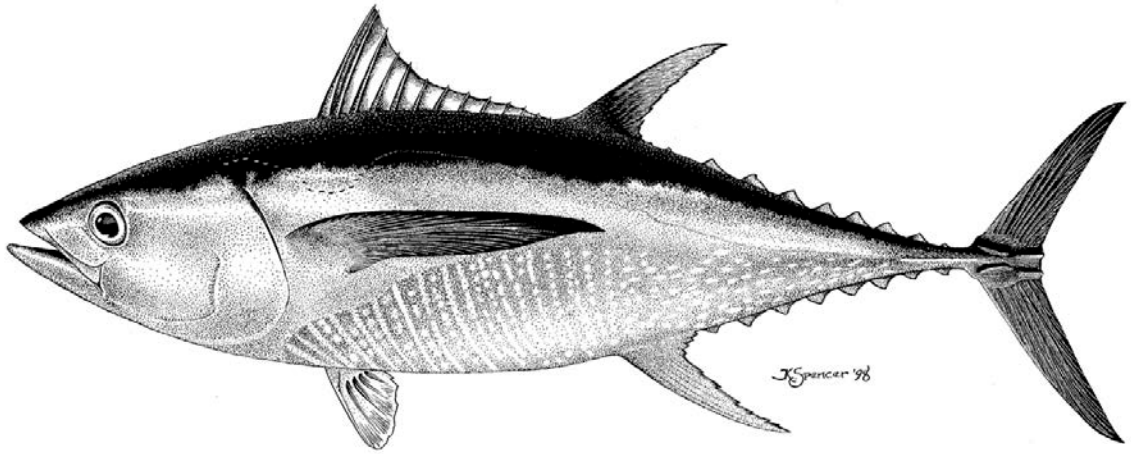
STOCK ASSESSMENT OF YELLOWFIN TUNA IN THE EASTERN PACIFIC OCEAN

UPDATE OF 2011 STOCK ASSESSMENT

January 1975 – December 2011



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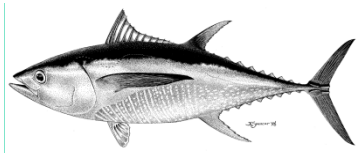
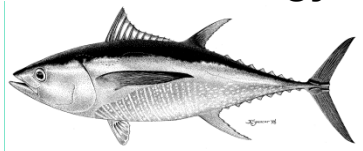
Outline

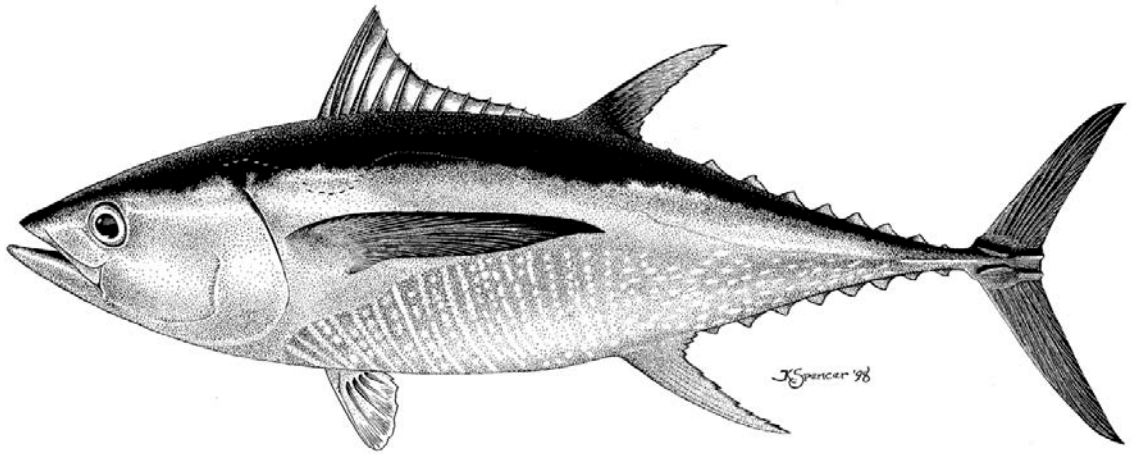


- Stock assessment (base case model)
  - Methodology (Stock Synthesis)
  - Fishery data
  - Model assumptions
  - Results (fishing mortality, recruitment, biomasses, others)
  - Retrospective analysis
  - Stock status (base case)
  - Simulations (projections with *status quo* and F_{MSY})
- Sensitivity analyses (Document YFT-01-08)
- Summary conclusions on stock status

Overview of assessment model



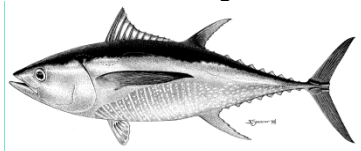
- Age-structured, statistical, catch-at- length model (Stock Synthesis – version 3.23b, Dec. 2011)
- Same type of model as MULTIFAN-CL, A-SCALA and CASAL (integrated analysis)



Fishery data

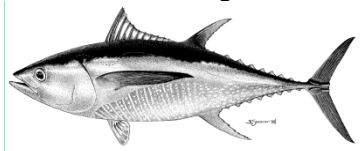
- Catches
- Fishery definitions
- Discards
- Fishing effort
- Catch-per-unit-effort (CPUE)
- Size-compositions

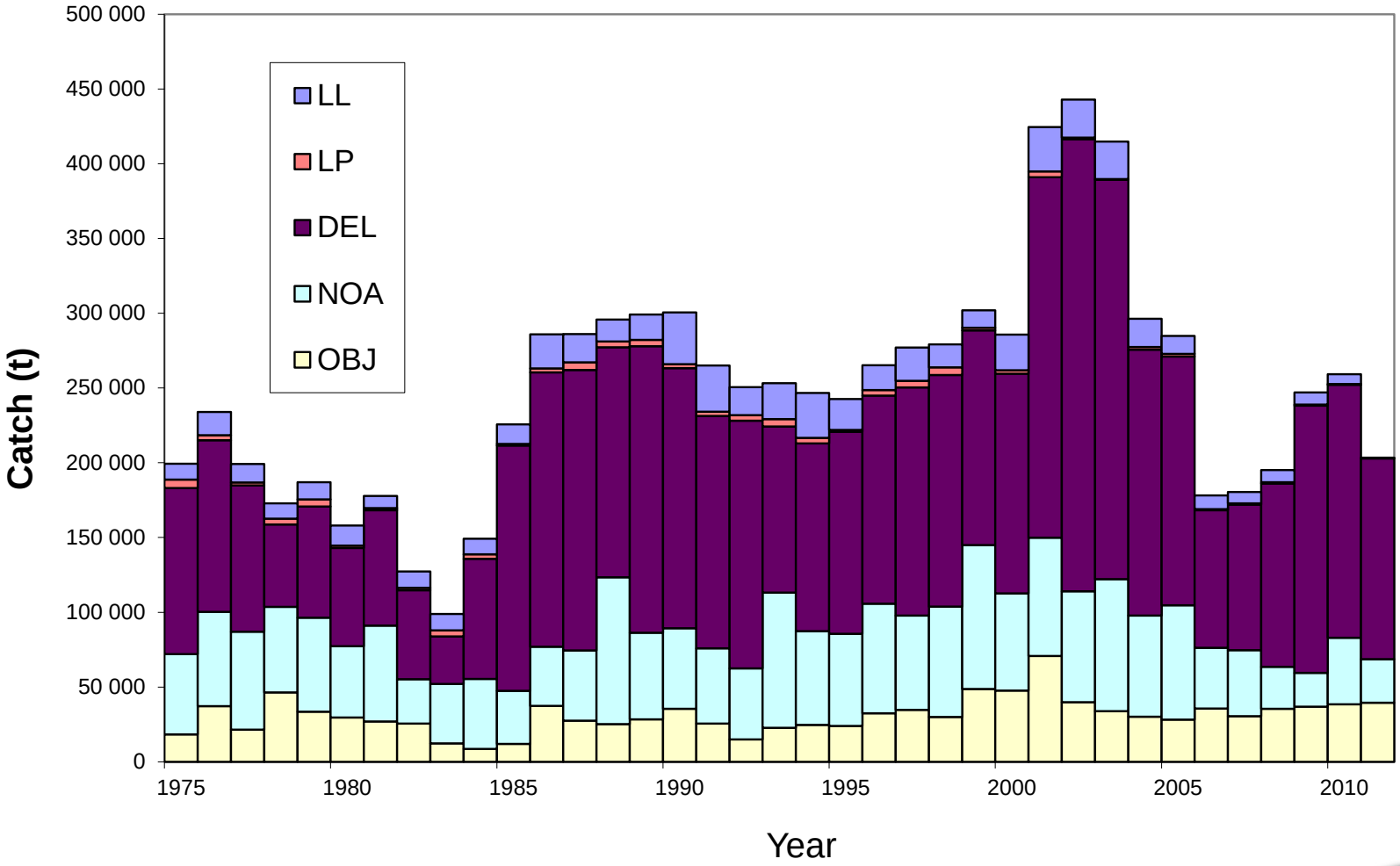
New or updated data



- Surface fisheries
  - Catch, CPUE and size-frequency data updated to include new data for 2011 and revised data for earlier years
- Longline fisheries
  - New or updated longline catch data: China (2010), Chinese Taipei (2008-2010), French Polynesia (2010), Japan (2007-2010), Republic of Korea (2009-2011) and US (2009-2010)
  - New or updated CPUE data available for Japan (2007-2010)
  - No new or updated longline size-frequency for Japan (data from 2011 submission used, 2007-2009)

YFT total catches





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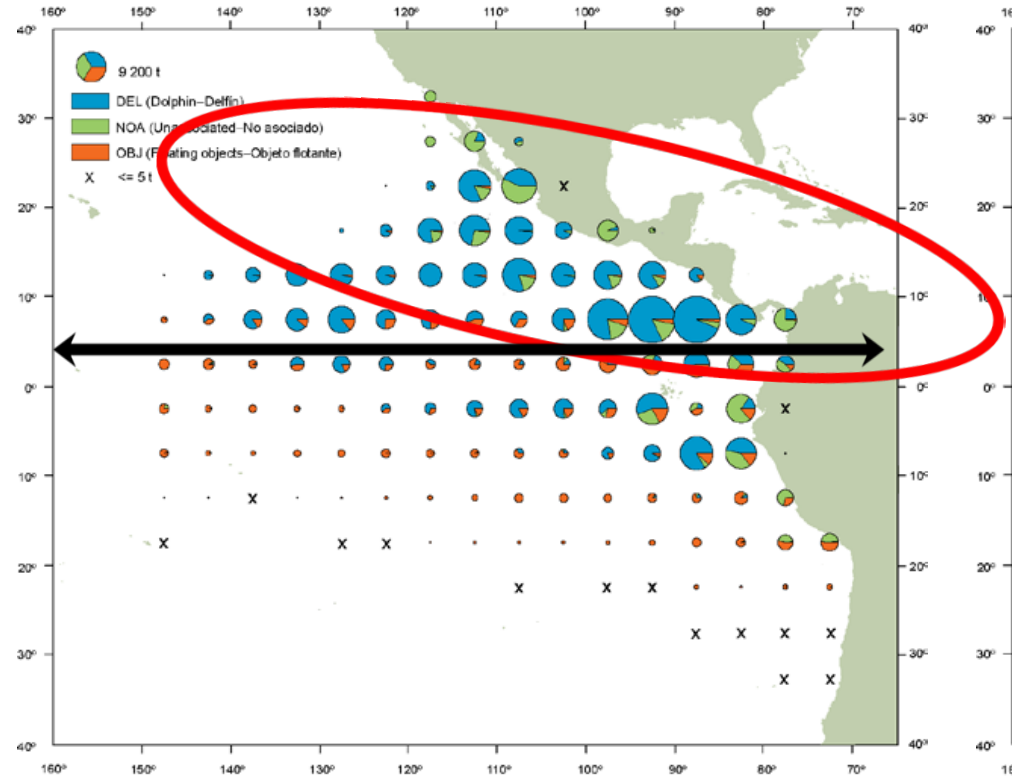
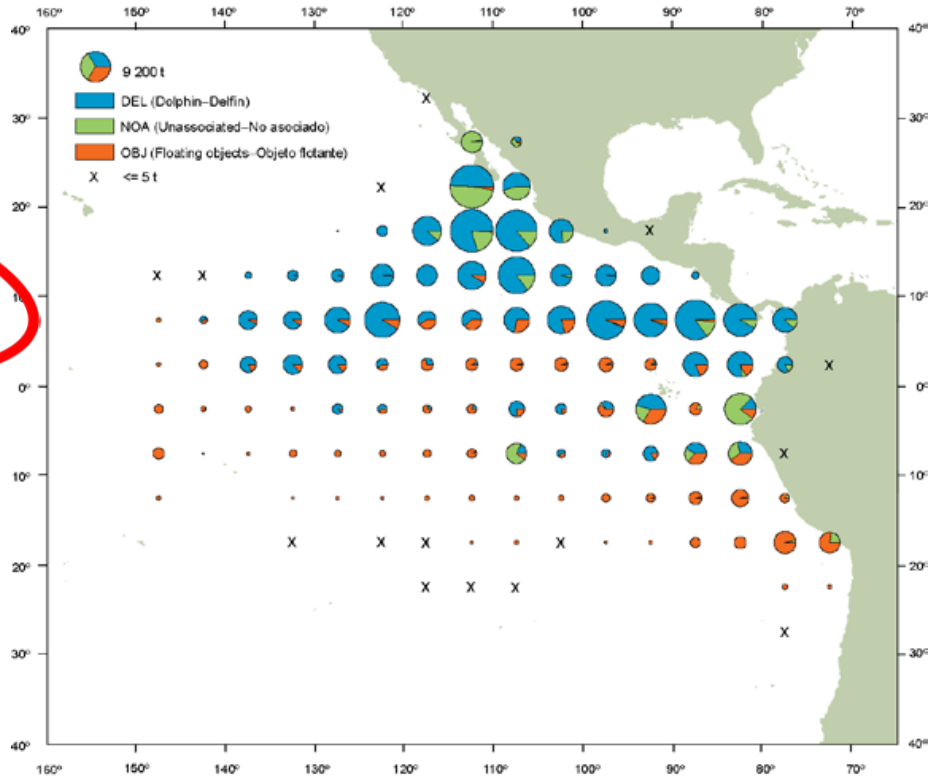
Spatial distribution of YFT PS catches

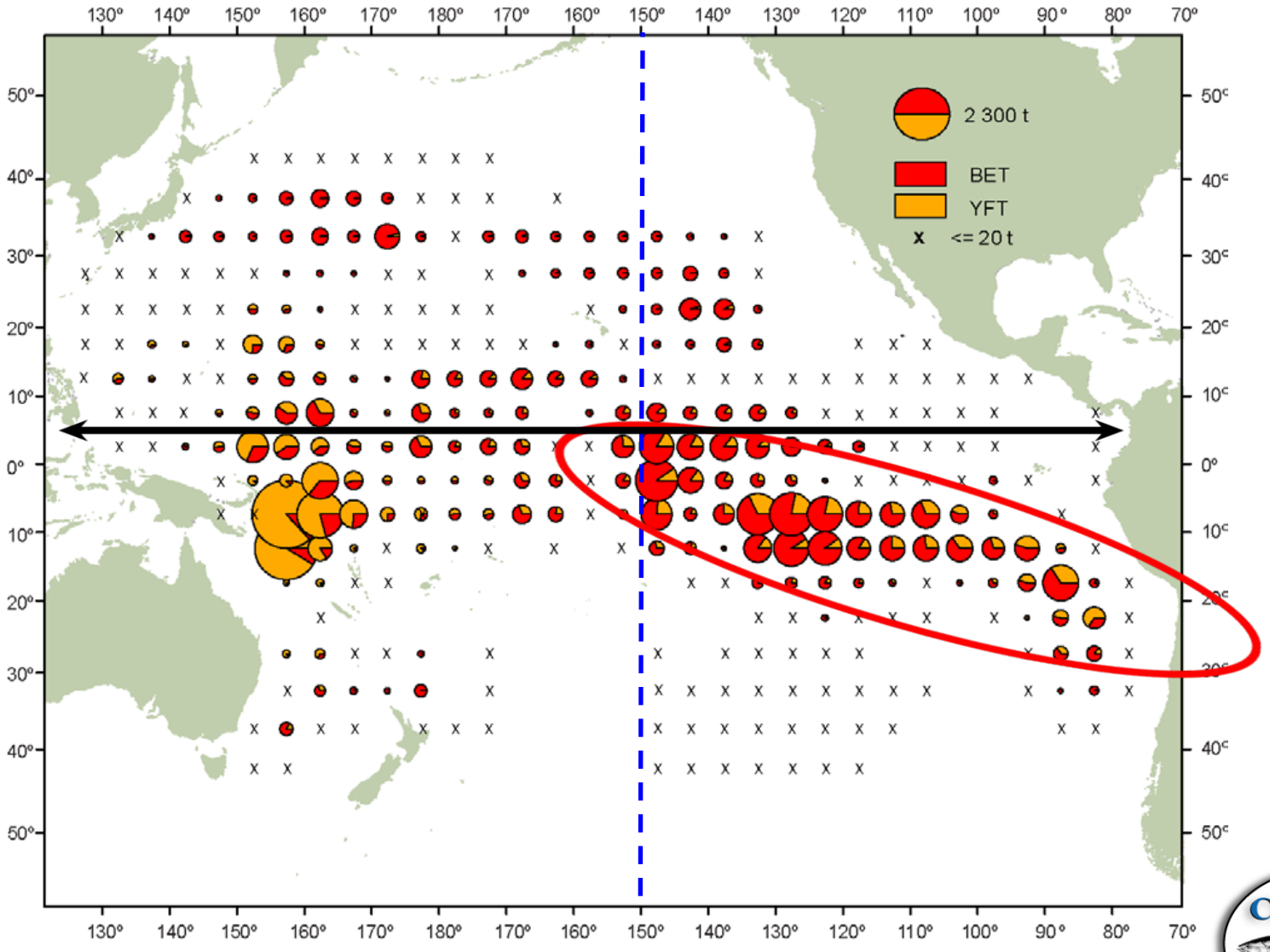


Average annual distribution of YFT PS catches, 2006-2010



Annual distribution of YFT PS catches, 2011

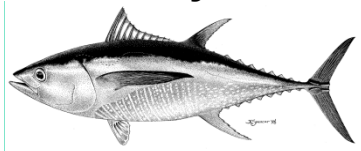
Spatial distribution of YFT LL catches



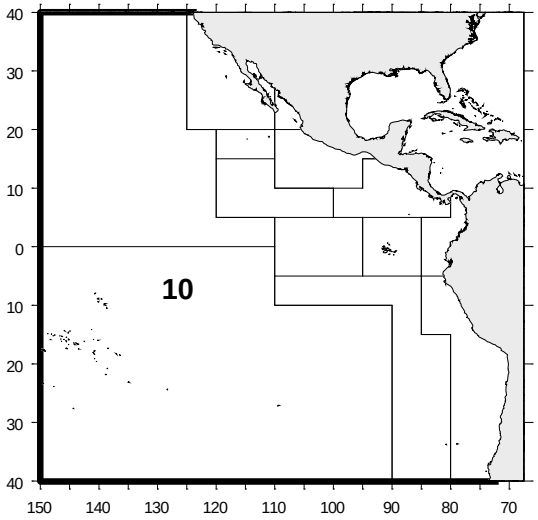
Average annual LL catch, 2006-2010

Fishery data

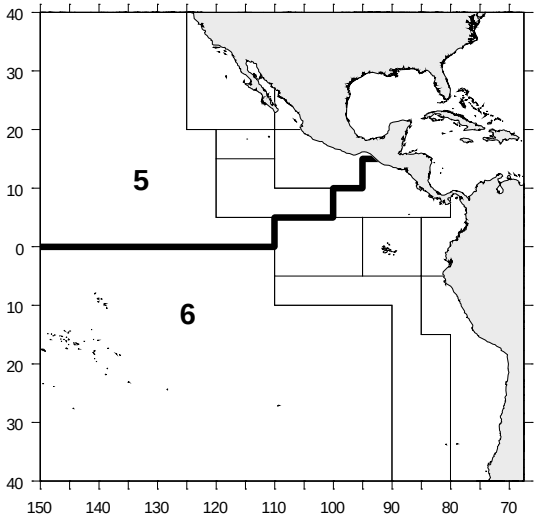
YFT fishery definitions



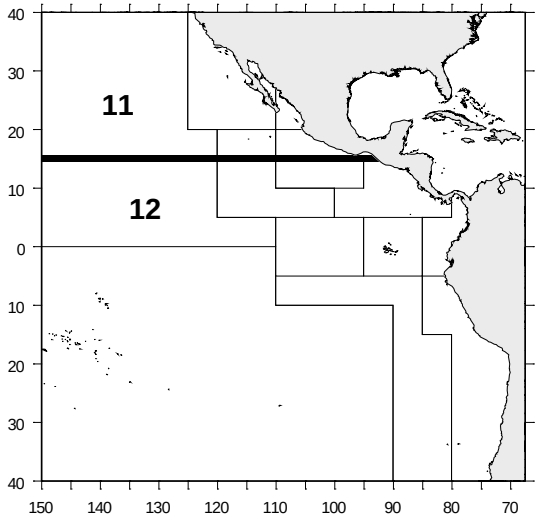
Baitboat **(LP)**



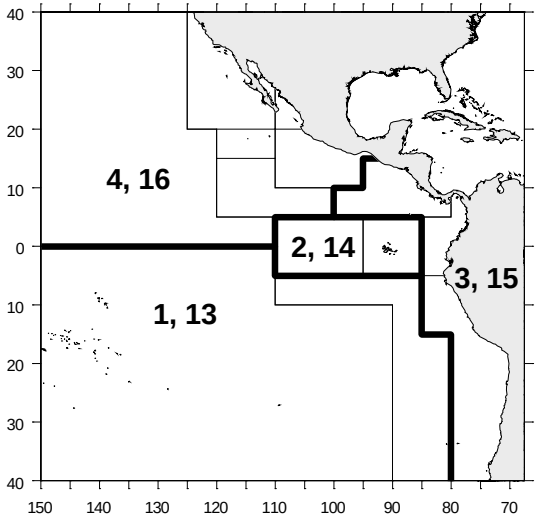
Unassociated **(NOA)**



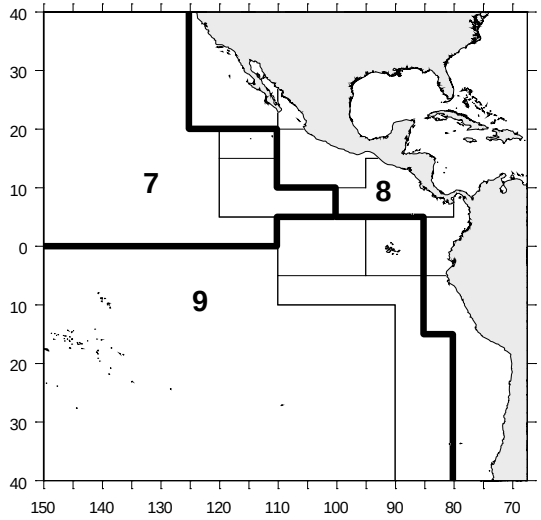
Longline **(LL)**



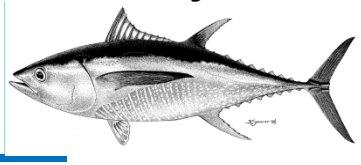
Floating Objects **(OBJ)**



Dolphin **(DEL)**



YFT fishery definitions



DOCUMENT YFT-01-02

EXPLORING LARGE-SCALE PATTERNS IN YELLOWFIN TUNA DATA FROM DOLPHIN SETS IN THE EASTERN PACIFIC OCEAN PURSE-SEINE FISHERY

Cleridy E. Lennert-Cody, Mark N. Maunder, Alexandre Aires-da-Silva

DOCUMENT YFT-01-03

POSTSTRATIFICATION OF PURSE-SEINE PORT-SAMPLING DATA FROM DOLPHIN SETS

Cleridy E. Lennert-Cody, Mark N. Maunder, Alexandre Aires-da-Silva, Alejandro Pérez, JoyDeLee Marrow

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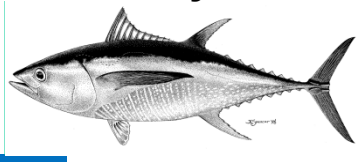
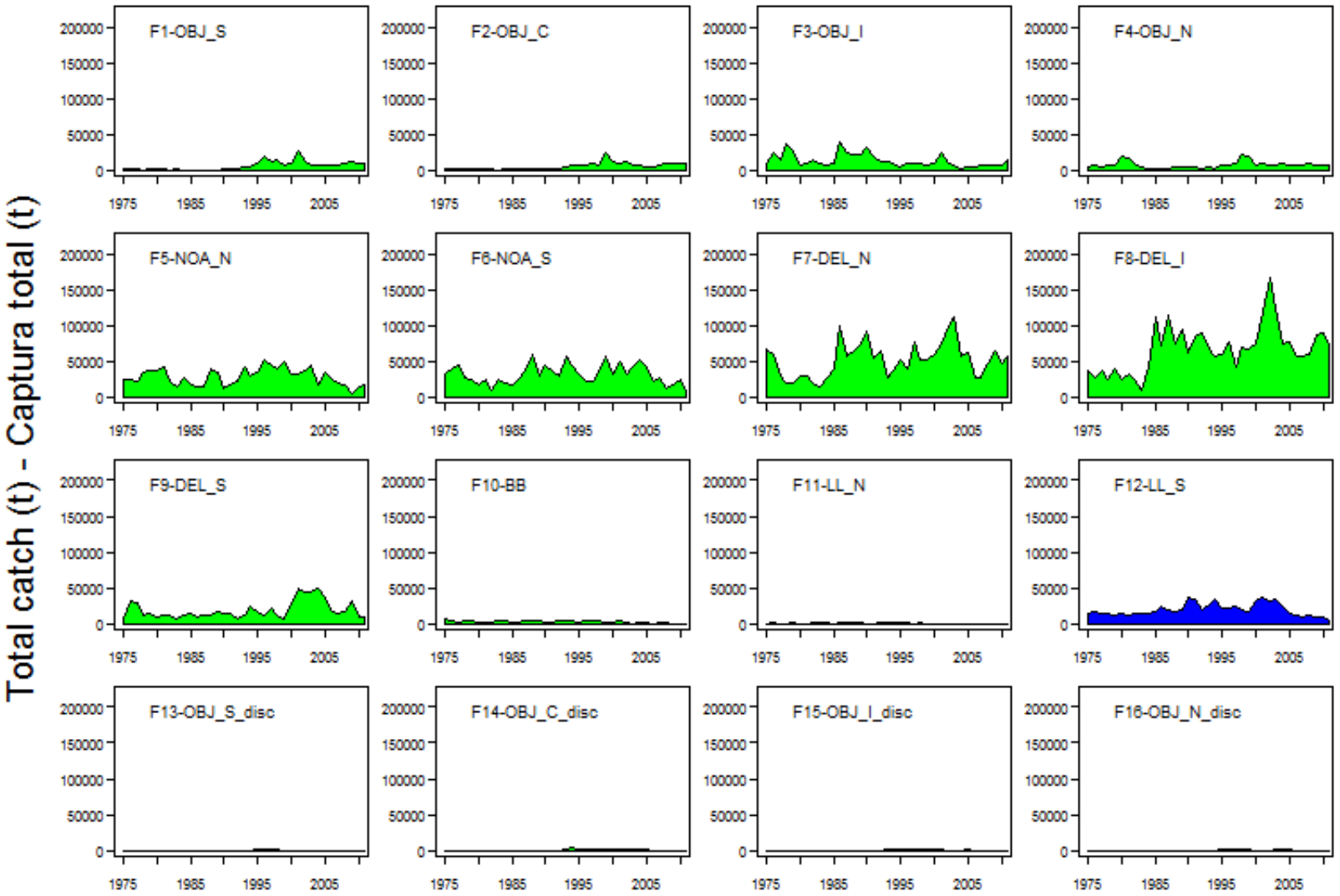
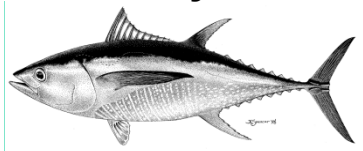
Annual YFT catches by fishery

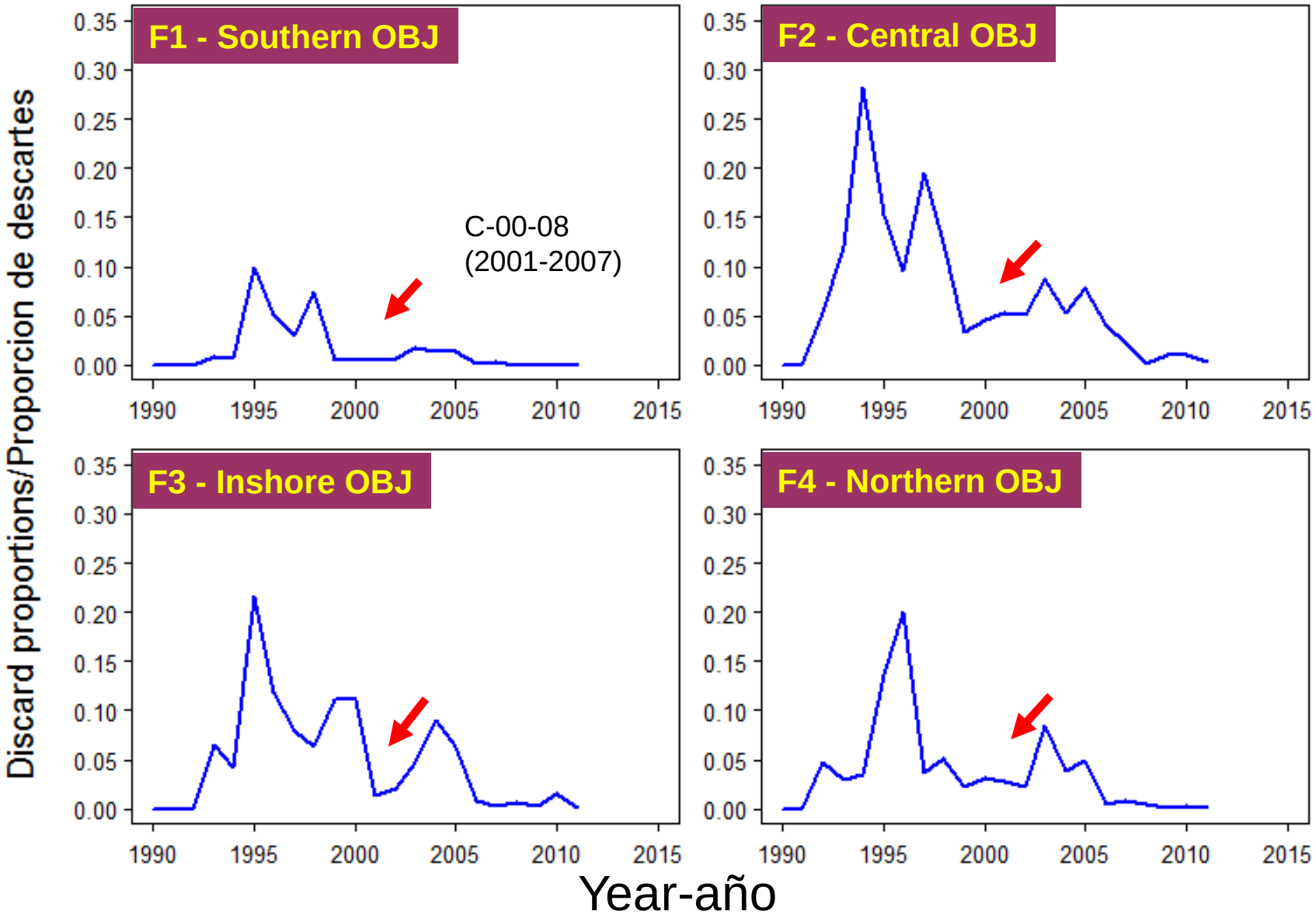




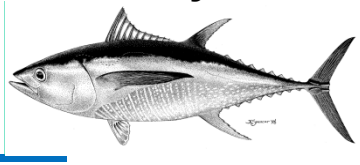
Fishery data

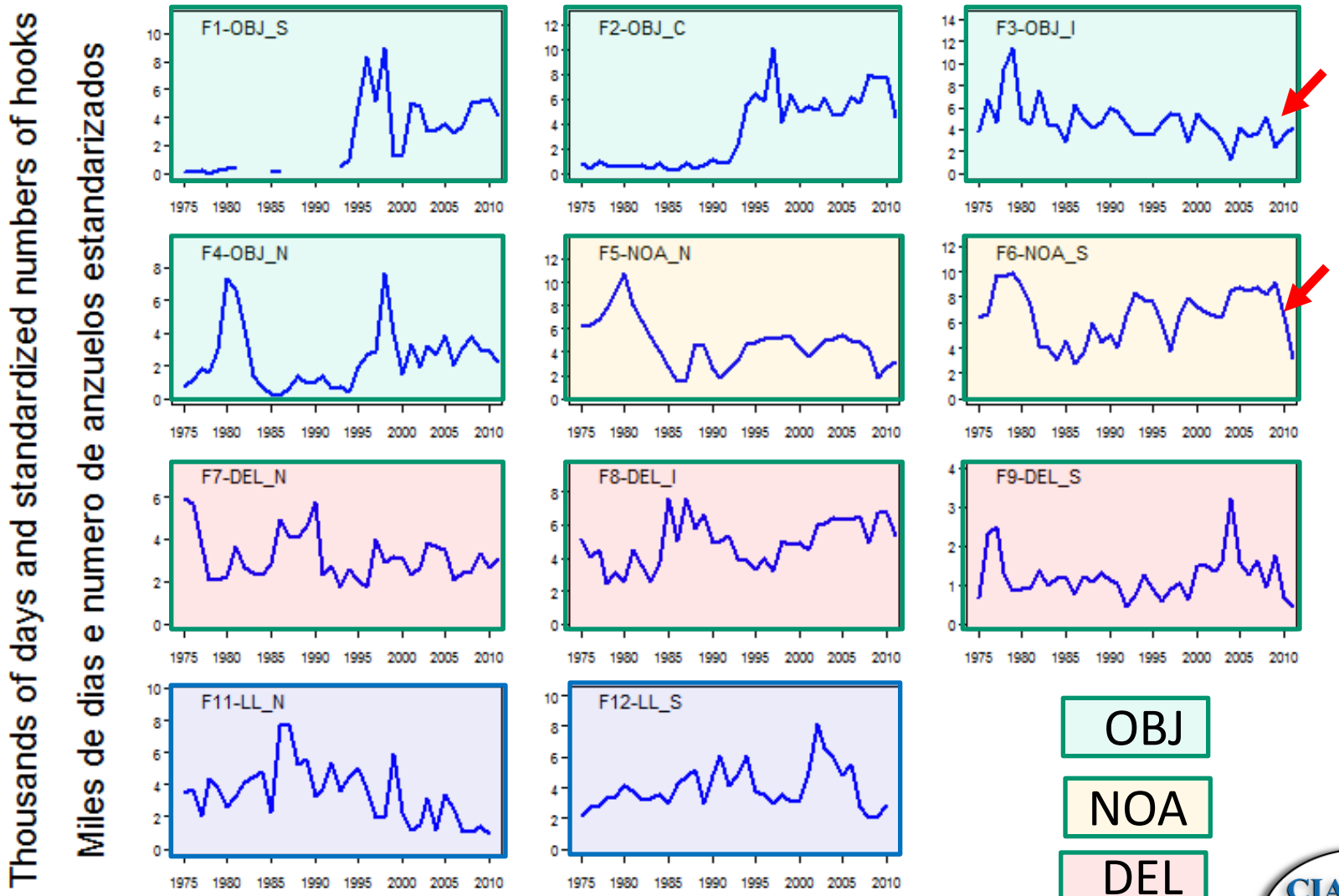
YFT discards





Fishing effort





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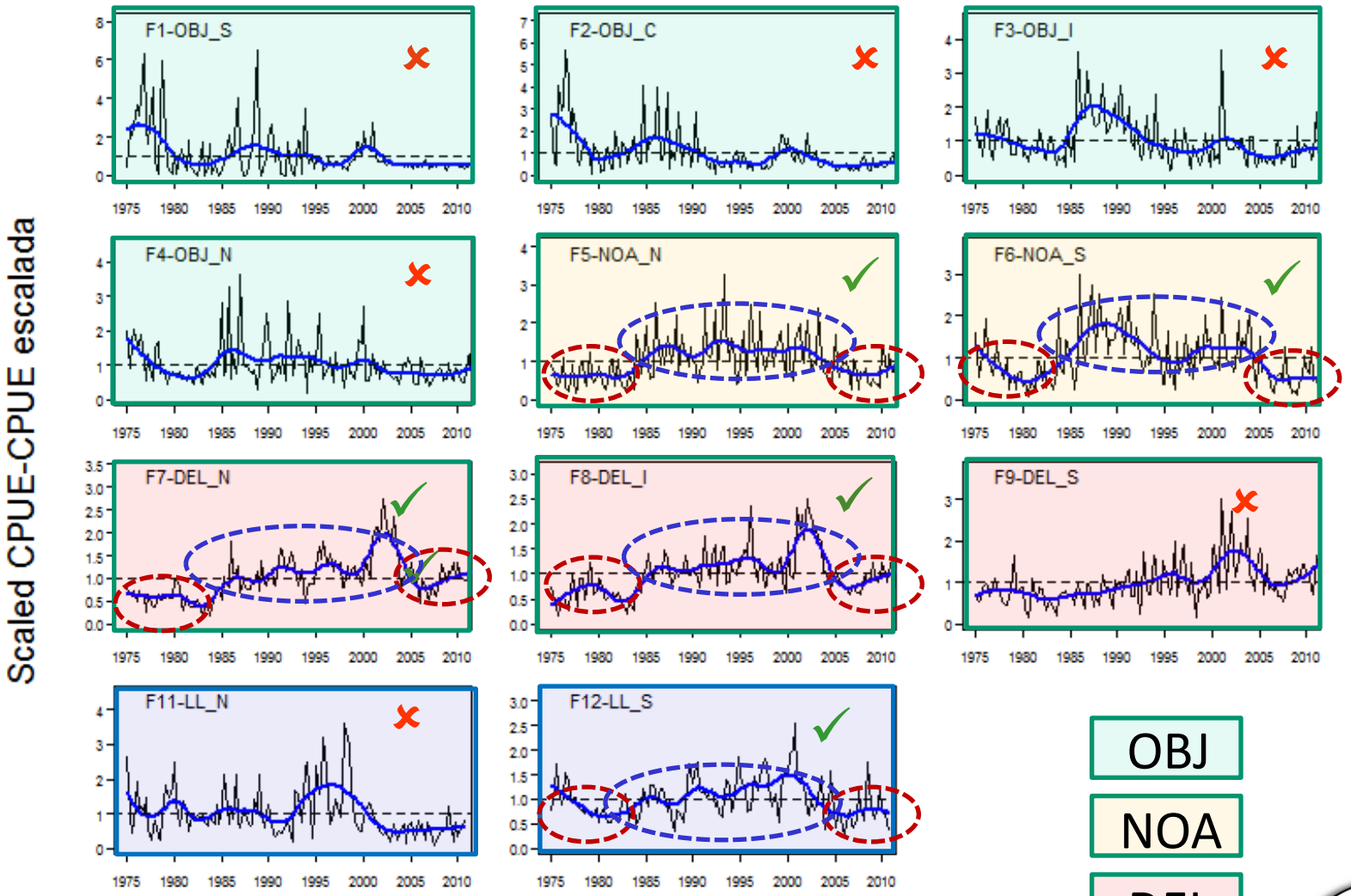
Fishery data

YFT catch-per-unit effort (CPUE)



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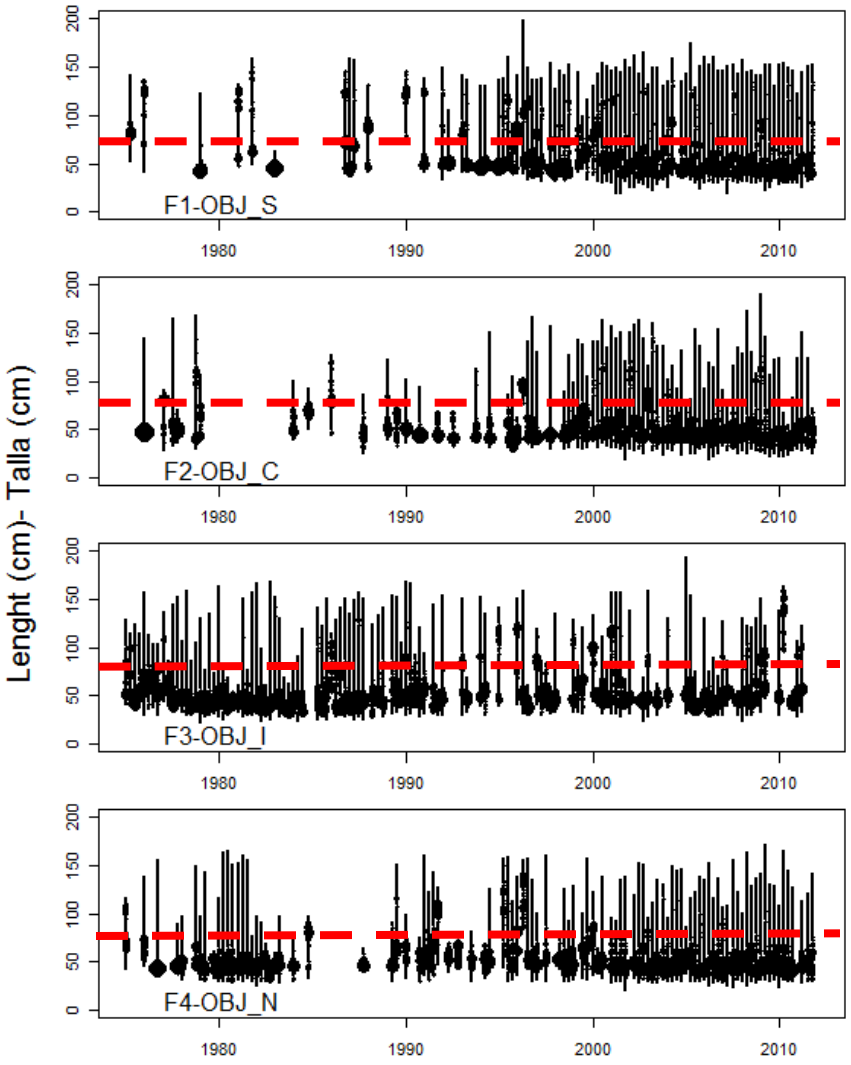
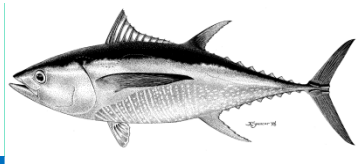
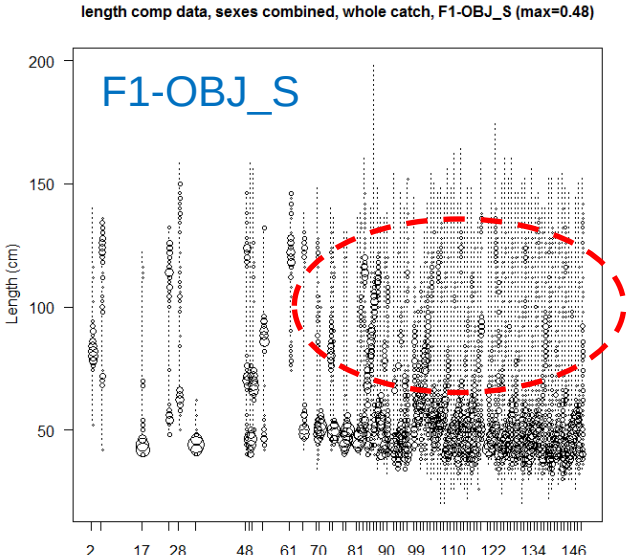
YFT size compositions – OBJ fisheries

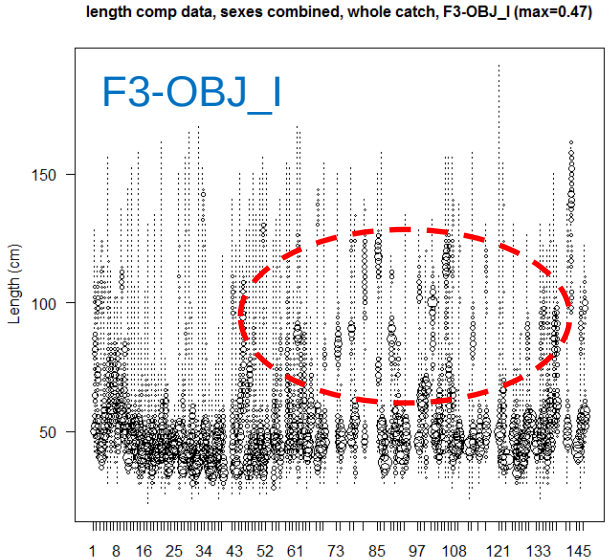


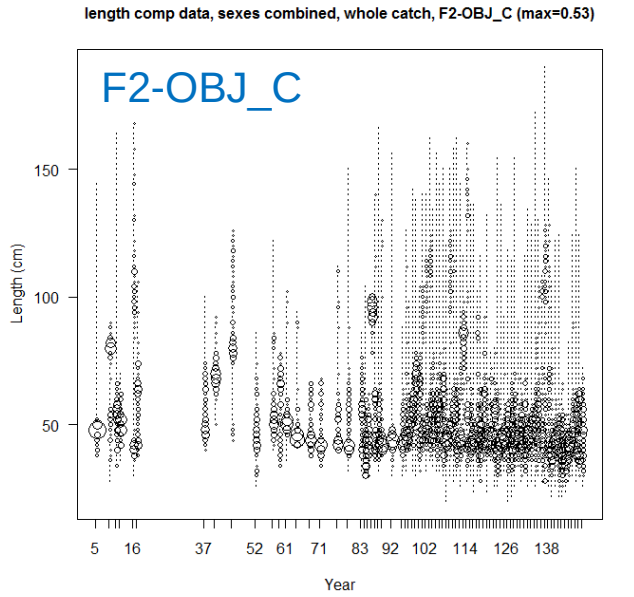
Small

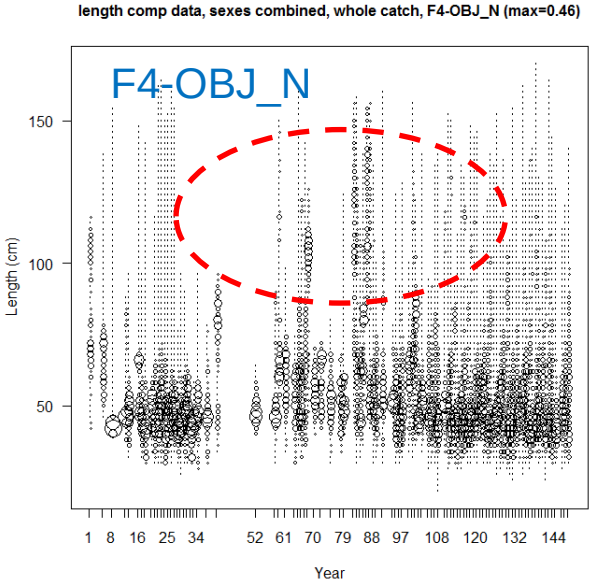
OBJ time-varying selectivity?









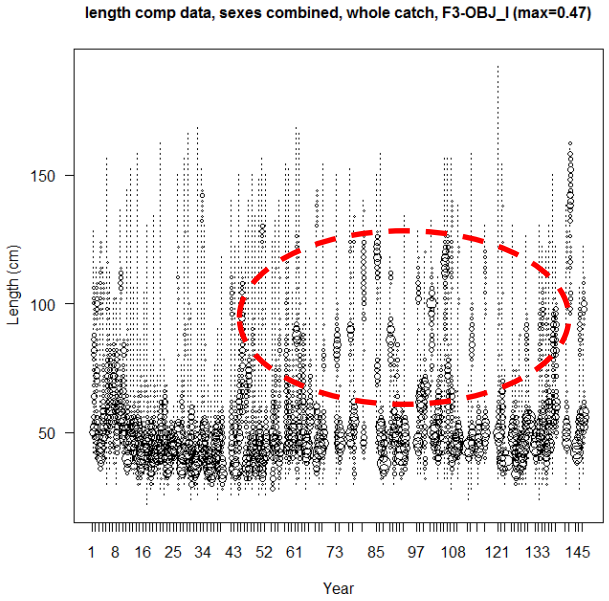


OBJ time-varying selectivity?

DOCUMENT YFT-01-06

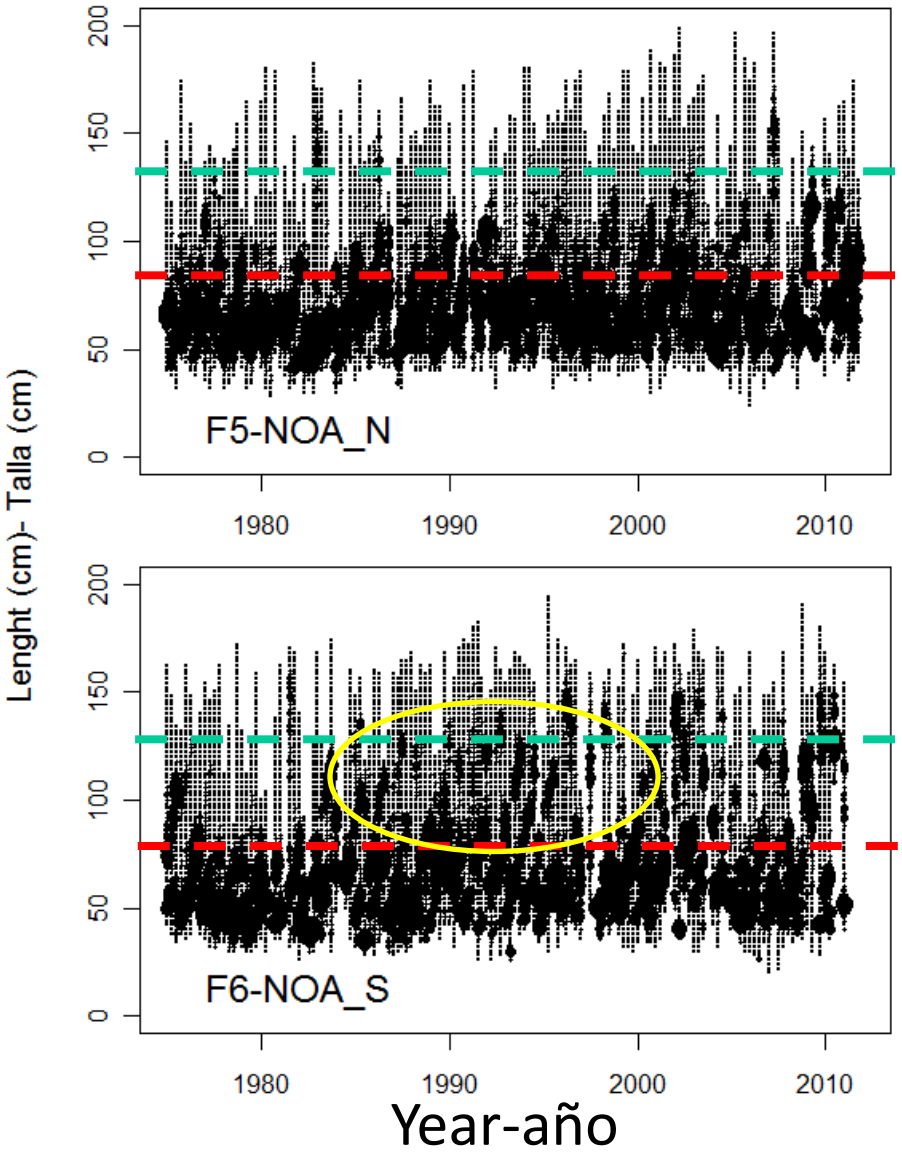
AN EXPLORATION OF ALTERNATIVE METHODS TO DEAL WITH TIME-VARYING SELECTIVITY IN THE STOCK ASSESSMENT OF YELLOWFIN TUNA IN THE EASTERN PACIFIC OCEAN

Alexandre Aires-da-Silva and Mark Maunder



Fishery data

YFT size compositions – NOA fisheries



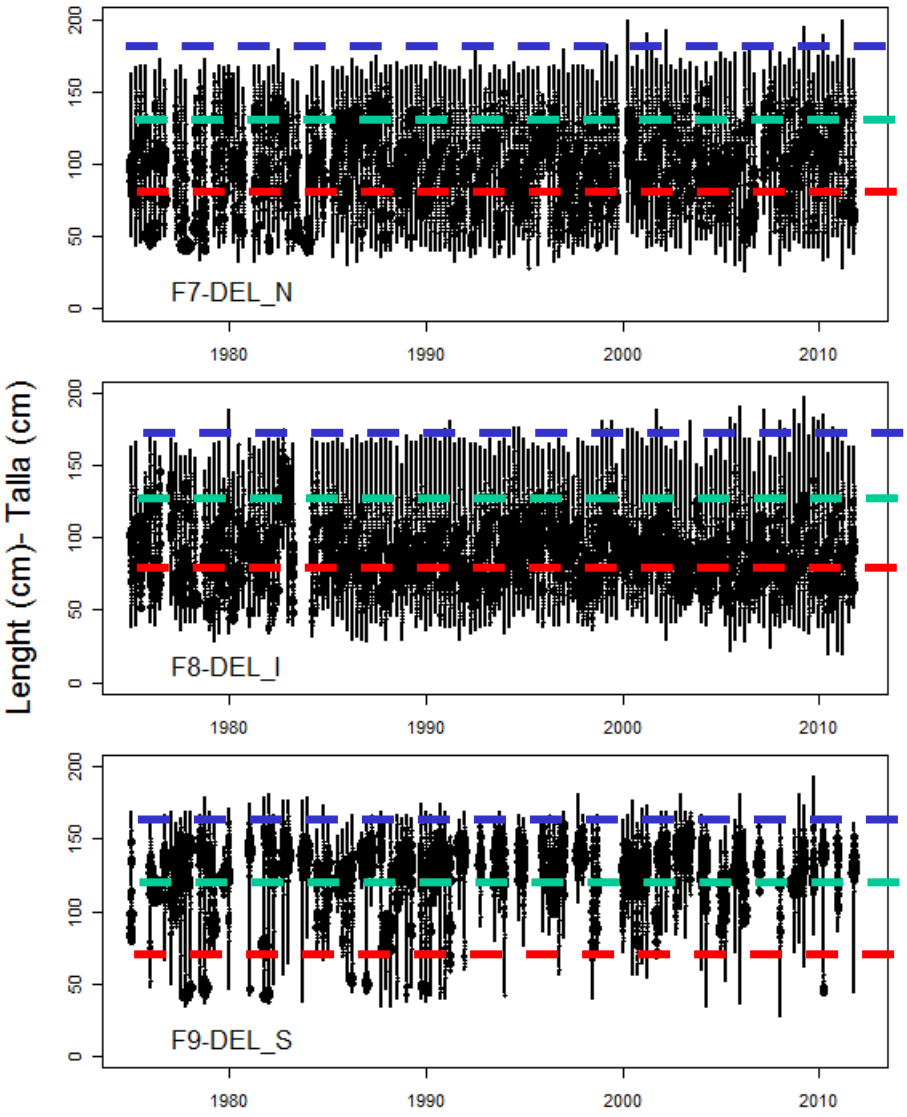
Medium

Small

Medium

Small

YFT size compositions – DEL fisheries

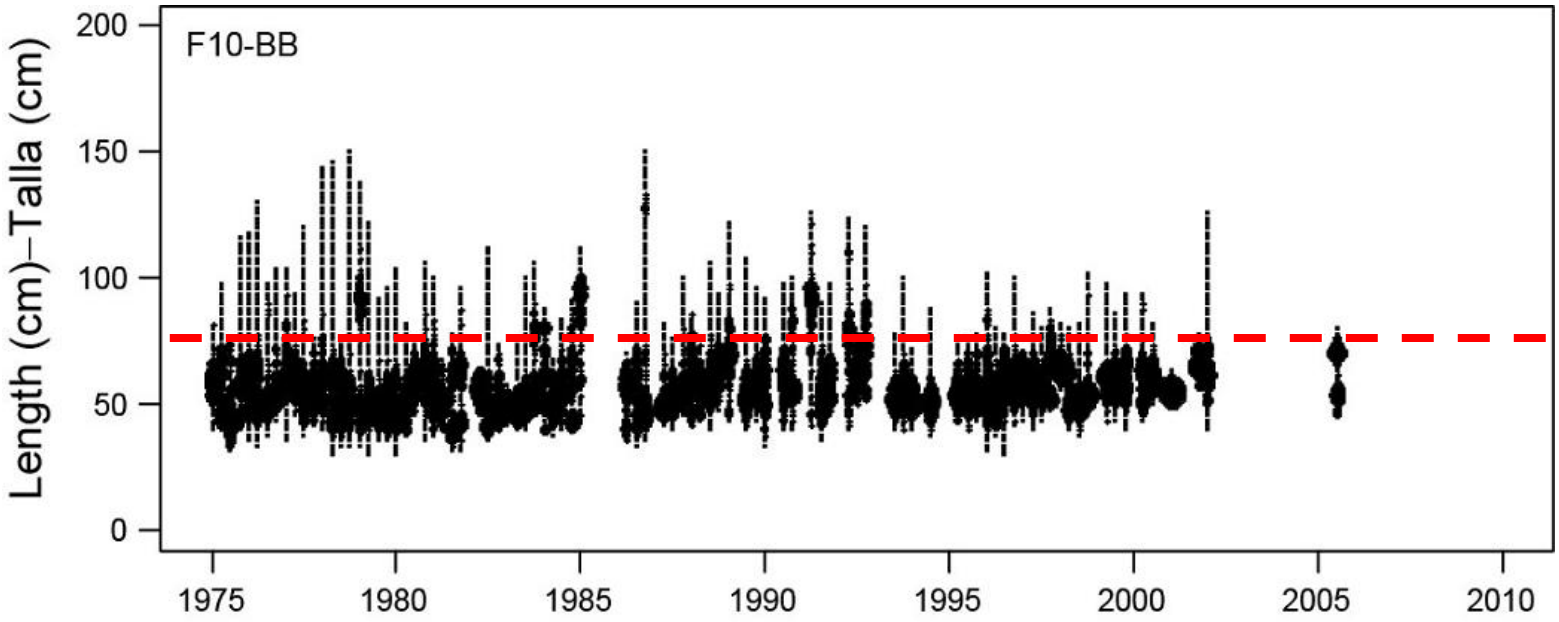


Large

Medium

Small

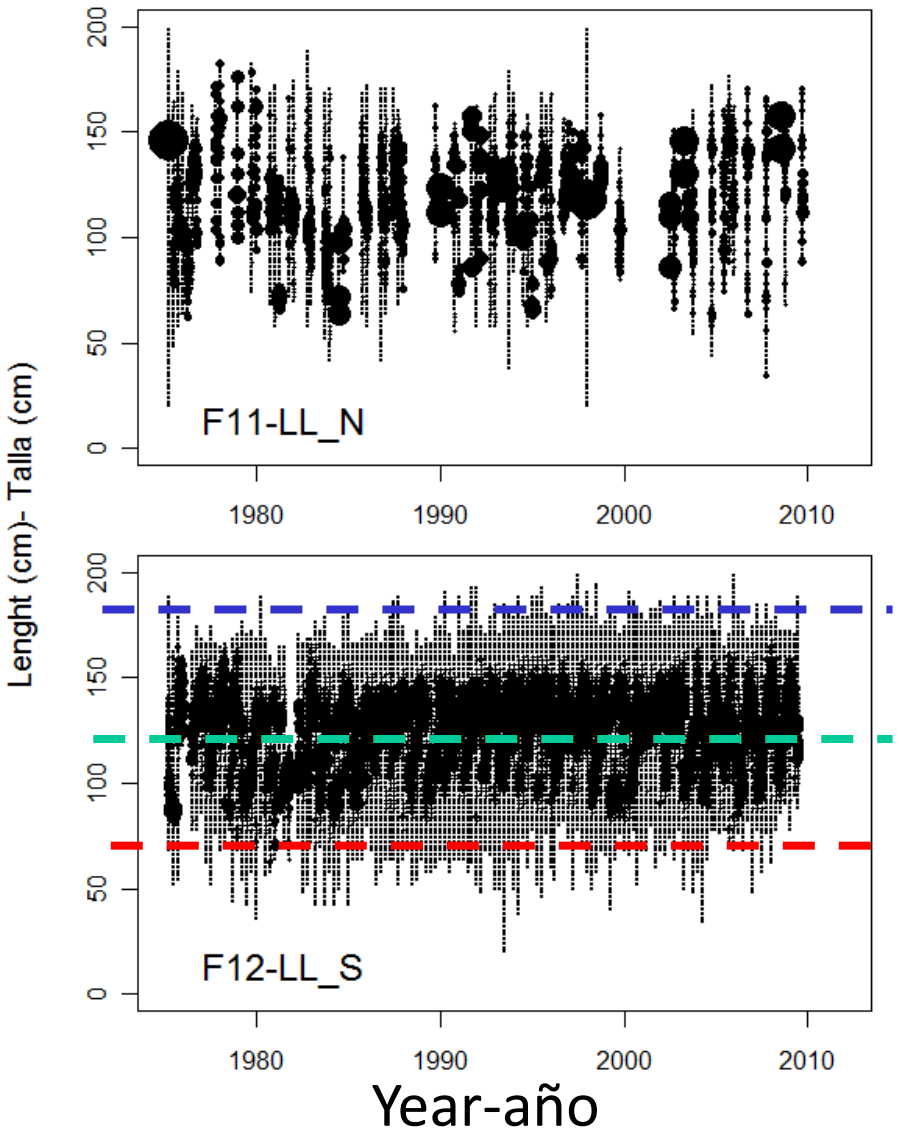
YFT size compositions – LP fishery



Small

Year-año

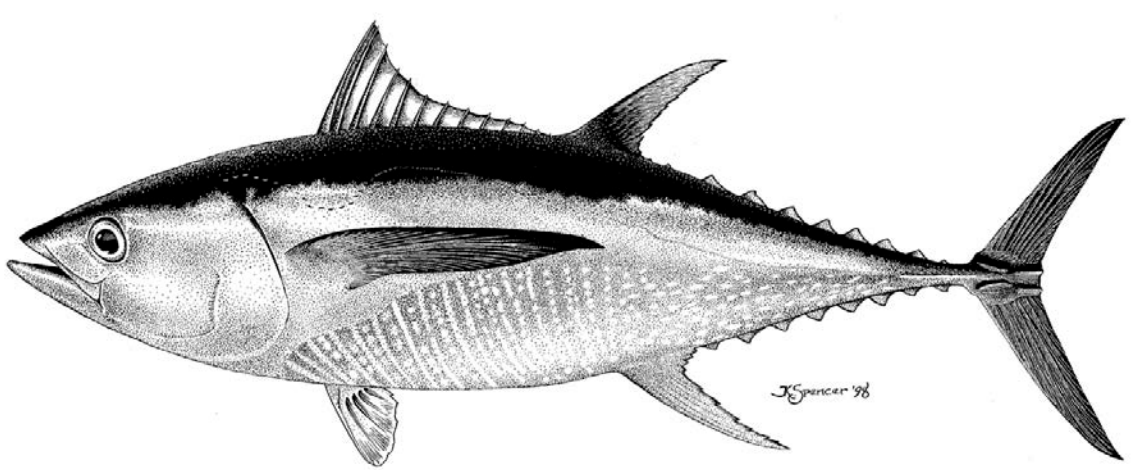
YFT size compositions – LL fisheries



Large

Medium

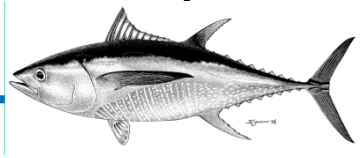
Small

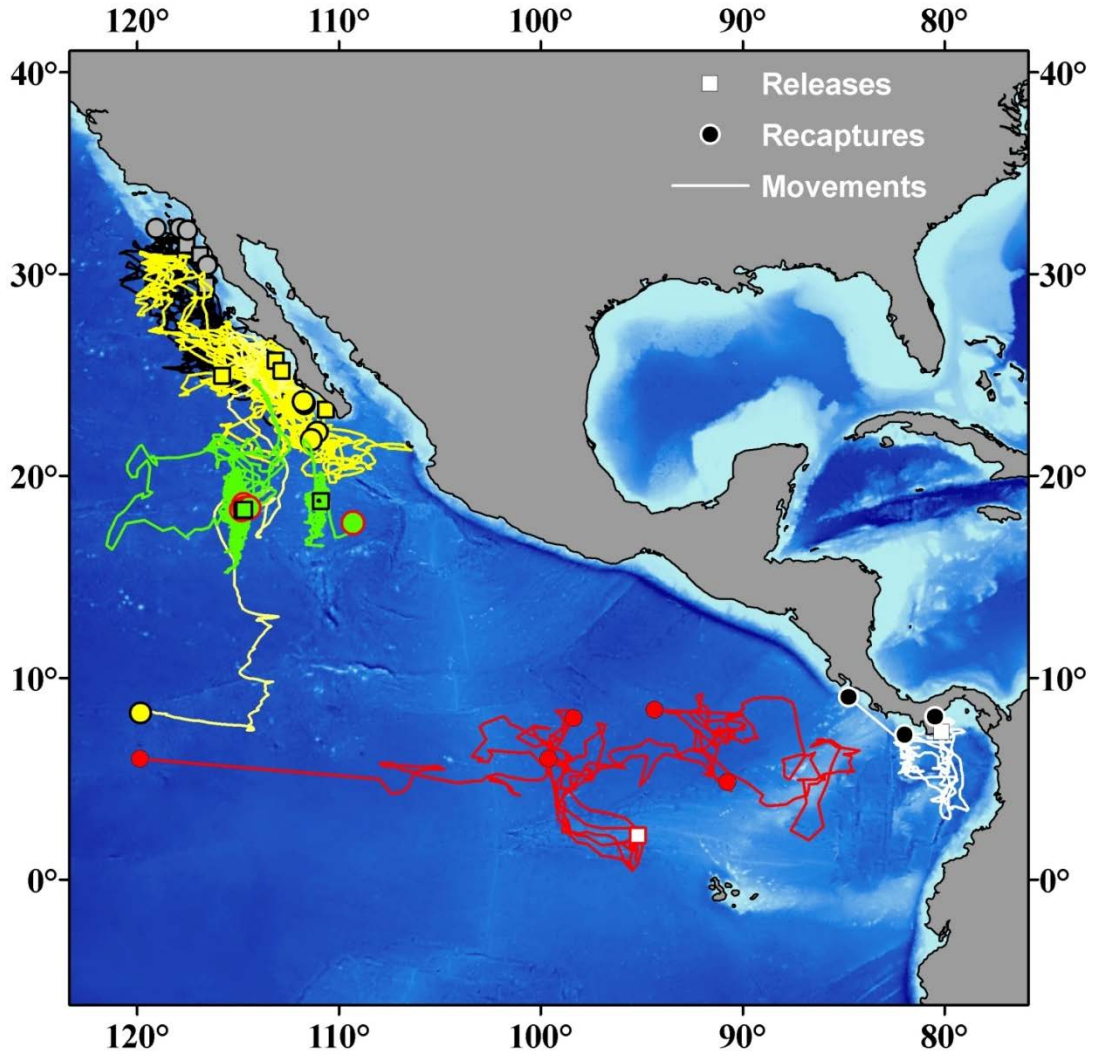


Model assumptions (base case)

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

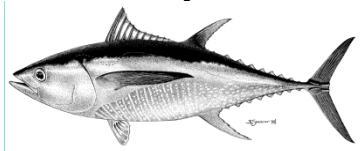
YFT movement in EPO





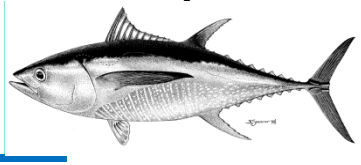
Most Probable Tracks, from Archival Tags, for the 5 Longest at Liberty Yellowfin Tuna Released in Each of 5 Areas in the eastern Pacific Ocean

YFT stock structure assumptions



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

YFT 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)

DOCUMENT YFT-01-05 (DRAFT)

A REVIEW AND EVALUATION OF RECRUITMENT AND THE STOCK-RECRUITMENT RELATIONSHIP FOR THE ASSESSMENT AND MANAGEMENT OF YELLOWFIN TUNA IN THE EASTERN PACIFIC OCEAN

Mark N. Maunder and Alexandre Aires-da-Silva

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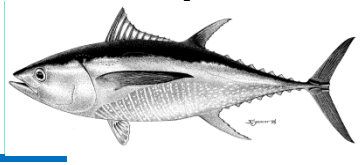
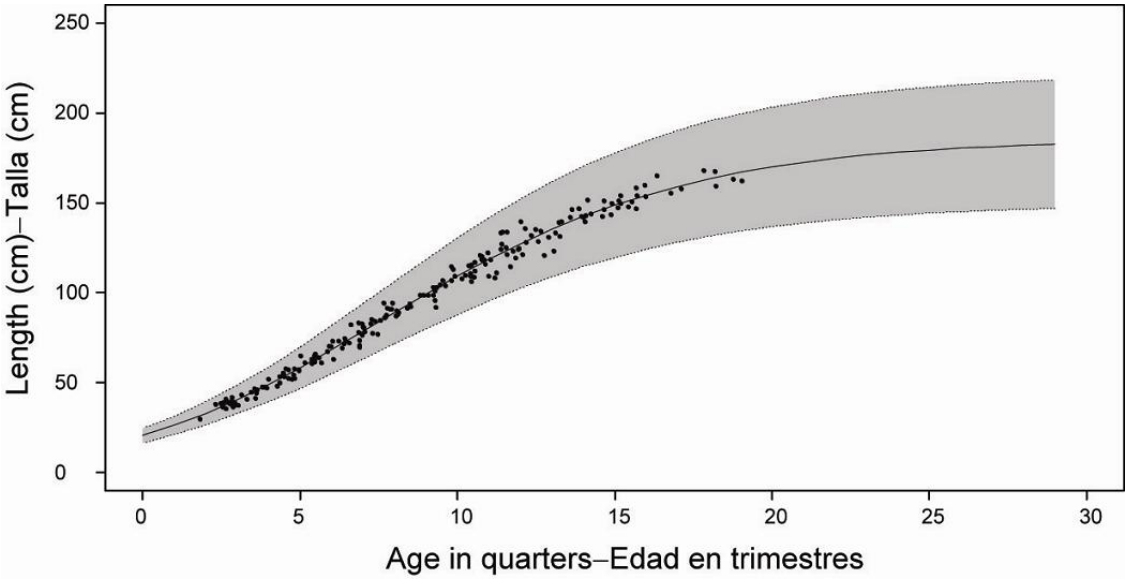
YFT age and growth

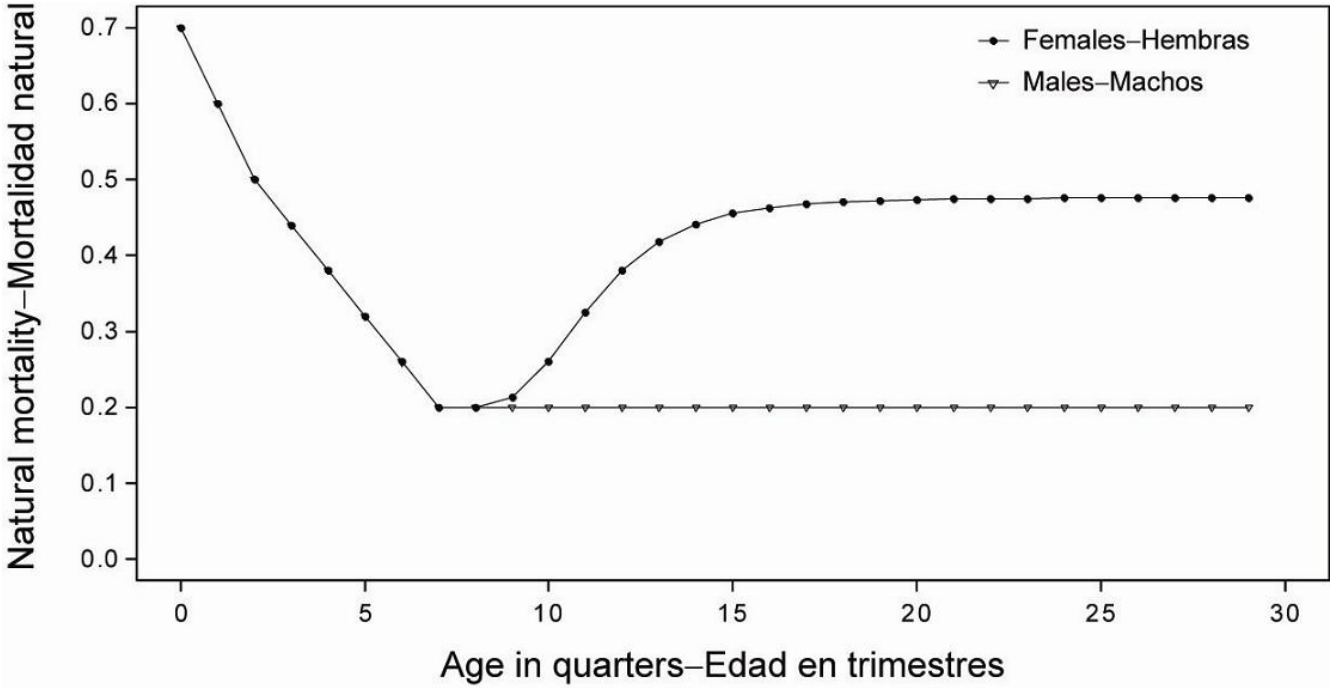


- Richards growth curve
  - Growth parameters fixed (Maunder and Aires-da-Silva, 2009)
  - Variability of length-at-age fixed, CV of L@A linear f(age)

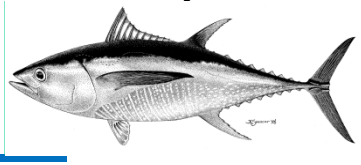


  - See **Document YFT-01-04** for new growth estimates from integrated age-at-length and tagging data

YFT natural mortality (*M*)



YFT natural mortality (*M*)

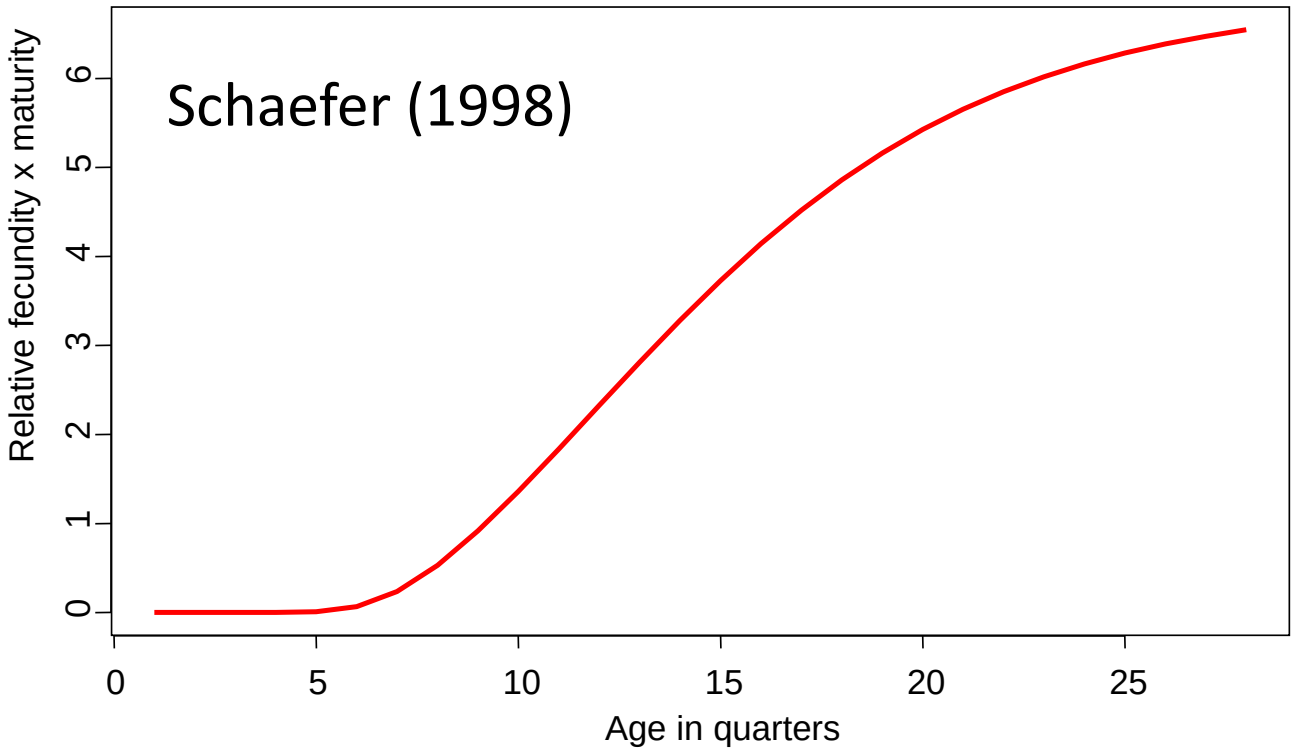


DOCUMENT YFT-01-07 (DRAFT)

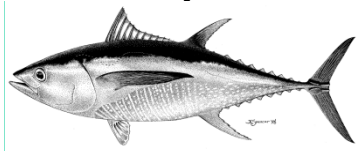
A REVIEW AND EVALUATION OF NATURAL MORTALITY FOR THE ASSESSMENT AND MANAGEMENT OF YELLOWFIN TUNA IN THE EASTERN PACIFIC OCEAN

Mark N. Maunder and Alex Aires-da-Silva

YFT relative fecundity



= Percent mature * Batch fecundity * spawning frequency



Fixed parameters

- Steepness (*h*) of S-R relationship (*h*=1)
- Rsigma (CV=0.6)
- Mean length at age
- Params of a linear model relating the CV of L@A to age
- Sex ratio at age 0 (=0.5)
- Sex and age-specific natural mortality-rates (*M*)
- Age-specific fecundity at age
- CV of LL-S CPUE (CV=0.2)
- Selectivity curves for discard fisheries

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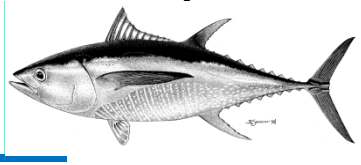
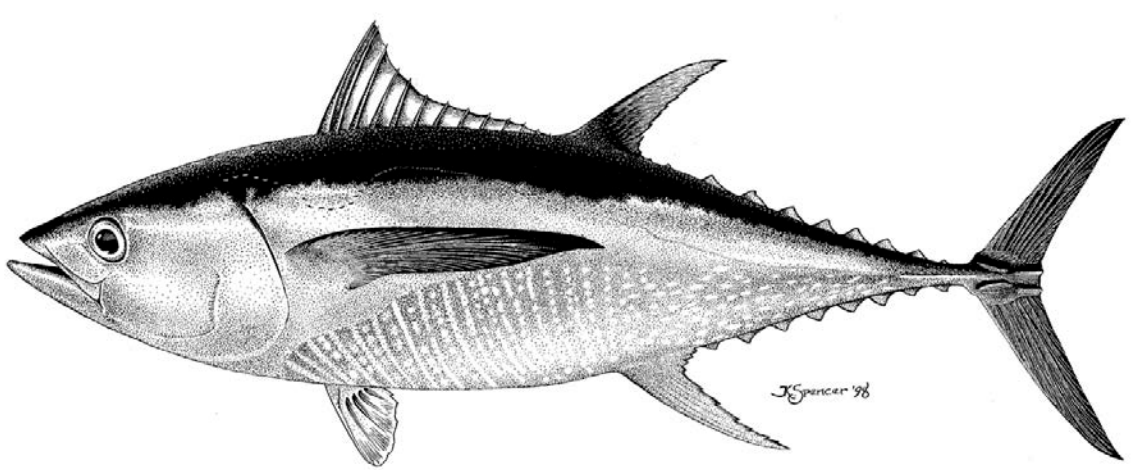
Estimated parameters



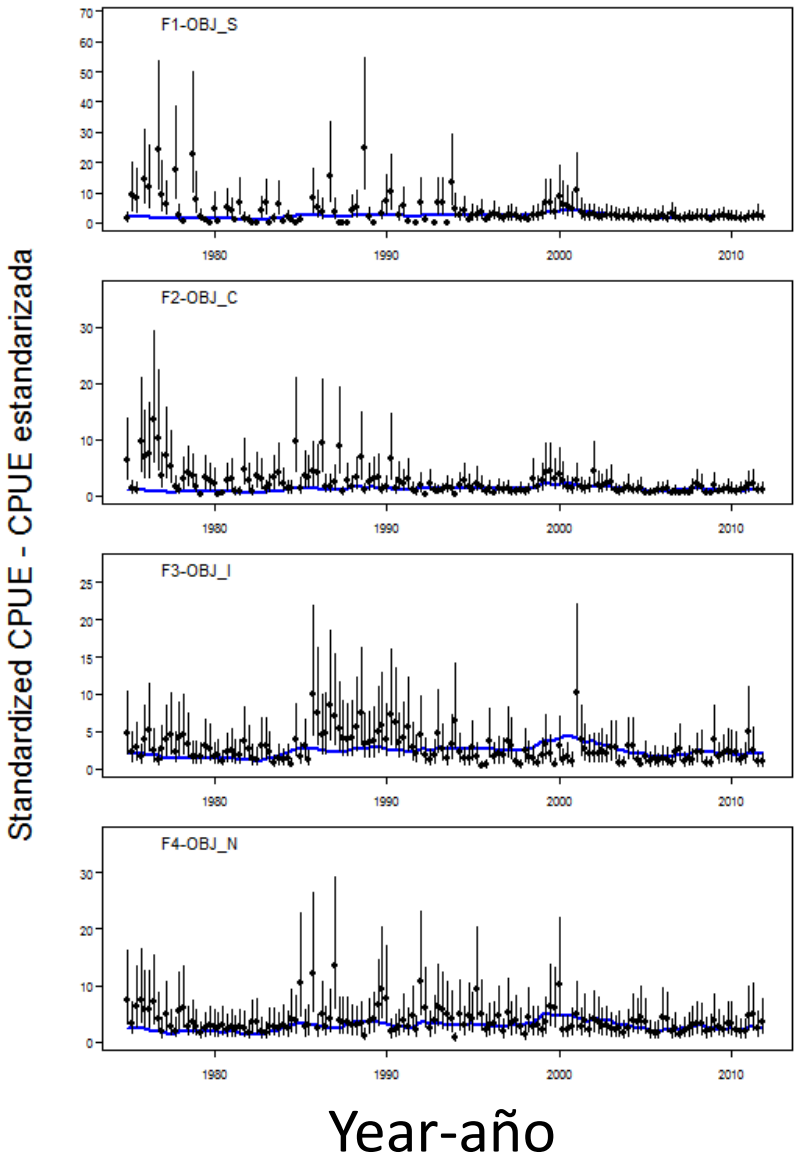
- Recruitment in every quarter from 1975 to 2012 (average recruitment and temporal recruitment anomalies)
- Catchability coefficients for the 5 CPUE indices (NOA-N, NOA-S, DEL-N, DEL-I, LL-S)
- CV for 4 CPUE indices (NOA, DEL)
- Selectivity curves for 11 of the 16 fisheries (DEL-S mirrors LL-S)
- Logistic selectivity for LL-S and DEL-S, and dome-shape for all other fisheries (except discards)
- Initial population size and age-structure (recruitment offset, initial F, deviates for ages 1 to 15 quarters)



Results (base case)

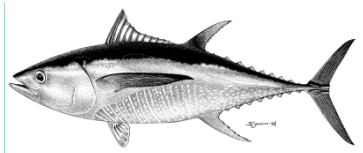
- Model fits (CPUE and size compositions)
- Fishing mortality
- Selectivity
- Recruitment
- Biomass

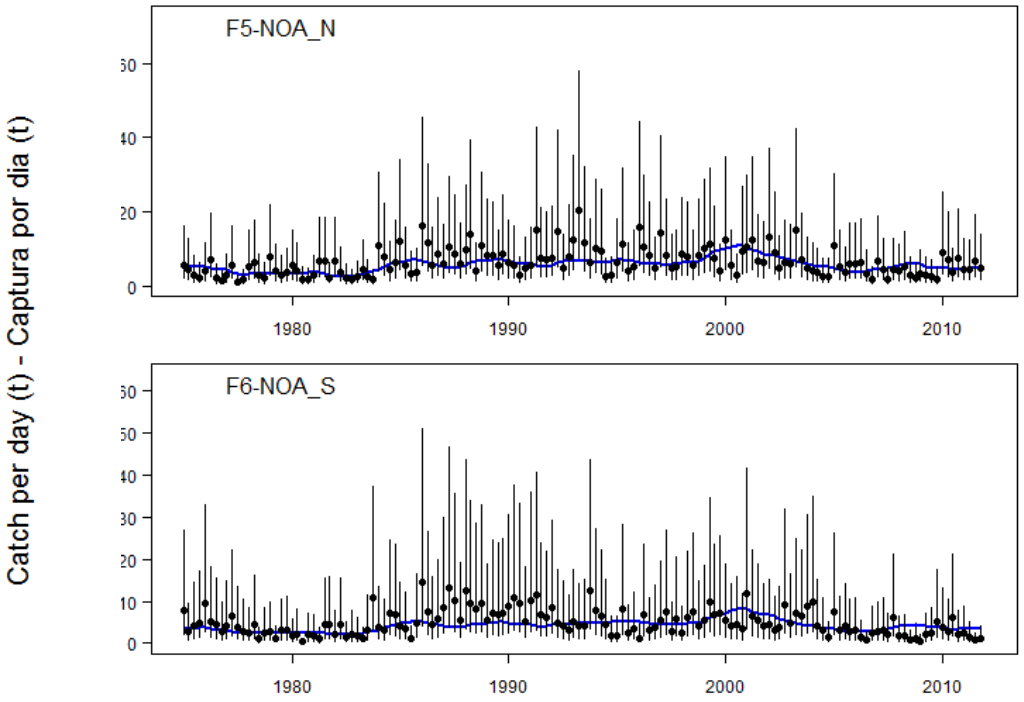
Fit to CPUE – OBJ fisheries



Fishery	r.m.s.e.	input	Used
F1-OBJ_S	0.35	estimated	No
F2-OBJ_C	0.41	estimated	No
F3-OBJ_I	0.69	estimated	No
F4-OBJ_N	0.41	estimated	No
F5-NOA_N	0.53	estimated	Yes
F6-NOA_S	0.64	estimated	Yes
F7-DEL_N	0.38	estimated	Yes
F8-DEL_I	0.37	estimated	Yes
F9-DEL_S	0.51	estimated	No
F11-LL_N	0.75	estimated	No
F12-LL_S	**0.37**	**0.2 (FIXED)**	**Yes**

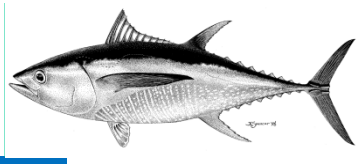
Fit to CPUE – NOA fisheries

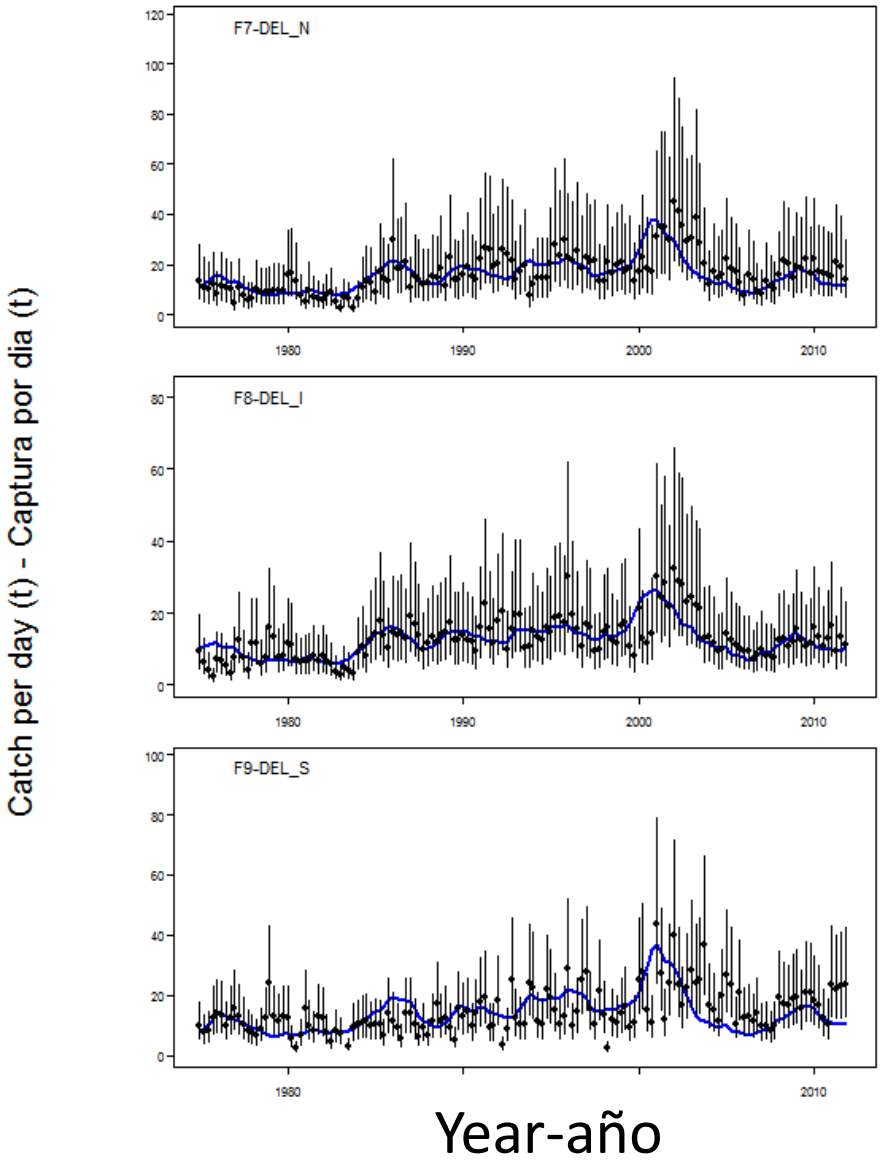




Fishery	r.m.s.e.	input	Used
F1-OBJ_S	0.35	estimated	No
F2-OBJ_C	0.41	estimated	No
F3-OBJ_I	0.69	estimated	No
F4-OBJ_N	0.41	estimated	No
F5-NOA_N	0.53	estimated	Yes
F6-NOA_S	0.64	estimated	Yes
F7-DEL_N	0.38	estimated	Yes
F8-DEL_I	0.37	estimated	Yes
F9-DEL_S	0.51	estimated	No
F11-LL_N	0.75	estimated	No
F12-LL_S	0.37	0.2 (FIXED)	Yes

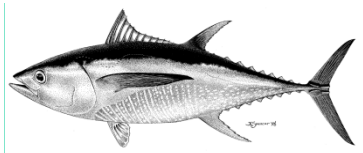
Fit to CPUE – DEL fisheries

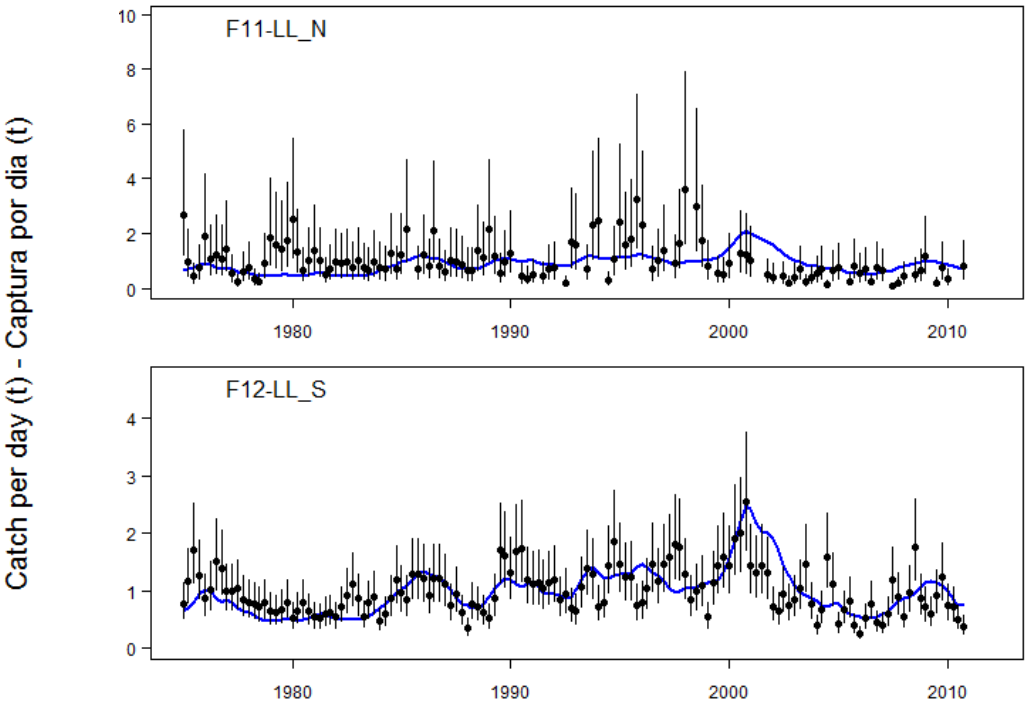




Fishery	r.m.s.e.	input	Used
F1-OBJ_S	0.35	estimated	No
F2-OBJ_C	0.41	estimated	No
F3-OBJ_I	0.69	estimated	No
F4-OBJ_N	0.41	estimated	No
F5-NOA_N	0.53	estimated	Yes
F6-NOA_S	0.64	estimated	Yes
F7-DEL_N	0.38	estimated	Yes
F8-DEL_I	0.37	estimated	Yes
F9-DEL_S	0.51	estimated	No
F11-LL_N	0.75	estimated	No
F12-LL_S	**0.37**	**0.2 (FIXED)**	**Yes**

Fit to CPUE – LL fisheries

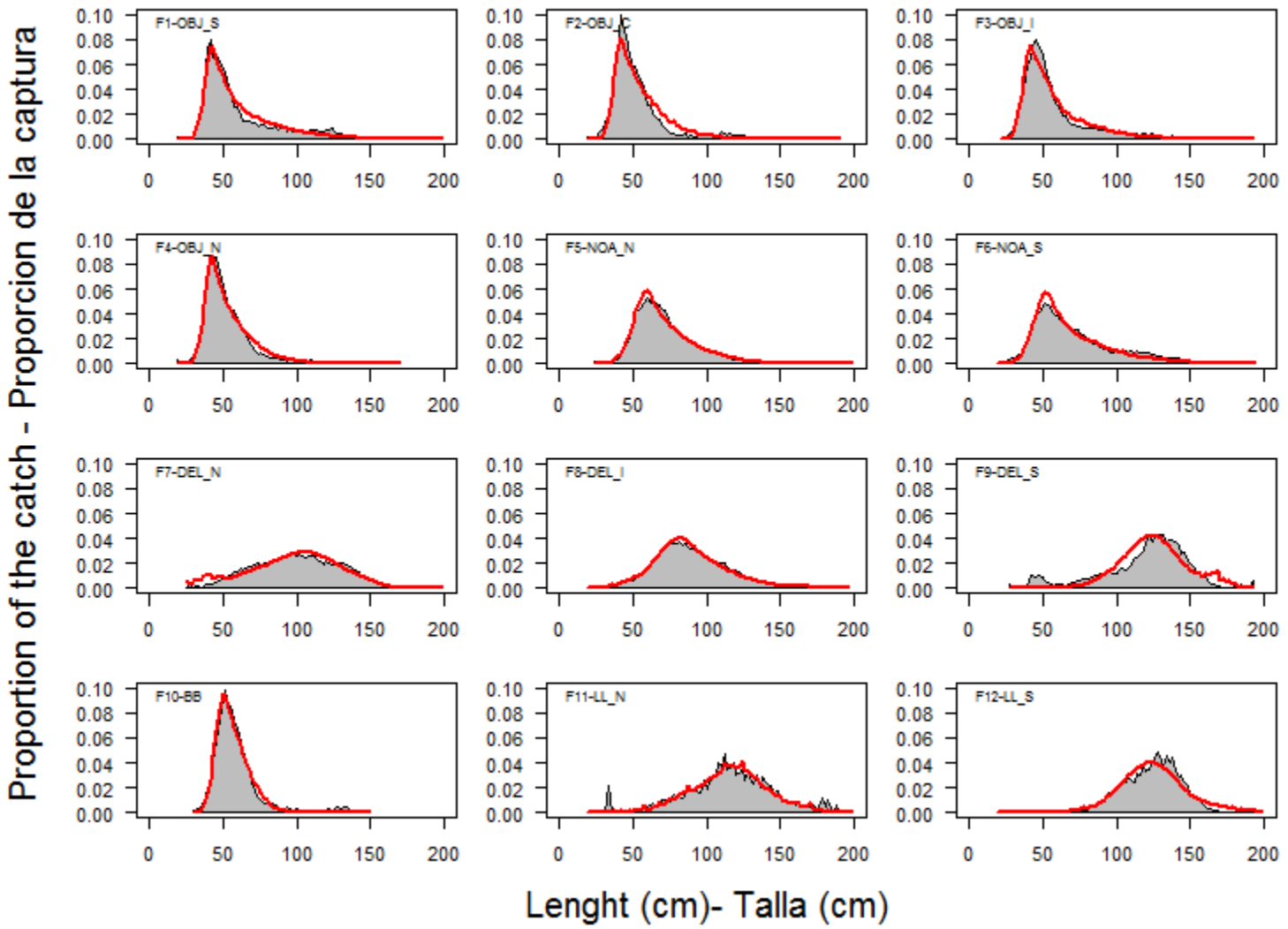




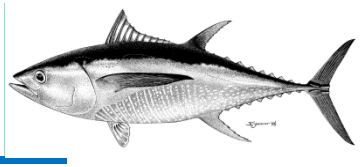
Year-año

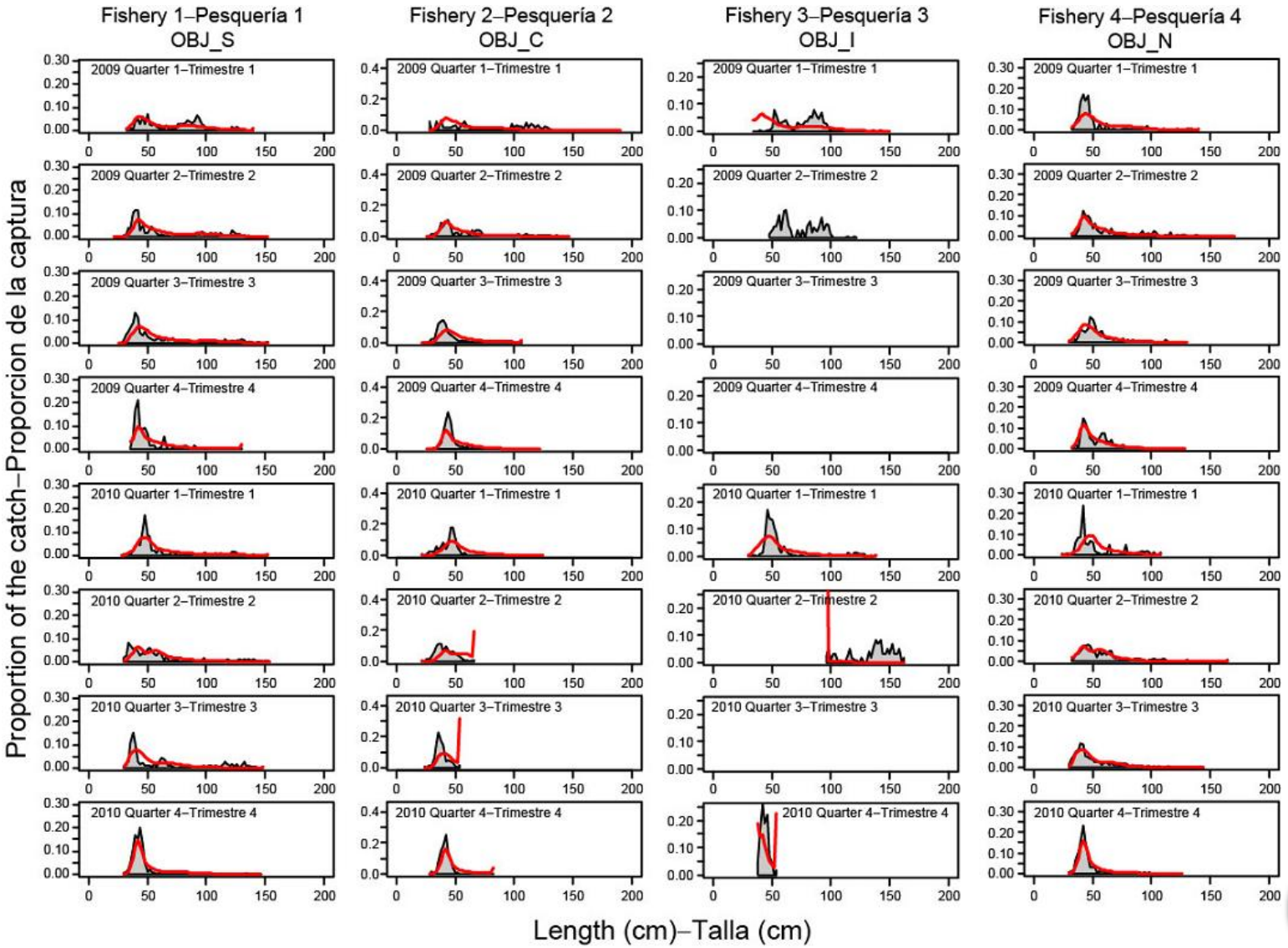
Fishery	r.m.s.e.	input	Used
F1-OBJ_S	0.35	estimated	No
F2-OBJ_C	0.41	estimated	No
F3-OBJ_I	0.69	estimated	No
F4-OBJ_N	0.41	estimated	No
F5-NOA_N	0.53	estimated	Yes
F6-NOA_S	0.64	estimated	Yes
F7-DEL_N	0.38	estimated	Yes
F8-DEL_I	0.37	estimated	Yes
F9-DEL_S	0.51	estimated	No
F11-LL_N	0.75	estimated	No
F12-LL_S	0.37	0.2 (FIXED)	Yes

Average fits to size comps.



Recent fits to size comps. - OBJ





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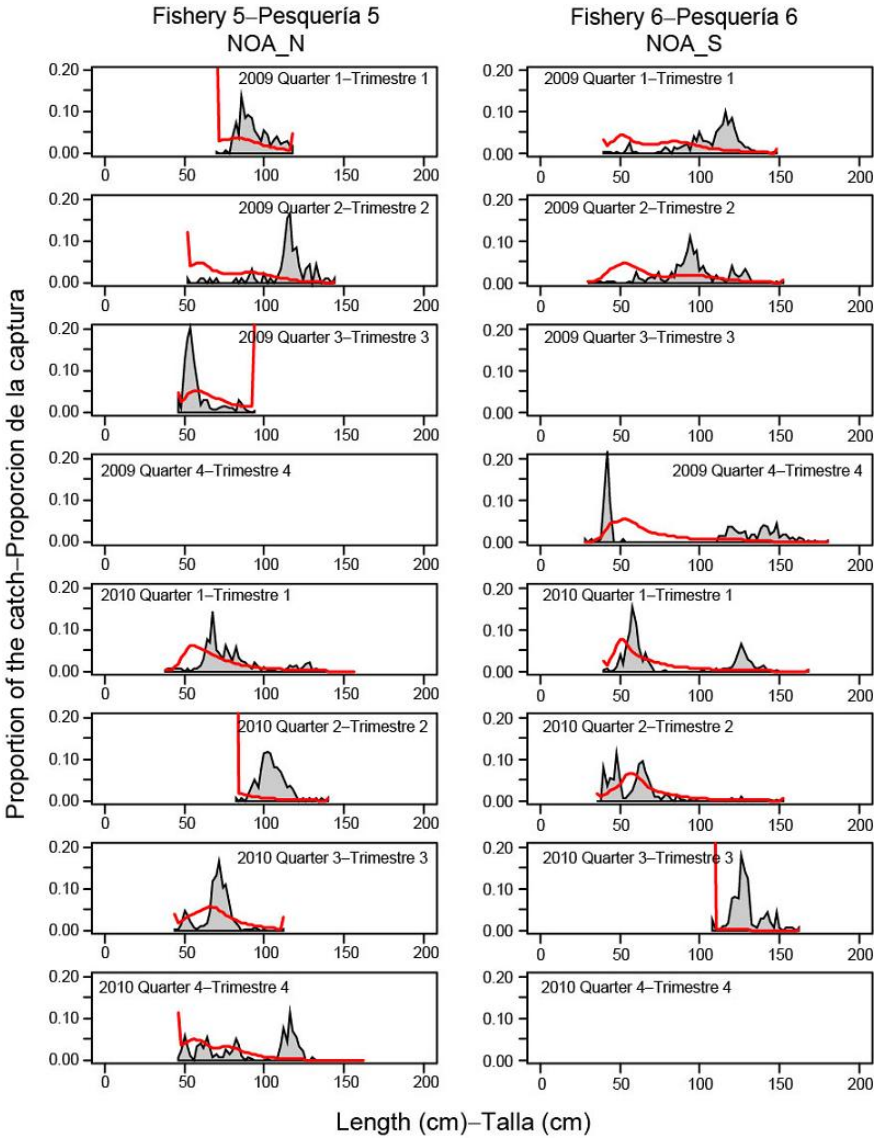
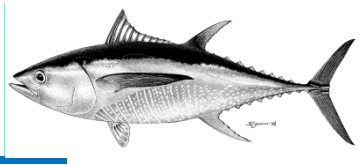
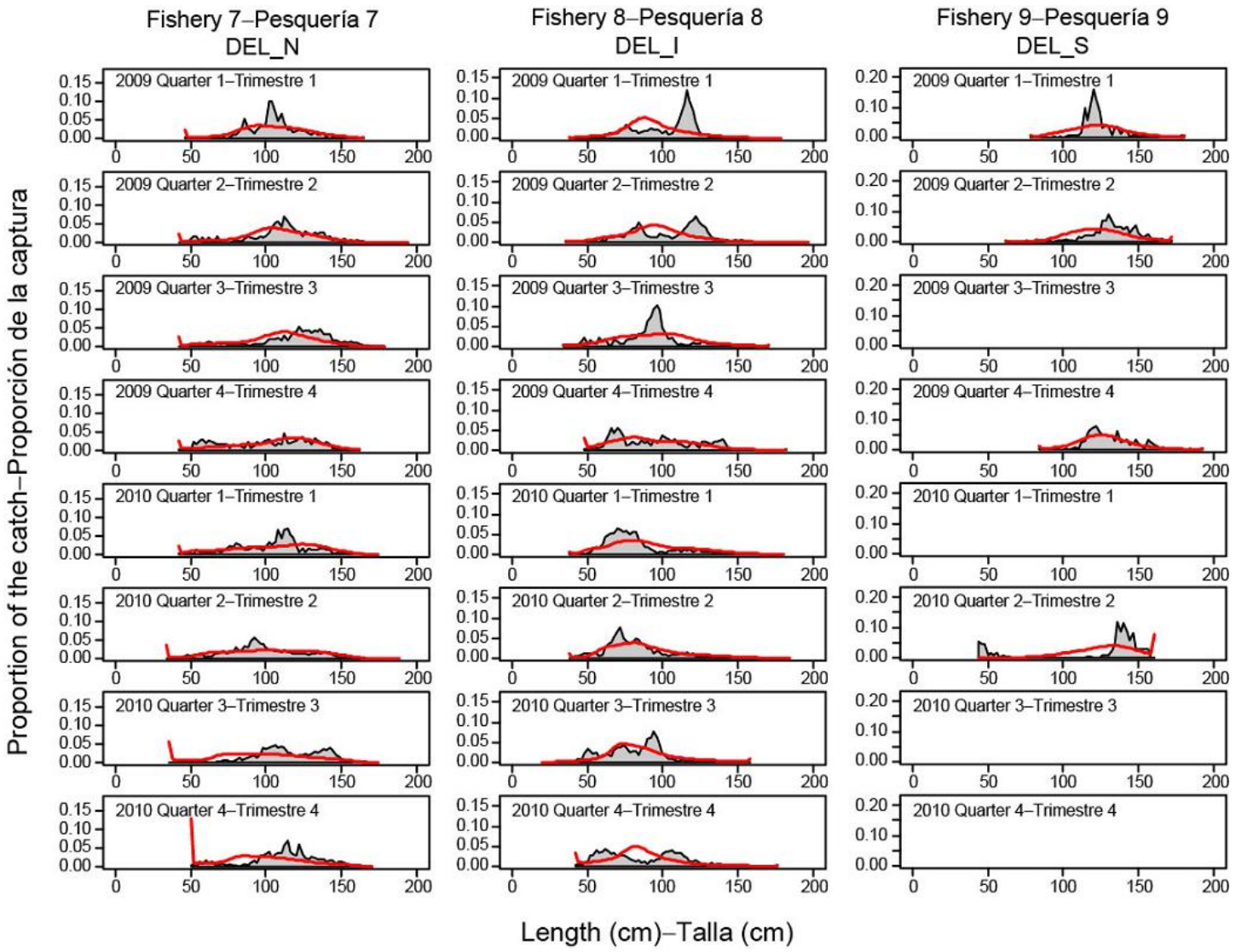
Recent fits to size comps. - NOA

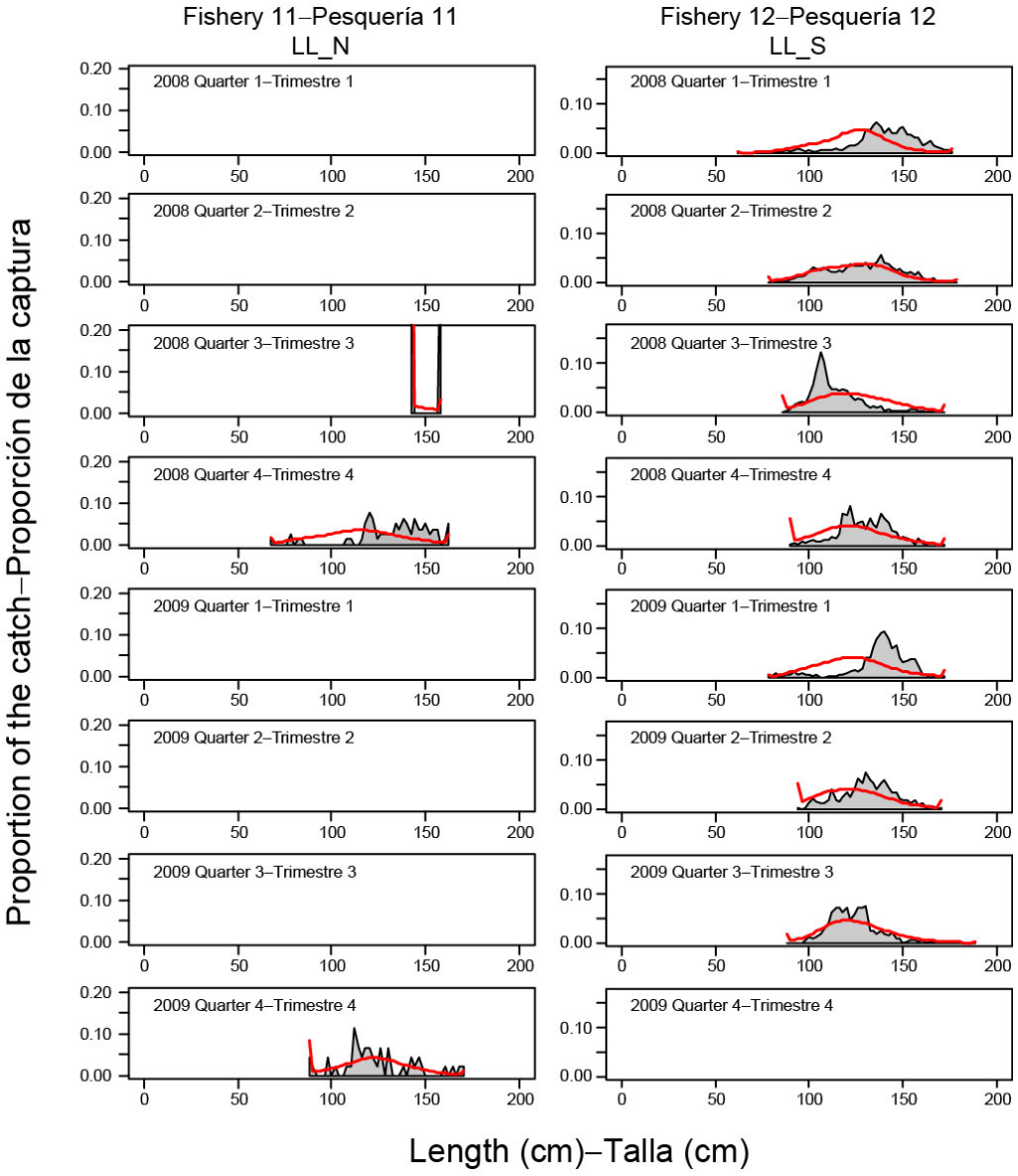


Recent fits to size comps. - DEL

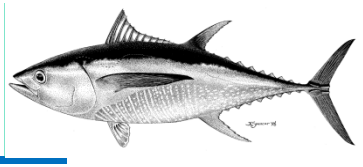




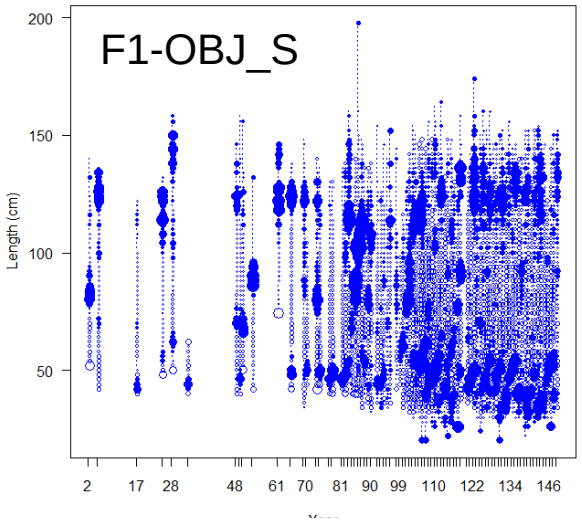
Recent fits to size comps. - LL



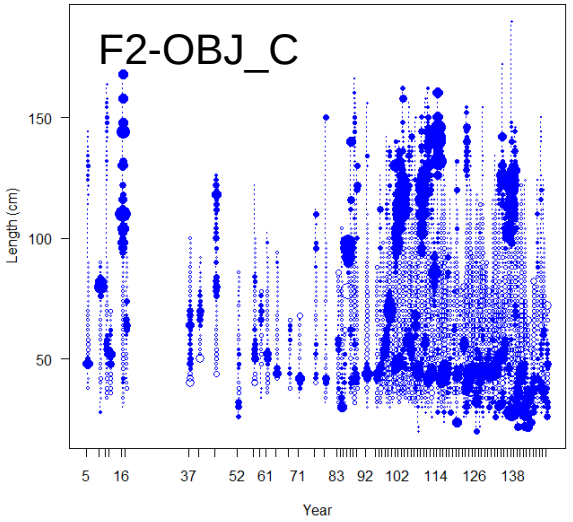
OBJ size comp. residual pattern



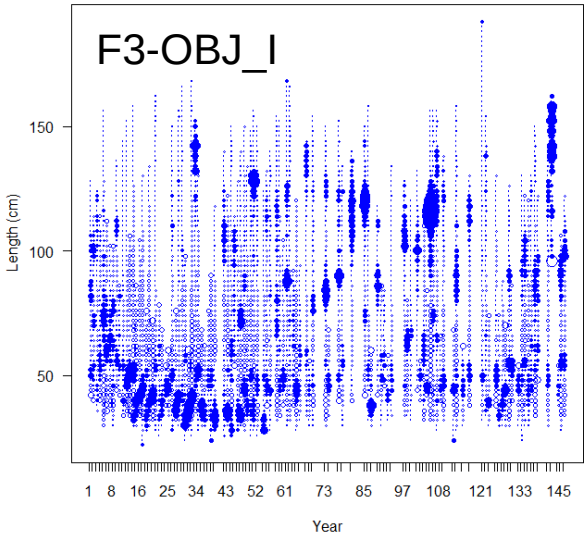
Pearson residuals, sexes combined, whole catch, F1-OBJ_S (max=5.2)



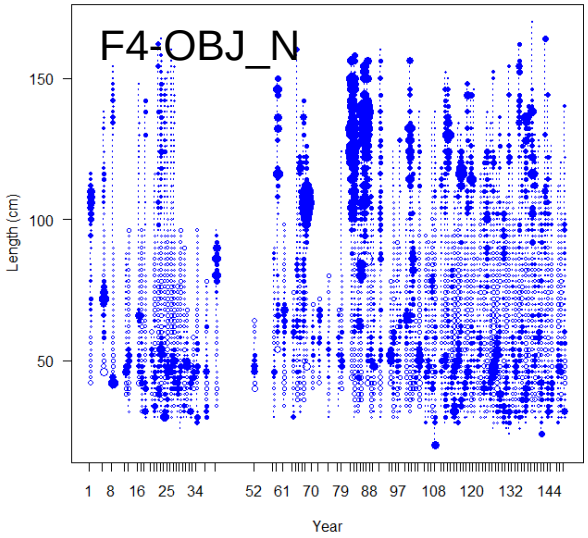
Pearson residuals, sexes combined, whole catch, F2-OBJ_C (max=5.46)



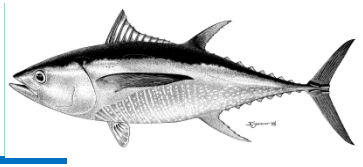
Pearson residuals, sexes combined, whole catch, F3-OBJ_I (max=12.18)

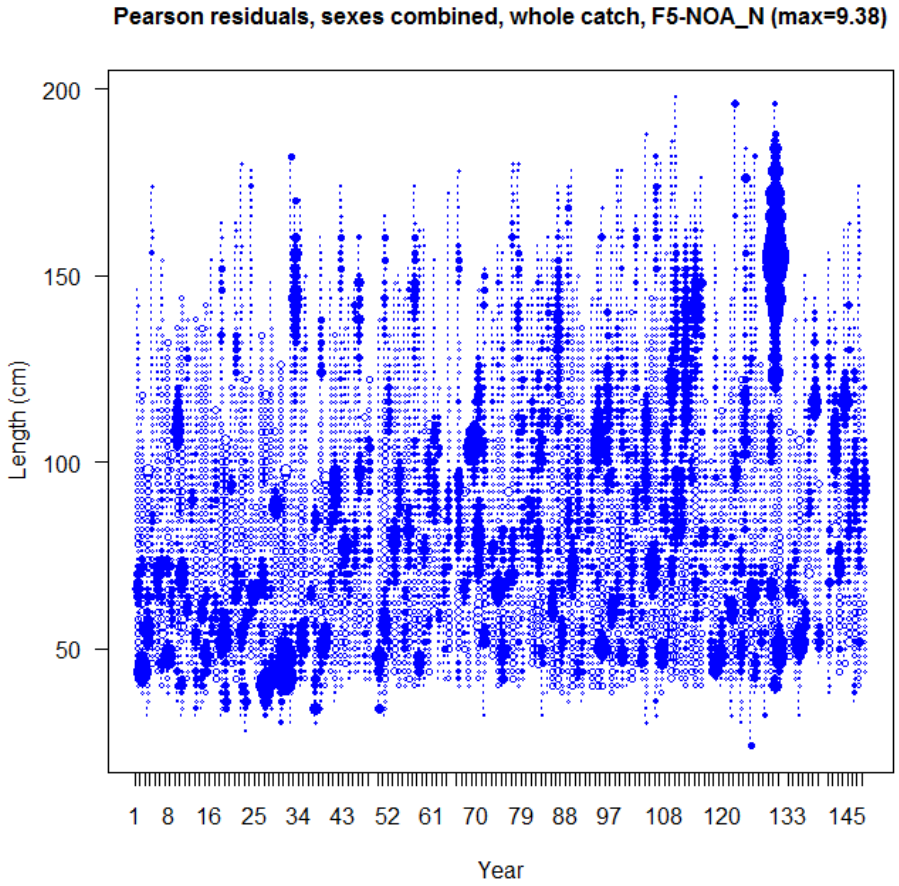


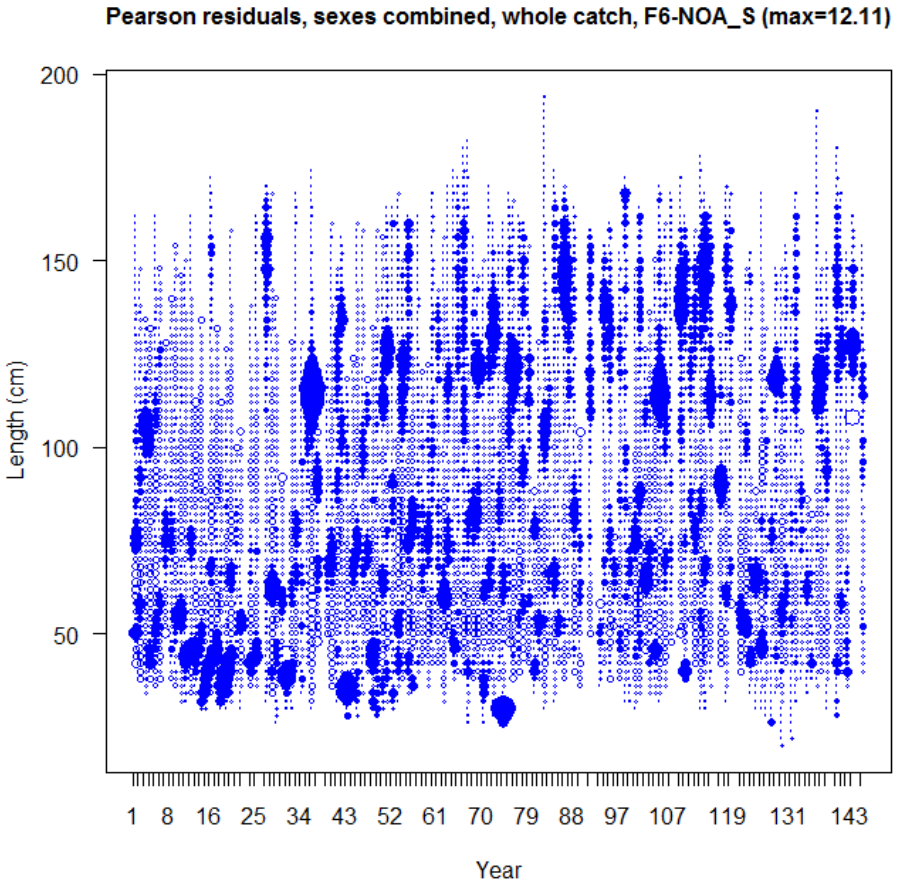
Pearson residuals, sexes combined, whole catch, F4-OBJ_N (max=7.61)



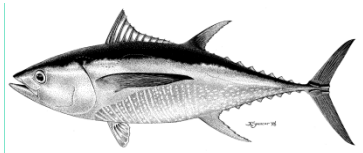
NOA size comp. residual pattern

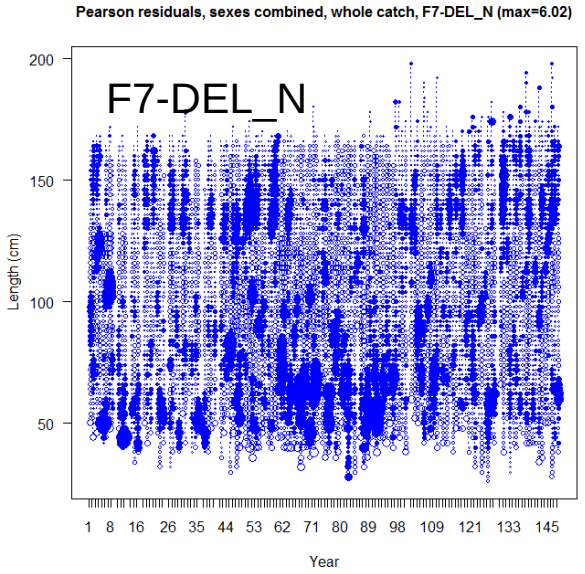


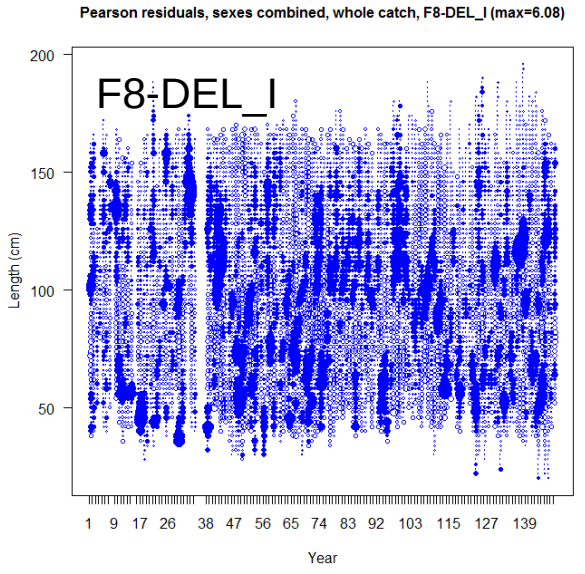


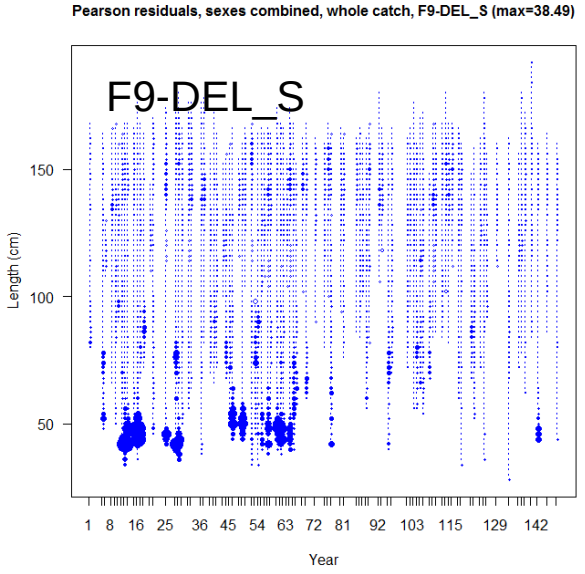


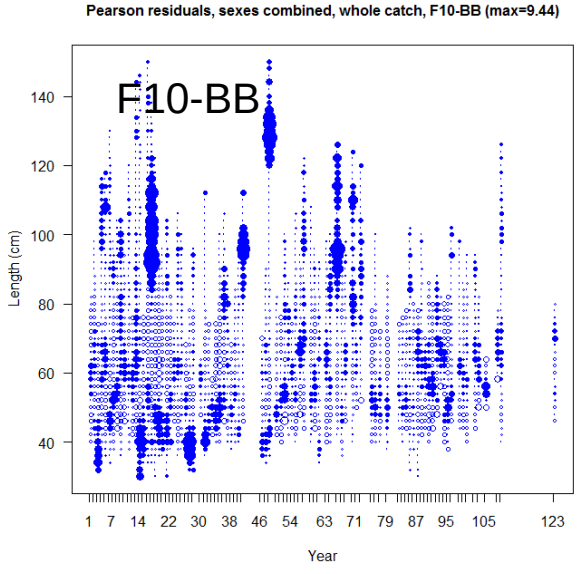
DEL size comp. residual pattern











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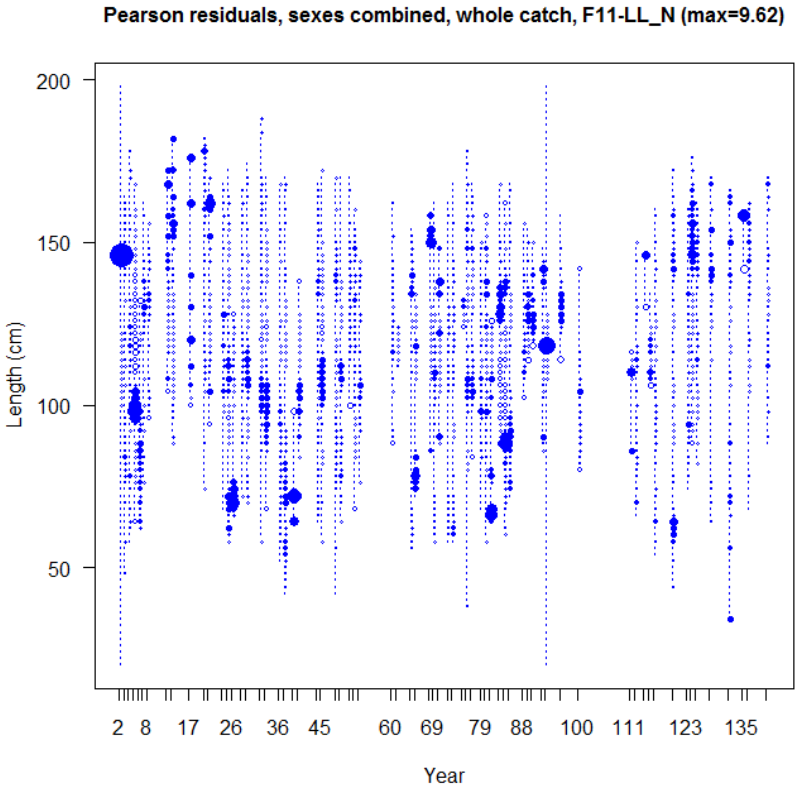
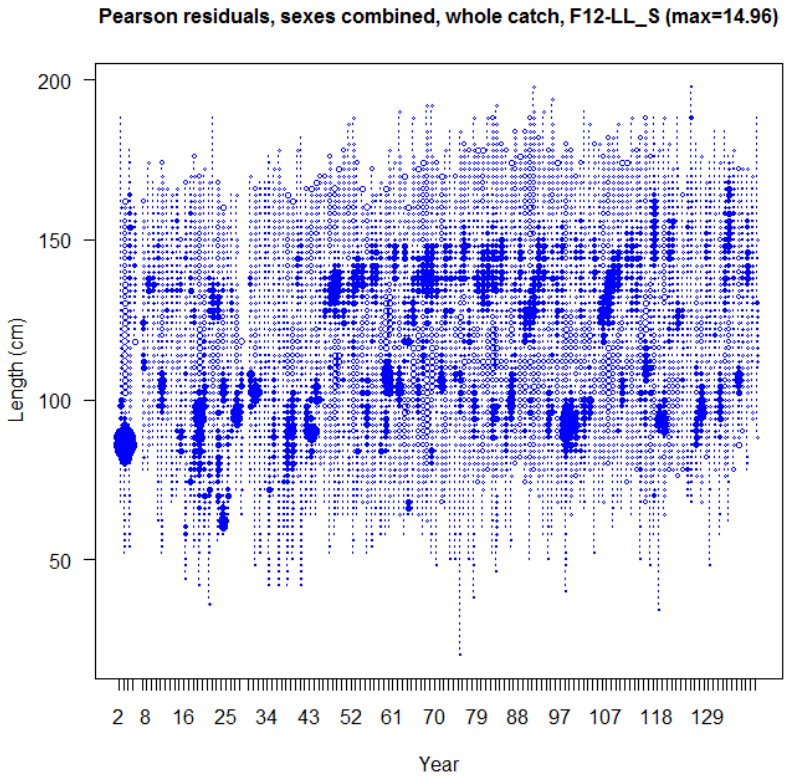
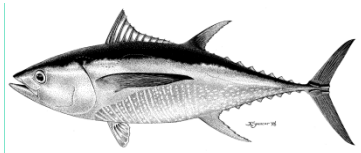
LL size comp. residual pattern





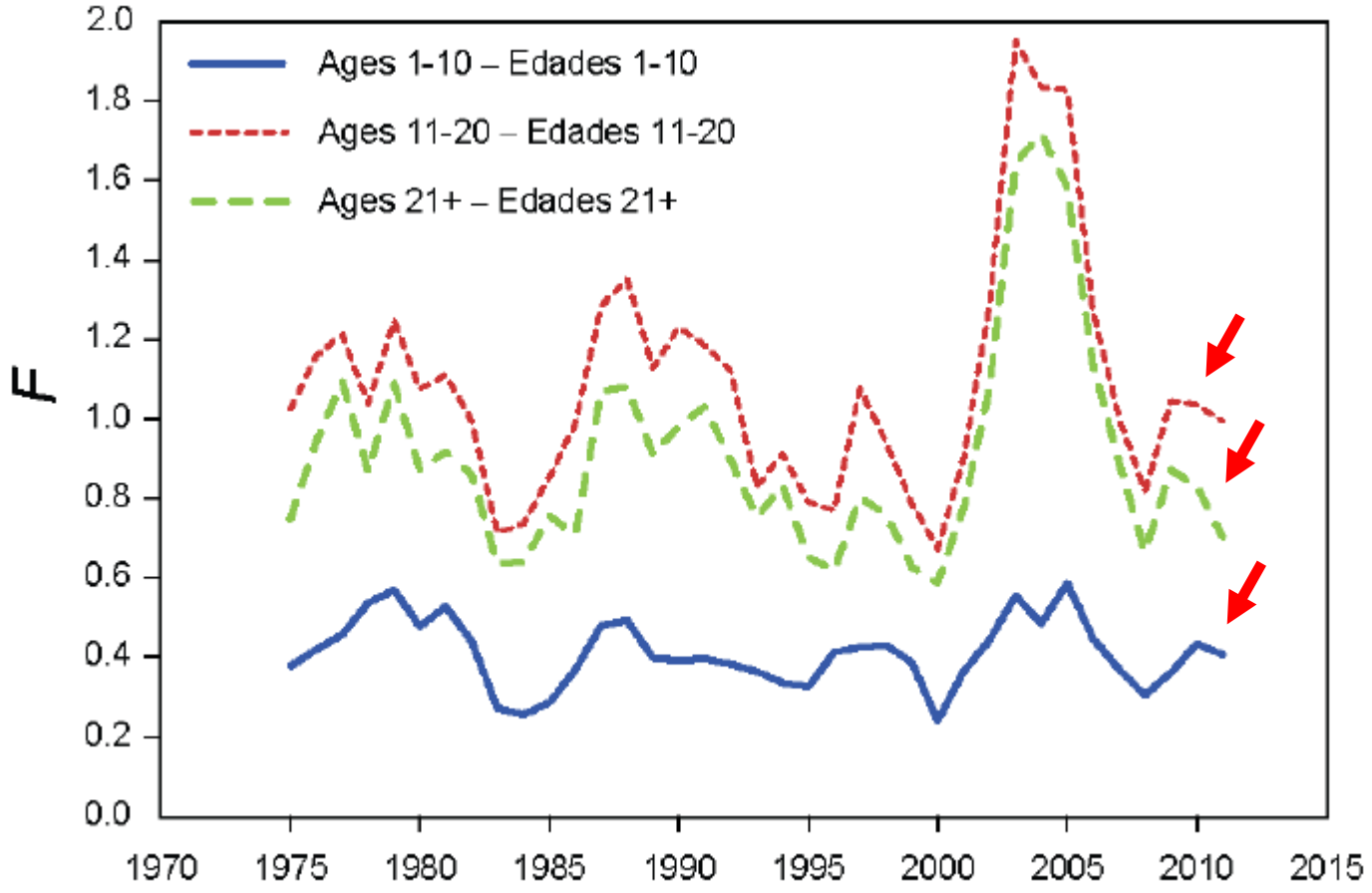
Year-año

Fit to the size compositions



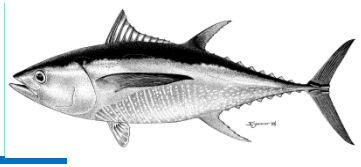
Fishery	Mean input N	Mean effN	effN/N
F1-OBJ_S	14.3	33.0	2.3
F2-OBJ_C	13.5	28.6	2.1
F3-OBJ_I	13.2	23.9	1.8
F4-OBJ_N	10.9	57.7	5.3
F5-NOA_N	23.0	55.8	2.4
F6-NOA_S	20.5	34.2	1.7
F7-DEL_N	31.7	120.6	3.8
F8-DEL_I	29.6	130.5	4.4
F9-DEL_S	8.7	53.3	6.1
F10-BB	11.9	35.5	3.0
F11-LL_N	1.9	31.1	16.3
F12-LL_S	30.3	105.1	3.5

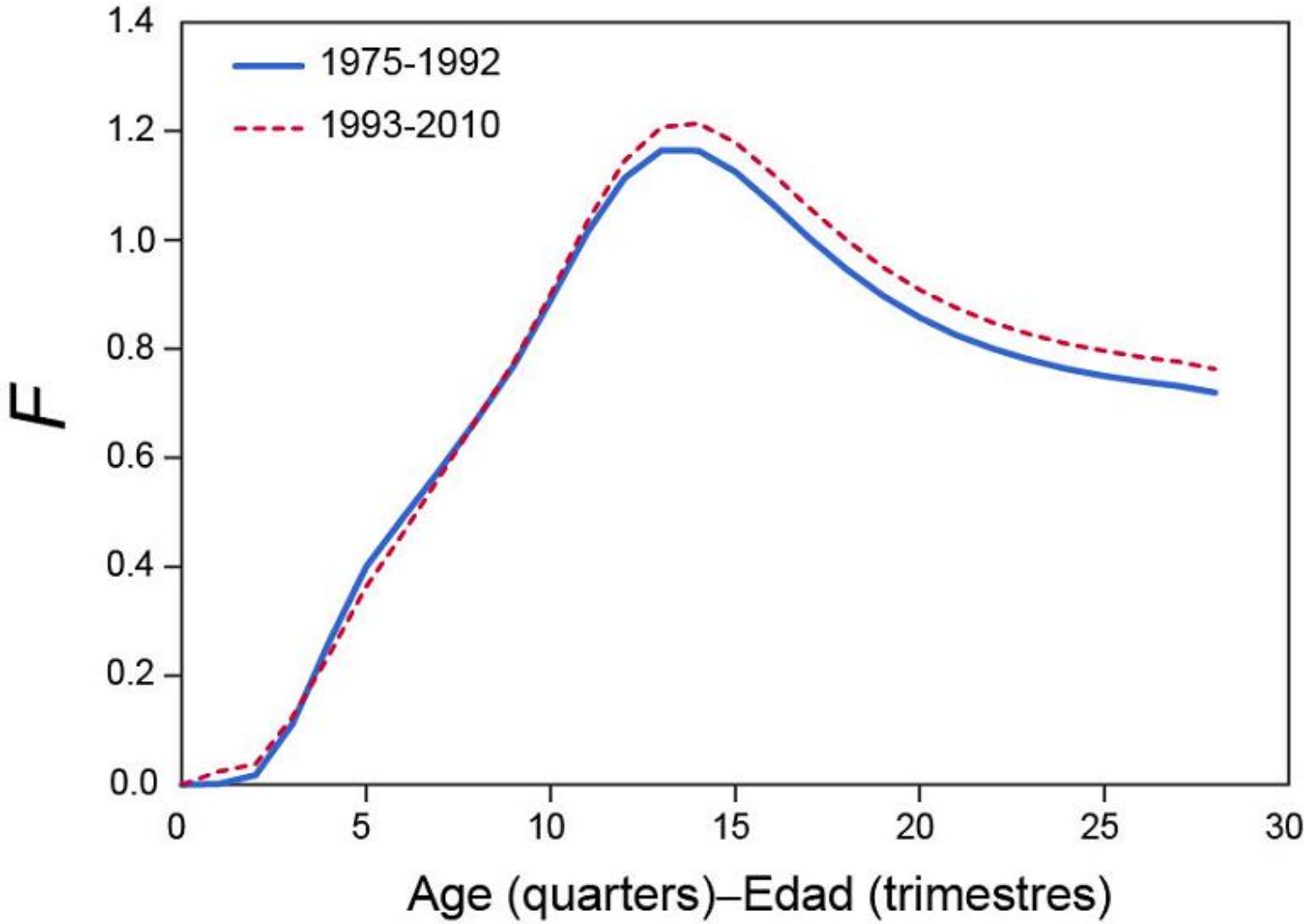
YFT fishing mortality (F)



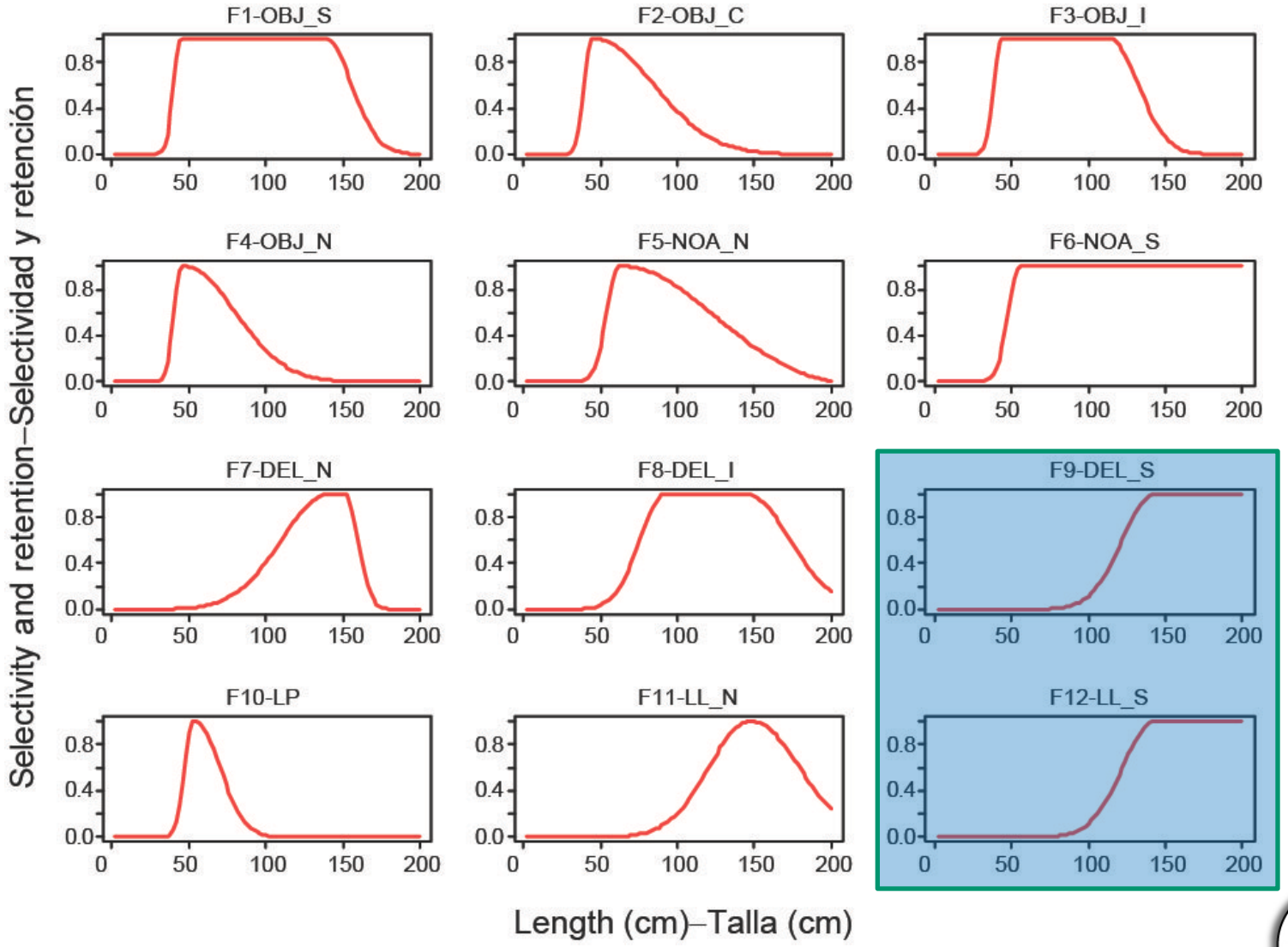
Year-año

YFT age-specific fishing mortality (F)

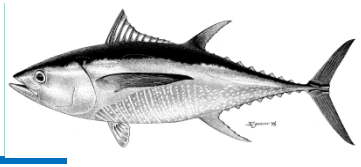


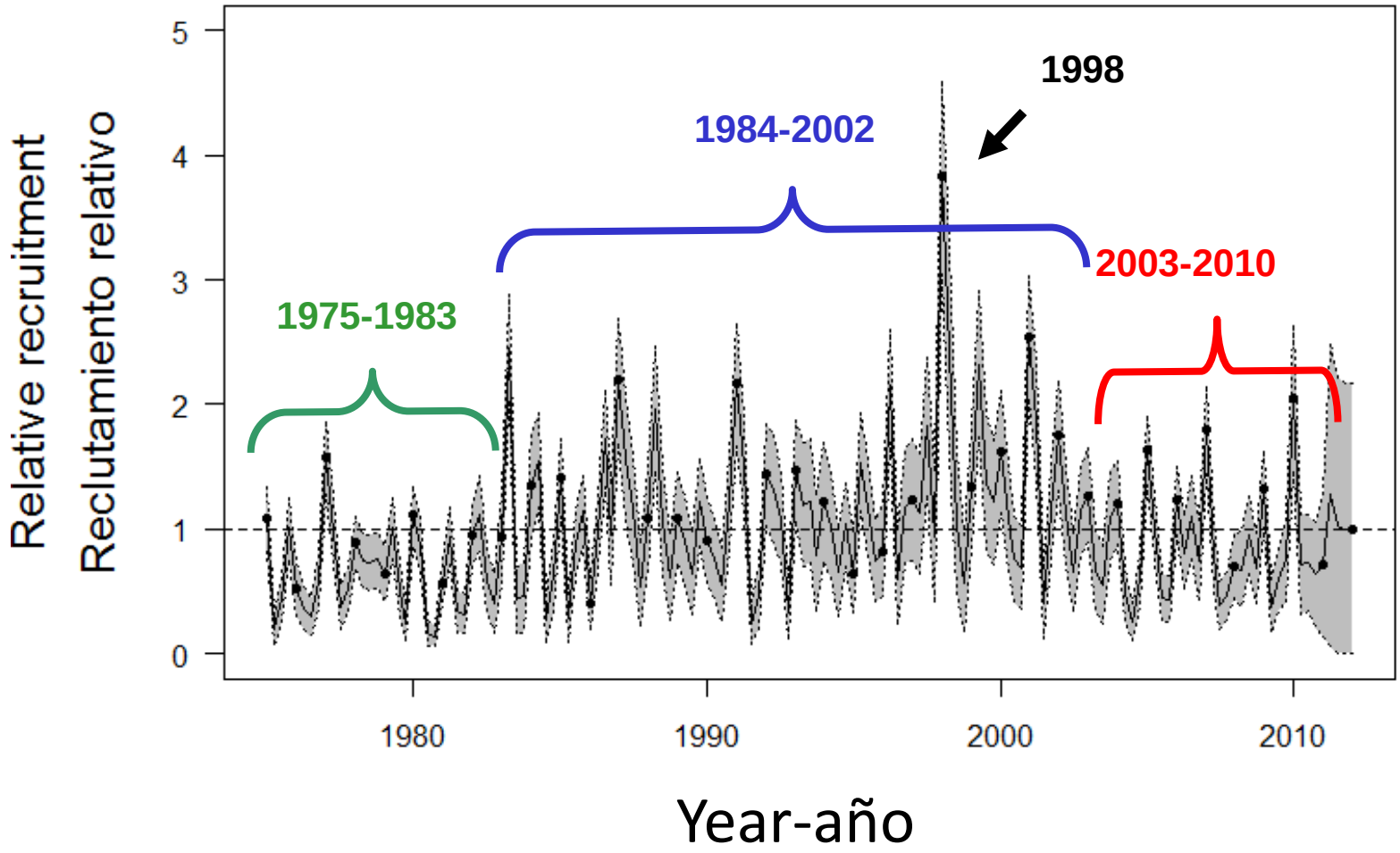


YFT size selectivity



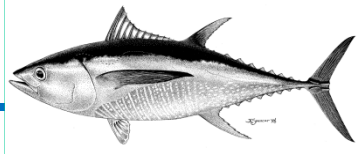
YFT quarterly recruitment

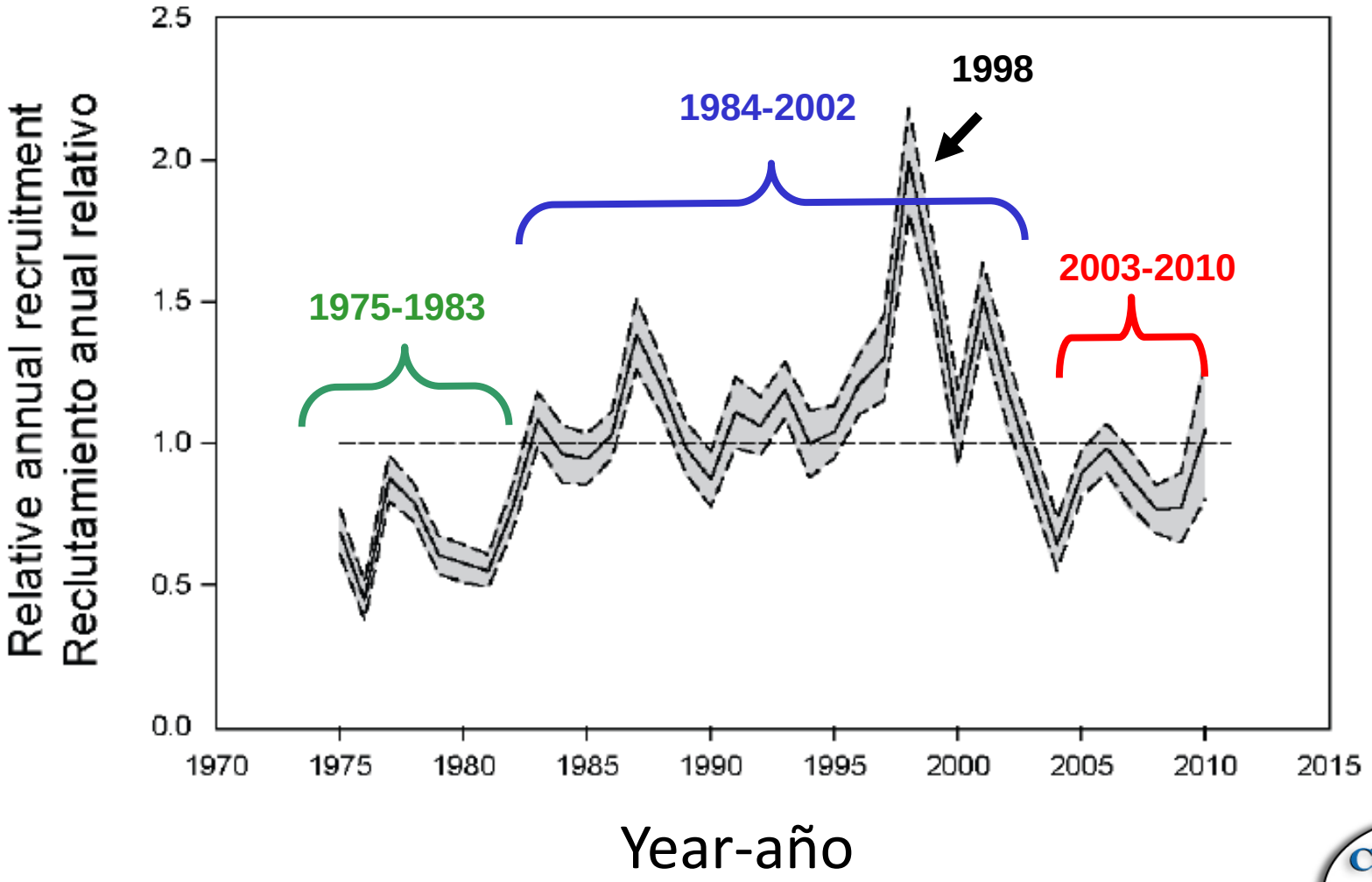




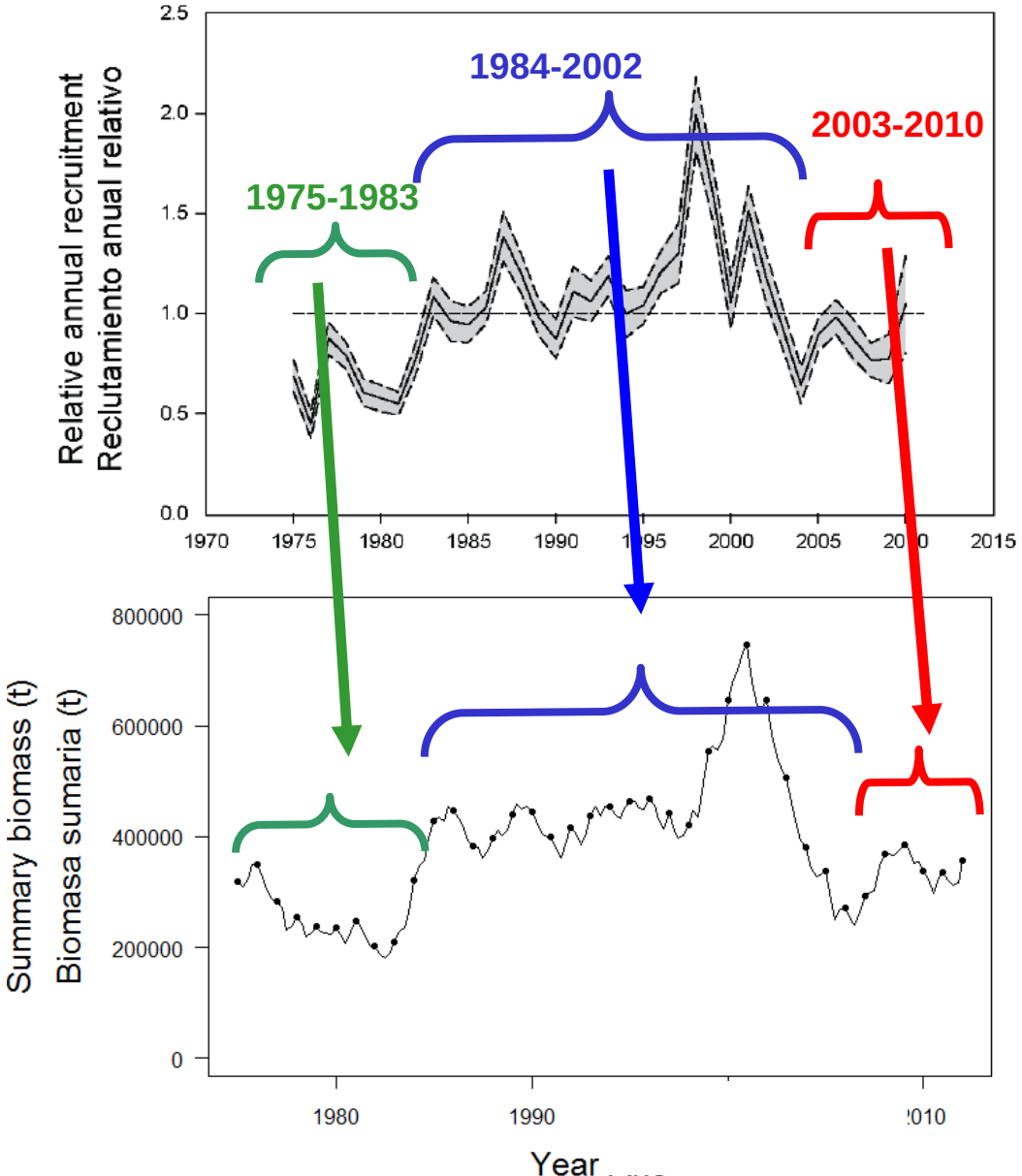
Recruitment

Results
(base case)

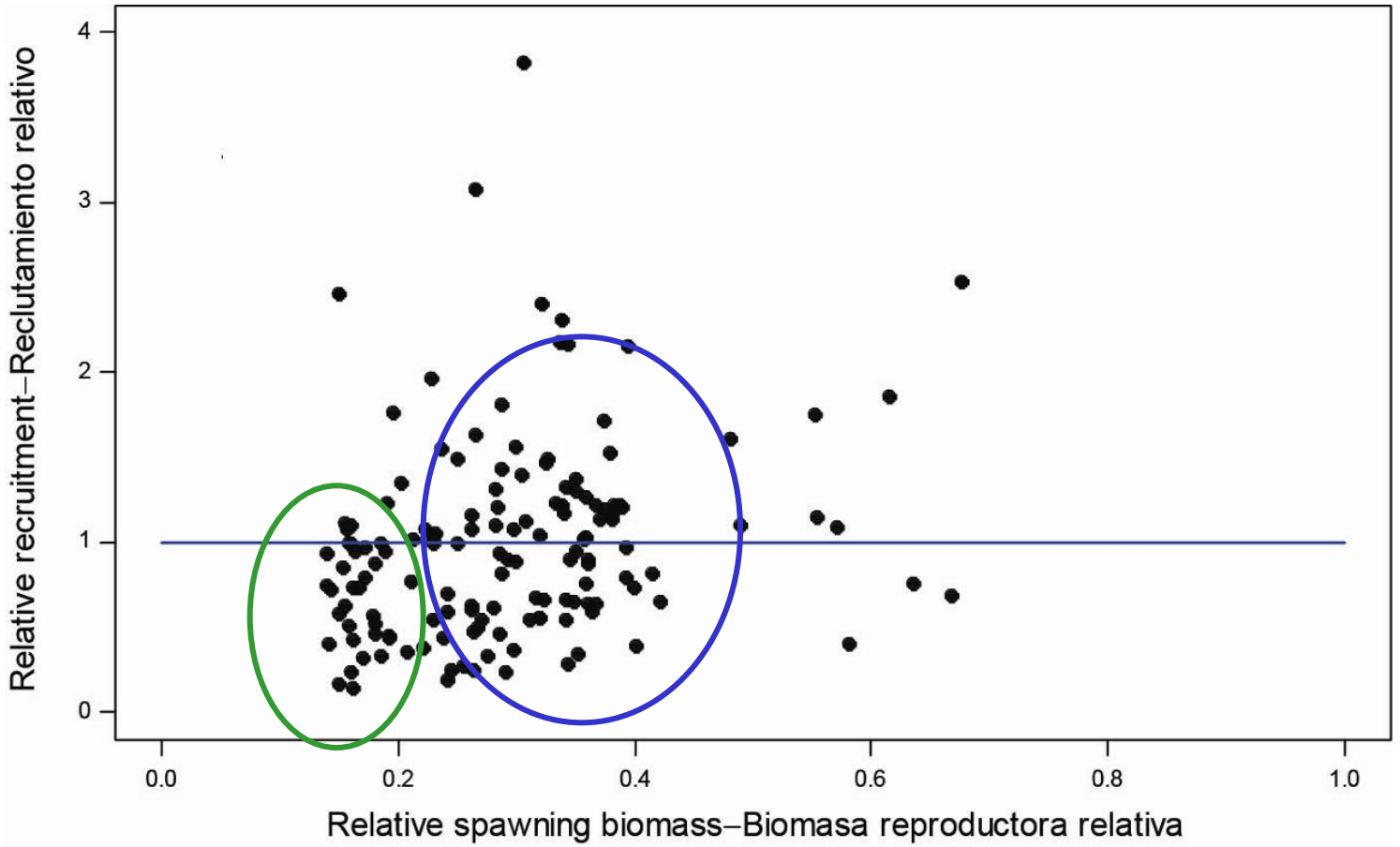




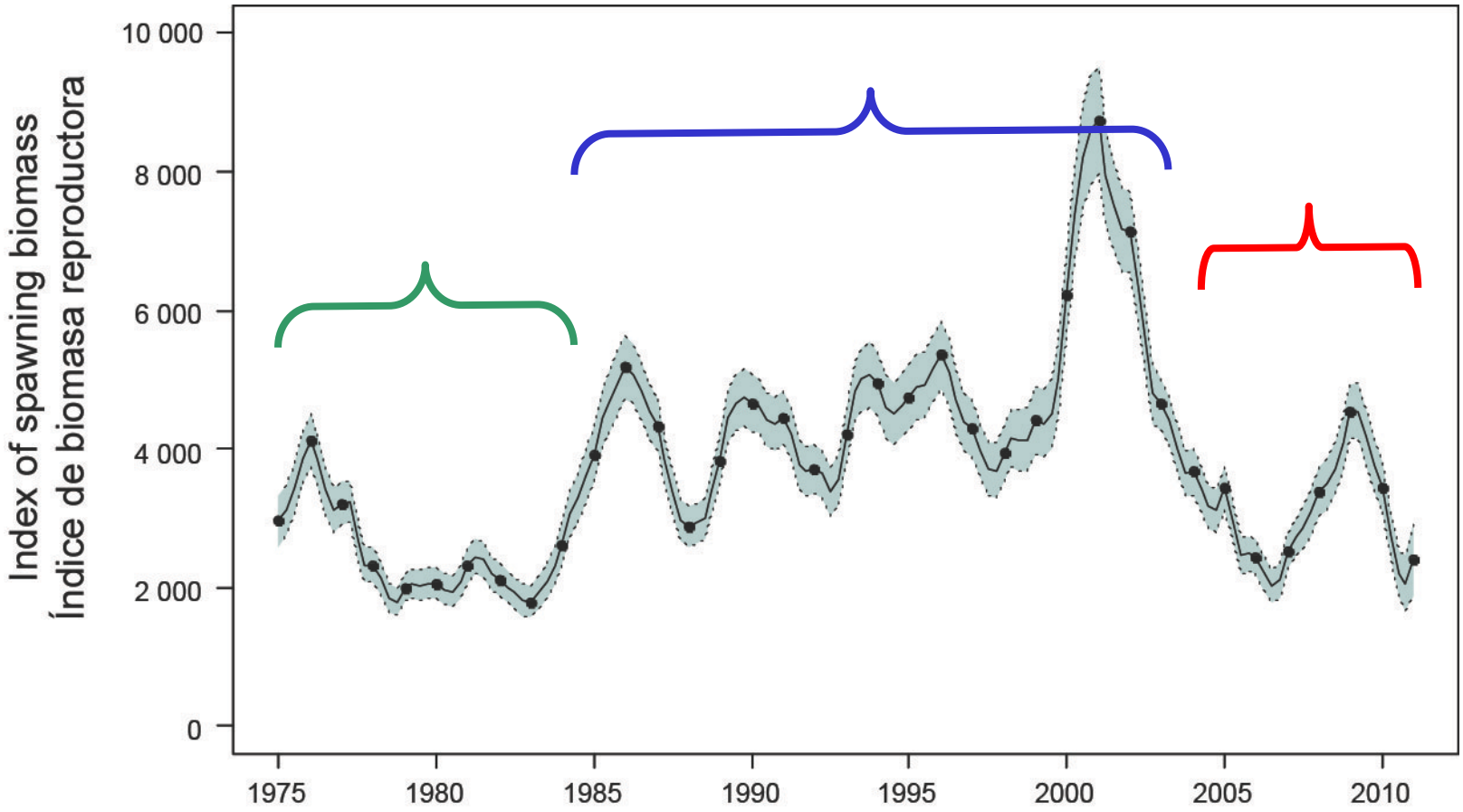
Summary biomass



Stock-recruitment

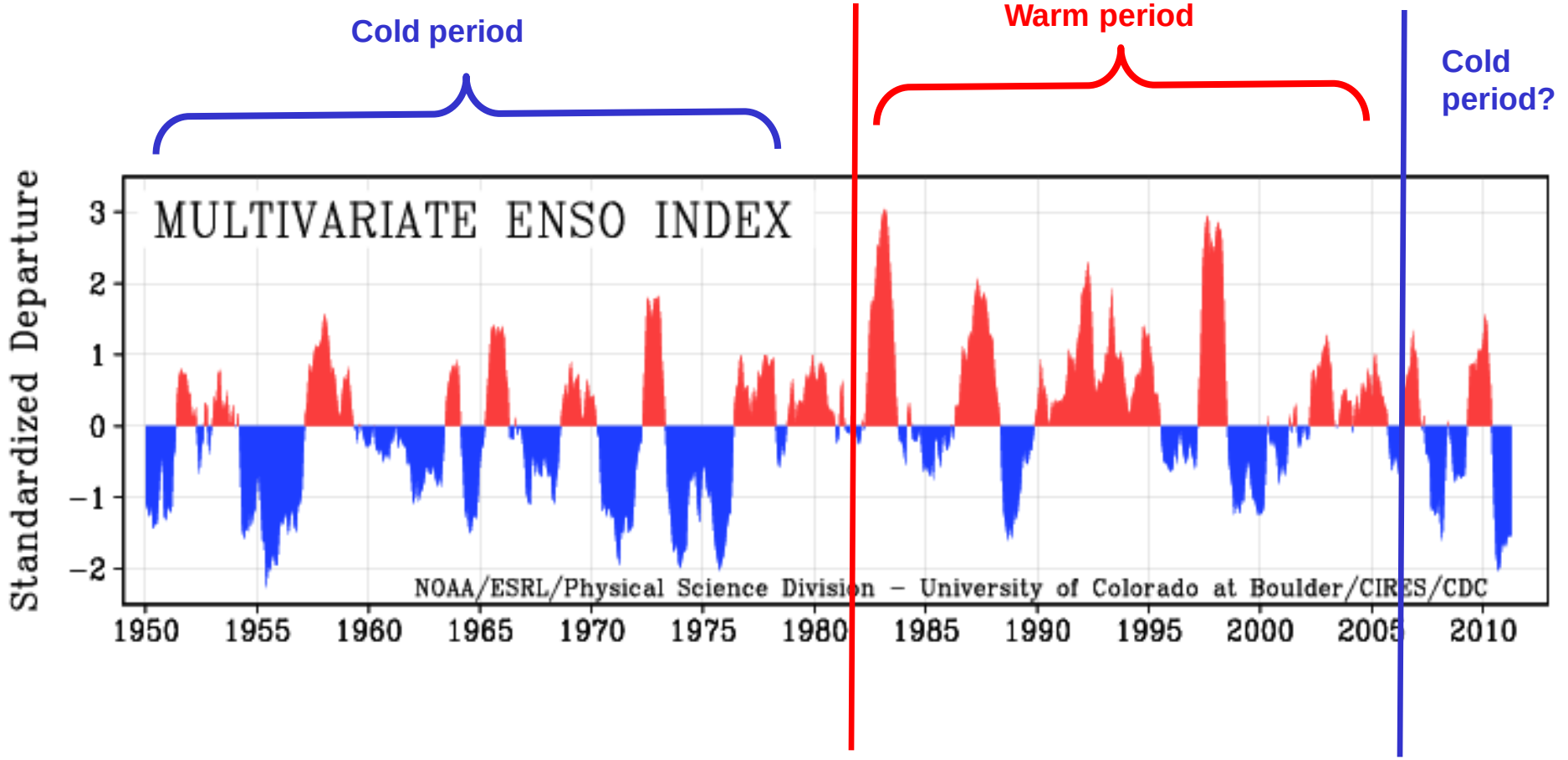


Spawning biomass

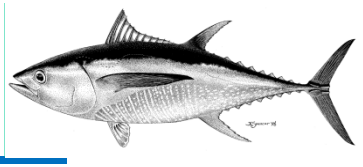


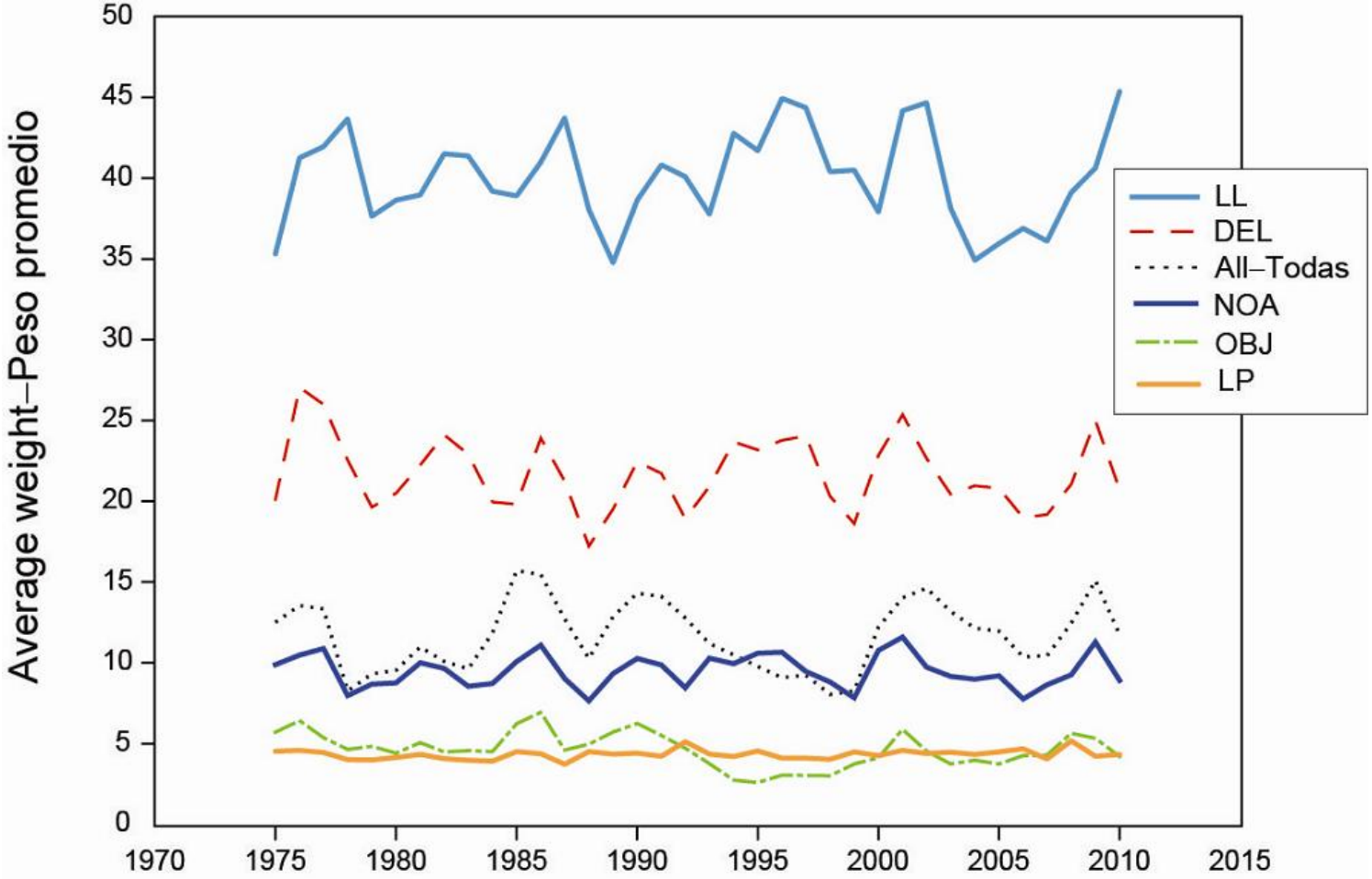
Summary

ENSO



YFT average weight





Year-año

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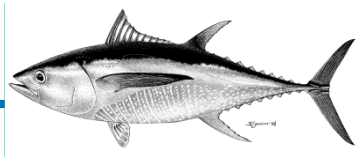
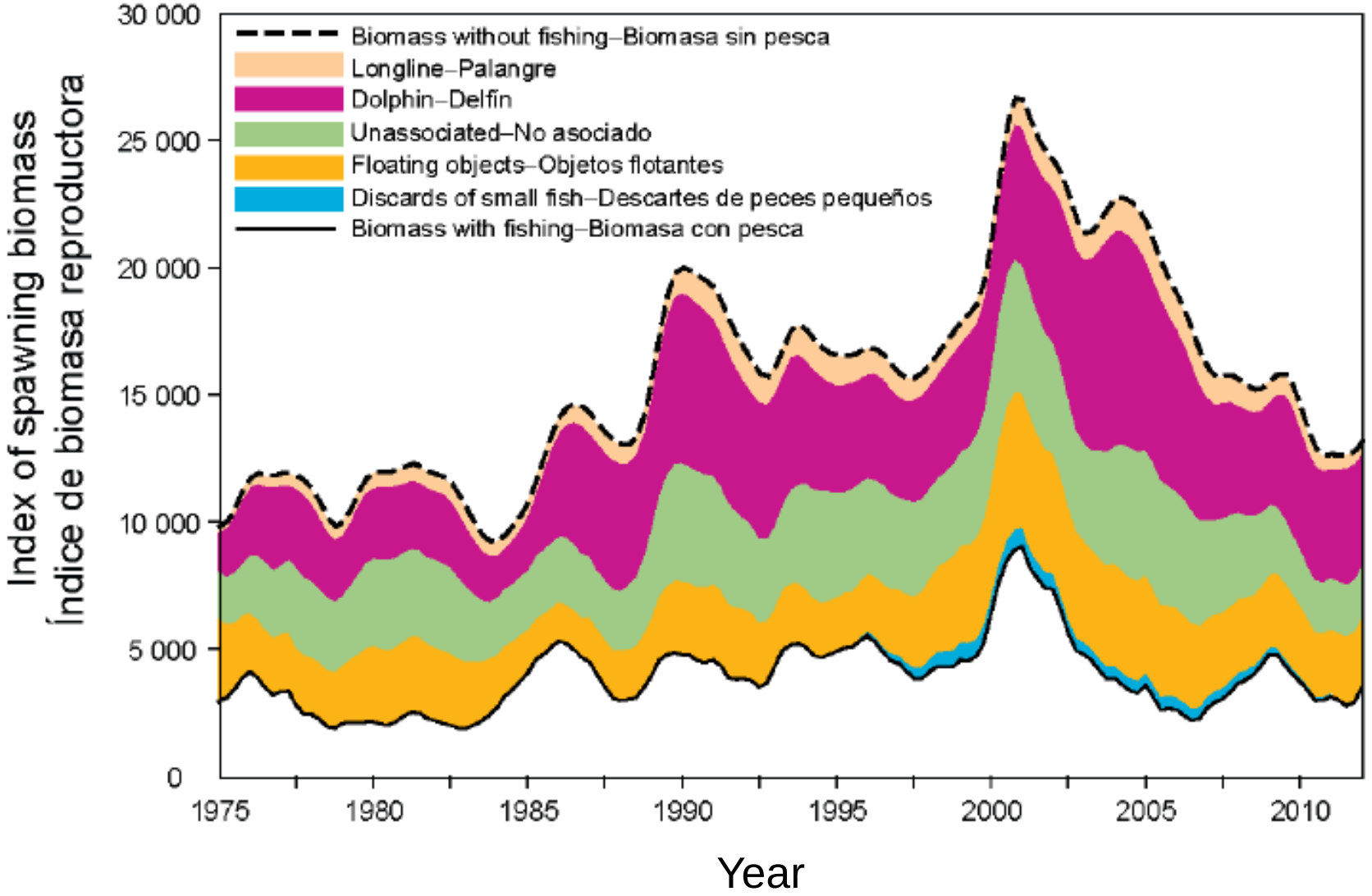
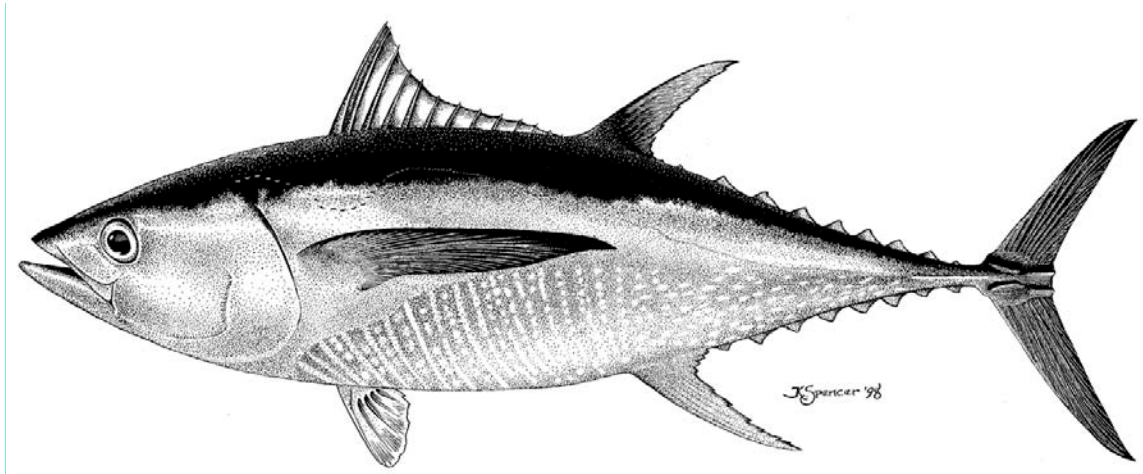
Fishery impact

Results (base case)



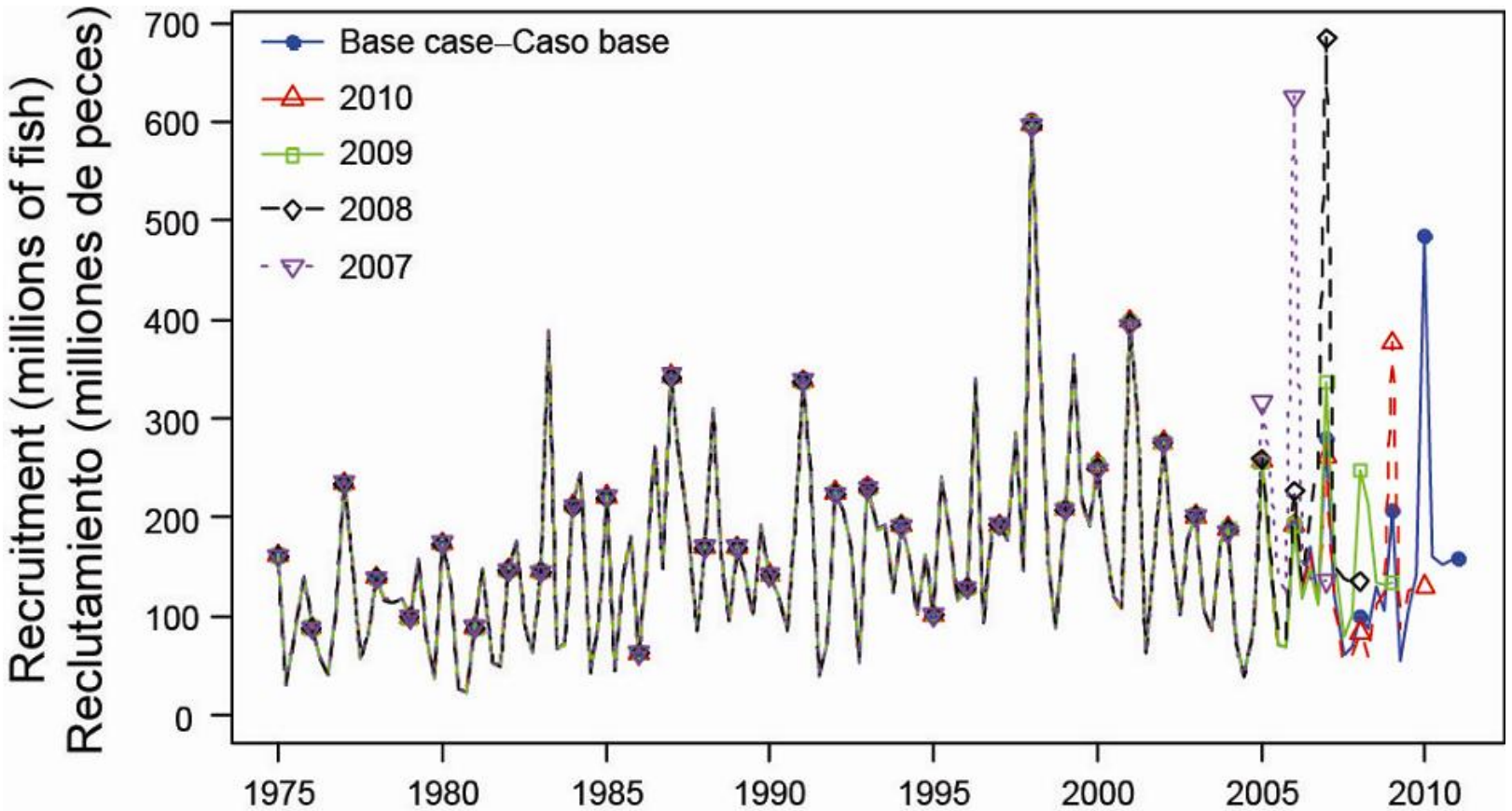




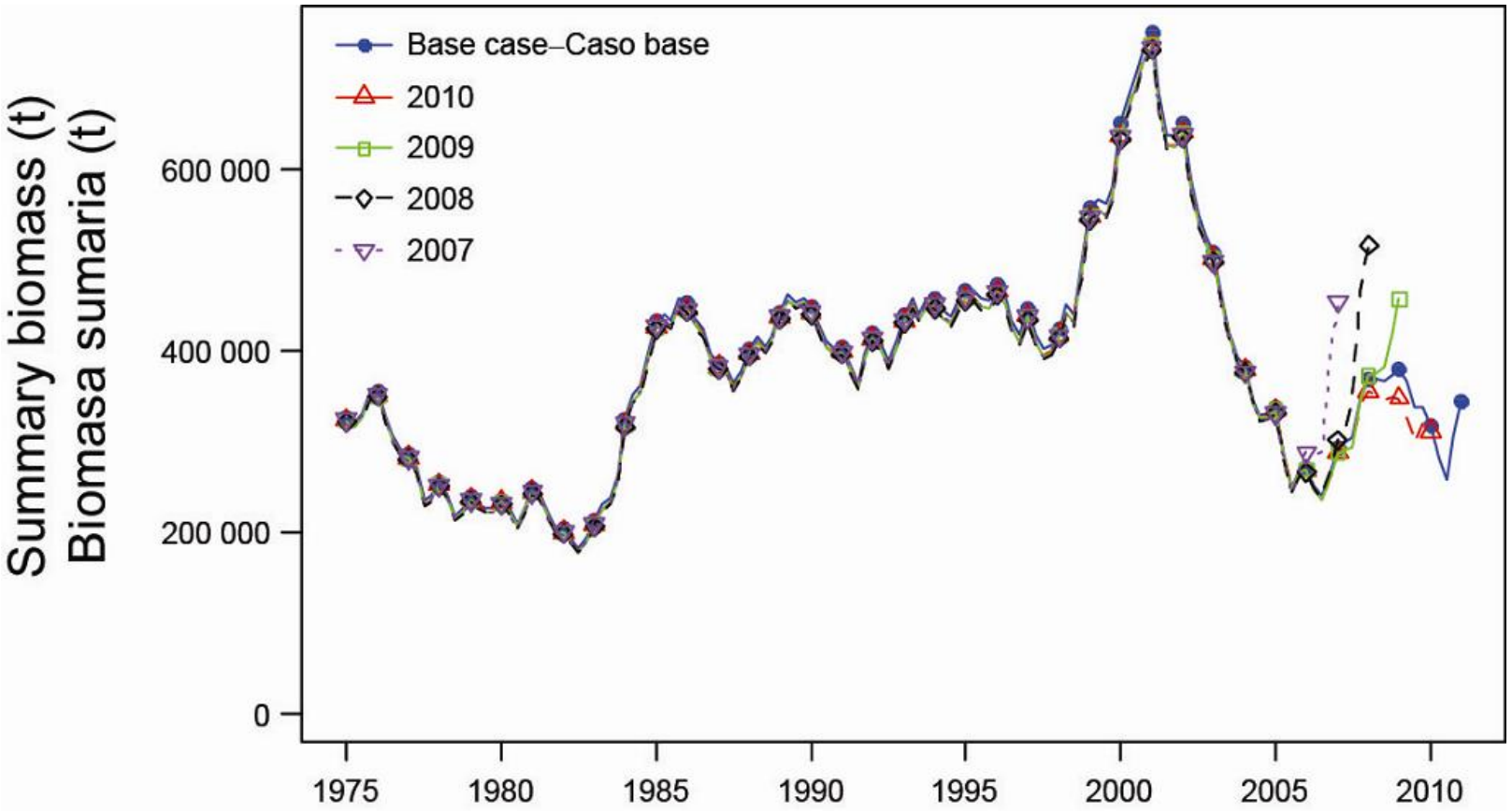
Retrospective analysis

Recruitment

Retrospective

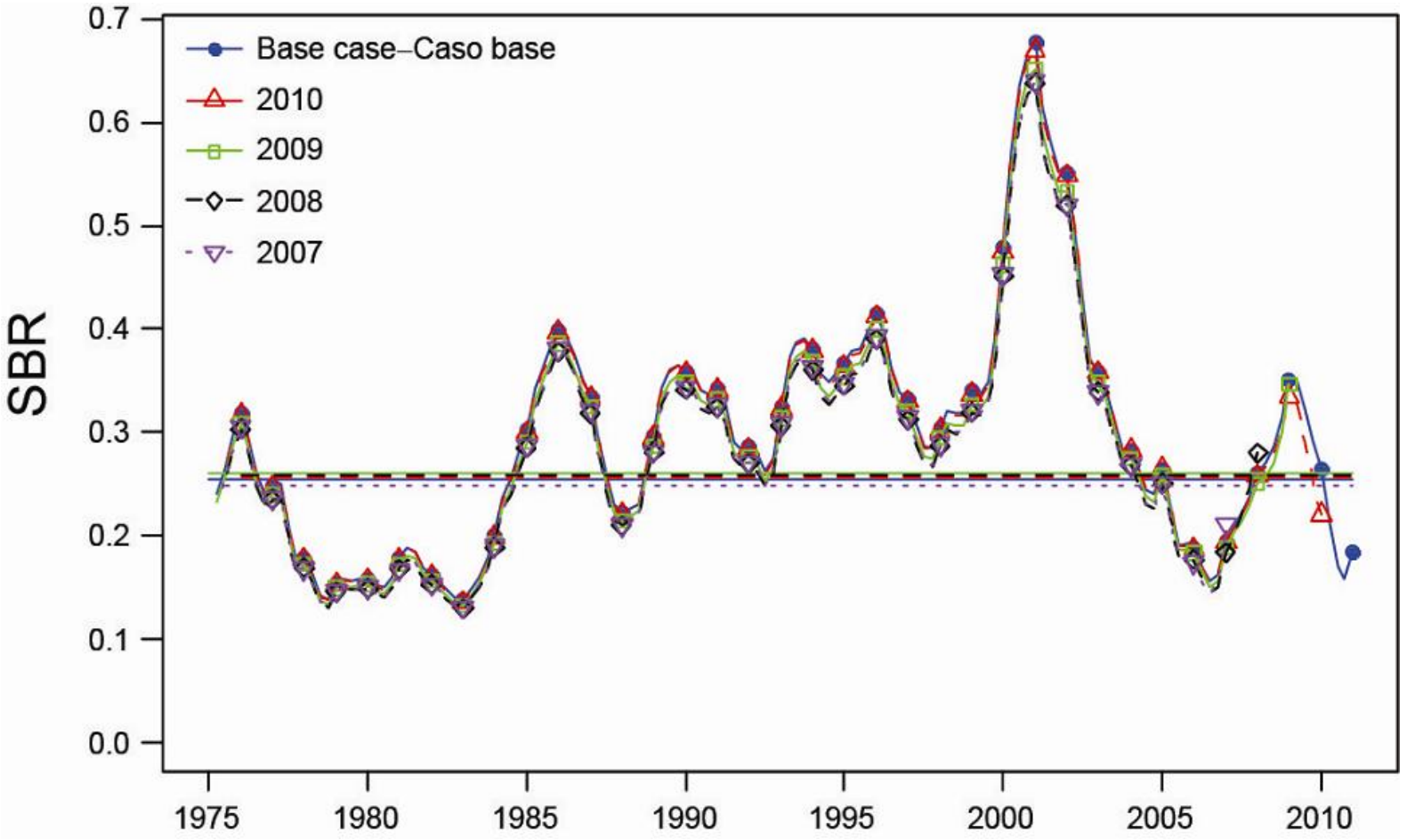


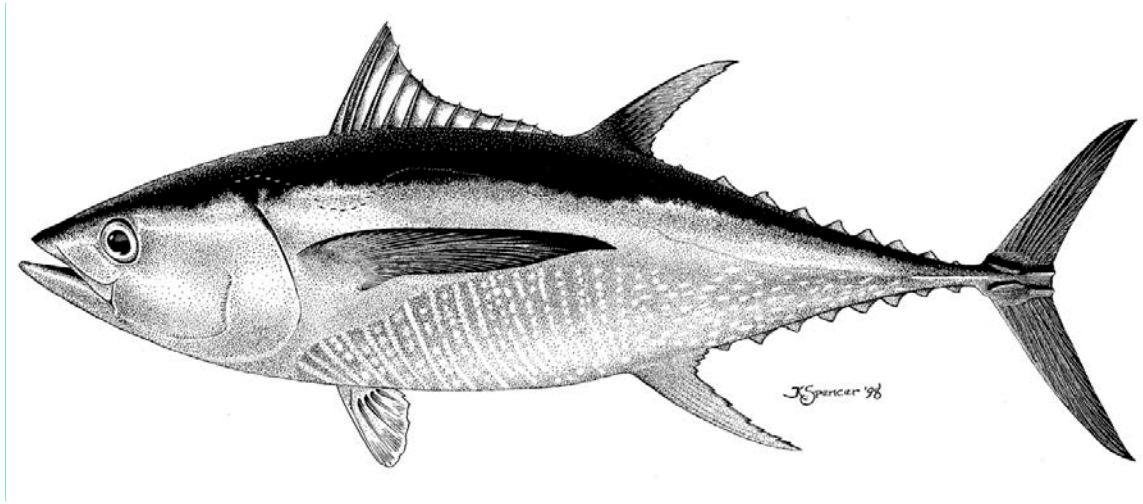
Summary biomass



Retrospective

Spawning biomass ratio



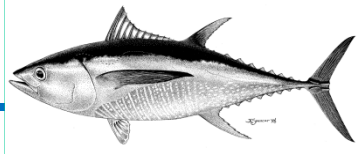


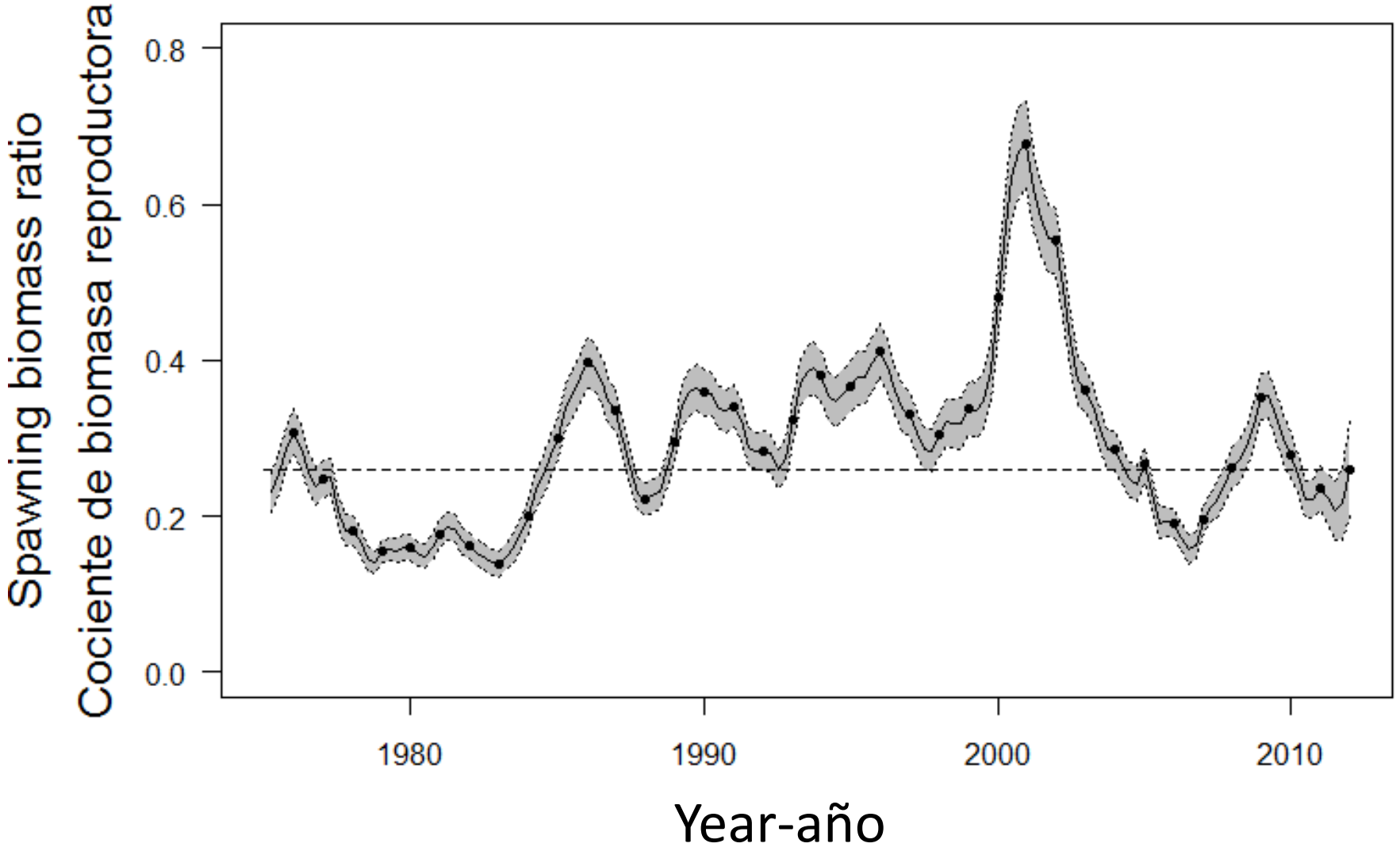
Stock status (base case)

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

Spawning biomass ratio

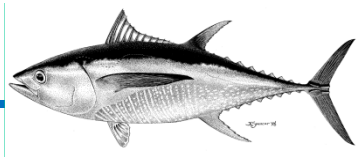
Stock status (base case)





Management quantities

Stock status (base case)



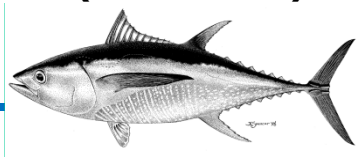
Data – Datos	Base case Caso base	$h = 0.75$
MSY-RMS	262,642	290,680
B_{MSY}- B_{RMS}	356,682	560,354
S_{MSY}- S_{RMS}	3,334	6,013
B_{MSY}/B_0- B_{RMS}/B_0	0.31	0.37
S_{MSY}/S_0- S_{RMS}/S_0	0.26	0.35
C_{recent}/MSY- C_{recent}/RMS	0.79	0.71
B_{recent}/B_{MSY}- B_{recent}/B_{RMS}	1.00	0.63
S_{recent}/S_{MSY}-S_{recent}/S_{RMS}	1.00	0.56
F multiplier-Multiplicador de F	1.15	0.72

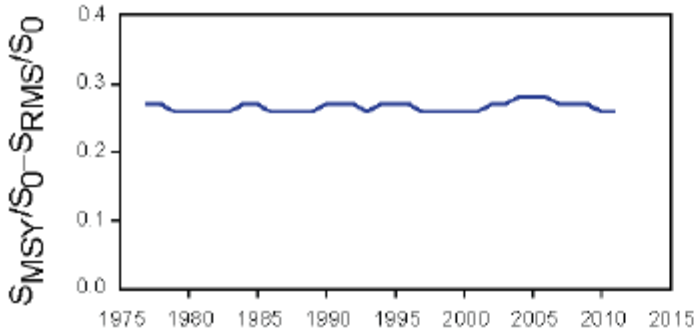
3,57050/356,682=1.00103

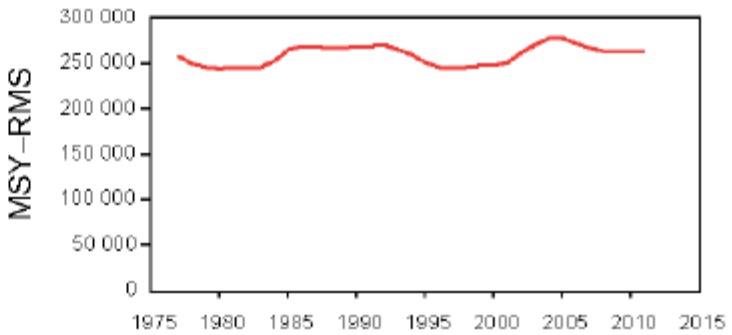
3,350/3,334=1.0048

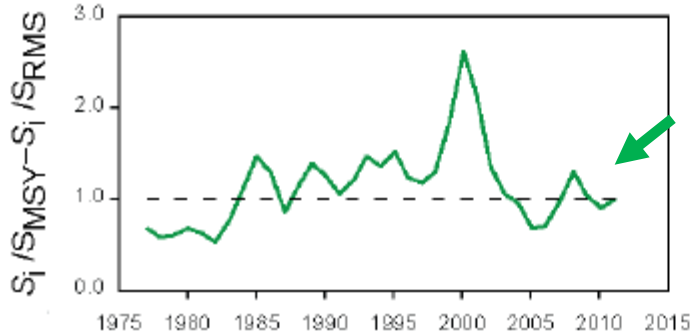
Time varying indicators

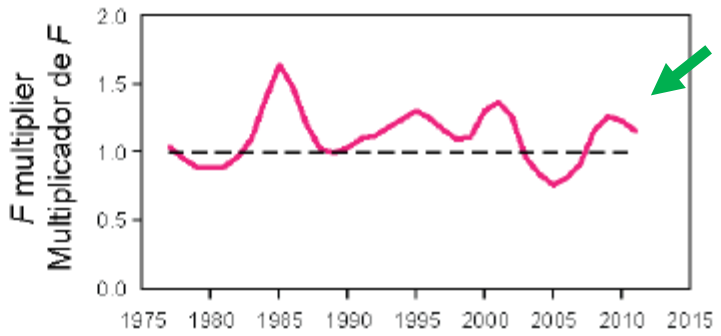
Stock status (base case)





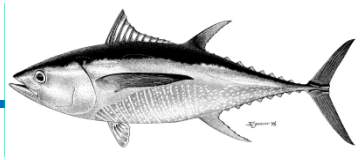


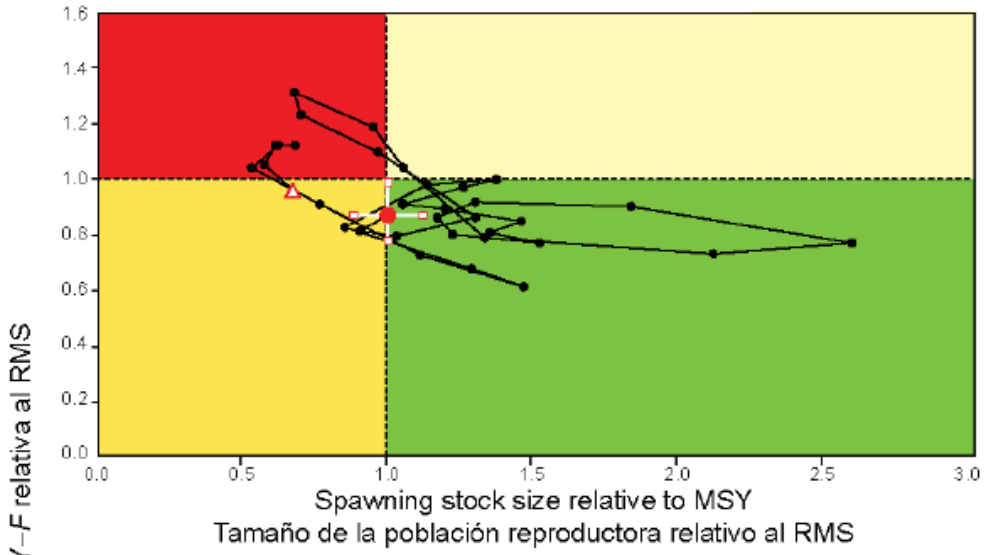


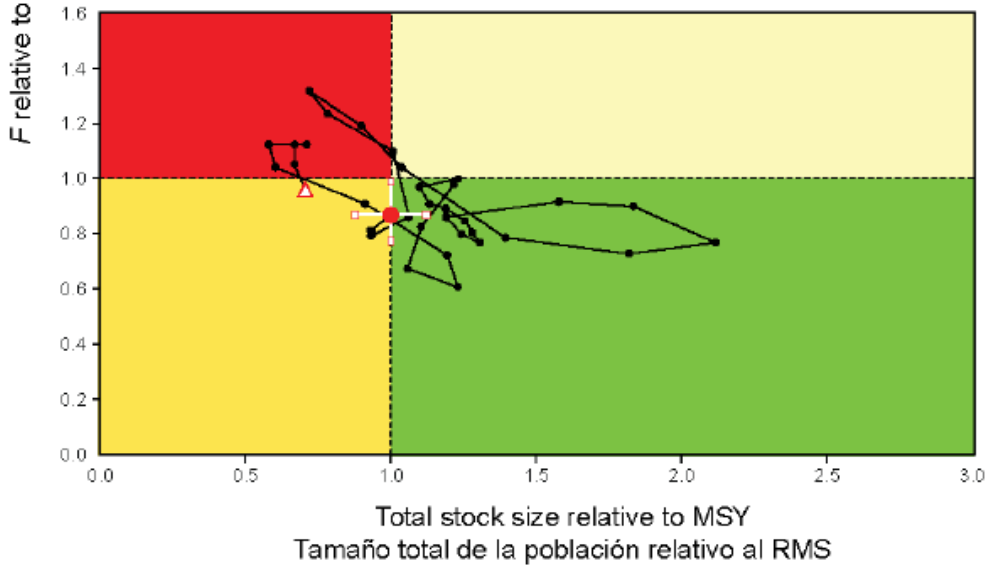


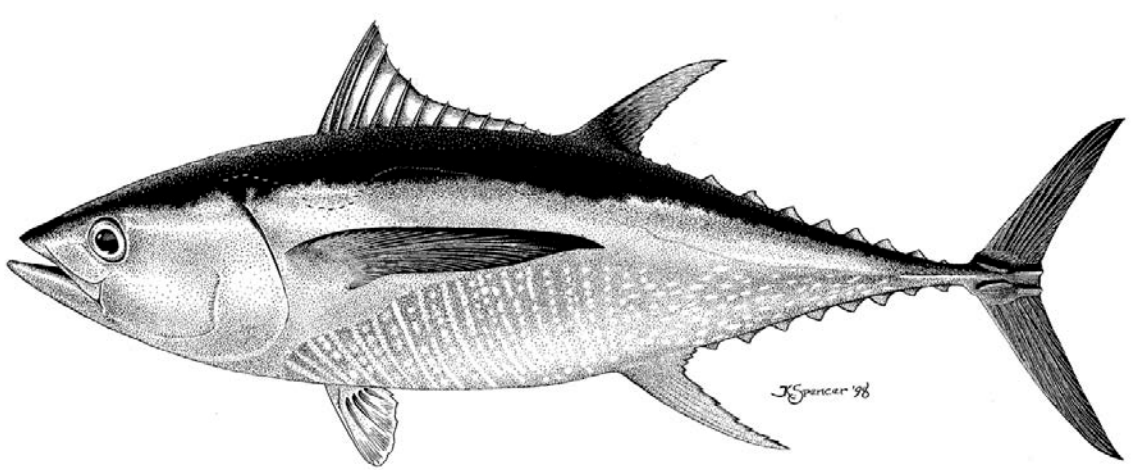
Kobe plots

Stock status (base case)



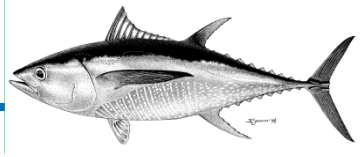






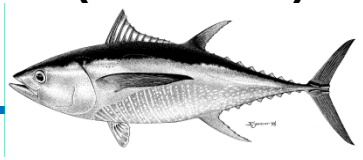
Projection simulations (base case)

- *Status quo* (Fcurrent) fishing strategy
- MSY fishing strategy

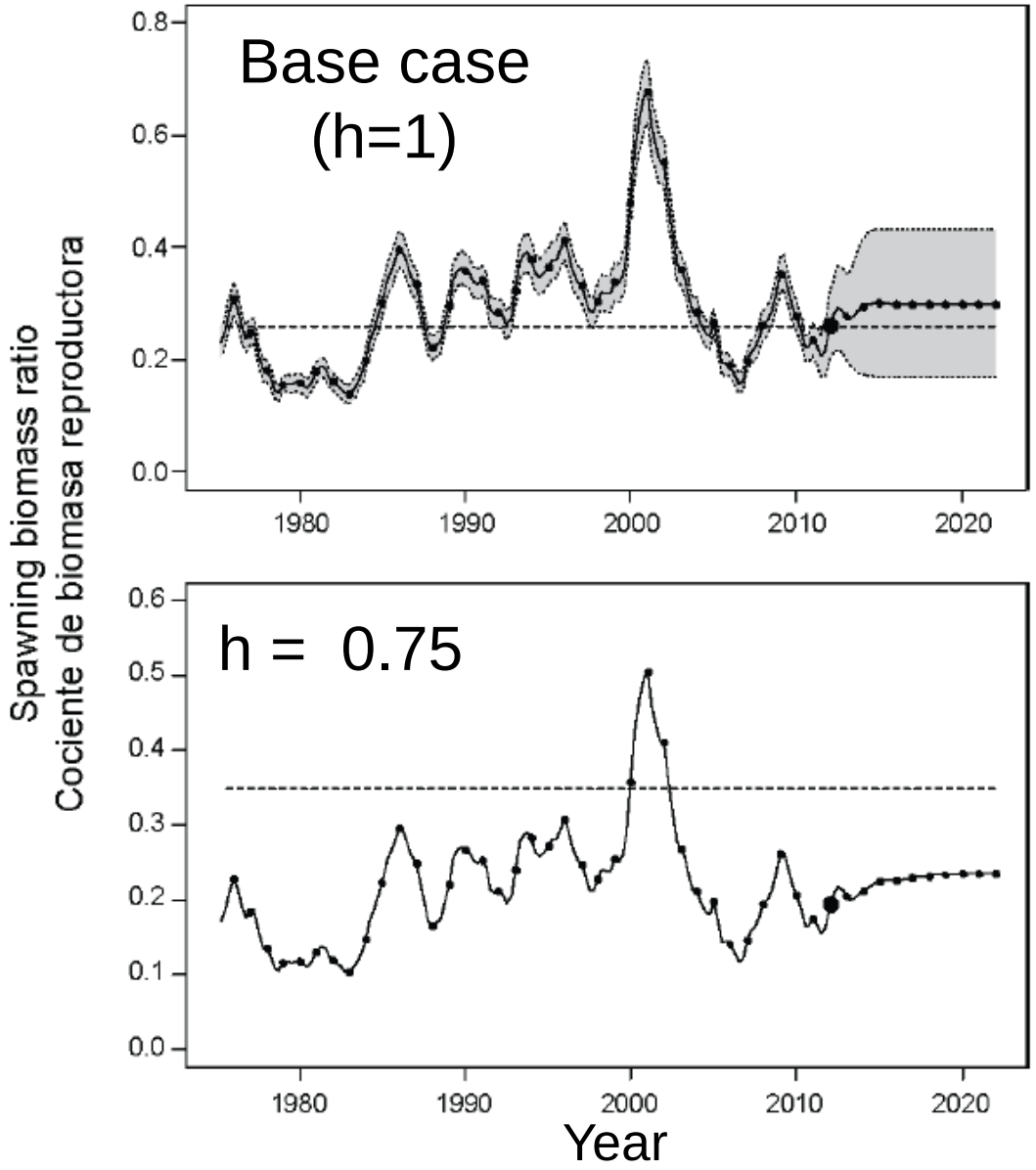


Forward projections

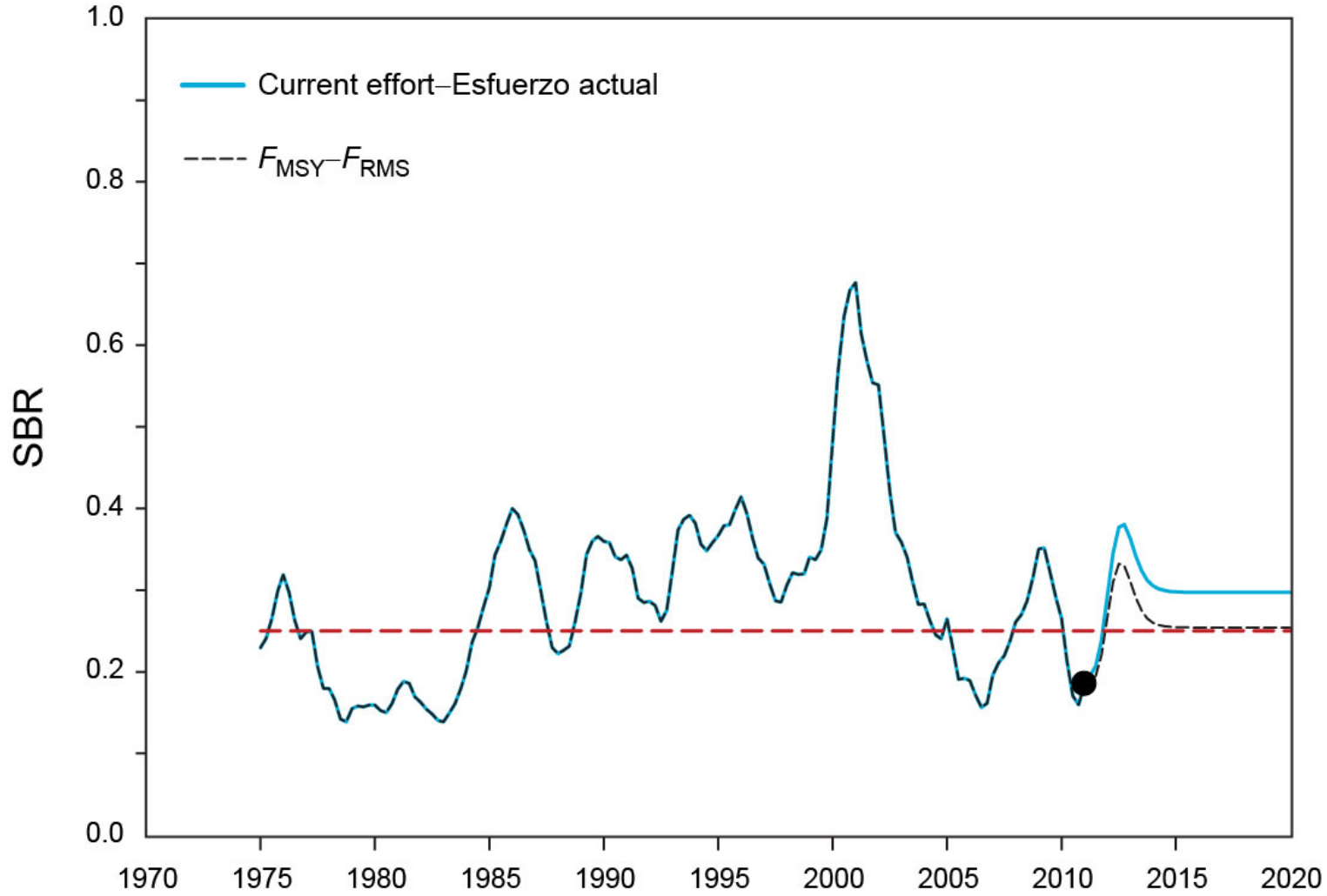
- Projection period: 10 years (2012-2022)
- Evaluate:
  - Catches (surface and longline fisheries)
  - Spawning Biomass Ratio (SBR)
- Two exploitation scenarios:
  - Status quo (F_{cur}): 3-year F average (2009-2011)
  - F_{MSY}



Projected SBR – F_{cur}

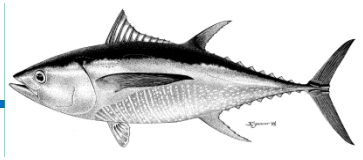


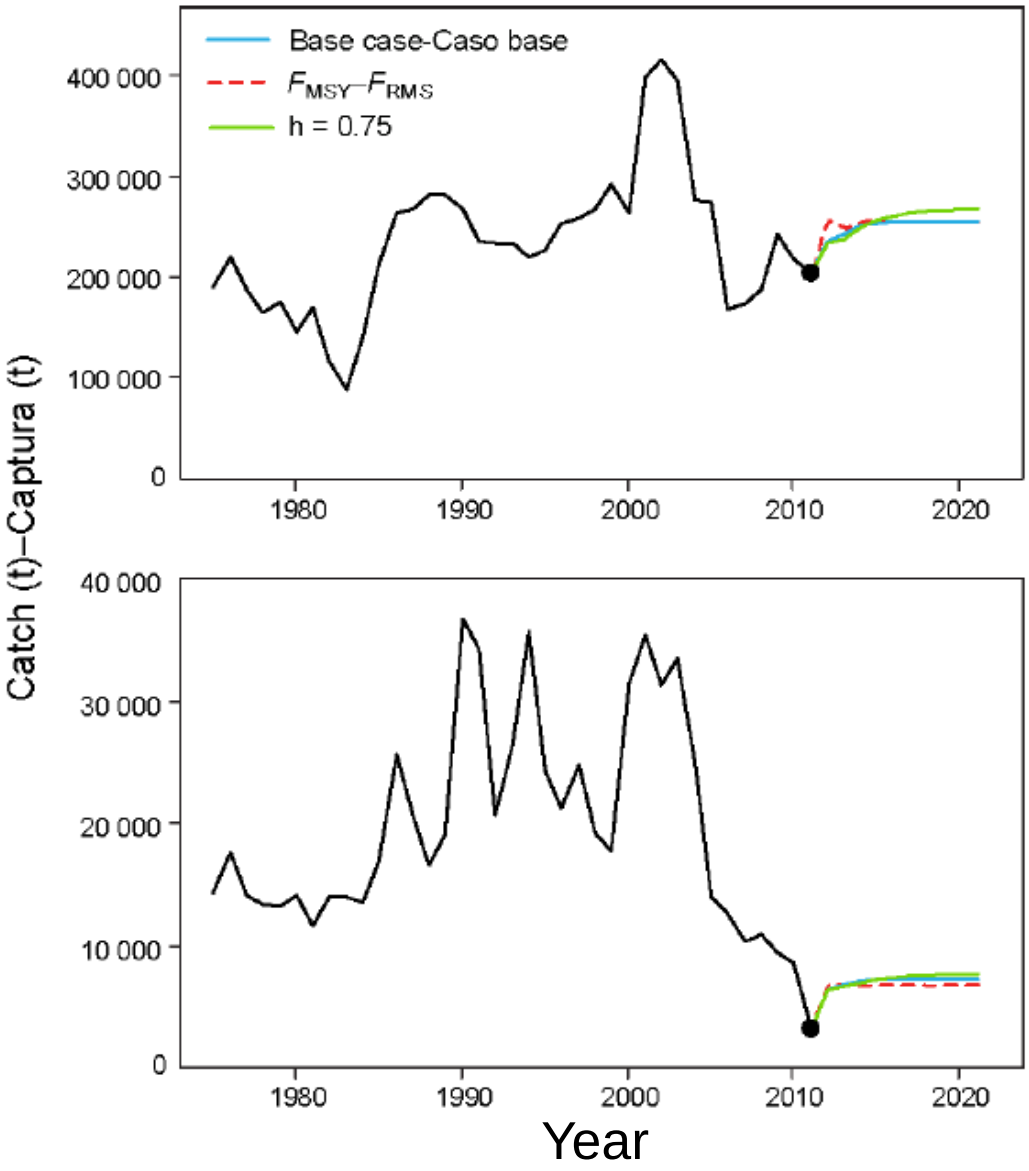
Projected SBR – F_{cur} and F_{msy}

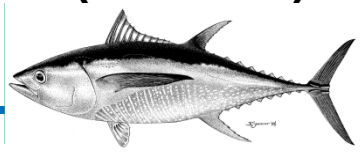


Projected catches – *Status quo* (F_{cur})

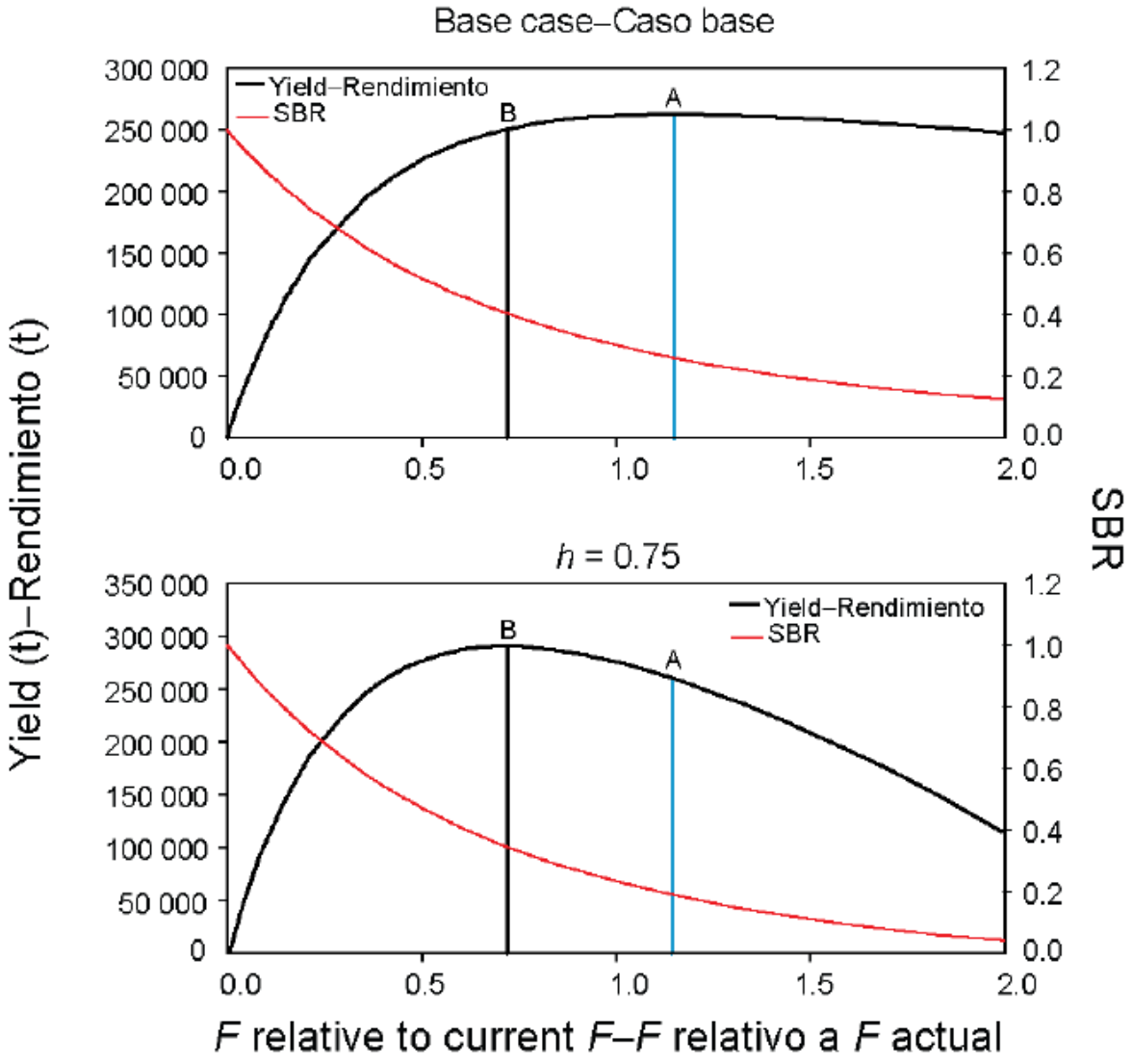
Projections (base case)

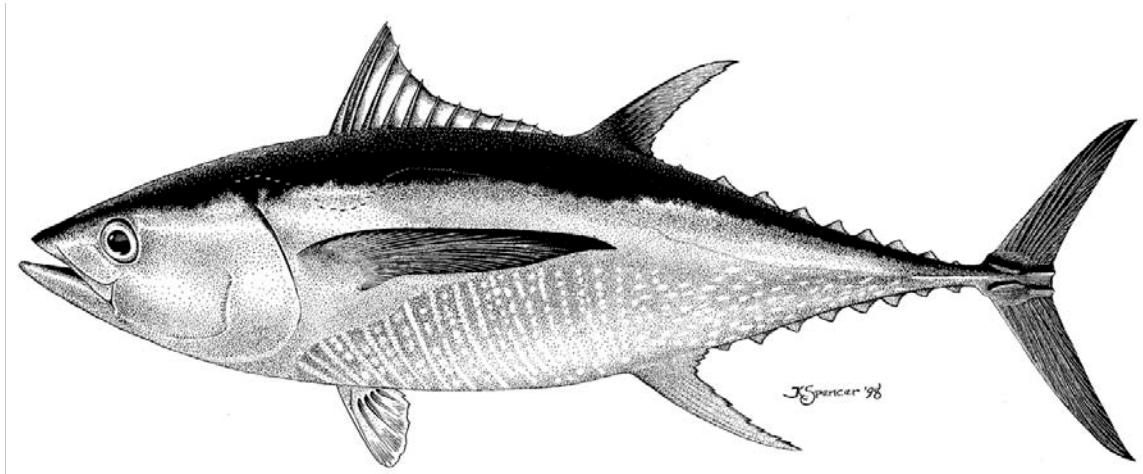






Yield


Base case–Caso base
Yield–Rendimiento
SBR
A
B
300 000
250 000
200 000
150 000
100 000
50 000
0
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.5
1.0
1.5
2.0
h = 0.75
Yield (t)–Rendimiento (t)
SBR
F relative to current F–F relativo a F actual



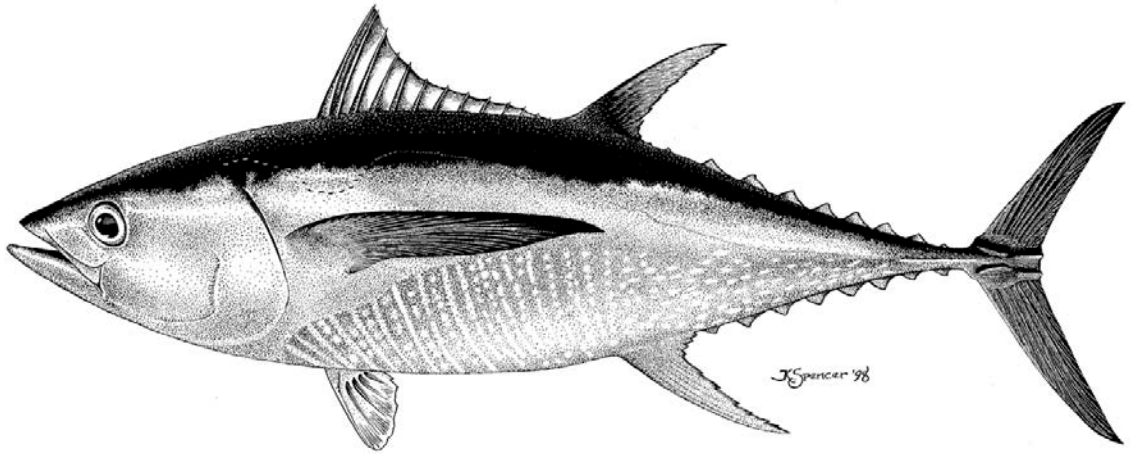
Sensitivity Analyses

DOCUMENT YFT-01-08

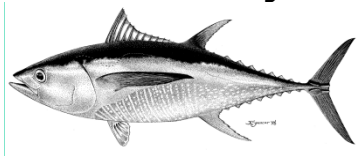
A REVIEW OF HISTORICAL EPO YFT STOCK ASSESSMENT SENSITIVITY ANALYSES

Mark N. Maunder and Alexandre Aires-da-Silva

CIAT IATTC

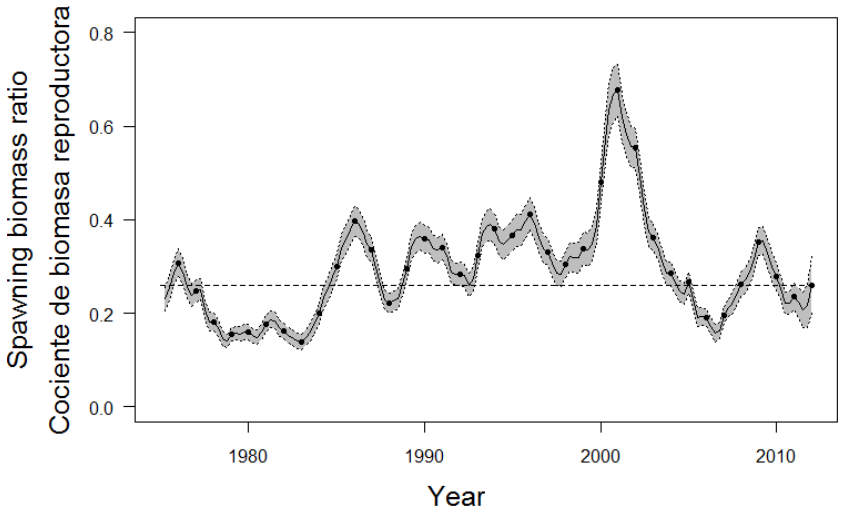


Summary



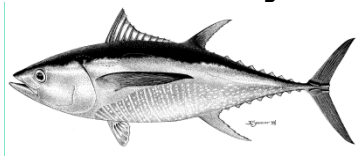
Summary: key results

- The recent **fishing mortality** rates are estimated to be lower than those corresponding to the MSY(F_{recent}<F_{MSY})
- The recent levels of **spawning biomass** are estimated to be at those corresponding to the MSY (S_{recent}=S_{MSY})



Plausible Sensitivities and Uncertainties
- lessons from previous assessments

Summary



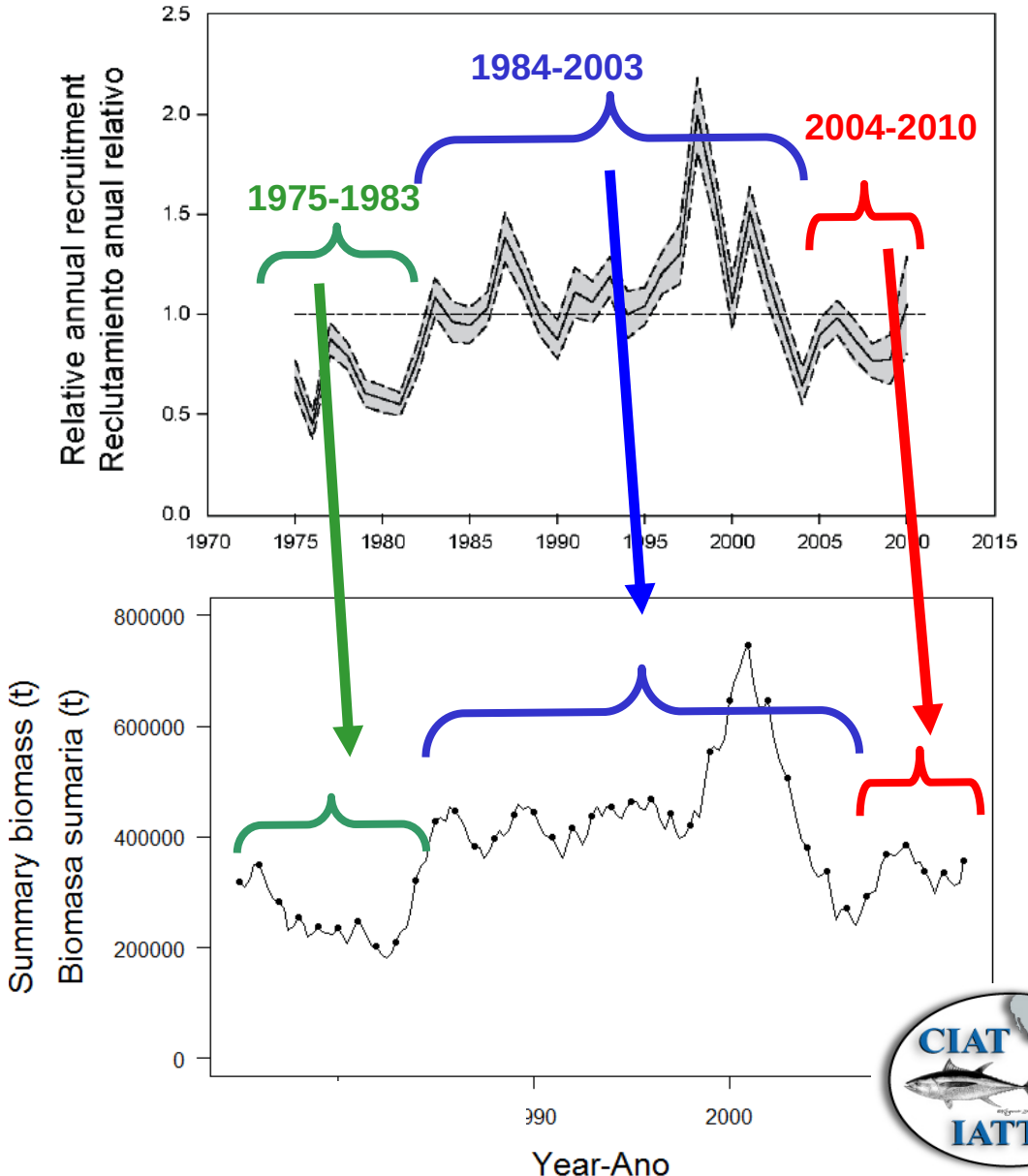
- Results are more **pessimistic** with:
  - The inclusion of a stock-recruitment relationship
  - Higher values of the average size of the oldest fish (L_2 > 182 cm)
  - Lower rates of adult natural mortality (M)

- Results are more **optimistic** with:
  - Lower values of the average size of the oldest fish (L_2 < 182 cm)
  - Higher rates of adult natural mortality (M)
  - Fitting to CPUE DEL-N as main index of abundance (S_{recent}>S_{MSY})

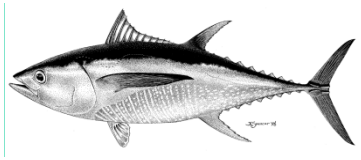
CIAT IATTC

Summary: key results (cont.)

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

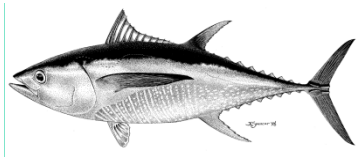


Future directions



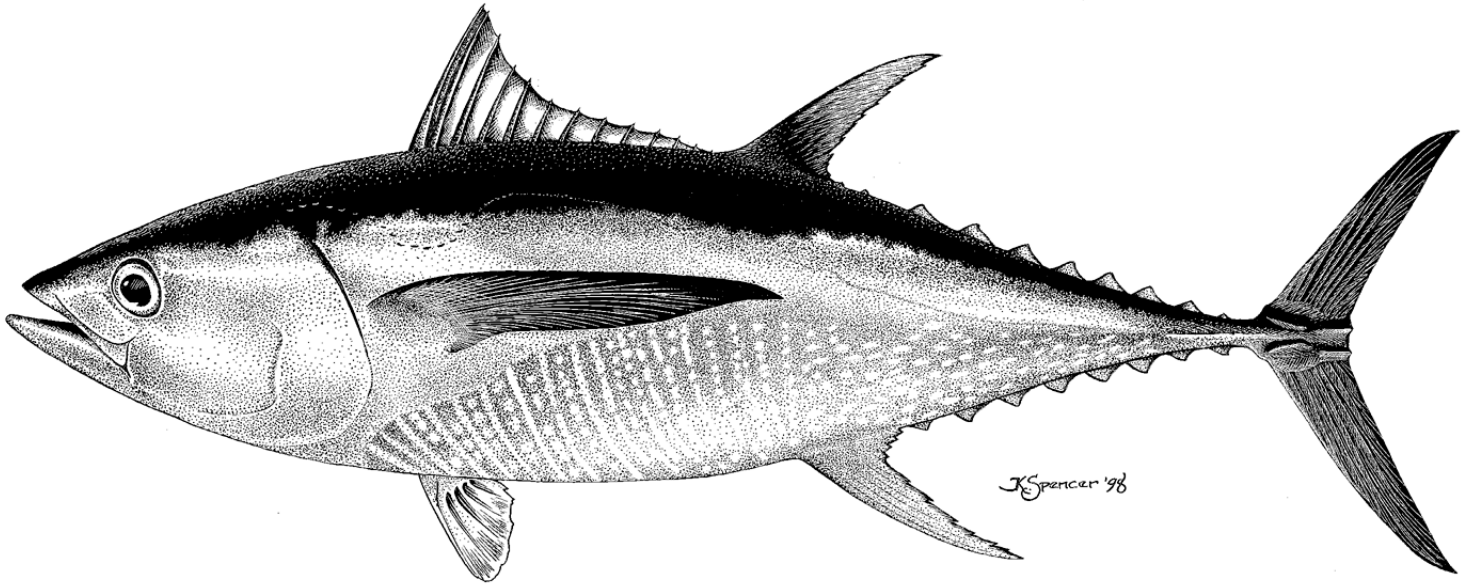
- Alternative assumptions on stock structure (see YFT-01-02 and YFT-01-03)
- Time-variant selectivity for PS fisheries (see YF-01-06)
- More robust selectivity curves
- Determine appropriate weighting of the different data sets (presentation ahead)

External Review



- External review of IATTC YFT assessment methods and assumptions (15-19 October, 2012)

Questions?



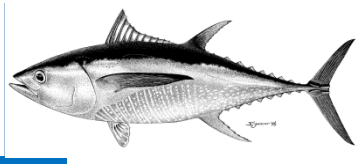
Lengths and Days at Liberty for 5 Yellowfin from 5 Areas of Release

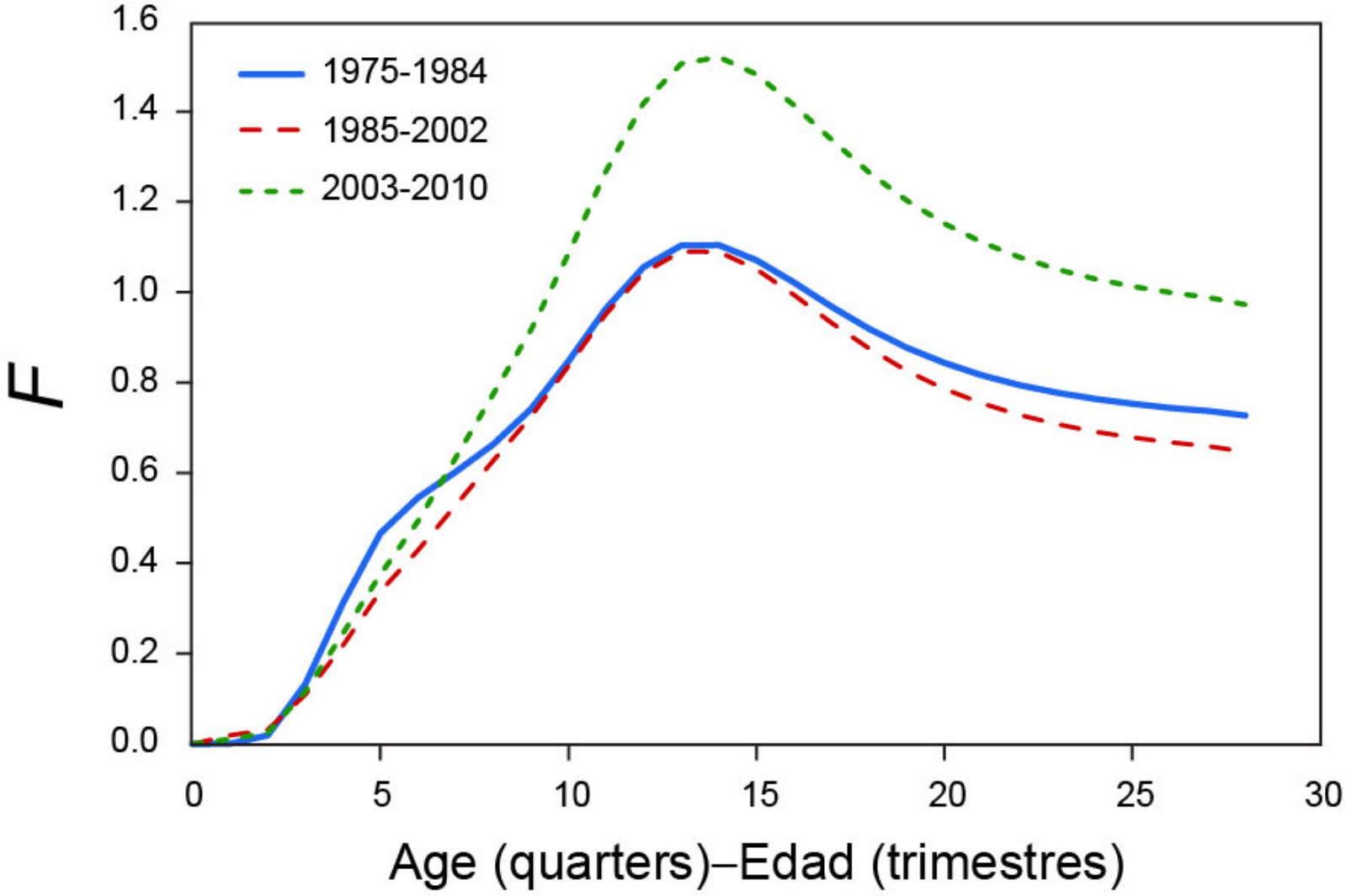
Area		Length (cm)	Days at Liberty
Northern Baja	Mean	64.8	423.6
	Range	60 - 76	364 - 603
Southern Baja	Mean	77.6	643.1
	Range	66 - 91	472 - 1161
Revillagigedo Islands	Mean	114.0	523.0
	Range	102 - 139	425- 632
Panama	Mean	64.2	172.8
	Range	58 - 75	137 - 239
Equatorial EPO	Mean	54.8	118.7
	Range	51 - 60	45 - 311

Summary of Movement Parameters from UKFSST

Area		σ_x (Degrees)	σ_y (Degrees)	*u* (nm/day)	*v* (nm/day)	*D* (nm^2/day)
Northern Baja	**Median**	0.46	1.67	0.16	-0.50	135.09
	Range	0.30 – 0.60	1.44 – 2.12	-0.38 – 0.59	-1.84 – 0.42	84.37 – 267.77
Southern Baja	**Median**	0.43	2.79	0.05	0.06	117.80
	Range	0.36 – 0.53	1.53 – 4.56	-0.14 – 0.22	-0.35 – 0.98	62.45 – 219.76
Revillagigedo Islands	**Median**	0.43	2.79	0.05	0.06	117.80
	Range	0.36 – 0.53	1.53 – 4.56	-0.14 – 0.22	-0.35 – 0.98	62.45 – 219.76
Panama	**Median**	0.97	3.04	0.56	0.54	92.06
	Range	0.79 – 1.31	1.46 – 5.36	-0.06 – 1.02	0.21 – 0.96	67.62 – 114.83
Equatorial EPO	**Median**	0.52	2.57	2.75	4.17	584.08
	Range	0.19 – 0.79	0.83 – 4.09	-4.79 – 7.78	0.66 – 10.42	411.76 – 858.10

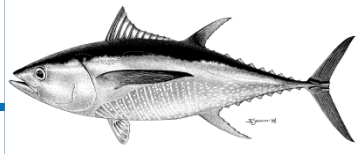
YFT age-specific fishing mortality (F)





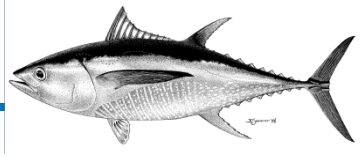
MSY-quantities by fishery

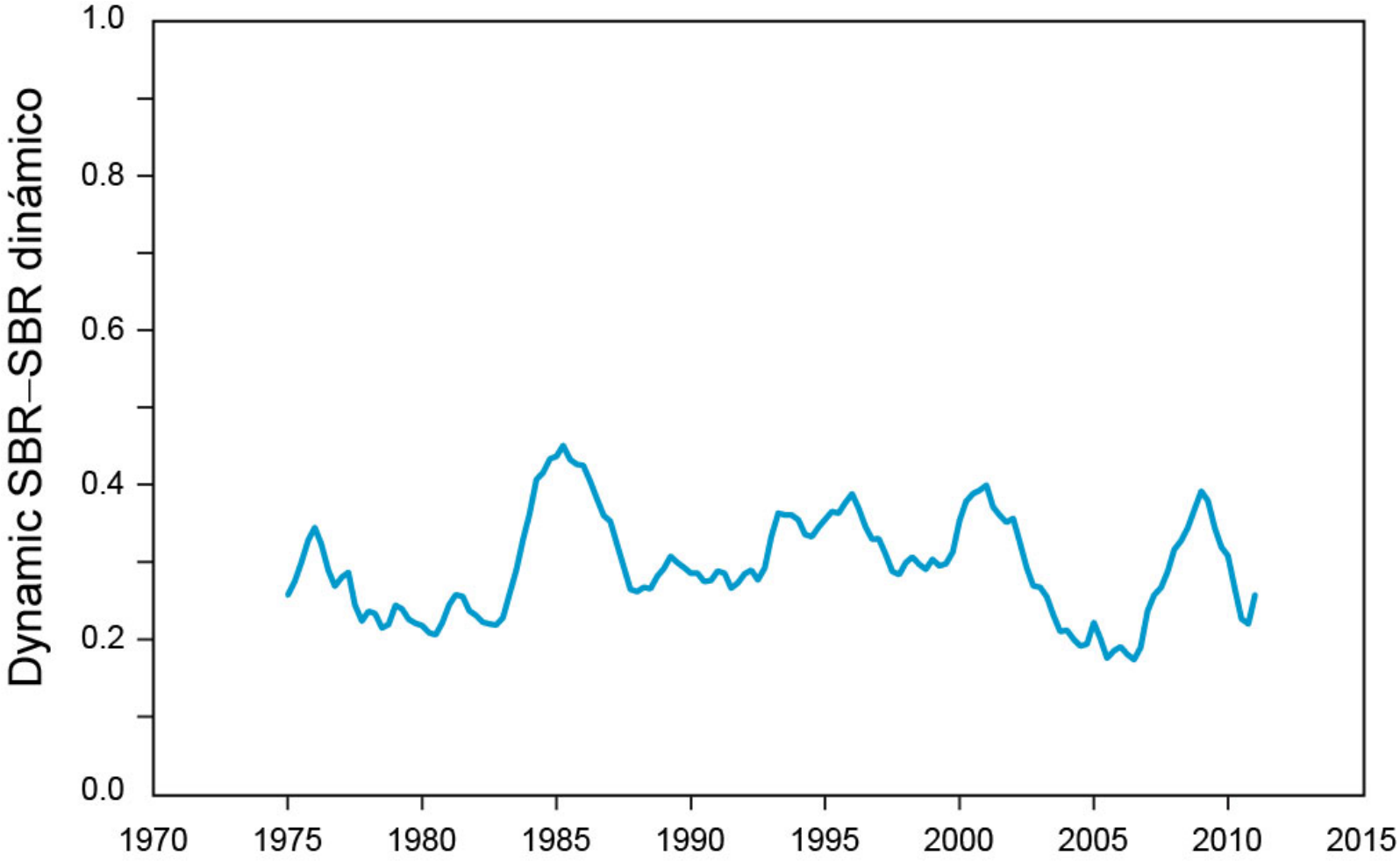
Stock status (base case)



	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

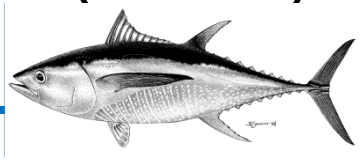
Dynamic SBR

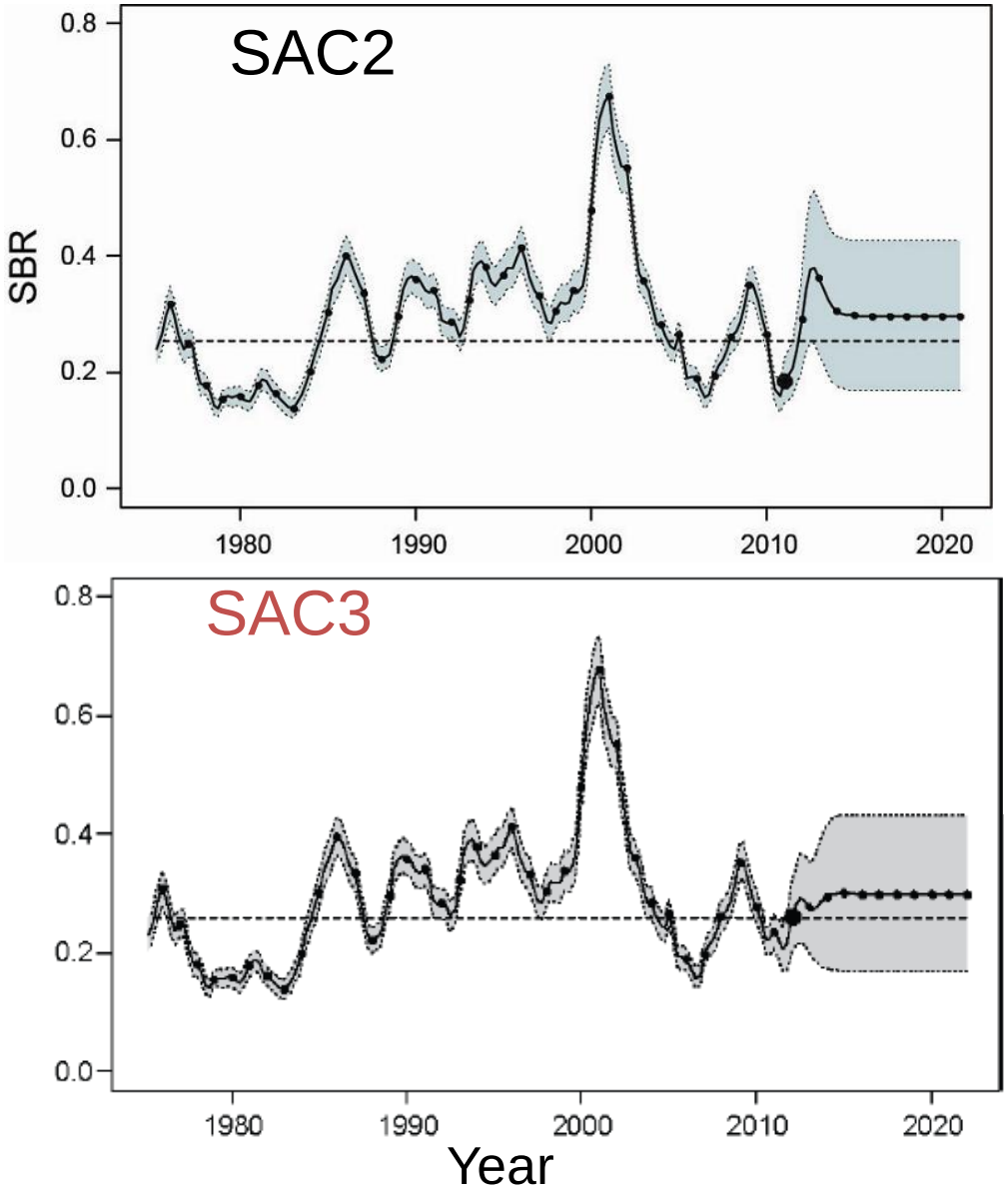


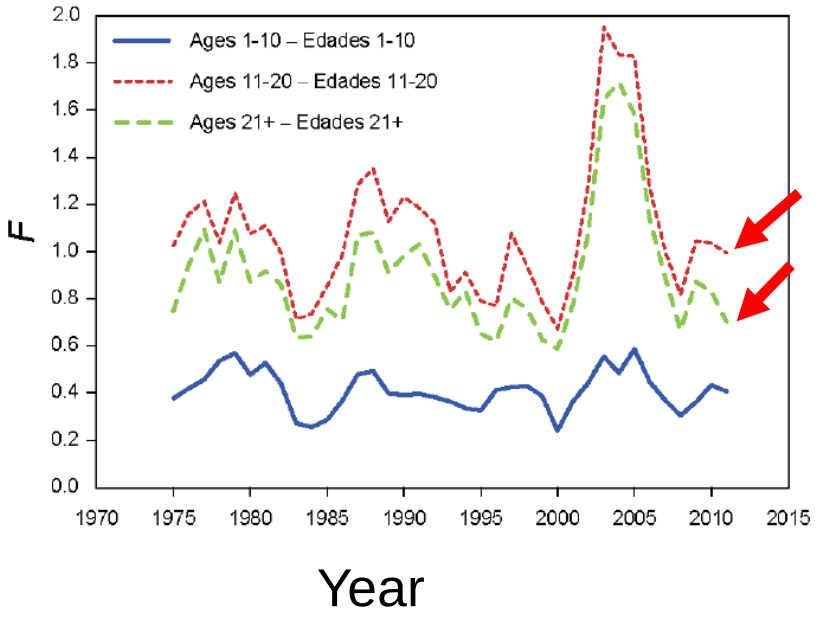

Dynamic SBR–SBR dinámico
1.0
0.8
0.6
0.4
0.2
0.0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015

Projected SBR – F_{cur}

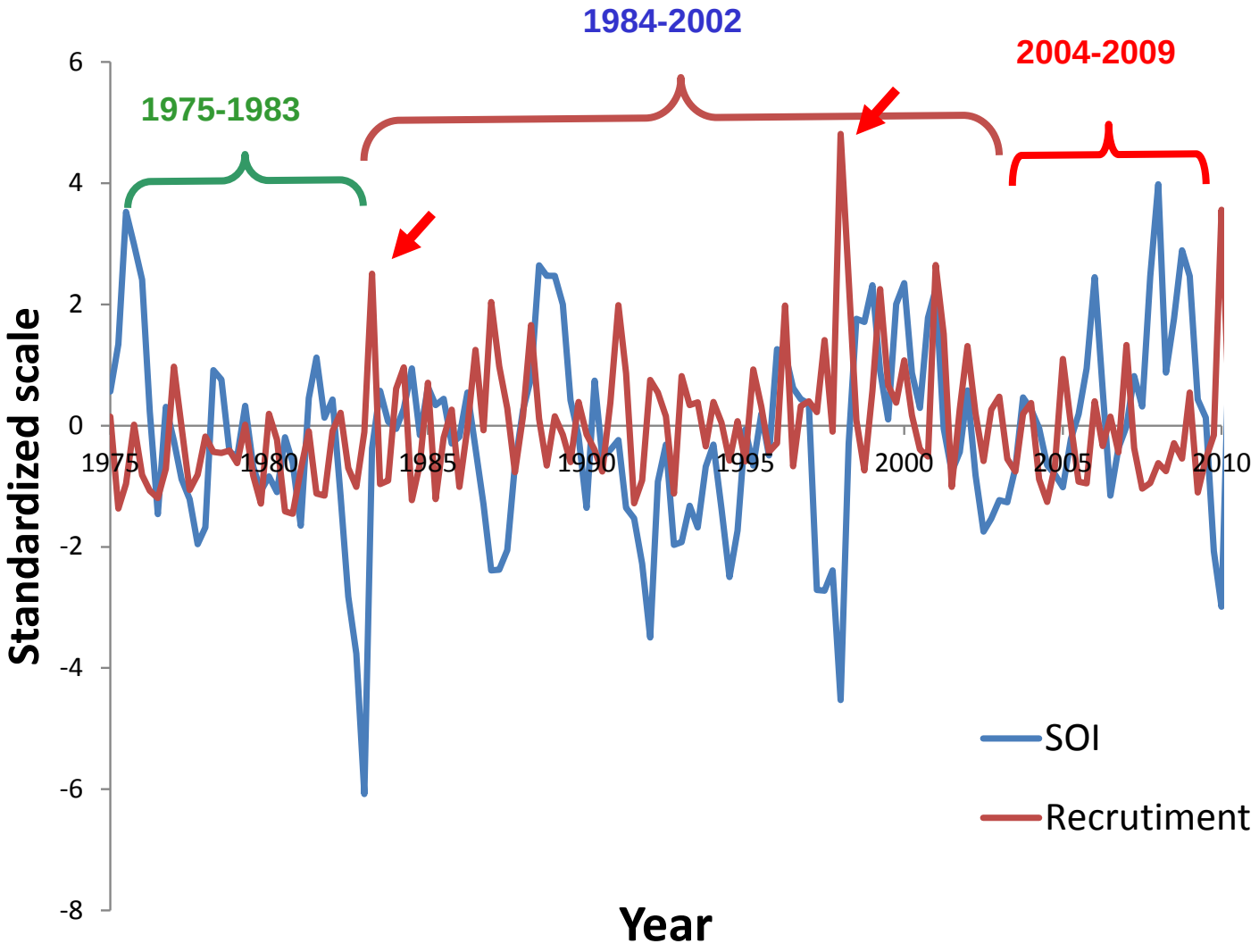
Stock status (base case)

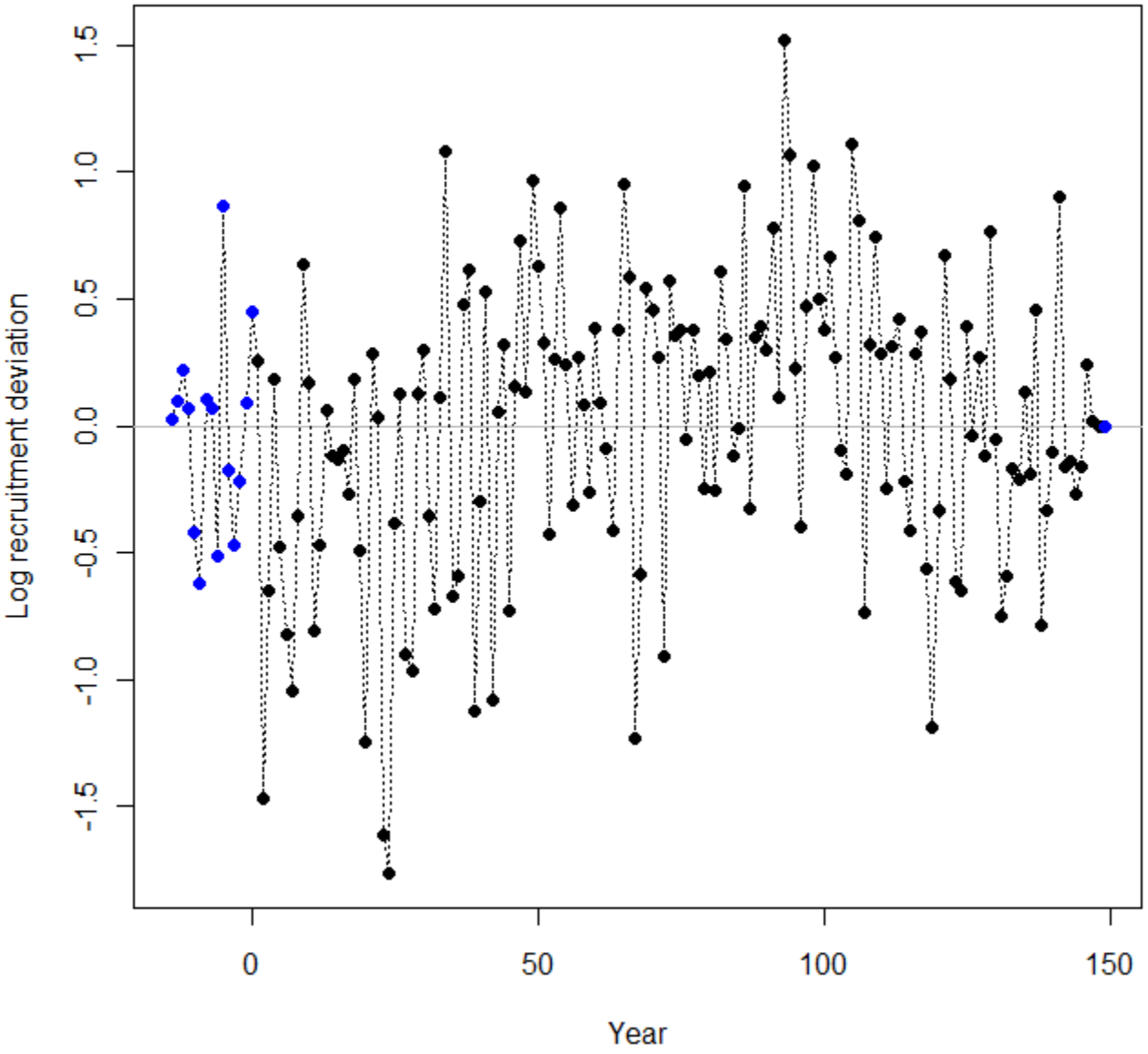


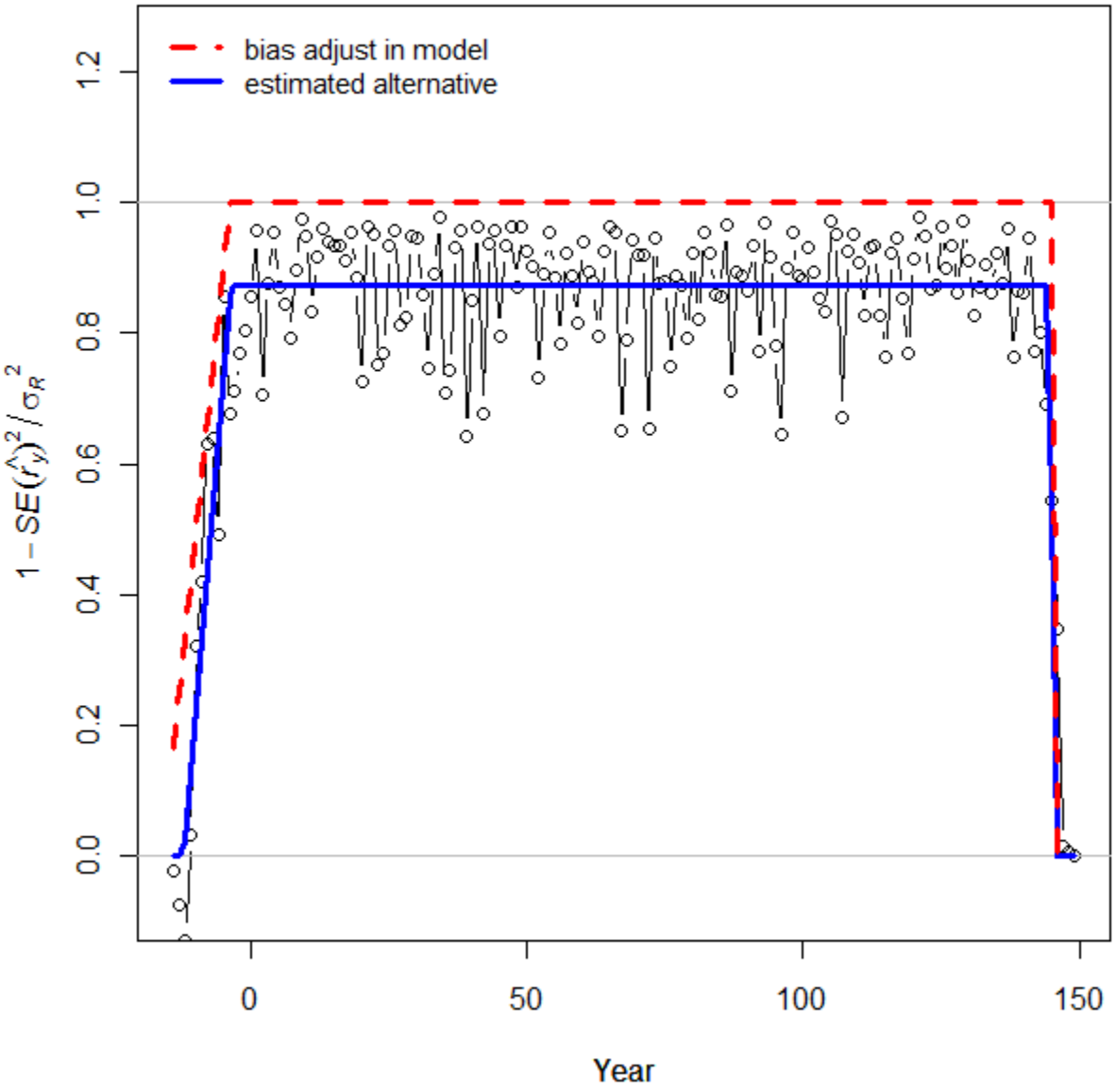




SOI - El Niño / La Niña?




Log recruitment deviation
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
0
50
100
150
Year


bias adjust in model
estimated alternative
1.2
1.0
0.8
0.6
0.4
0.2
0.0
$1 - SE(\hat{r}_y)^2 / \sigma_R^2$
0
50
100
150
Year