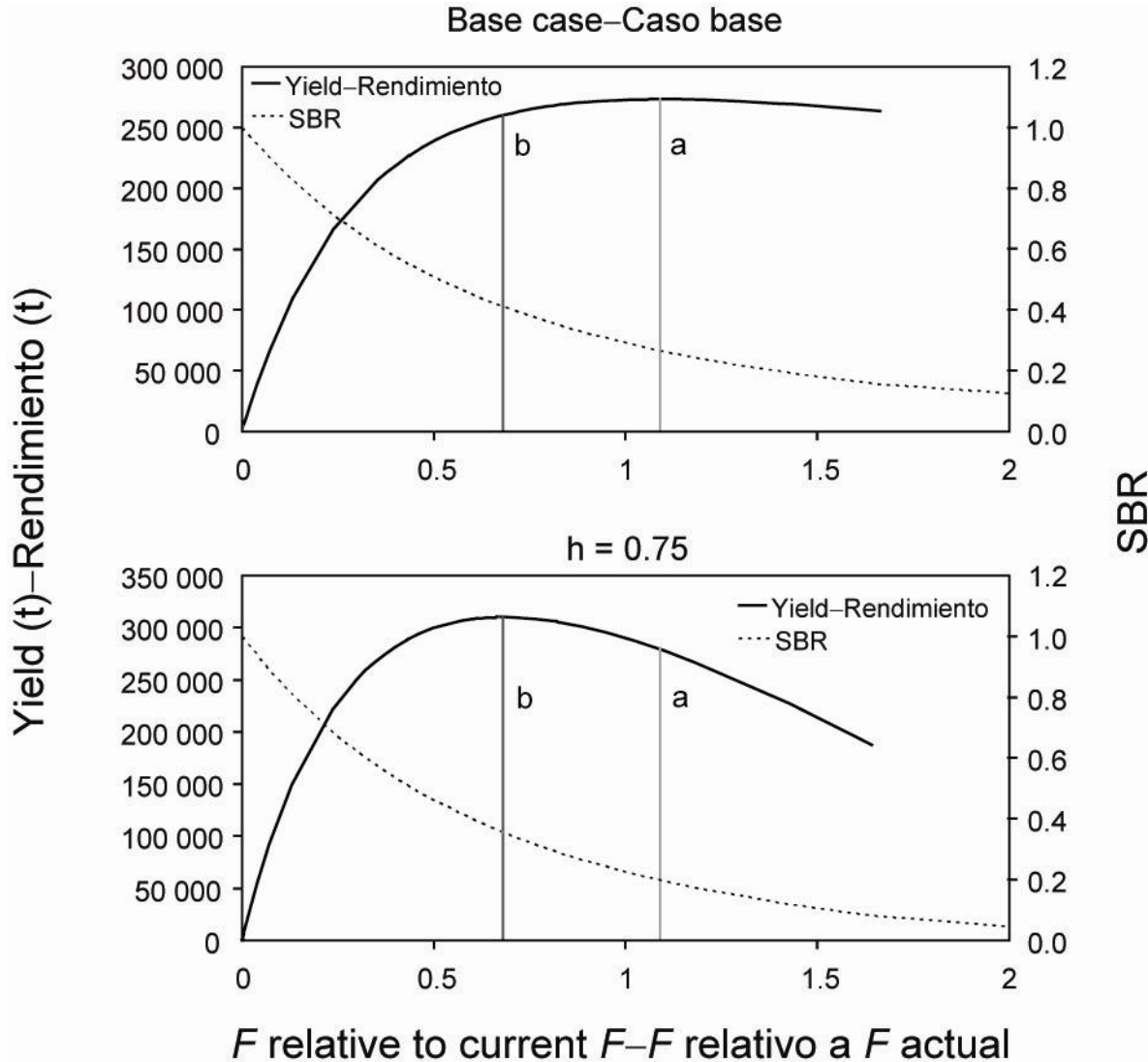
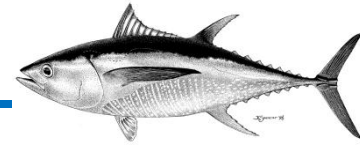
Sensitivities
(Steepness)



	Basecase	$h = 0.75$
MSY	262,857	291,790
Bmsy	354,958	559,967
Smsy	3,305	5,993
Bmsy/B0	0.31	0.37
Smsy/S0	0.26	0.35
Crecent/AMSY	0.88	0.79
Brecent/Bmsy	0.96	0.61
Srecent/Smsy	0.71	0.39
Fmultiplier	1.13	0.71

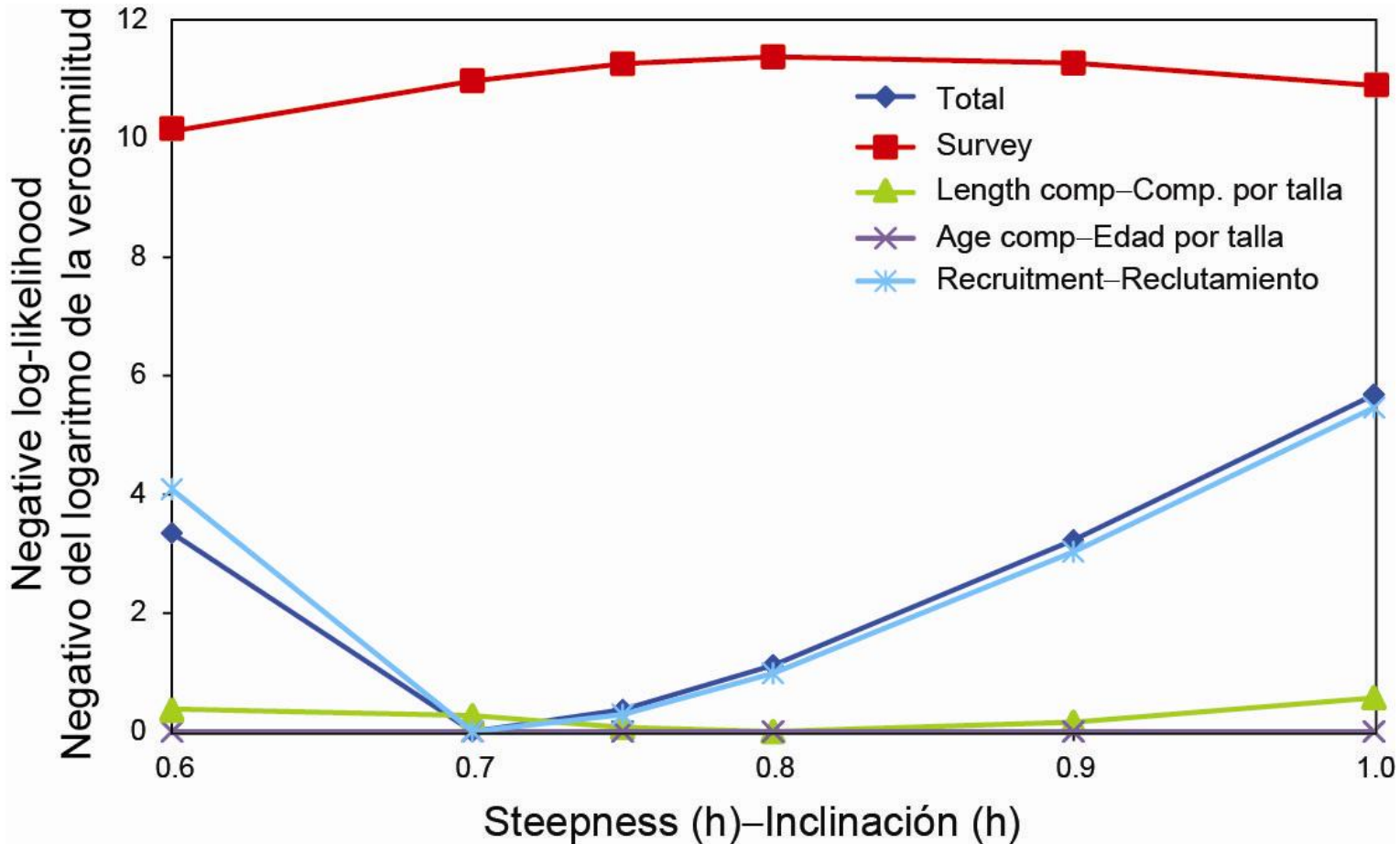
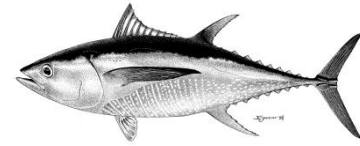
Yield

Stock status
(base case)



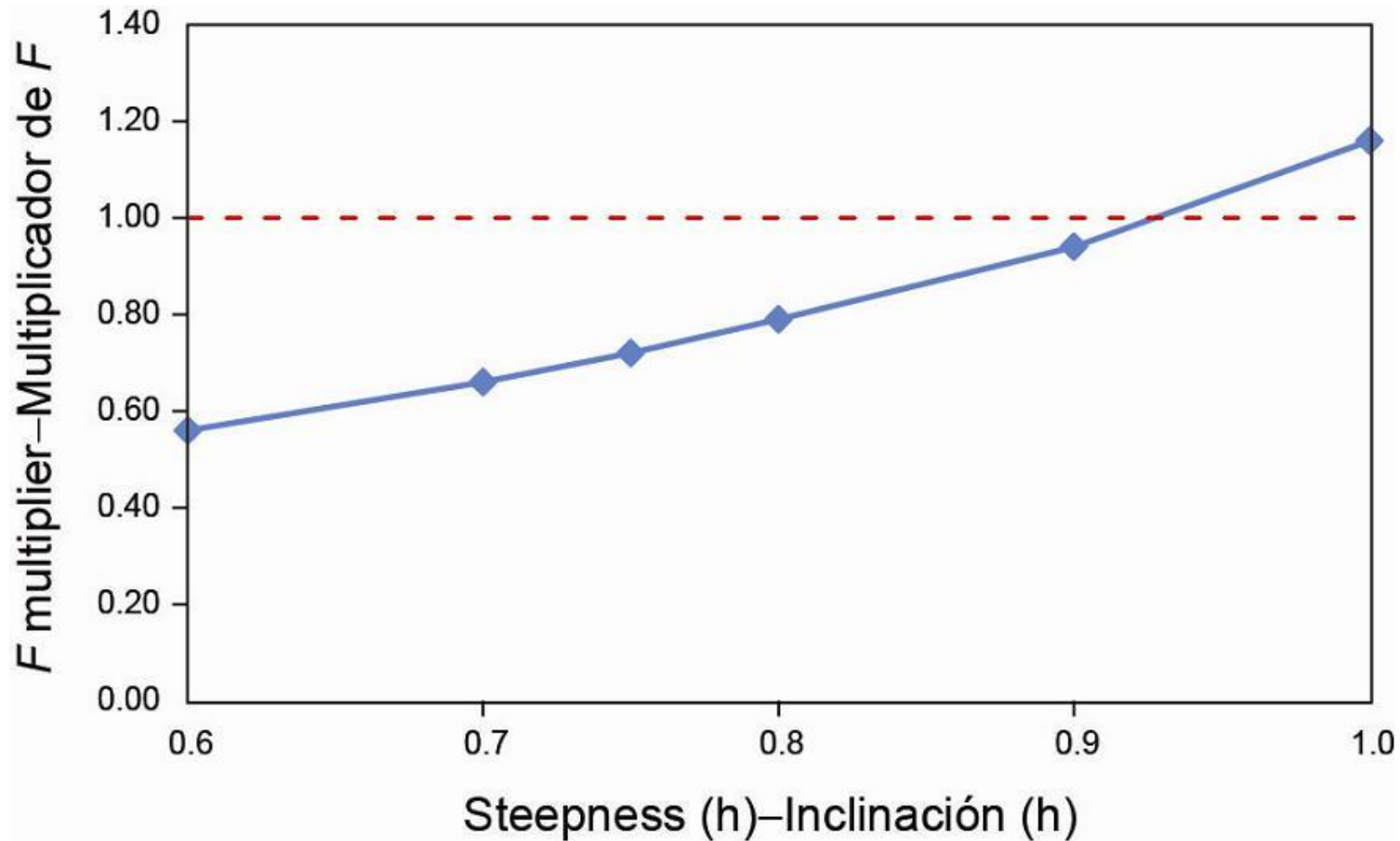
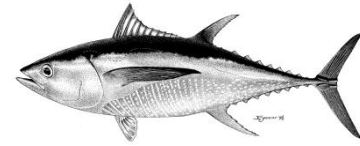
Likelihood profile on steepness

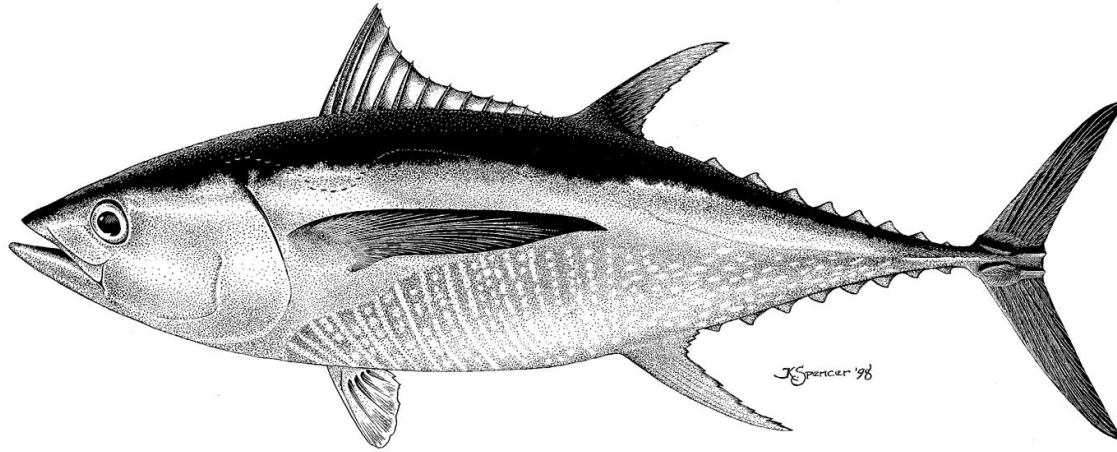
Sensitivities
(Steepness)



F multiplier and steepness

Sensitivities
(Steepness)



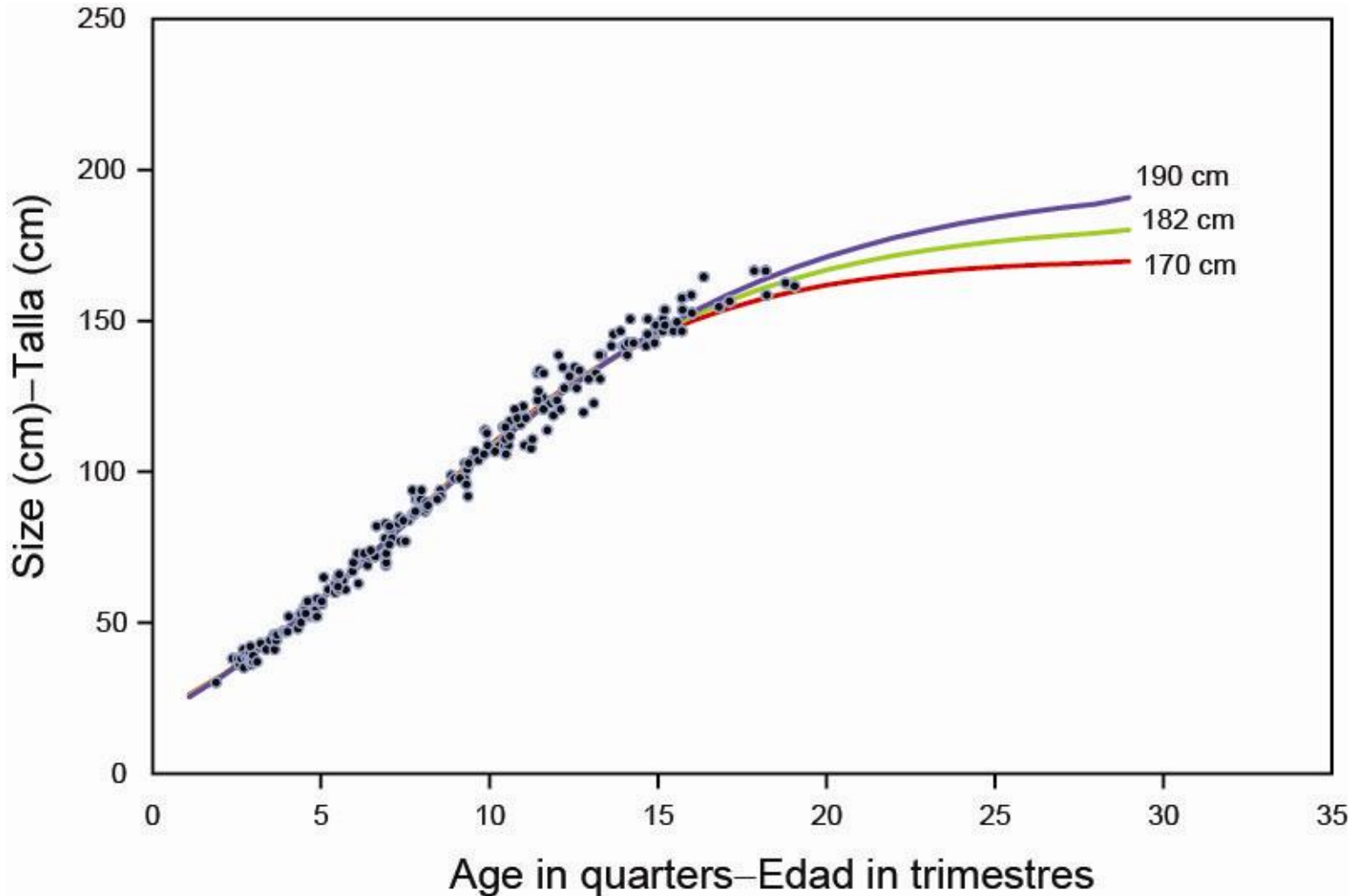
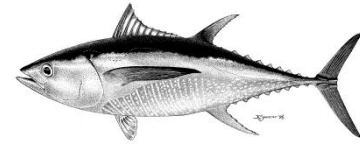


Sensitivity analyses

- Steepness of SR relationship (Appendix A)
- Average size of oldest fish L_2 (Appendix B)
- Fitting to CPUE of DEL-N as main index (Appendix C)

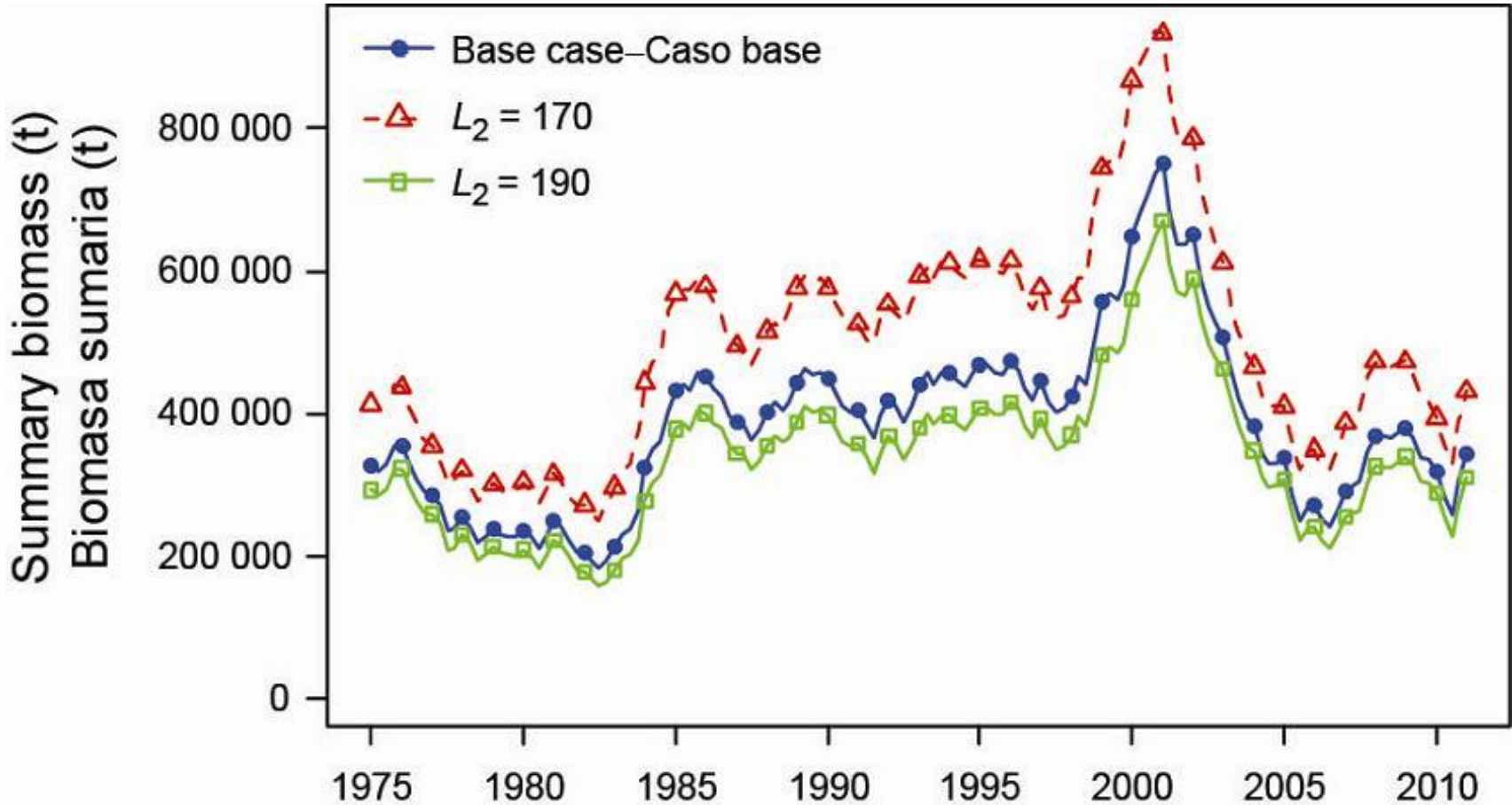
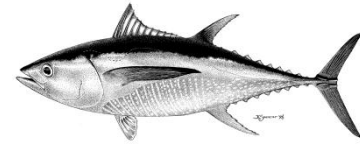
Richards growth curve

Sensitivities
(L_2)



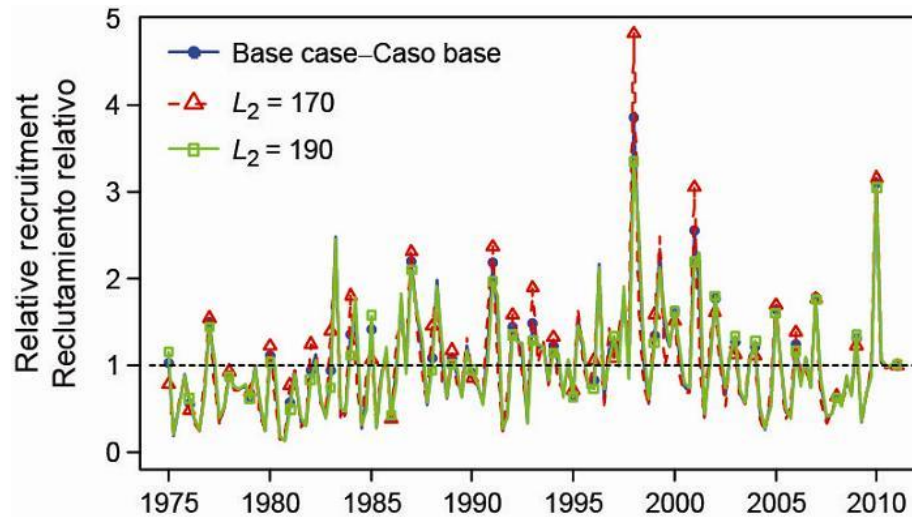
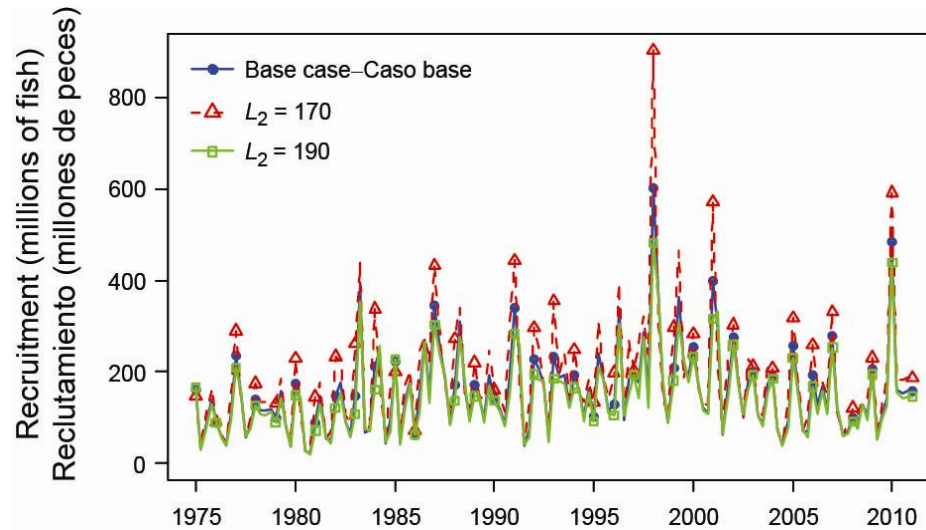
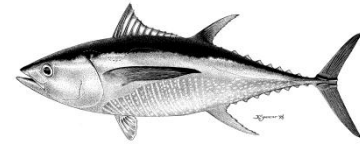
Summary biomass

Sensitivities
(L_2)



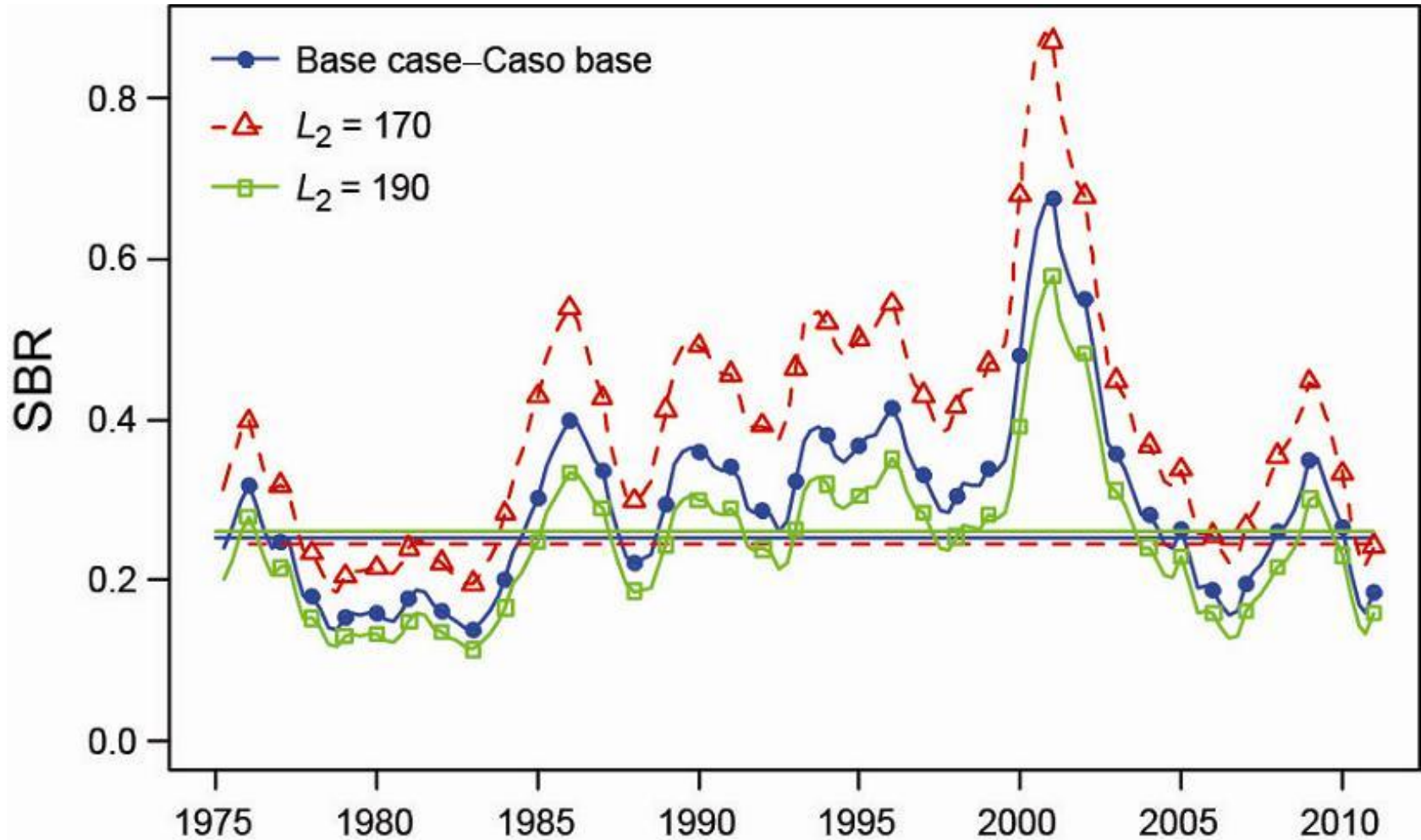
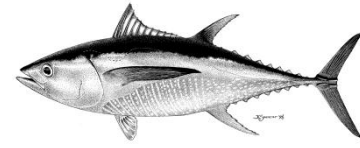
Recruitment

Sensitivities
(L_2)



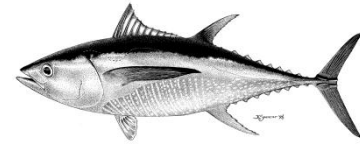
Spawning biomass ratio

Sensitivities
(L_2)

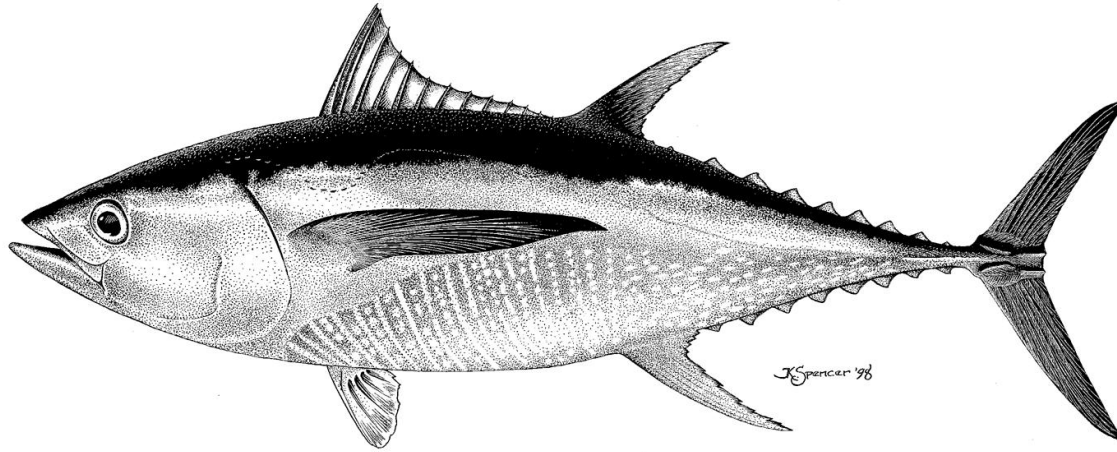


Management quantities

Sensitivities
(L₂)



	Basecase	L2	
		170 cm	190 cm
MSY	262,857	275,310	264,704
Bmsy	354,958	370,334	359,144
Smsy	3,305	3,777	3,169
Bmsy/B0	0.31	0.31	0.31
Smsy/S0	0.26	0.24	0.27
Crecent/AMSY	0.88	0.84	0.87
Brecent/Bmsy	0.96	1.20	0.85
Srecent/Smsy	0.71	1.03	0.59
Fmultiplier	1.13	1.65	0.94

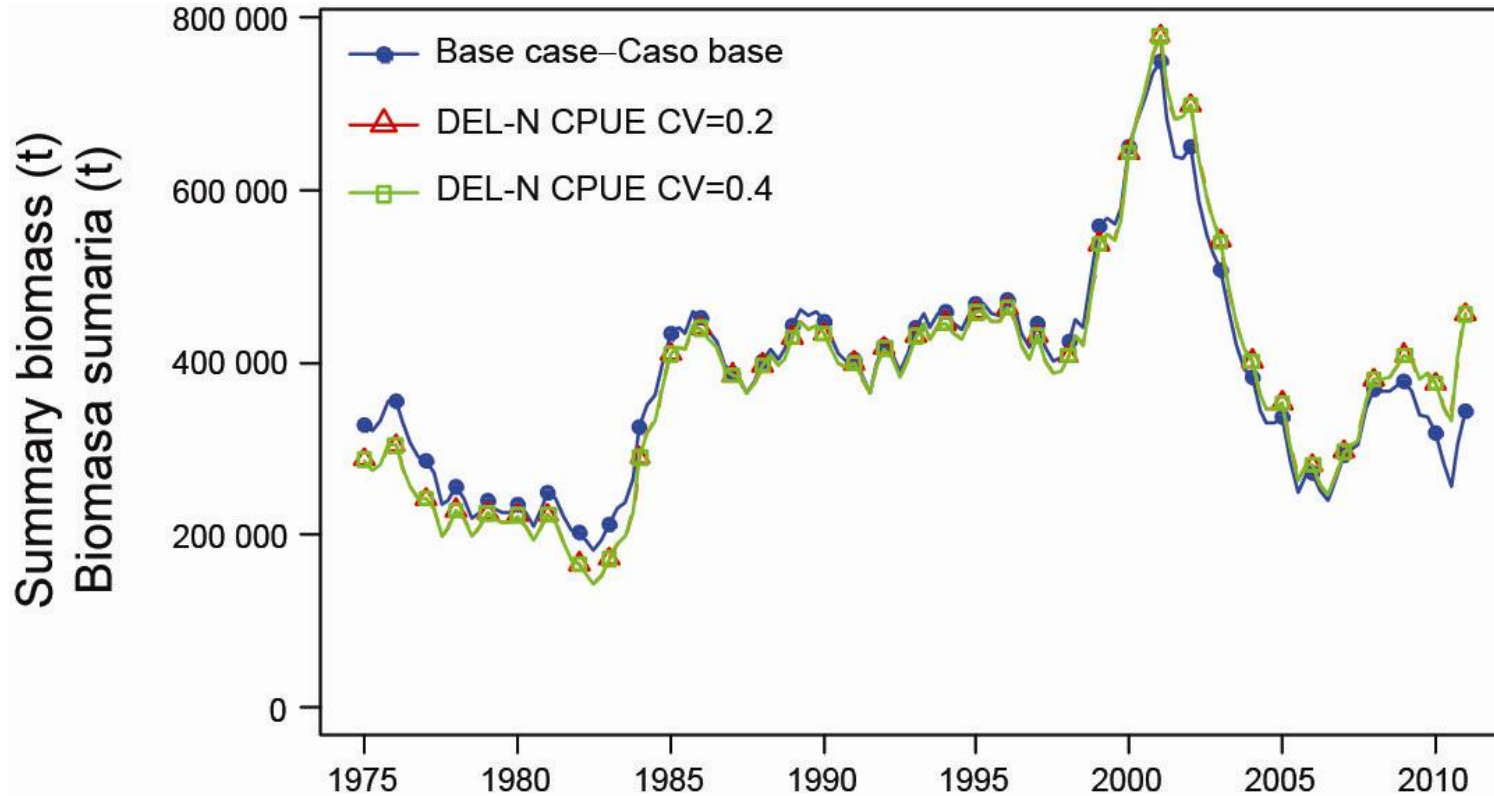
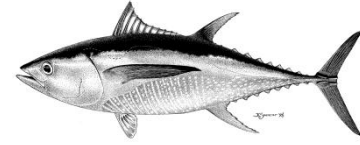


Sensitivity analyses

- Steepness of SR relationship (Appendix A)
- Average size of oldest fish L_2 (Appendix B)
- Fitting to CPUE of DEL-N as main index (Appendix C)

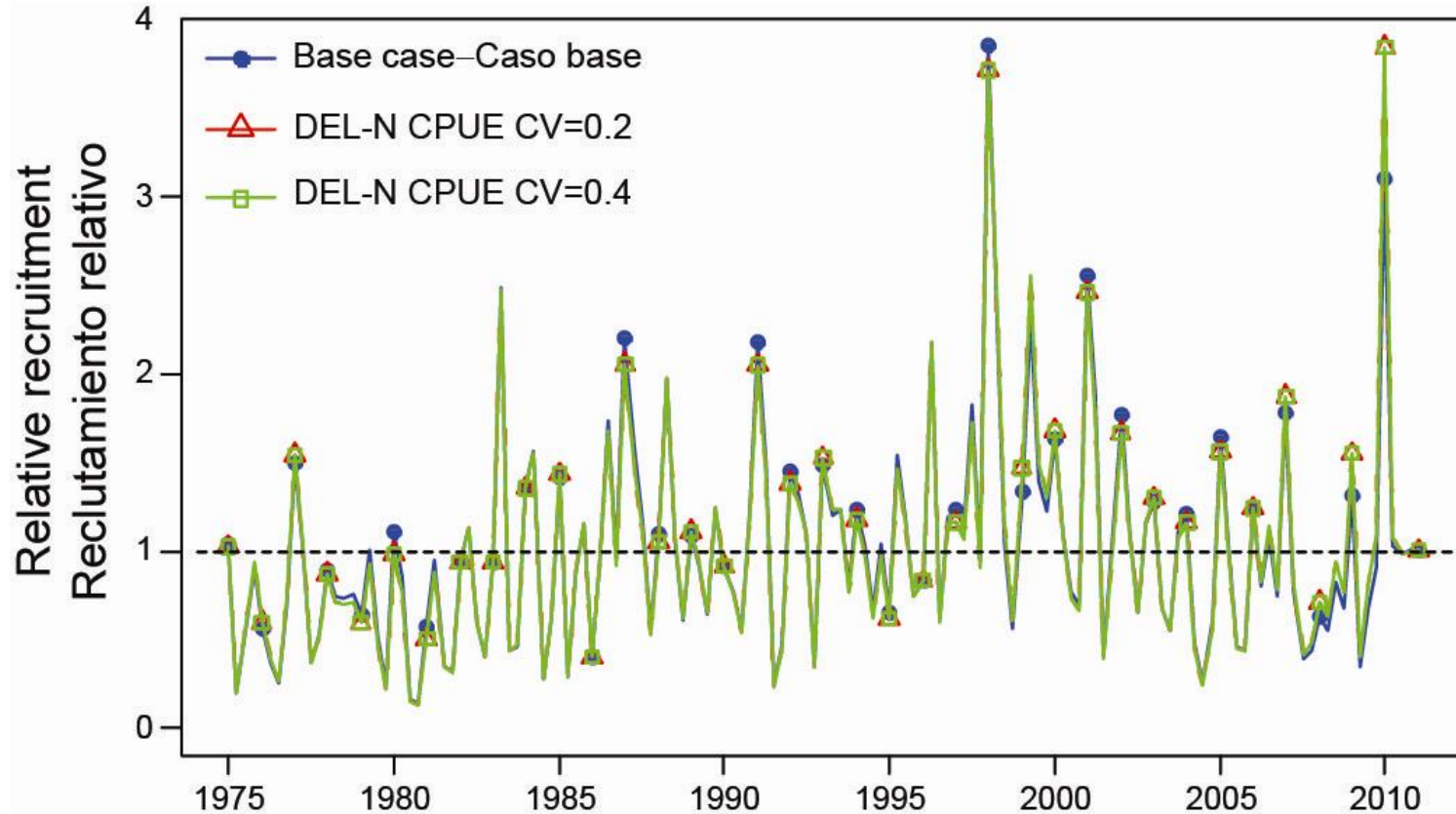
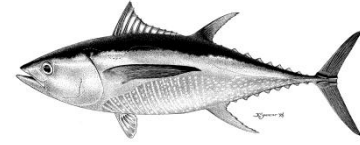
Summary biomass

Sensitivities
(*CPUE DEL-N*)



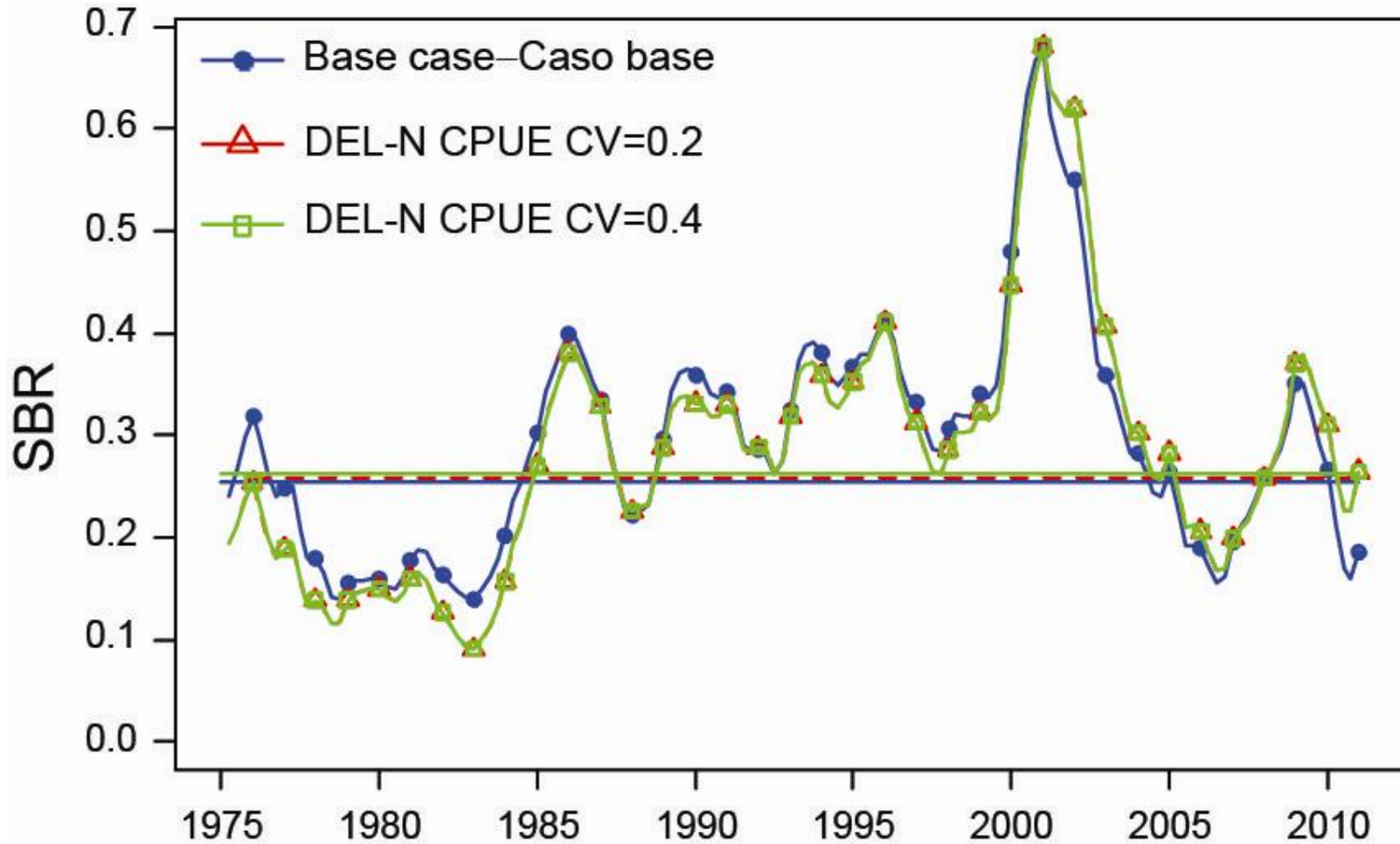
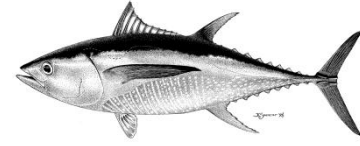
Recruitment

Sensitivities
(*CPUE DEL-N*)



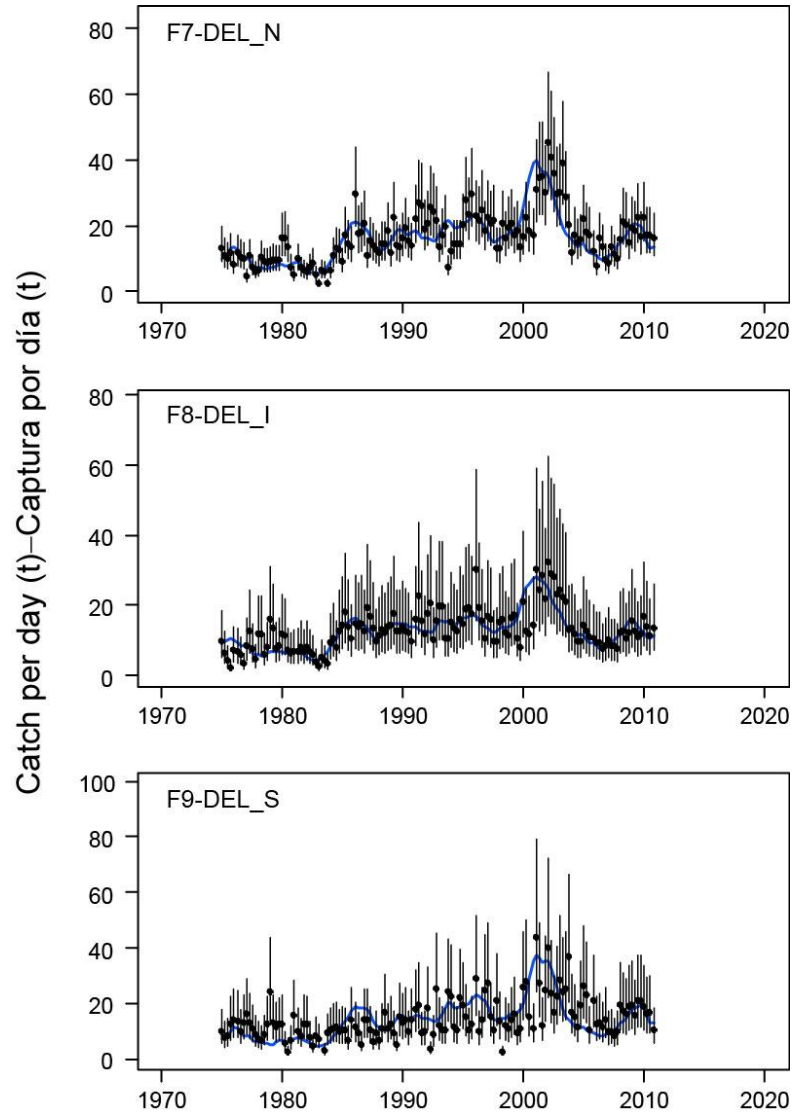
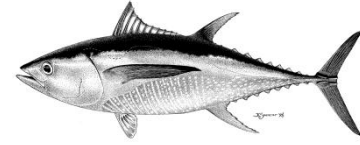
Spawning biomass ratio

Sensitivities
(*CPUE DEL-N*)



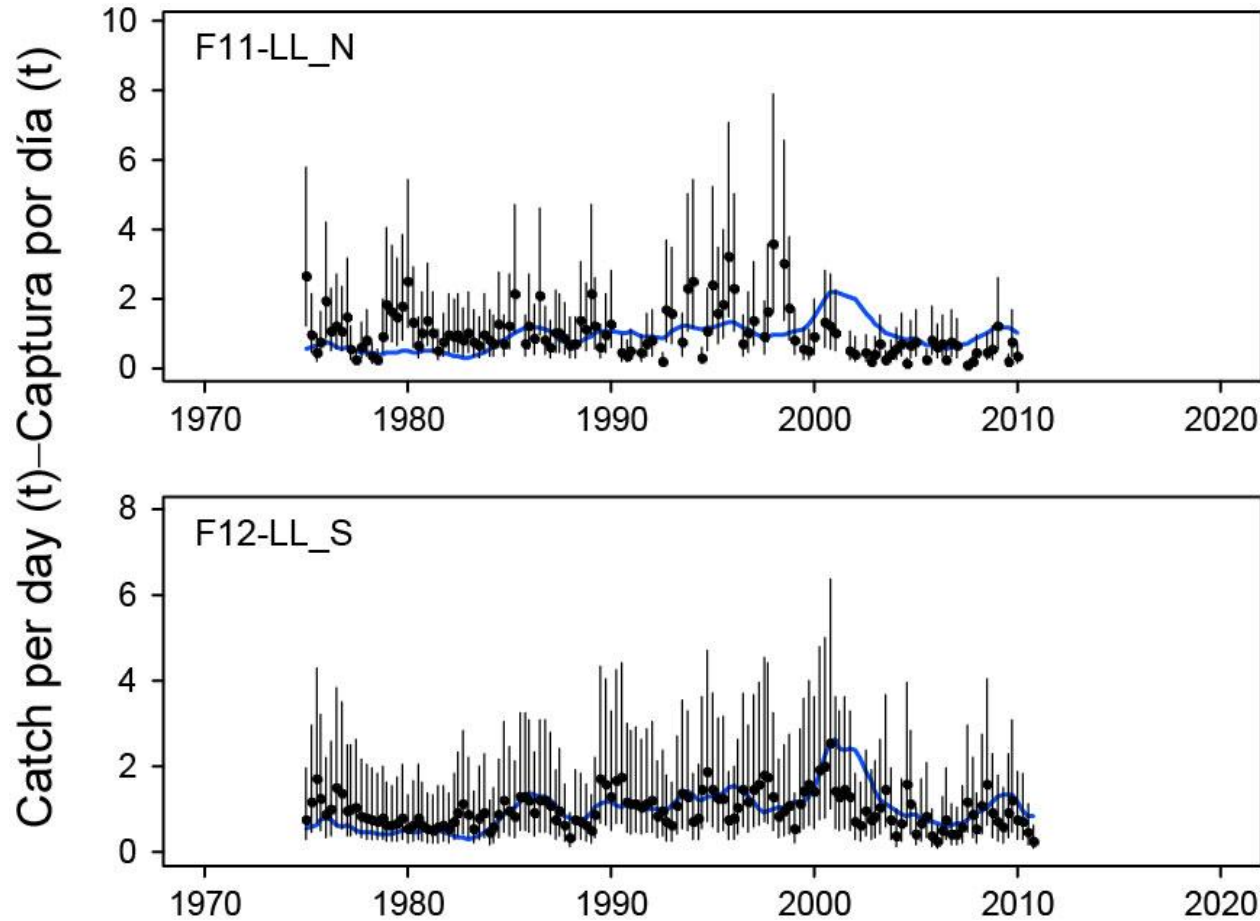
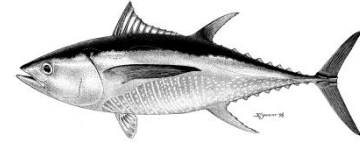
DEL CPUE fits

Sensitivities
(*CPUE DEL-N*)



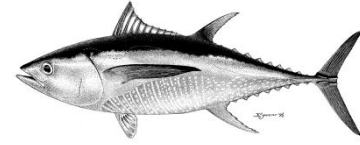
LL CPUE fits

Sensitivities
(*CPUE DEL-N*)

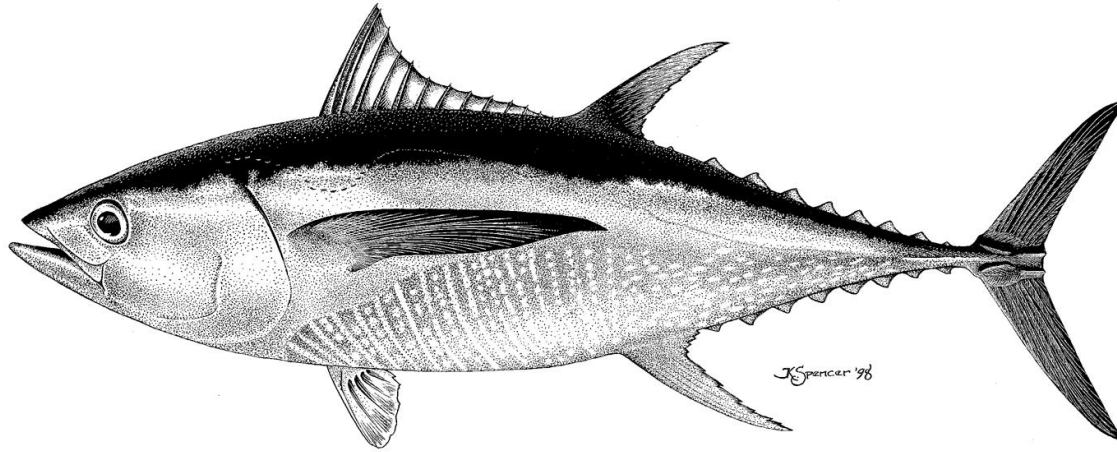


Management quantities

Sensitivities
(CPUE DEL-N)



	Basecase	CPUE DEL-N
MSY	262,857	266,470
Bmsy	354,958	362,808
Smsy	3,305	3,413
Bmsy/B0	0.31	0.32
Smsy/S0	0.26	0.26
Crecent/AMSY	0.88	0.87
Brecent/Bmsy	0.96	1.23
Srecent/Smsy	0.71	0.98
Fmultiplier	1.13	1.29

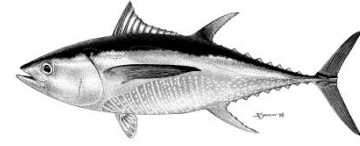


Sensitivity analyses

- Overall results

Management quantities

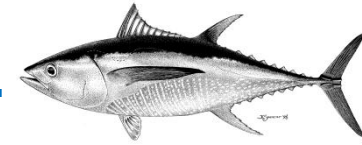
Sensitivities
(Overall)



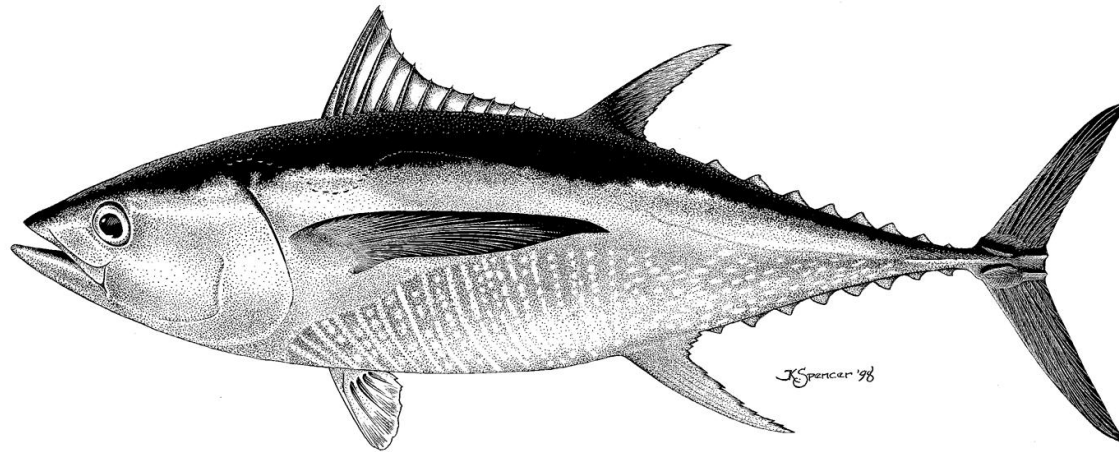
	Basecase	h = 0.75	L_2		CPUE DEL-N
			170 cm	190 cm	
MSY	262,857	291,790	275,310	264,704	266,470
Bmsy	354,958	559,967	370,334	359,144	362,808
Smsy	3,305	5,993	3,777	3,169	3,413
Bmsy/B0	0.31	0.37	0.31	0.31	0.32
Smsy/S0	0.26	0.35	0.24	0.27	0.26
Crecent/AMSY	0.88	0.79	0.84	0.87	0.87
Brecent/Bmsy	0.96	0.61	1.20	0.85	1.23
Srecent/Smsy	0.71	0.39	1.03	0.59	0.98
Fmultiplier	1.13	0.71	1.65	0.94	1.29

Likelihoods

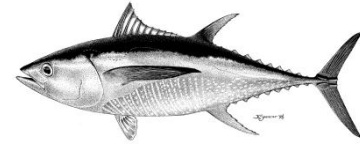
Sensitivities
(Overall)



Data Datos	Base case Caso base	L_2			CPUE DEL-N
		$h = 0.75$	170 cm	190 cm	
CPUE	-140.54	-140.23	-143.58	-138.48	-177.80
Size compositions – Composiciones por talla	8300.04	8299.45	8260.65	8336.89	8272.20
Age at length – Talla por edad	100.87	100.99	122.68	107.05	104.76
Recruitment - Reclutamiento	-2.37	-7.39	0.53	-5.36	-0.74
Total	8257.99	8252.83	8240.27	8300.10	8198.41

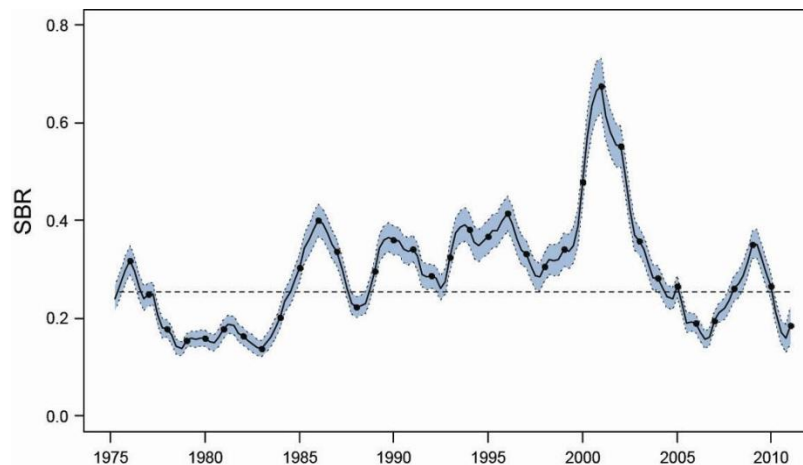


Summary

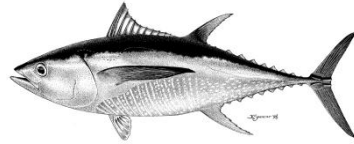


Summary: key results

- The recent **fishing mortality** rates are estimated to be lower than those corresponding to the MSY
- The recent levels of **spawning biomass** are estimated to be below those corresponding to the MSY ($S_{\text{recent}} < S_{\text{MSY}}$)

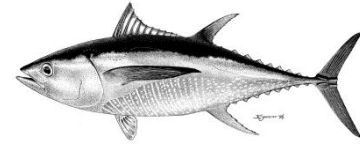


Plausible Sensitivities and Uncertainties



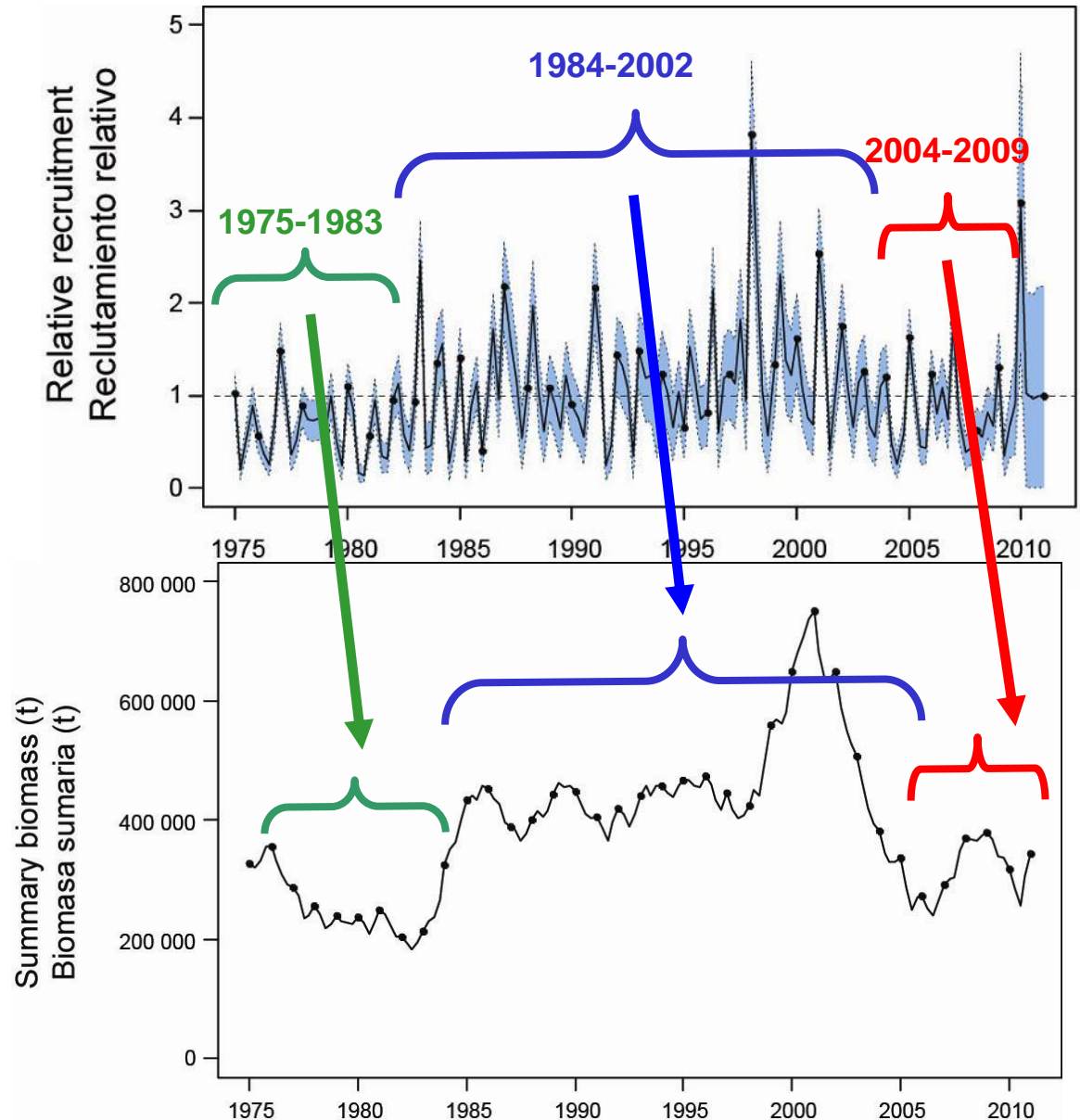
- Results are more **pessimistic** with:
 - The inclusion of a stock-recruitment relationship
 - Higher values of the average size of the oldest fish ($L_2 > 190$ cm)

- Results are more **optimistic** with:
 - Lower values of the average size of the oldest fish ($L_2 < 182$ cm)
 - Fitting to CPUE DEL-N as main index of abundance ($S_{\text{recent}} = S_{\text{MSY}}$)

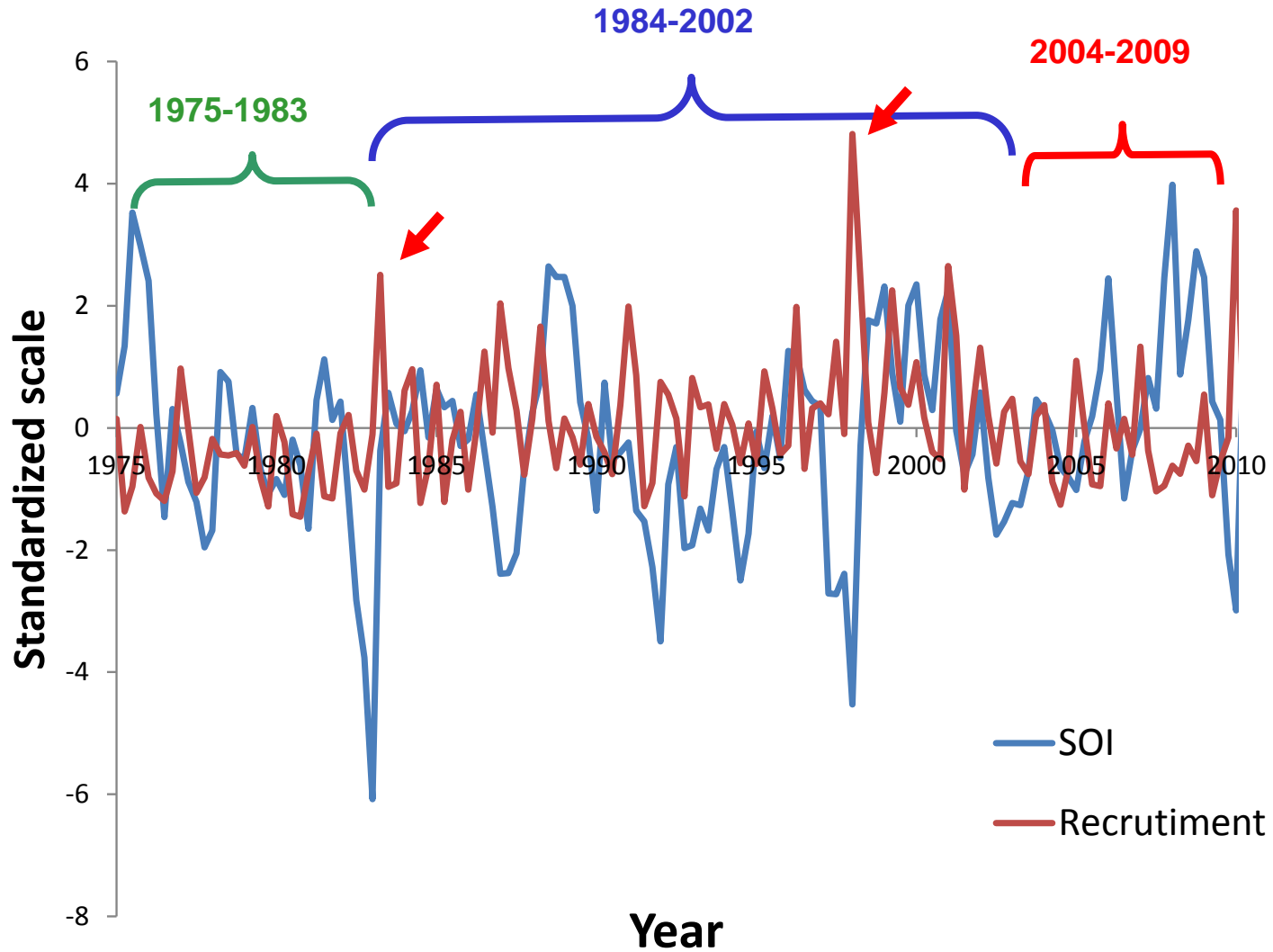
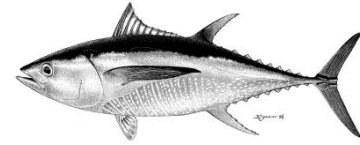


Summary: key results (cont.)

- There population may have recently switched from a high to a an lower productivity regime

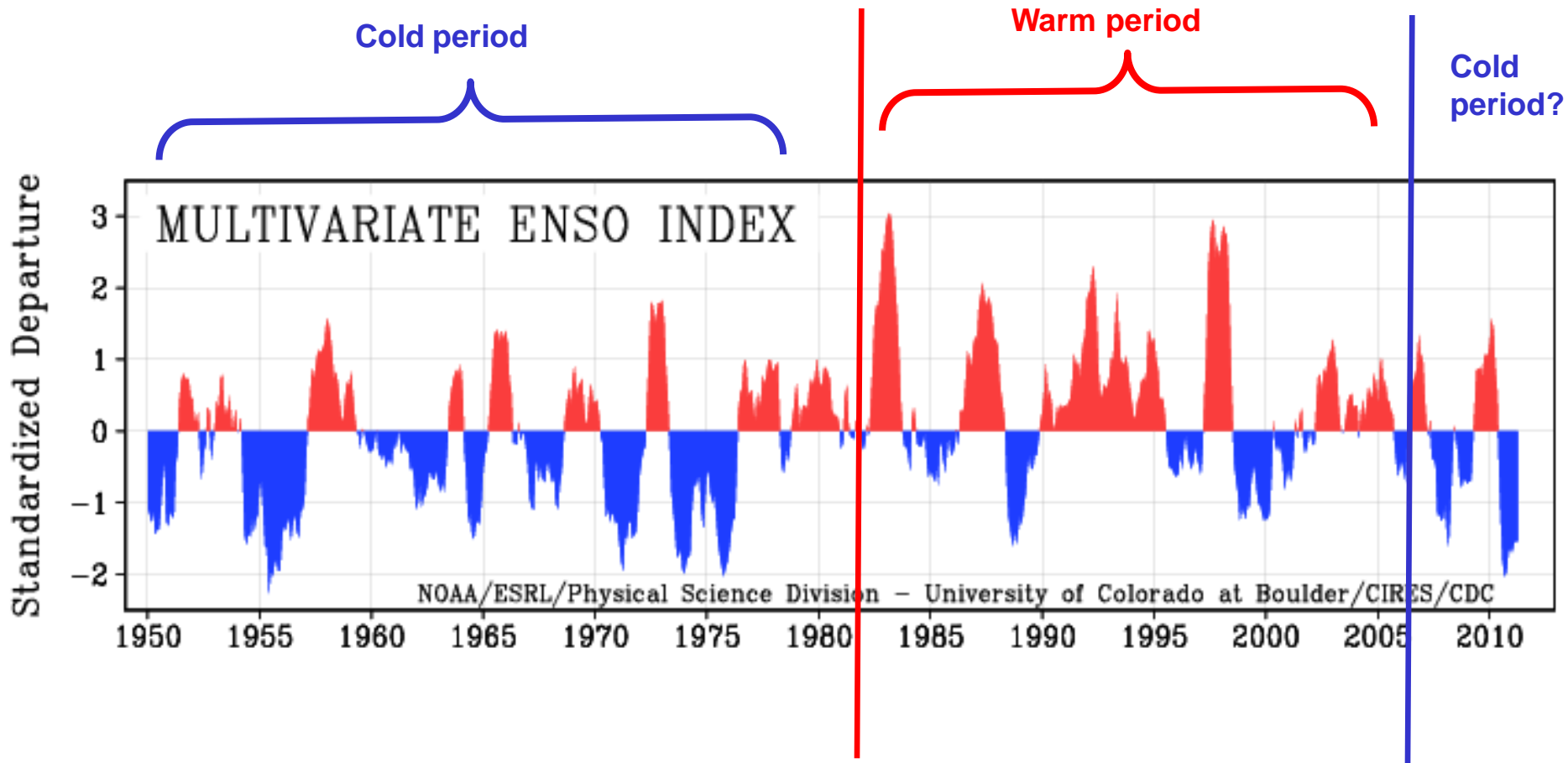
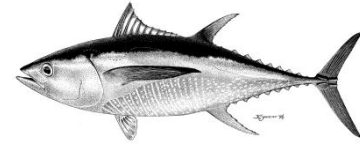


SOI - El Niño / La Niña?



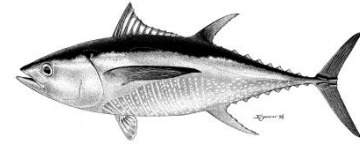
ENSO

Summary



Future directions

Future



- Alternative assumptions on stock structure (LL fishery definitions)
- Time-variant selectivity for PS fisheries
- More robust selectivity curves
- Determine appropriate weighting of the different data sets



Questions?

