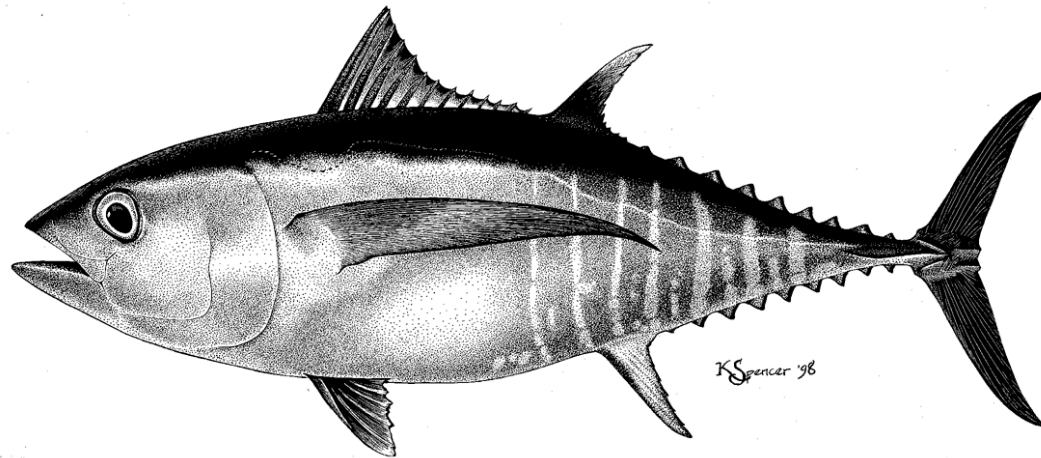


# ASSESSMENT OF BIGEYE TUNA (*THUNNUS OBESUS*) IN THE EASTERN PACIFIC OCEAN

January 1975 – December 2004



# Overview of assessment

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- Age-structured, statistical, catch-at-length model (A-SCALA).
- Quarterly time step from 1975 to the start of 2005.
- No net movement of fish between the eastern and western Pacific.

# Major changes

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- Revised biological inputs
  - Growth
  - Maturity
  - Fecundity
  - Natural Mortality
  - start at the age of one quarter
- Purse-seine catch and length-frequency new for 2004 and updated 2000-2003
- Purse-seine effort data new for 2004 and updated 1975-2003

# Major changes

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- Longline
  - Monthly reporting catch data for 2004
  - Japanese catch updated for 1999-2002 and new for 2003
  - Chinese Taipei catch new data for 2002
  - Peoples Republic of China new for 2003 and updated for 2001 and 2002.
  - Japanese length-frequency updated for 2001-2002 and new for 2003
  - Effort data based on statistical habitat-based standardization include data for 2002, and regression using raw catch and effort data extend to the second quarter of 2004.

# Sensitivity analyses

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- Spawner-recruitment relationship (steepness = 0.75)

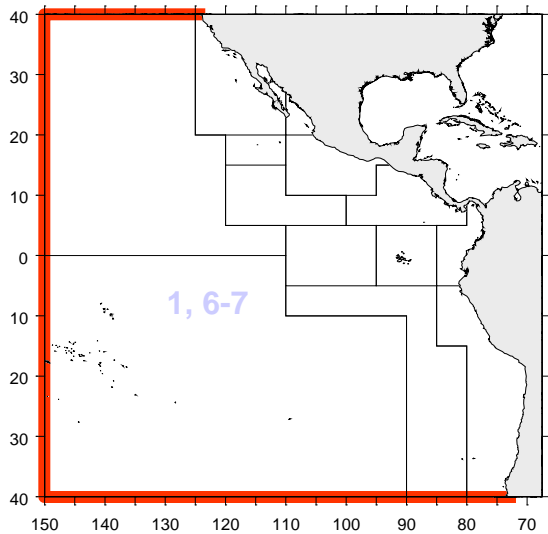
# Data

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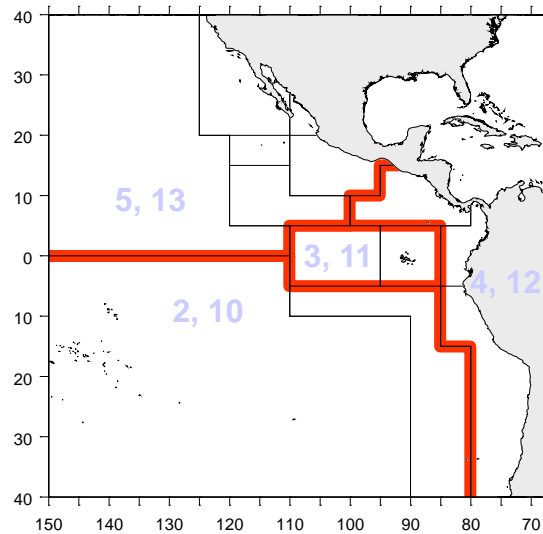
- Fishery definitions
- Catch
- Effort
- Length frequency
- Discards
- Environmental indices (not significant this year)

# Bigeye fishery definitions

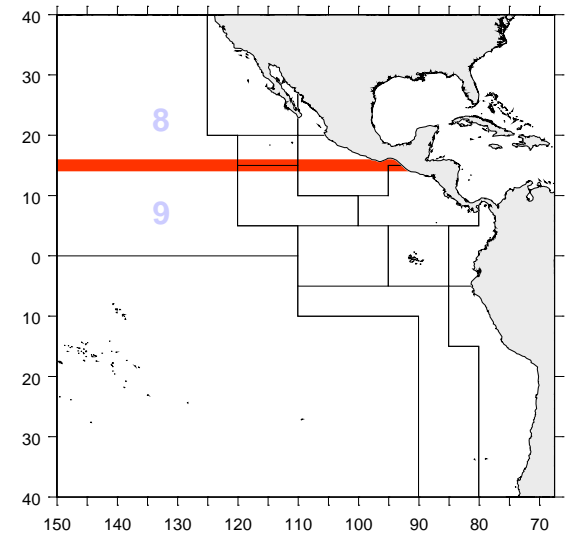
Early FLT (1)  
Early & Recent UNA (6, 7)



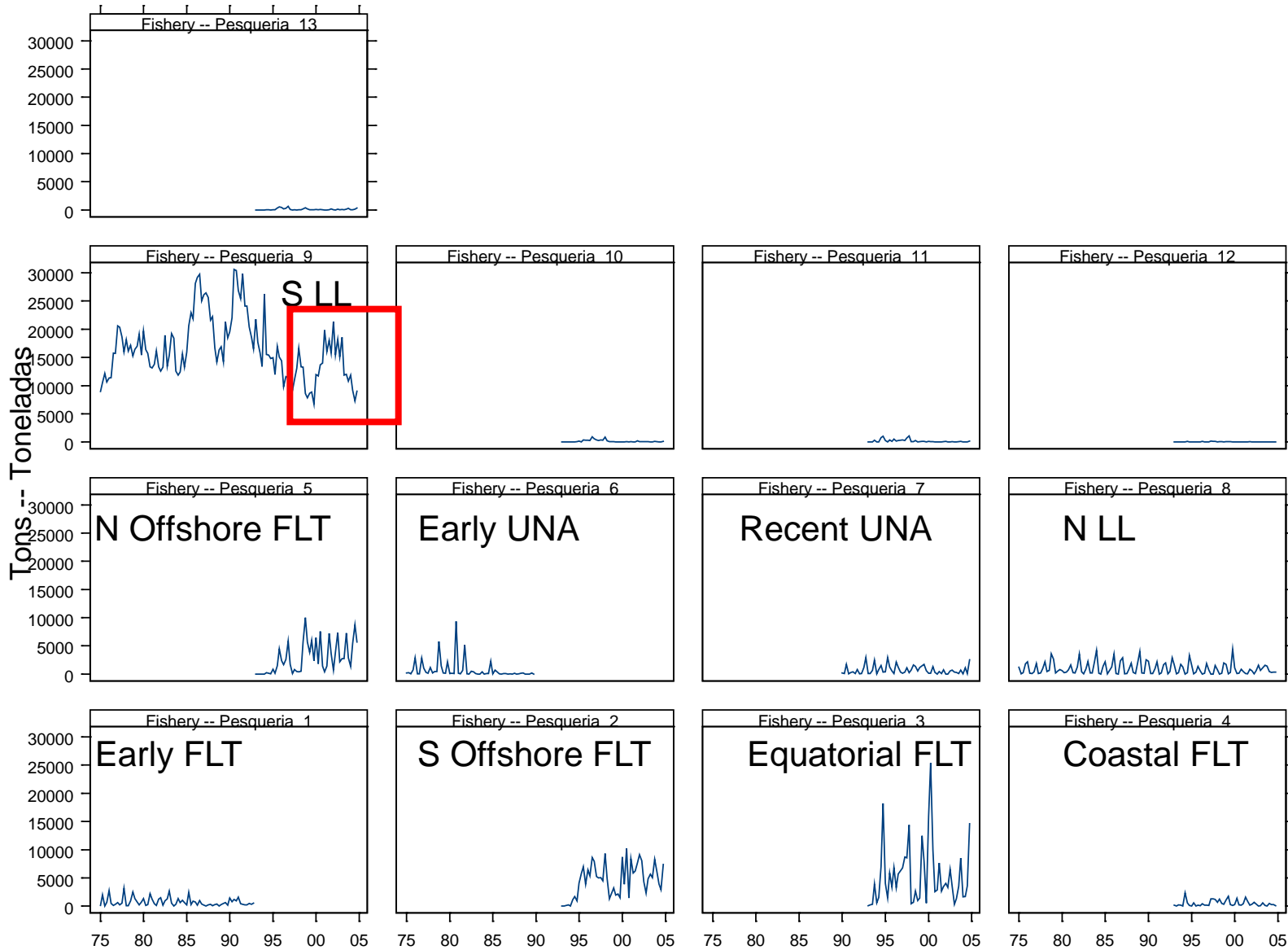
Recent FLT (2-5)  
Discards (10-13)



N Longline (8)  
S Longline (9)

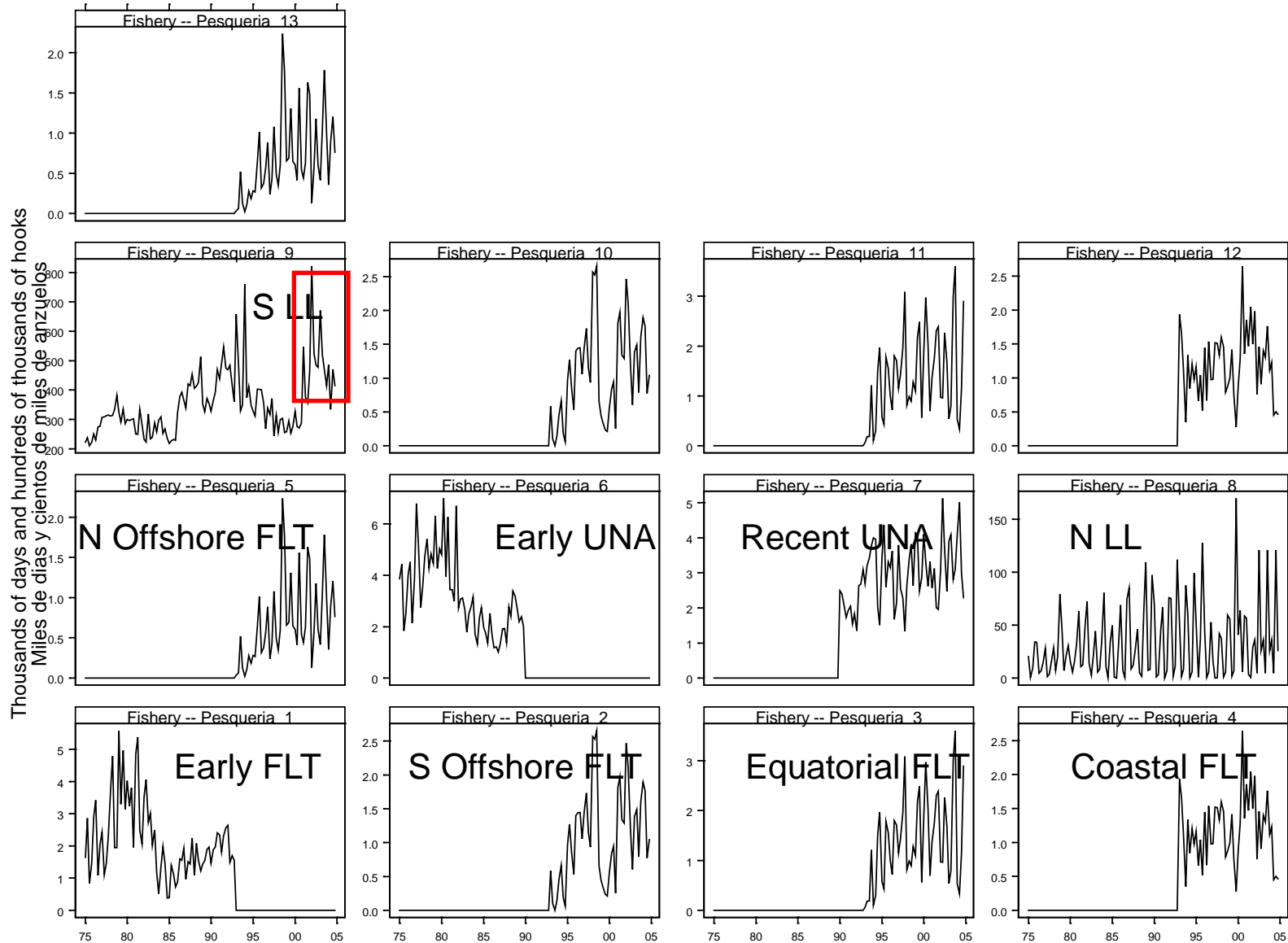


# Catch

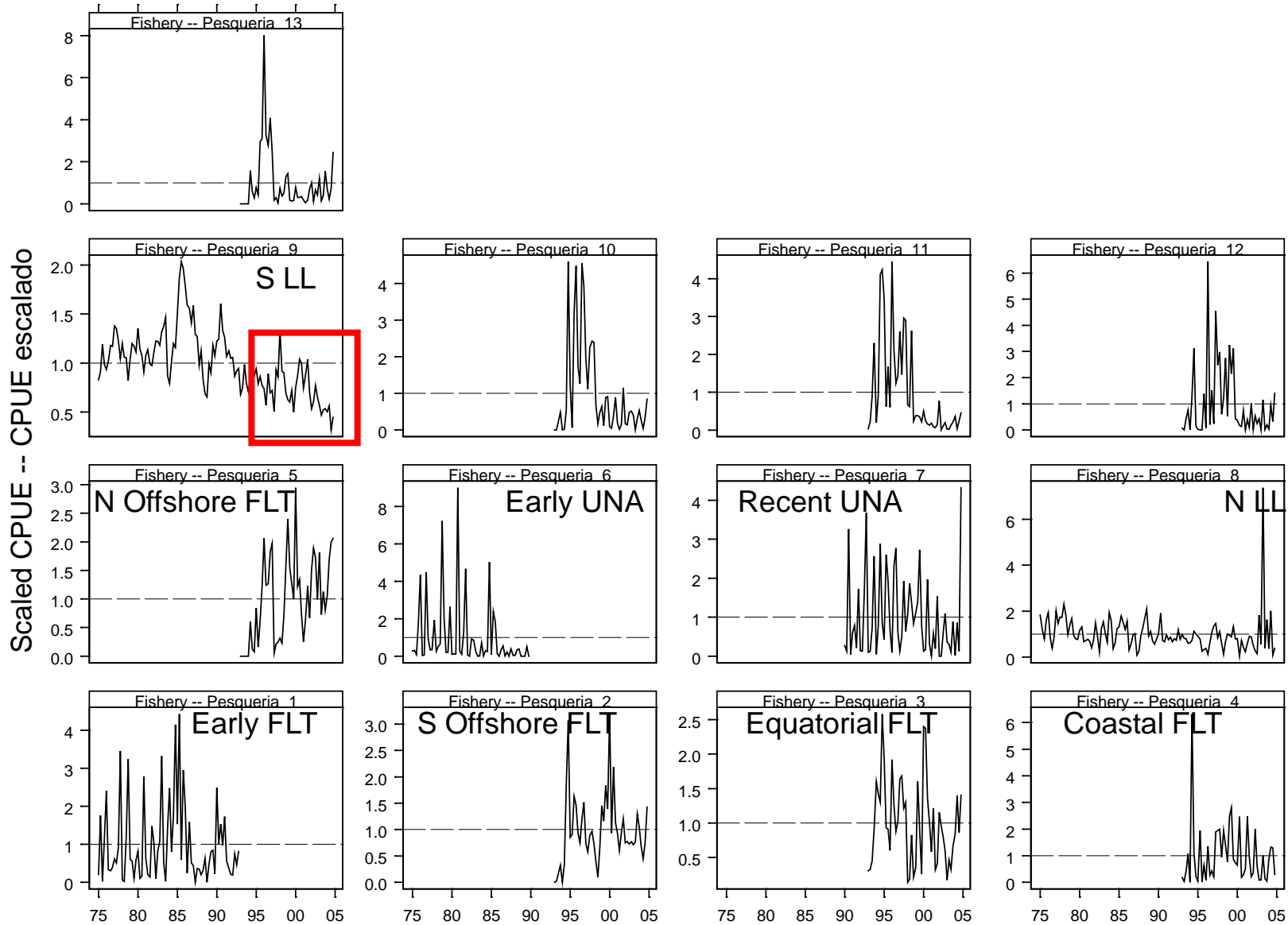




# Effort



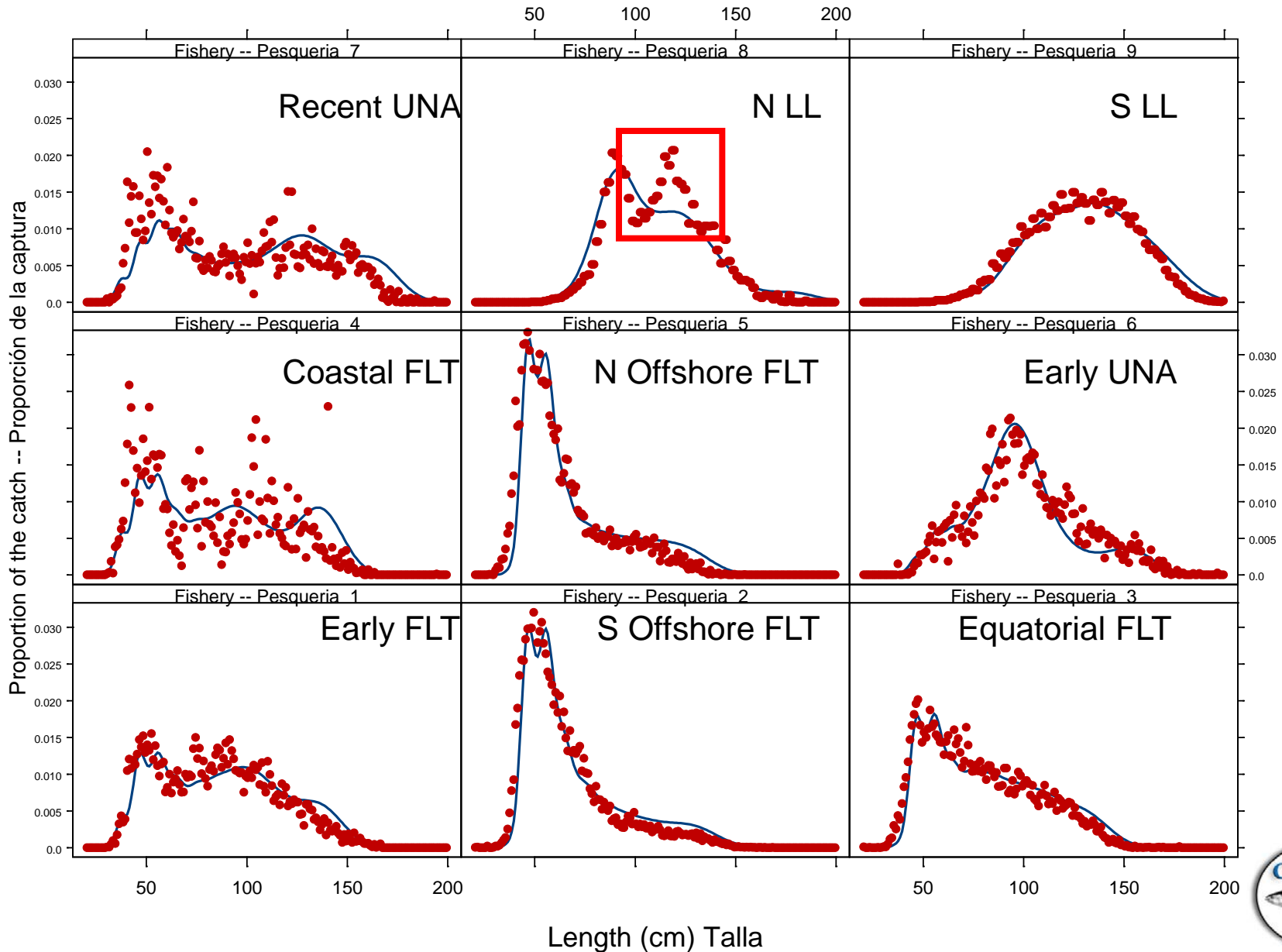
# CPUE



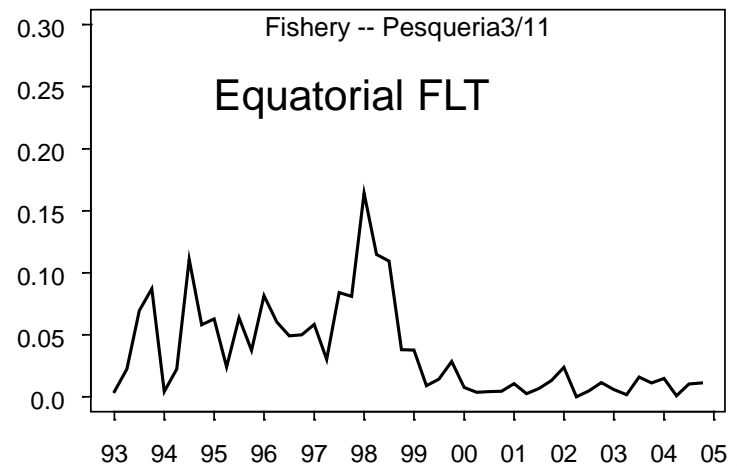
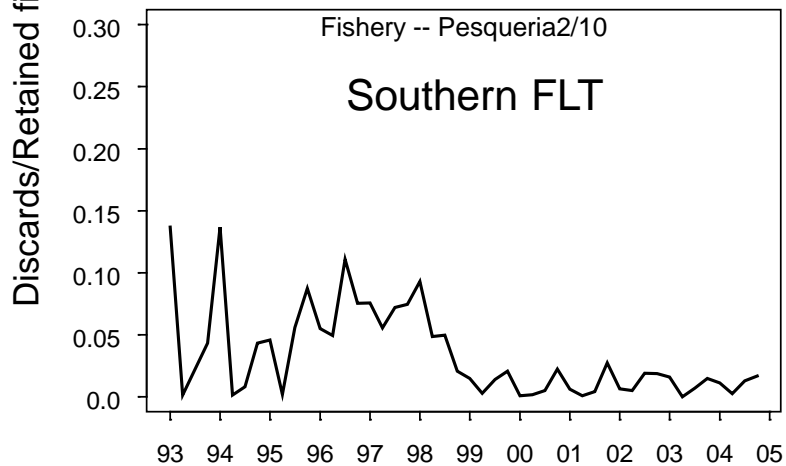
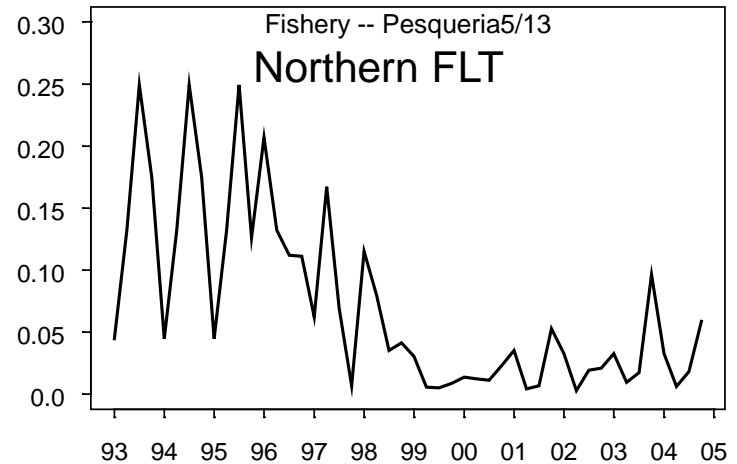
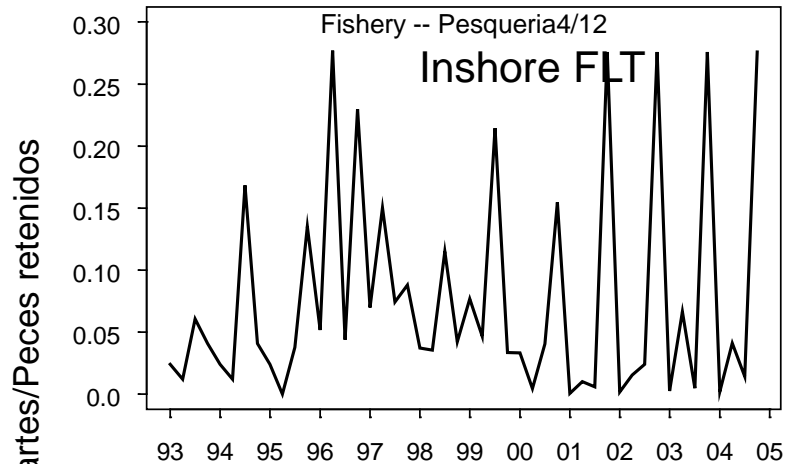
Year -- Año



# Length frequency data



# Discards



Year -- Año

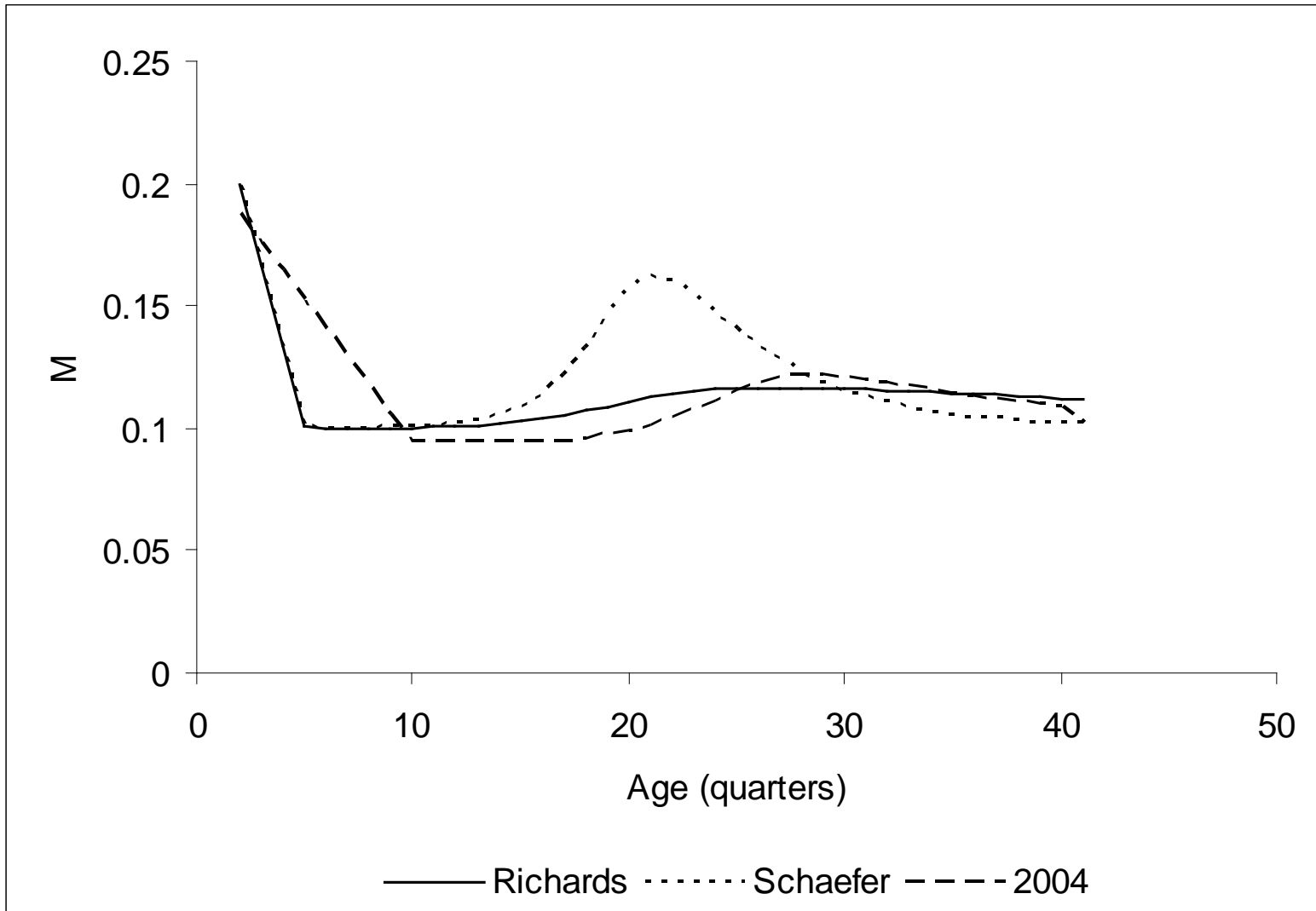


# Fixed parameters

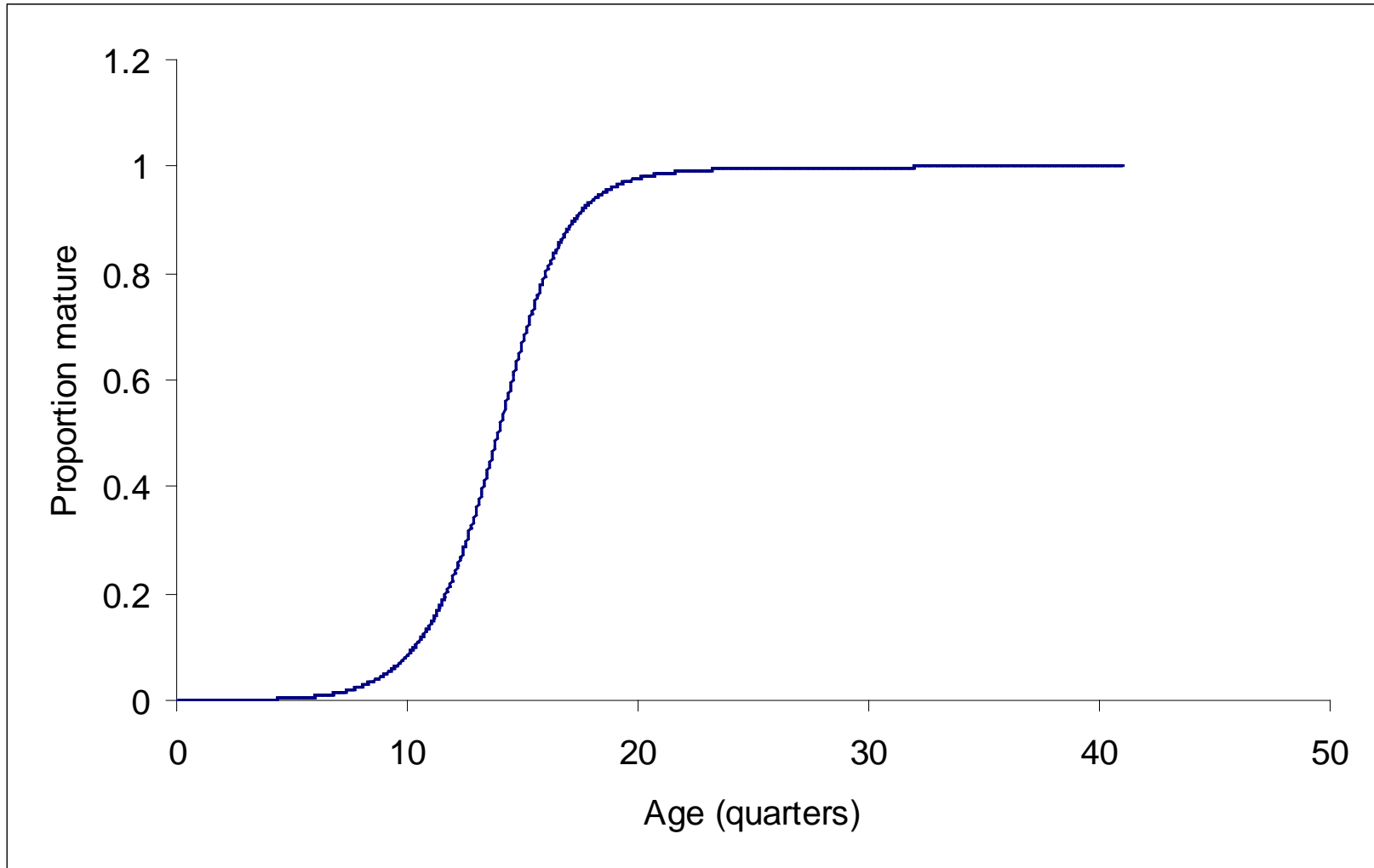
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- Natural Mortality
- Fecundity at age
- Sex ratio at age
- Selectivity curves for the discard fisheries
- The steepness of the stock recruitment relationship

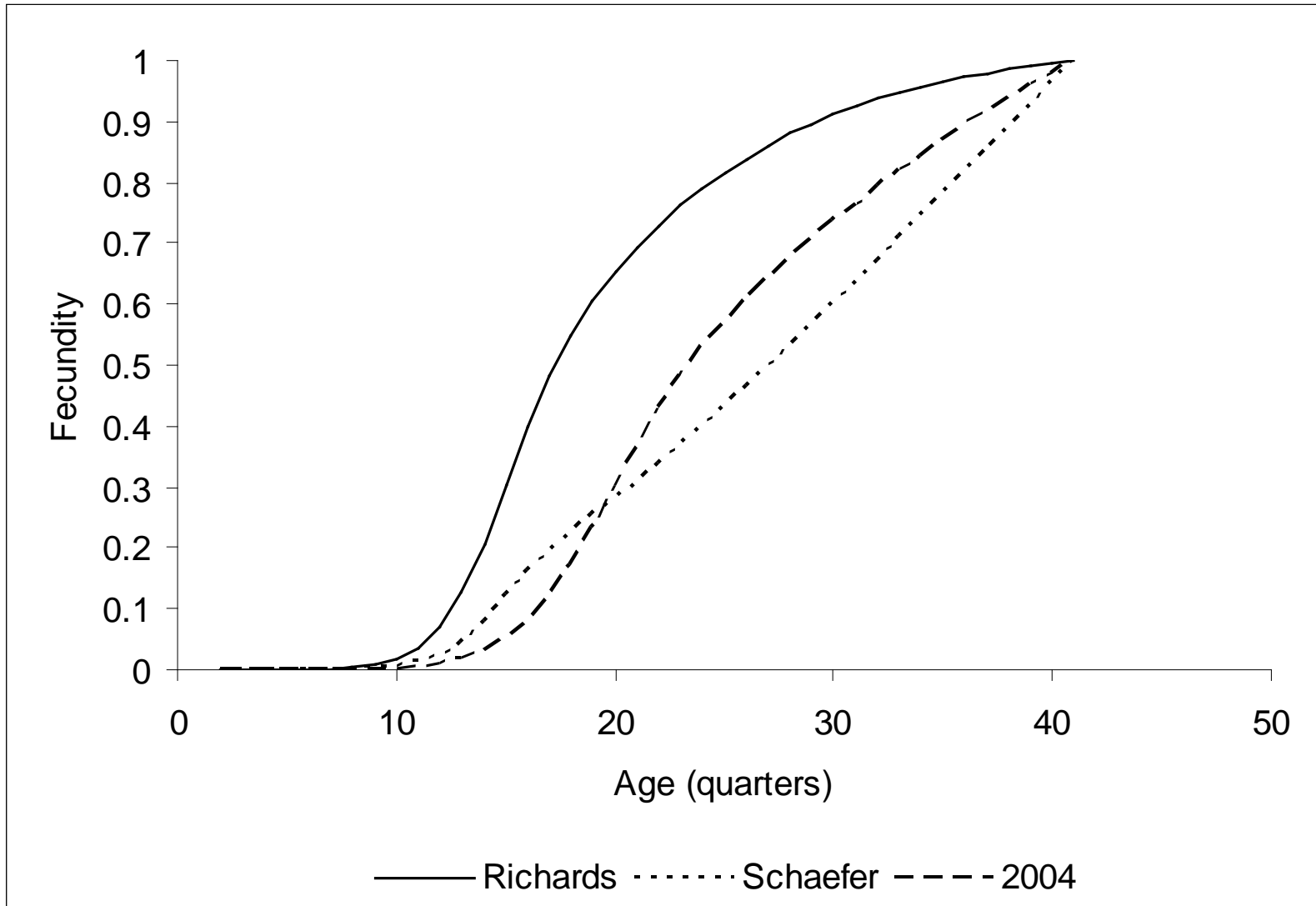
# Natural mortality



# Maturity curves

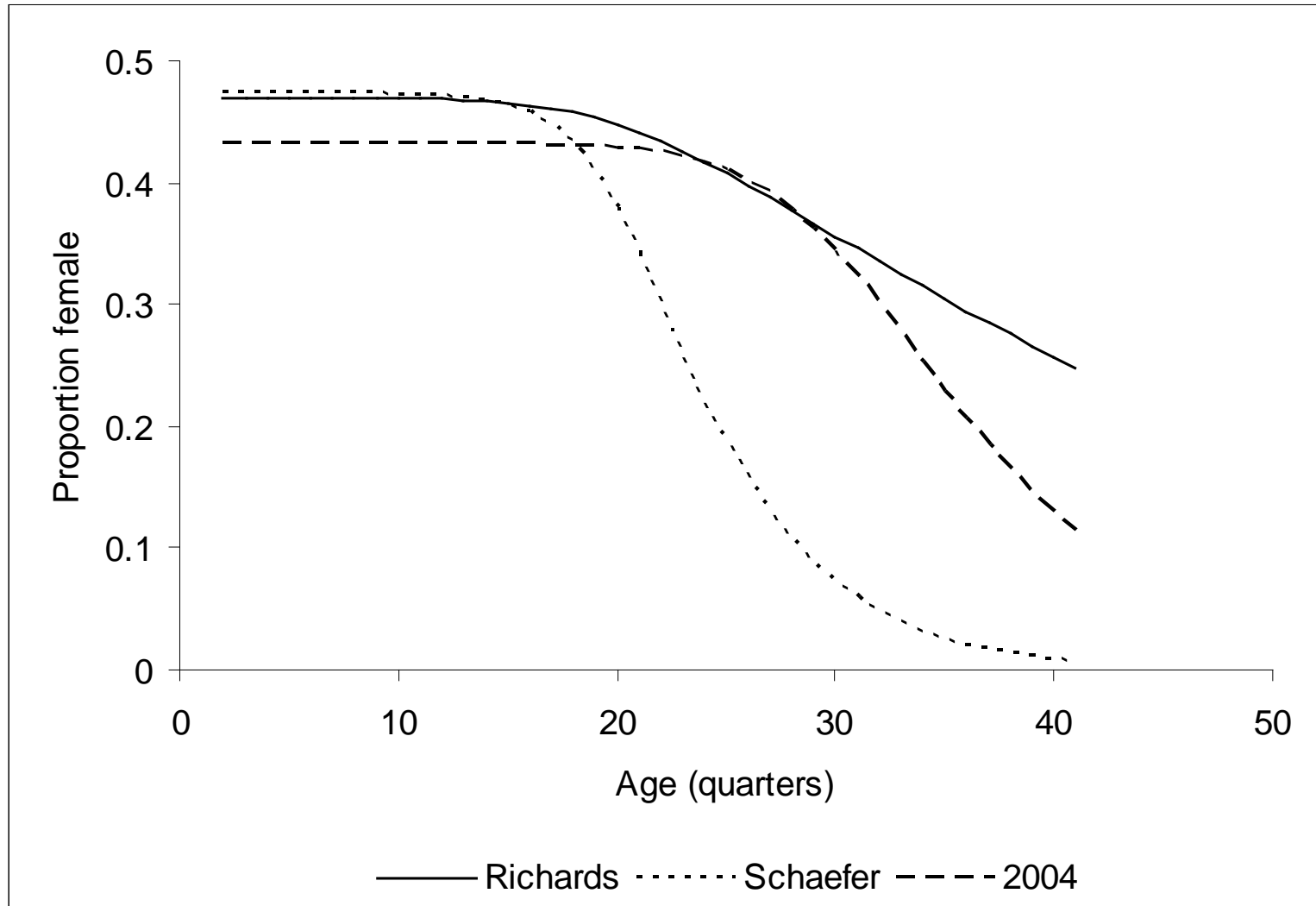


# Fecundity curve

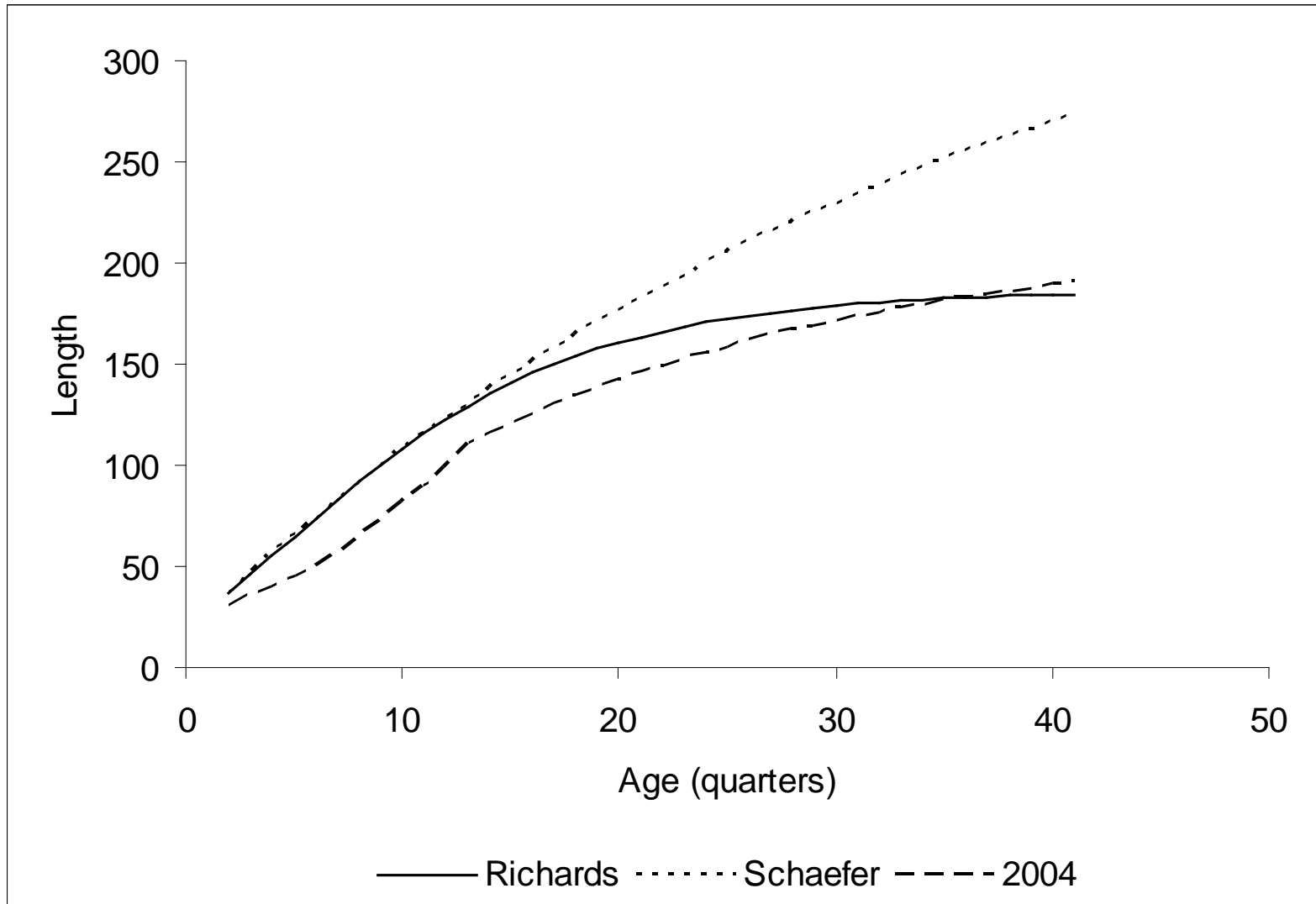




# Proportion of females



# WPO Bigeye Growth



# Estimated parameters

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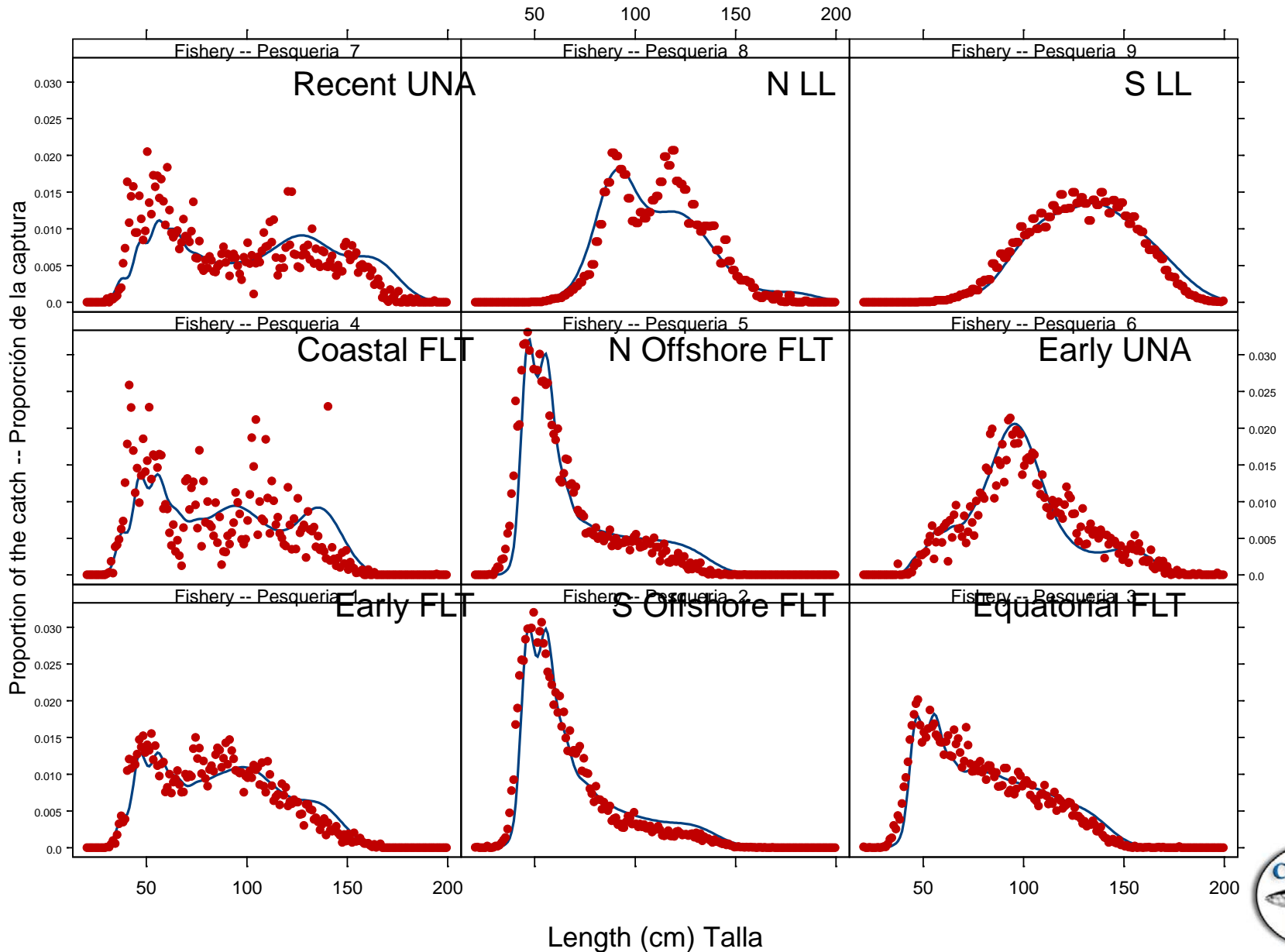
- **Recruitment**
  - Temporal anomalies and environmental influence
- **Catchability**
  - Temporal anomalies
- **Selectivity**
- **Initial population size and age-structure**
- **Mean length at age**
- **Variation of length at age**

# Results

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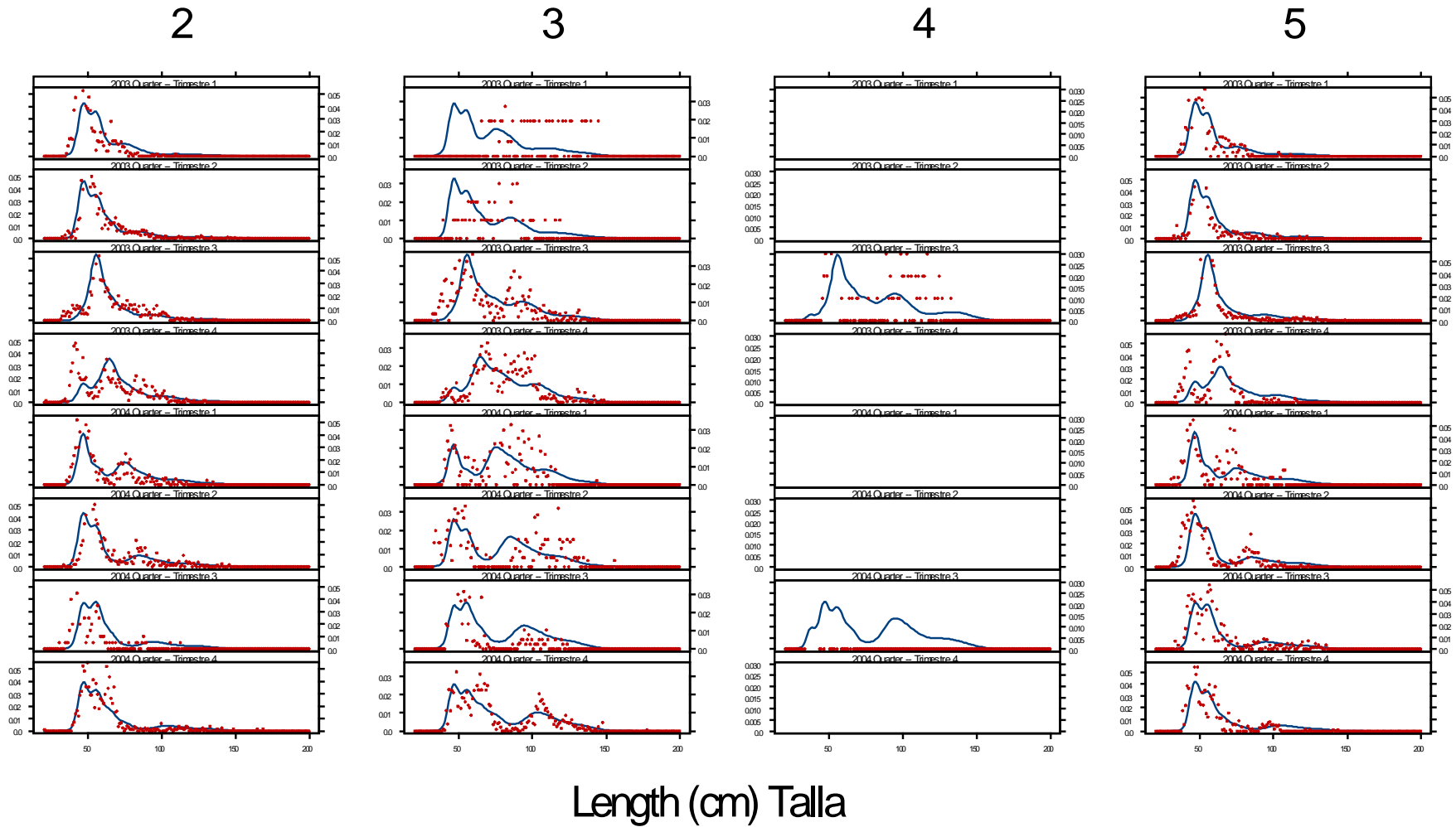
- Fit to the length frequency
- Growth
- Fishing mortality
- Selectivity
- Recruitment
- Biomass
- Catchability

# Average fit to the length frequency data



# Fit to recent length frequency data

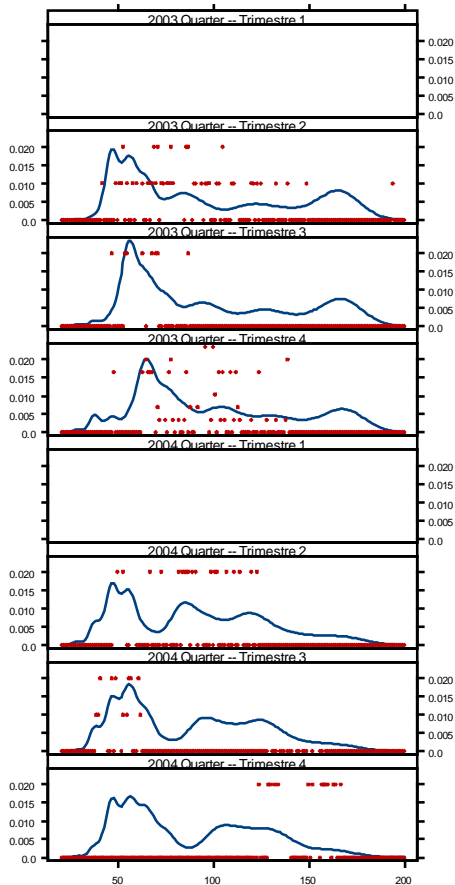
Proportion of the catch -- Proporción de la captura



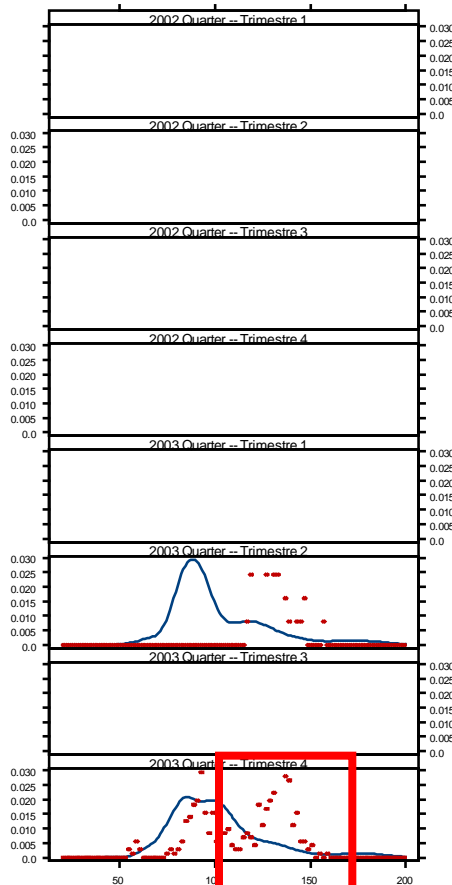
# Fit to recent length frequency data

Proportion of the catch -- Proporción de la captura

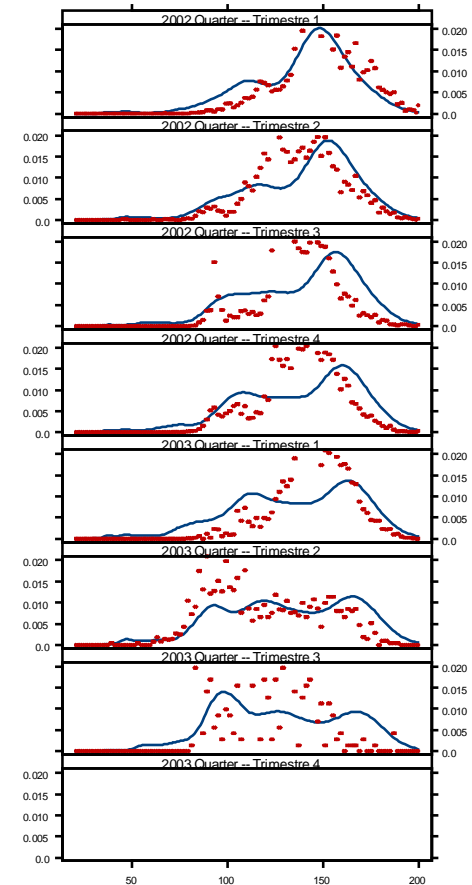
7



8



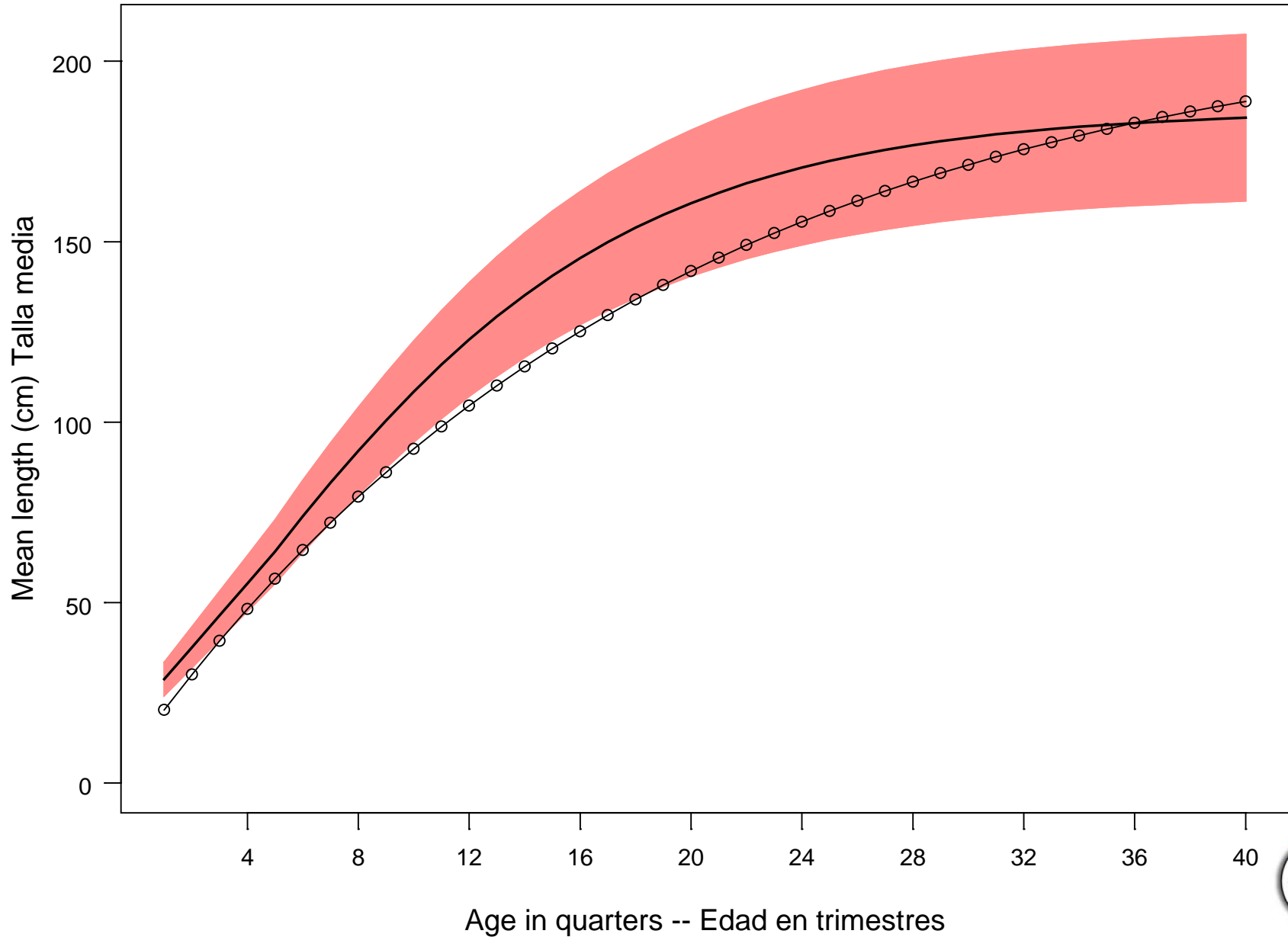
9



Length (cm) Talla

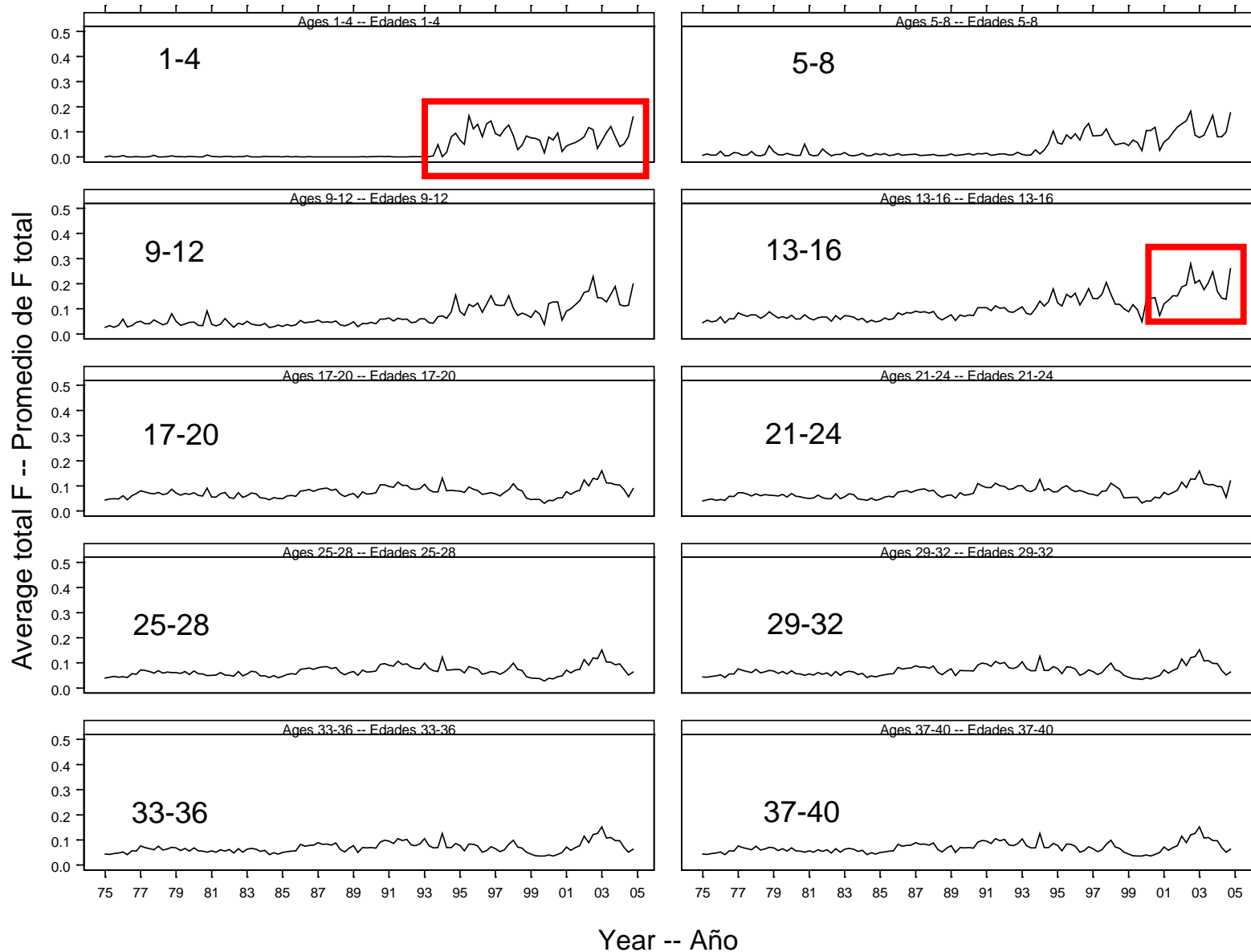


# Growth

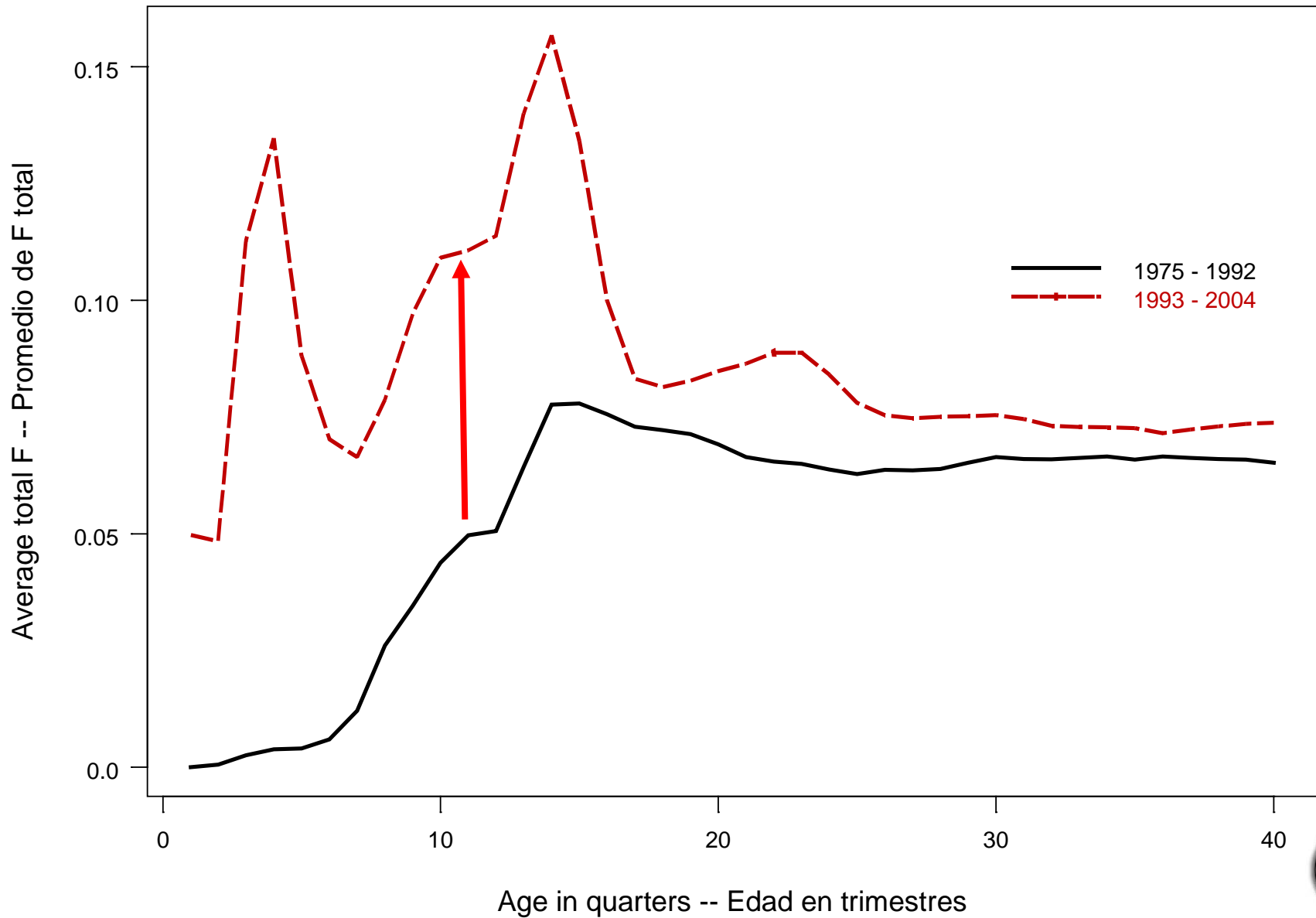




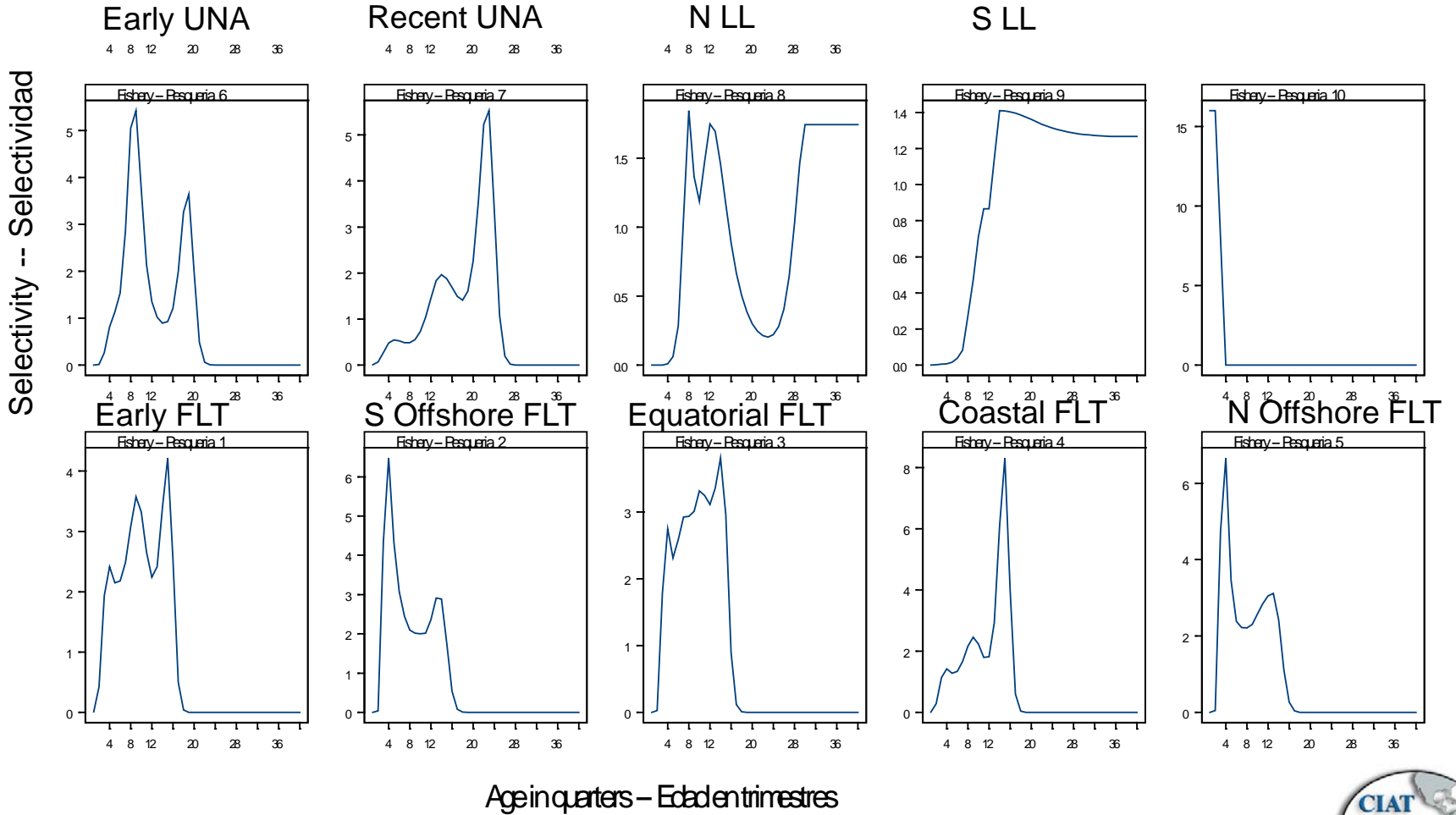
# Fishing mortality



# Age-specific fishing mortality



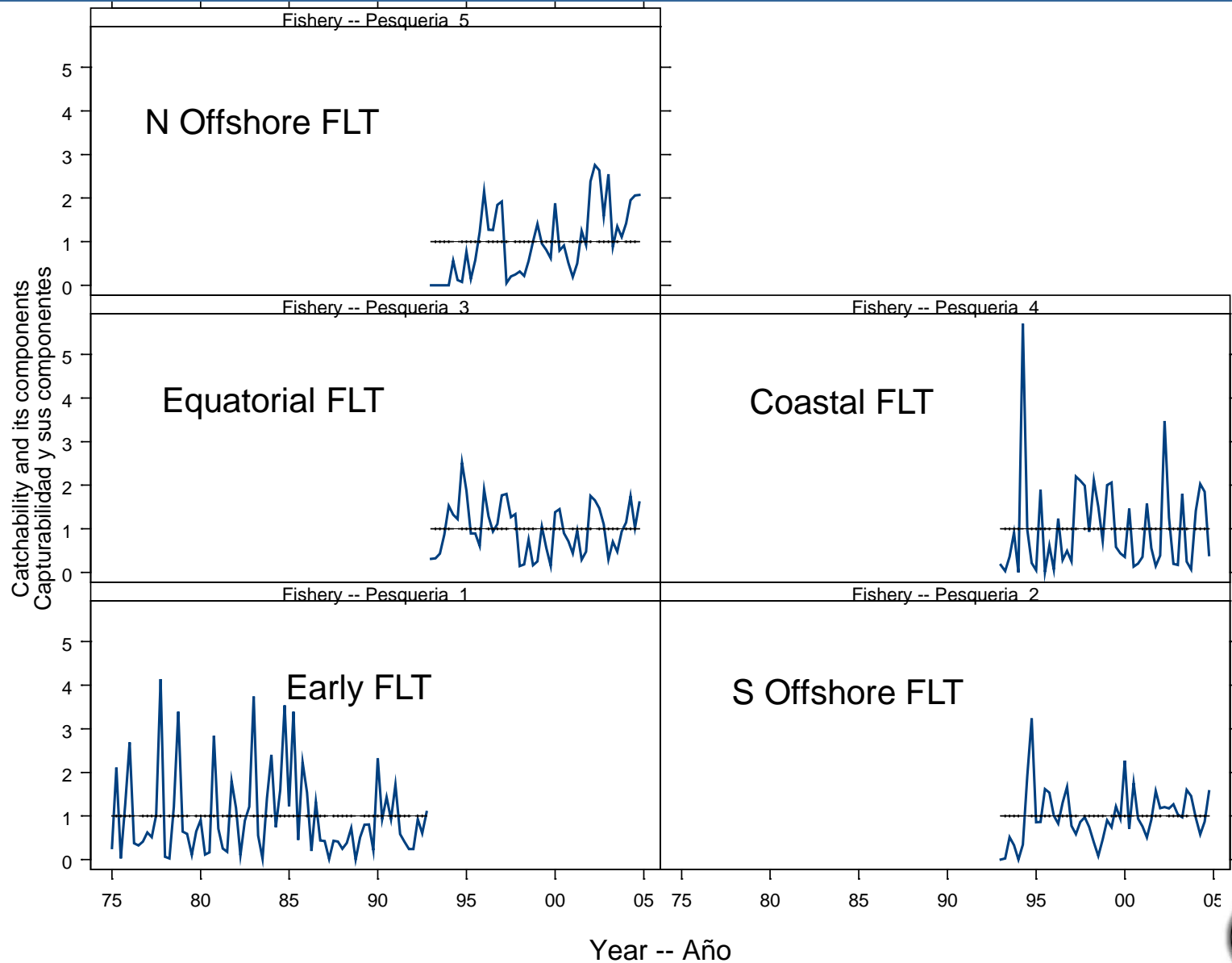
# Selectivity



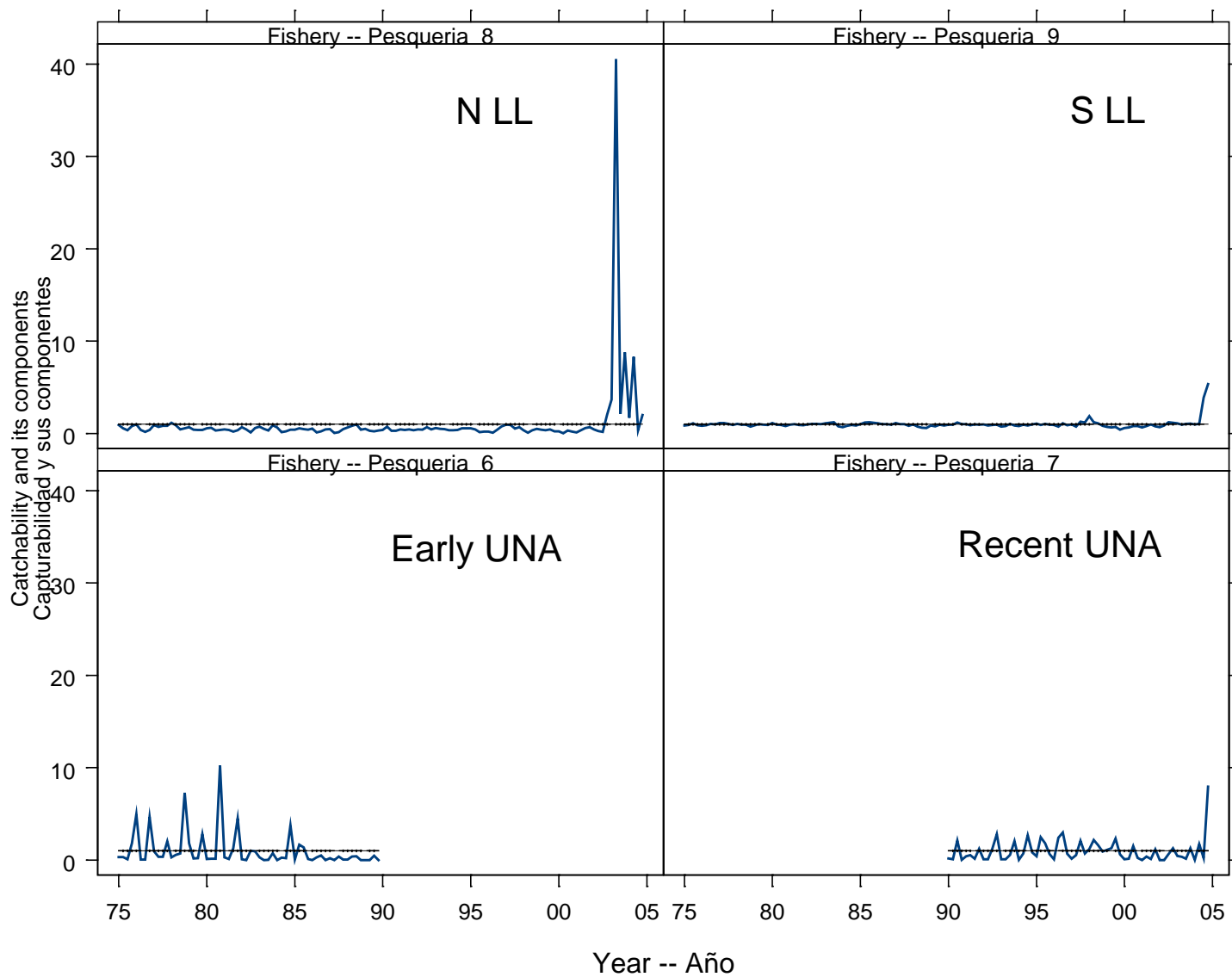
Age in quarters - Edad en trimestres



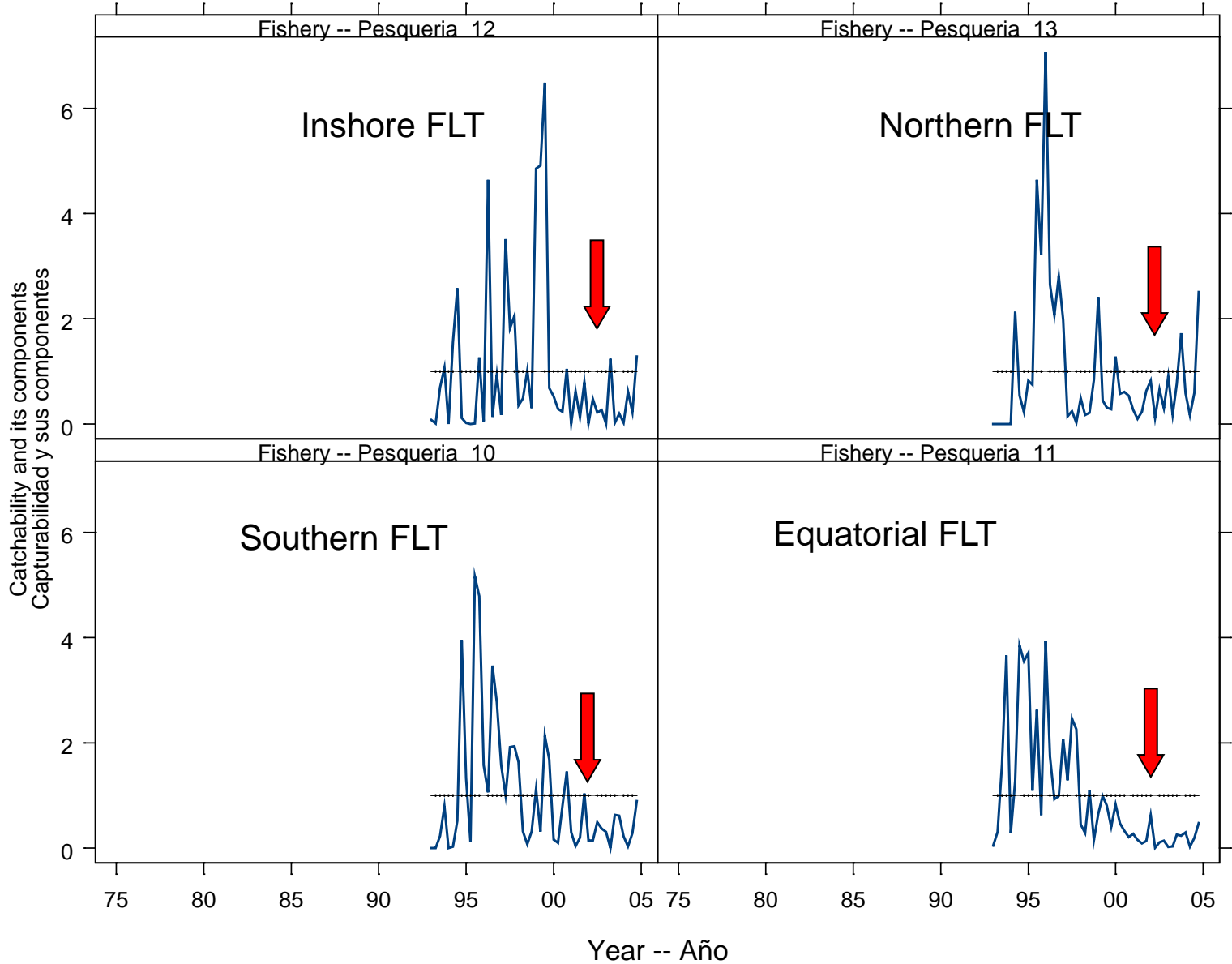
# Catchability



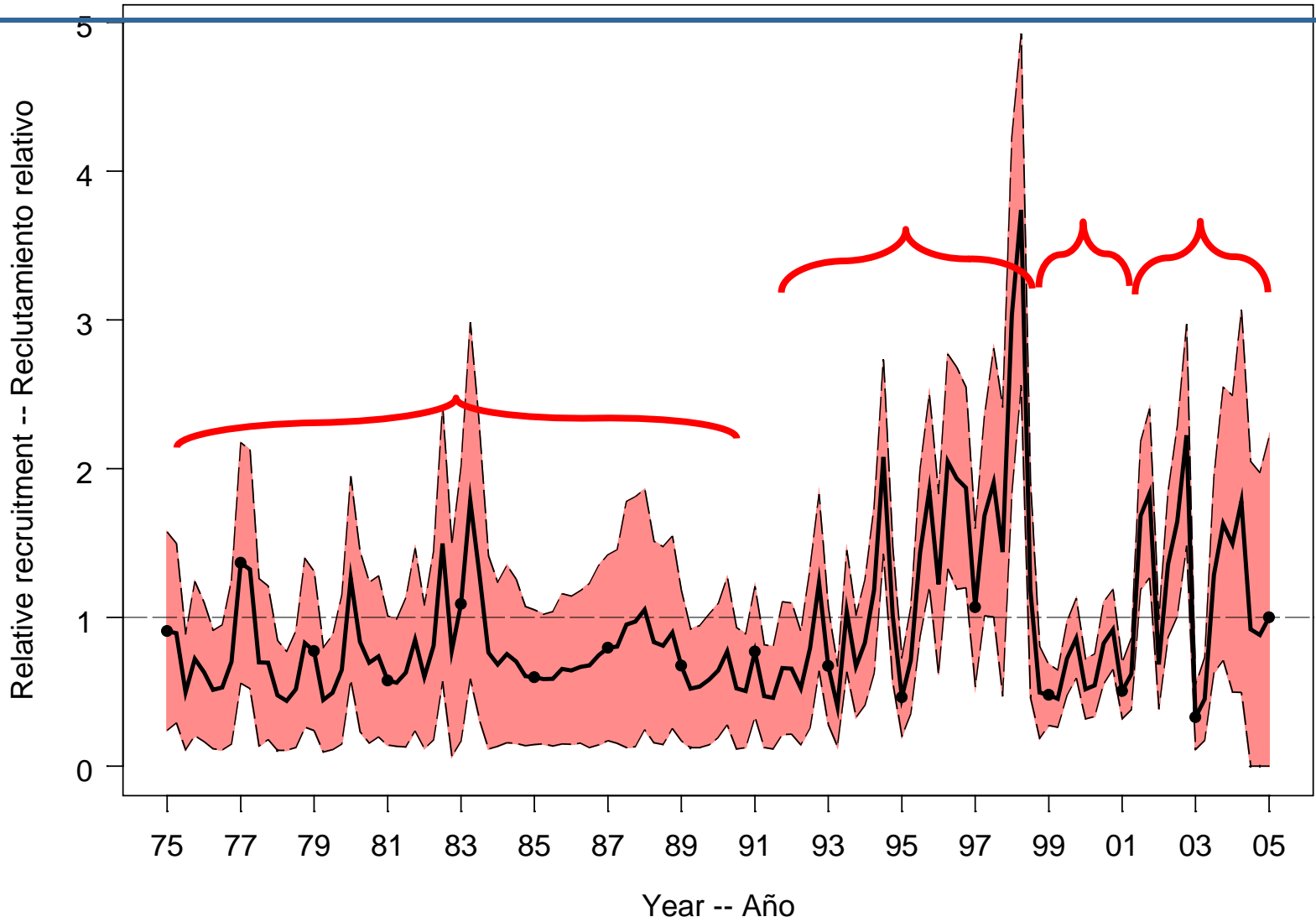
# Catchability



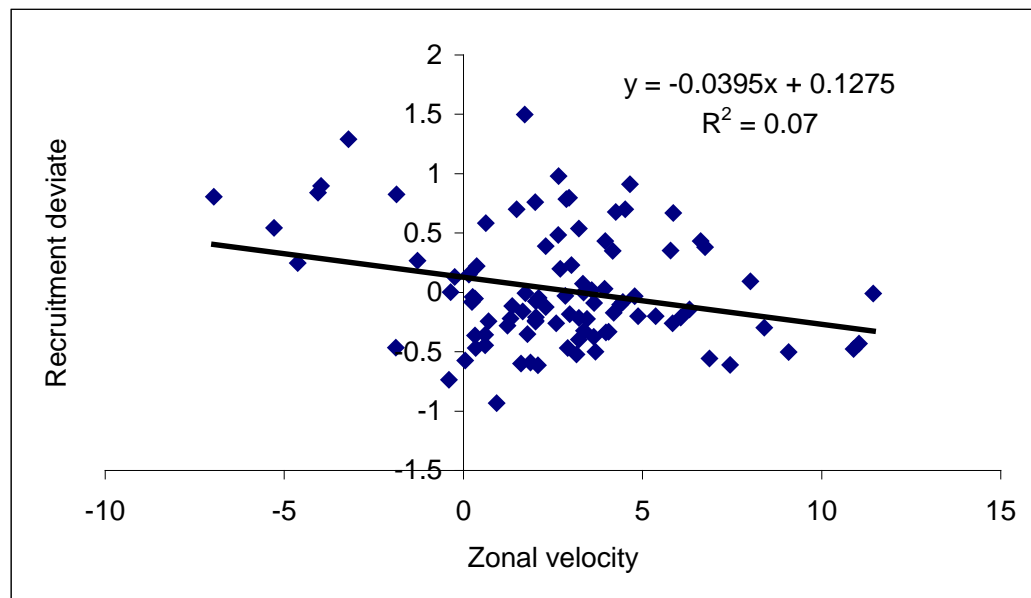
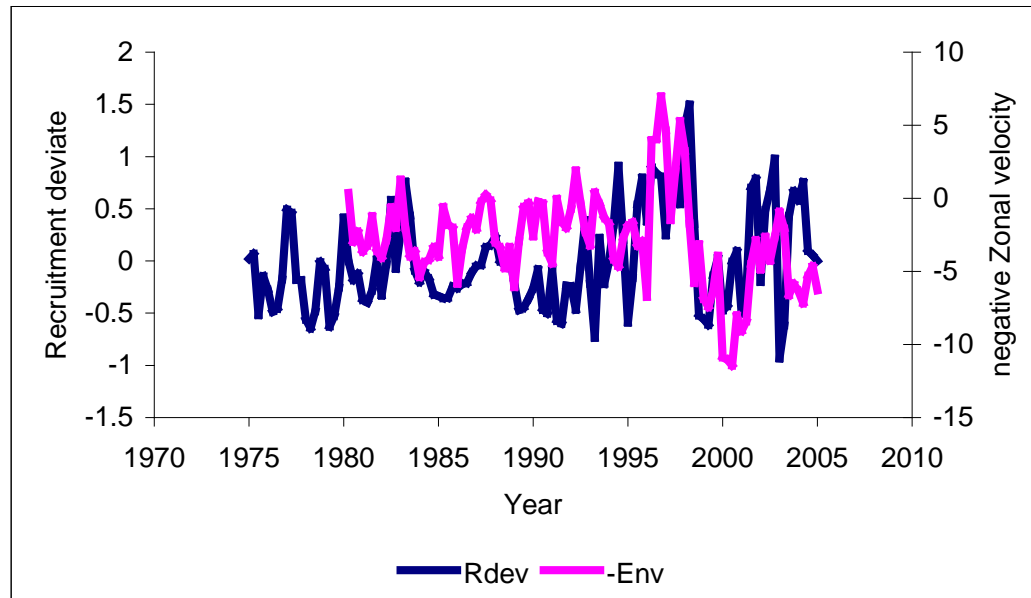
# Catchability



# Recruitment

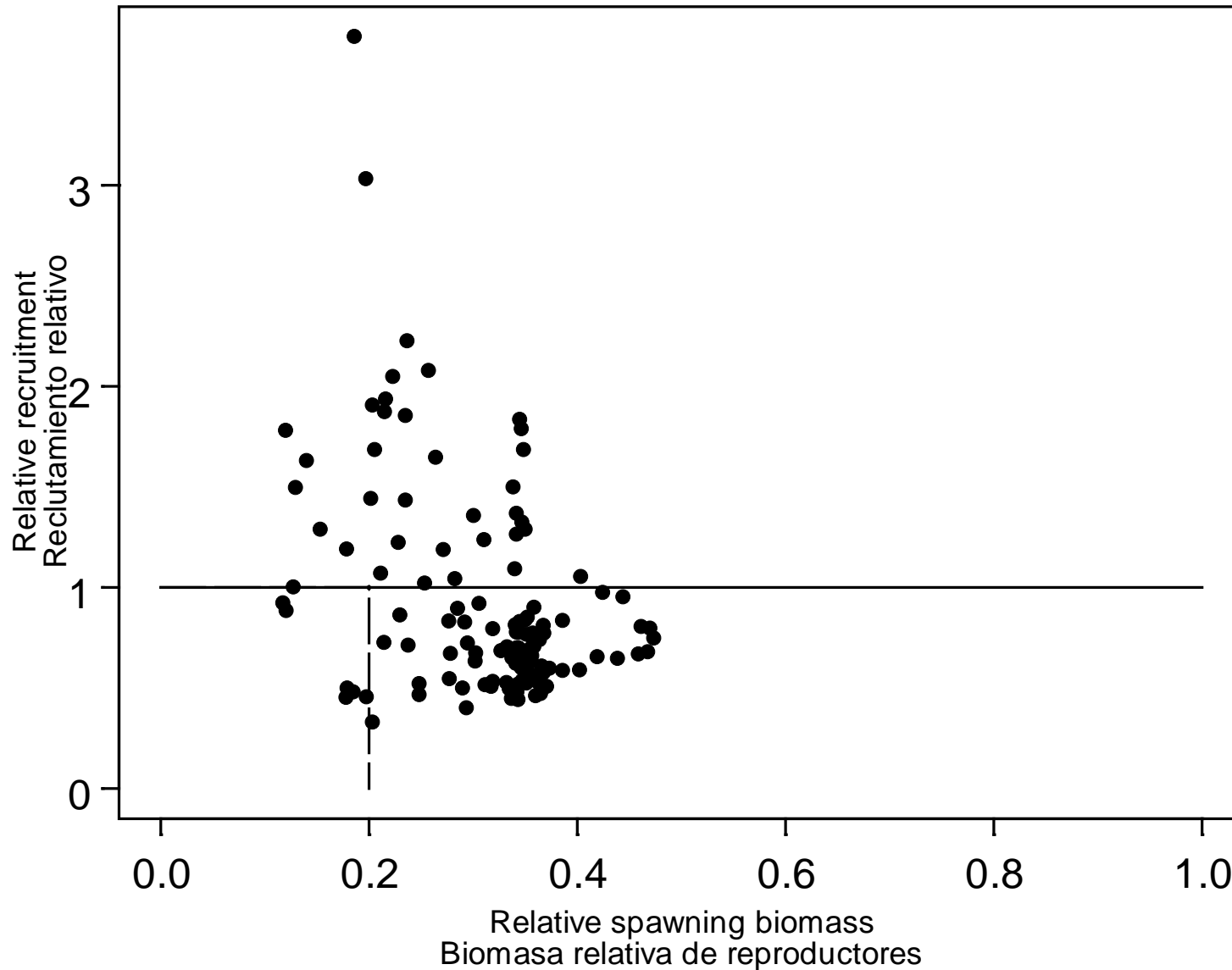


# Environmental-recruitment relationship



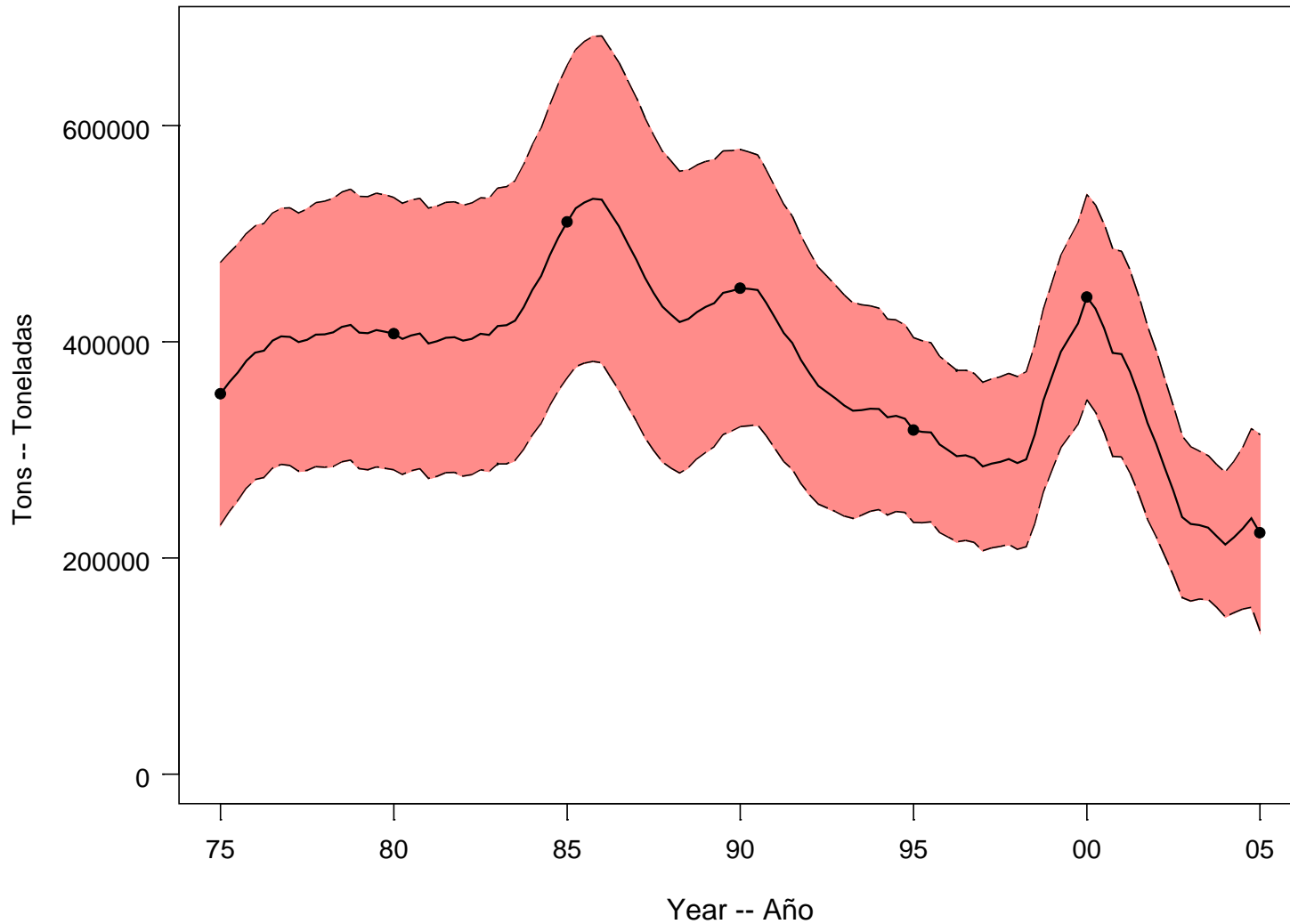


# Spawner-recruitment curve



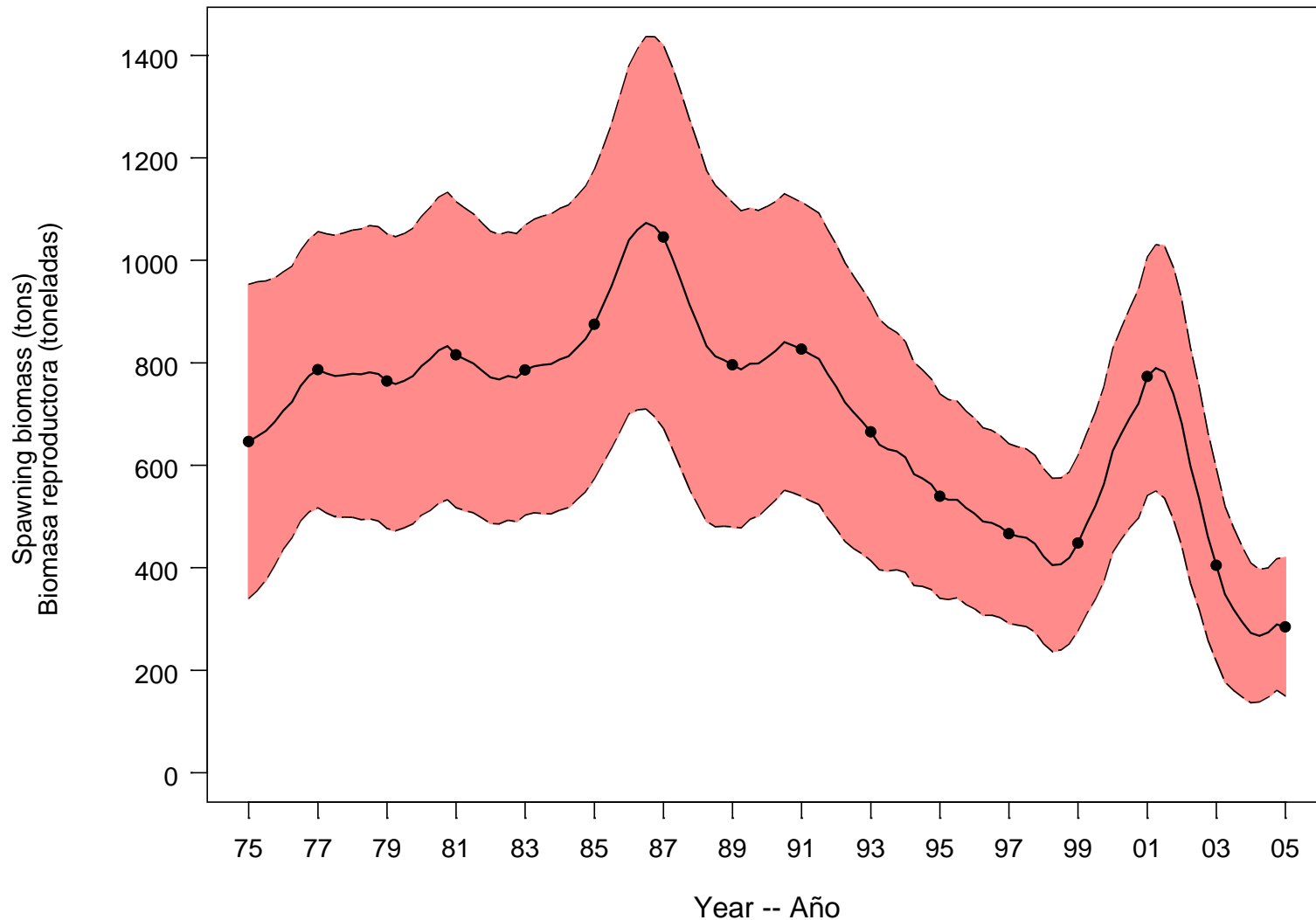
# Biomass

Biomass of fish 0.75+ years old -- Biomasa de peces de 0.75+ años de edad

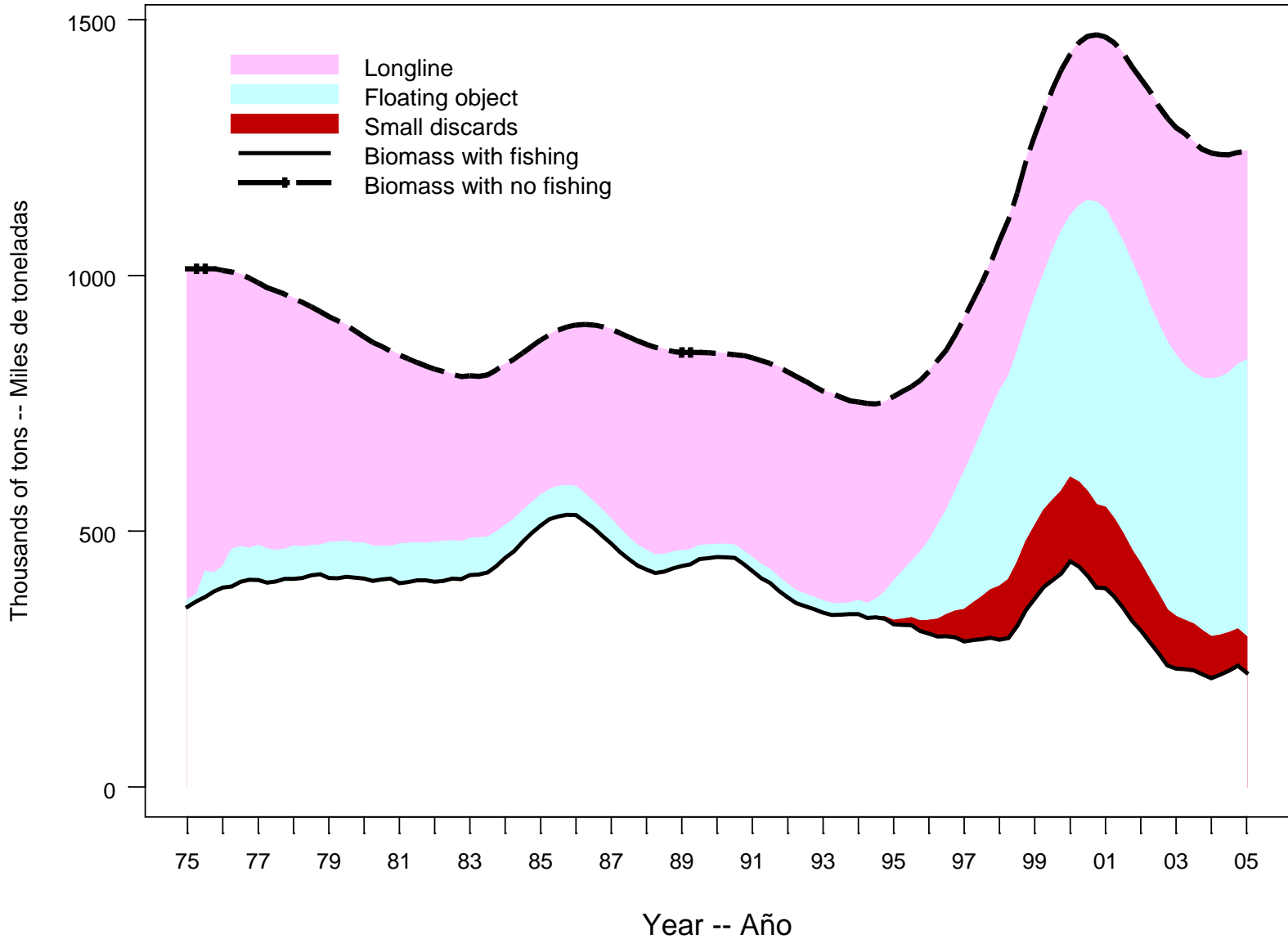


# Spawning biomass

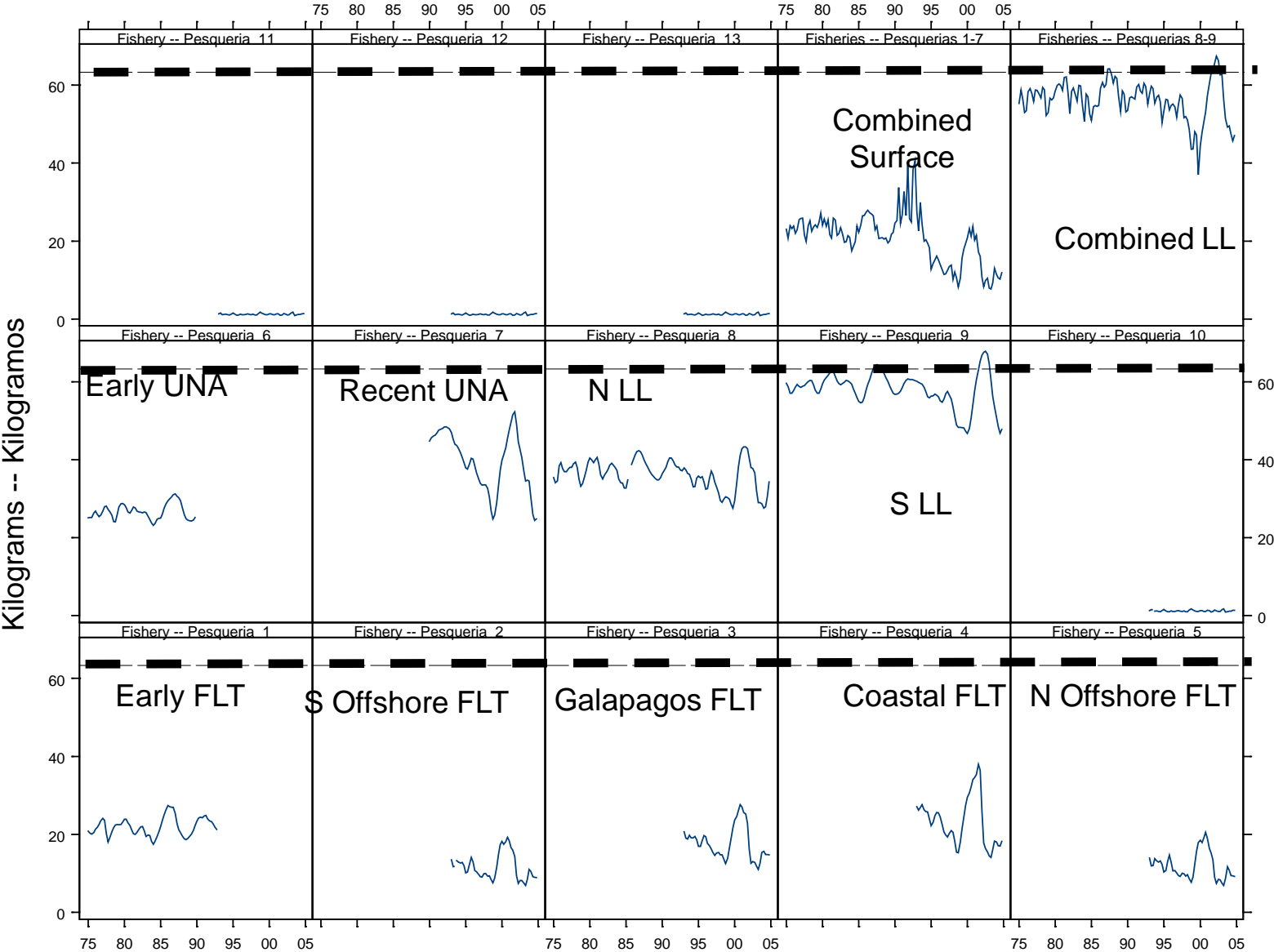
Population fecundity -- Fecundidad de la poblacion



# No-fishing plot



# Average weight

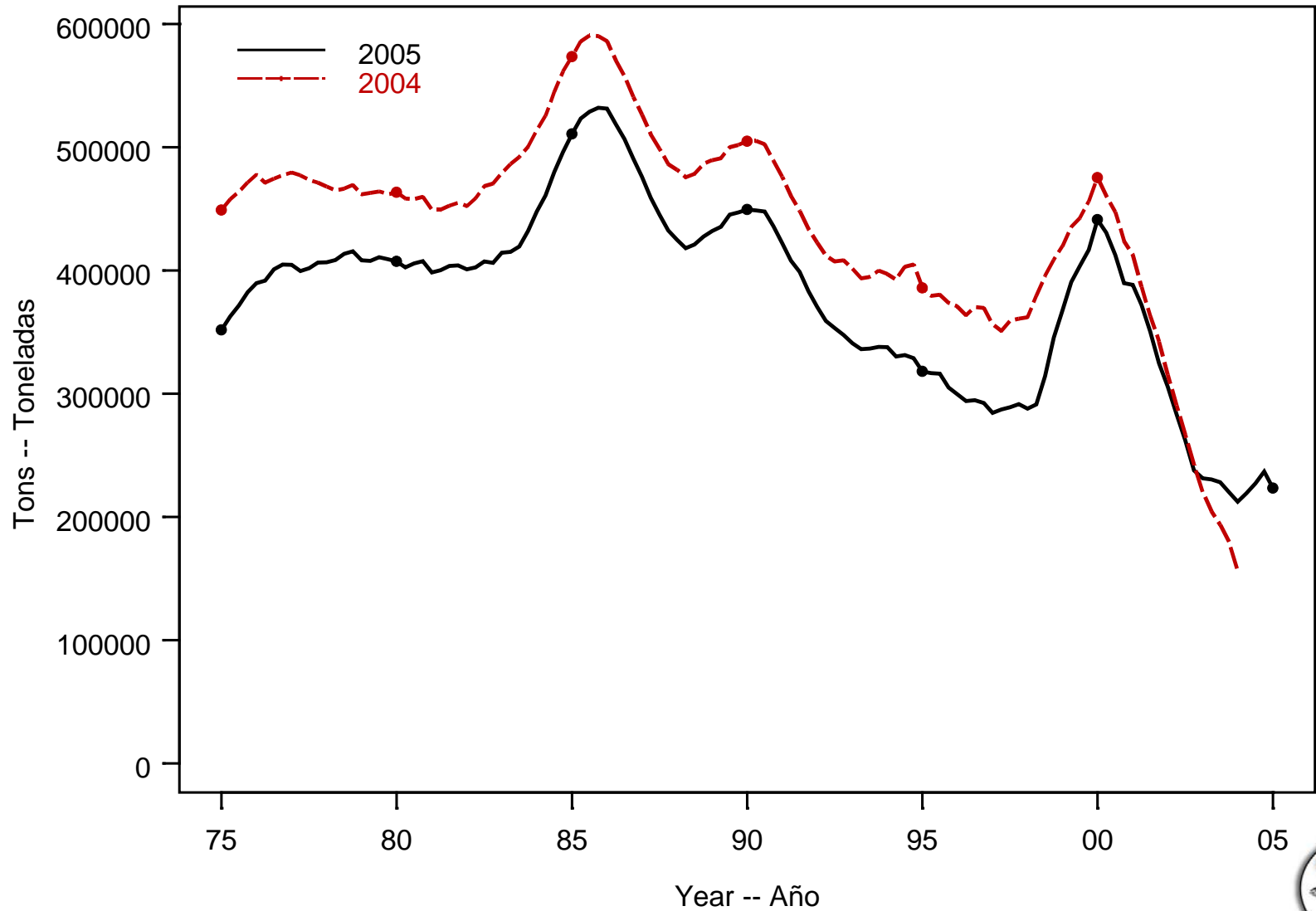


# Comparisons with previous assessments

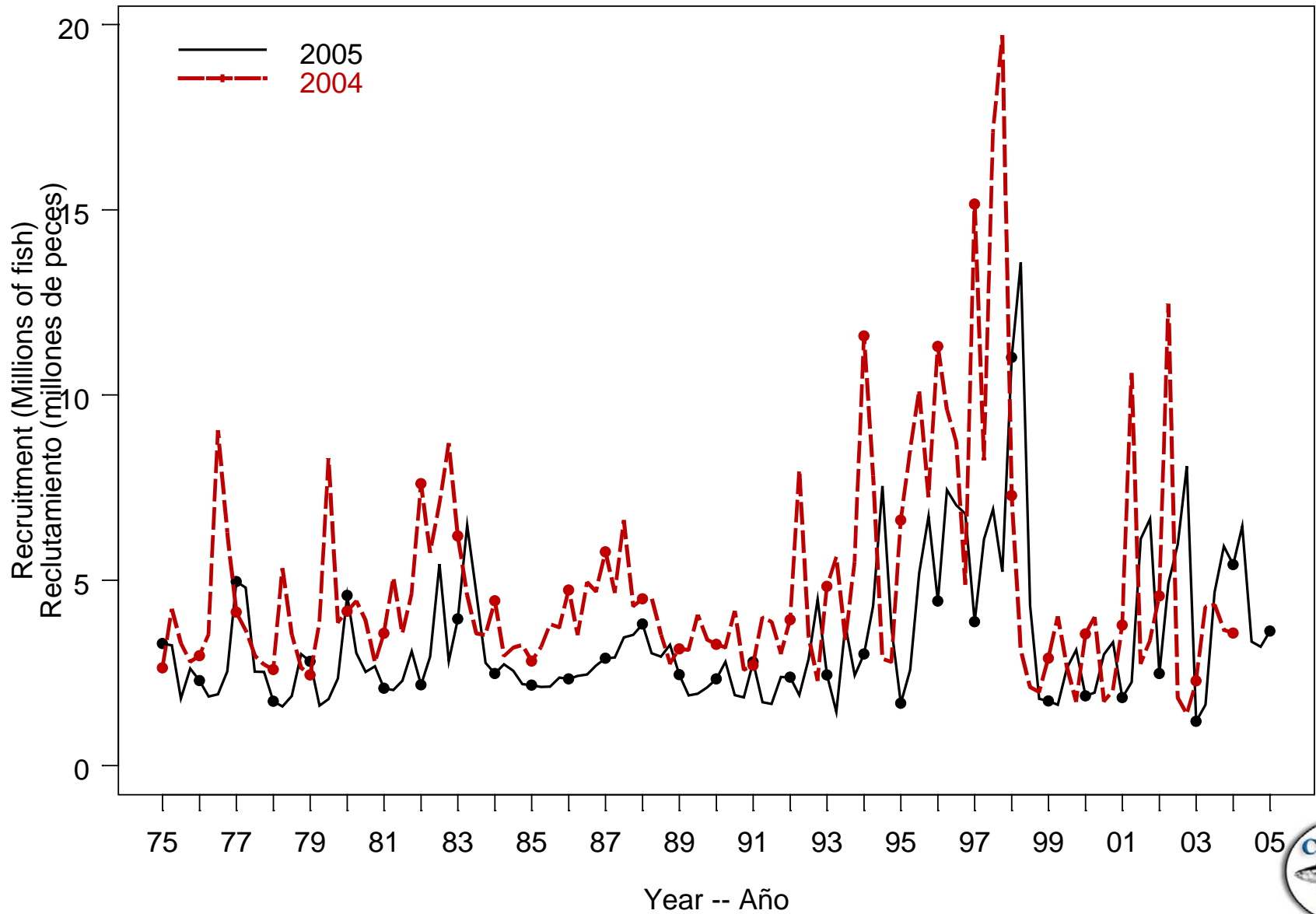
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- Biomass
- Recruitment
- Spawning biomass

# Biomass



# Recruitment



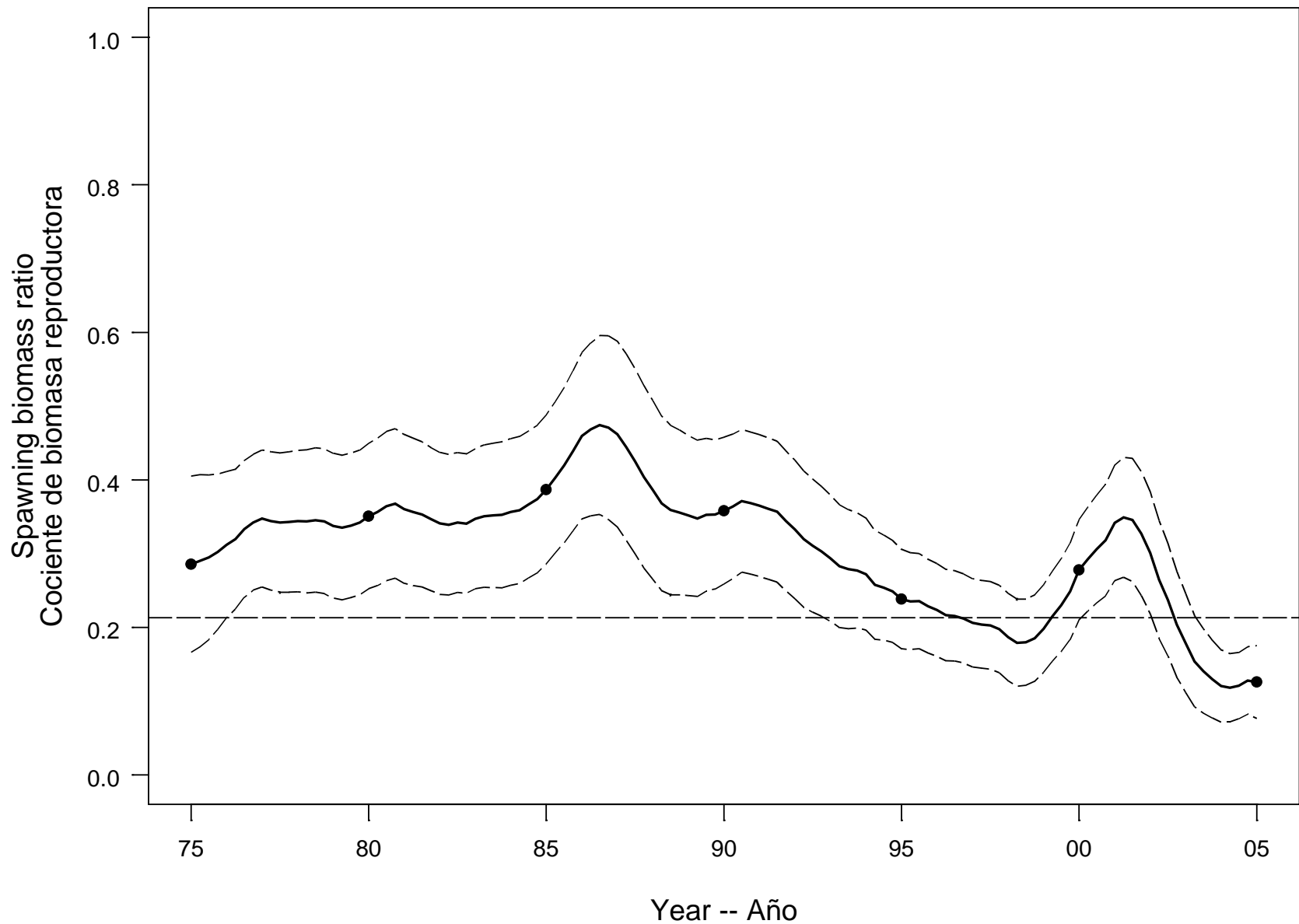


# Comparisons to reference points

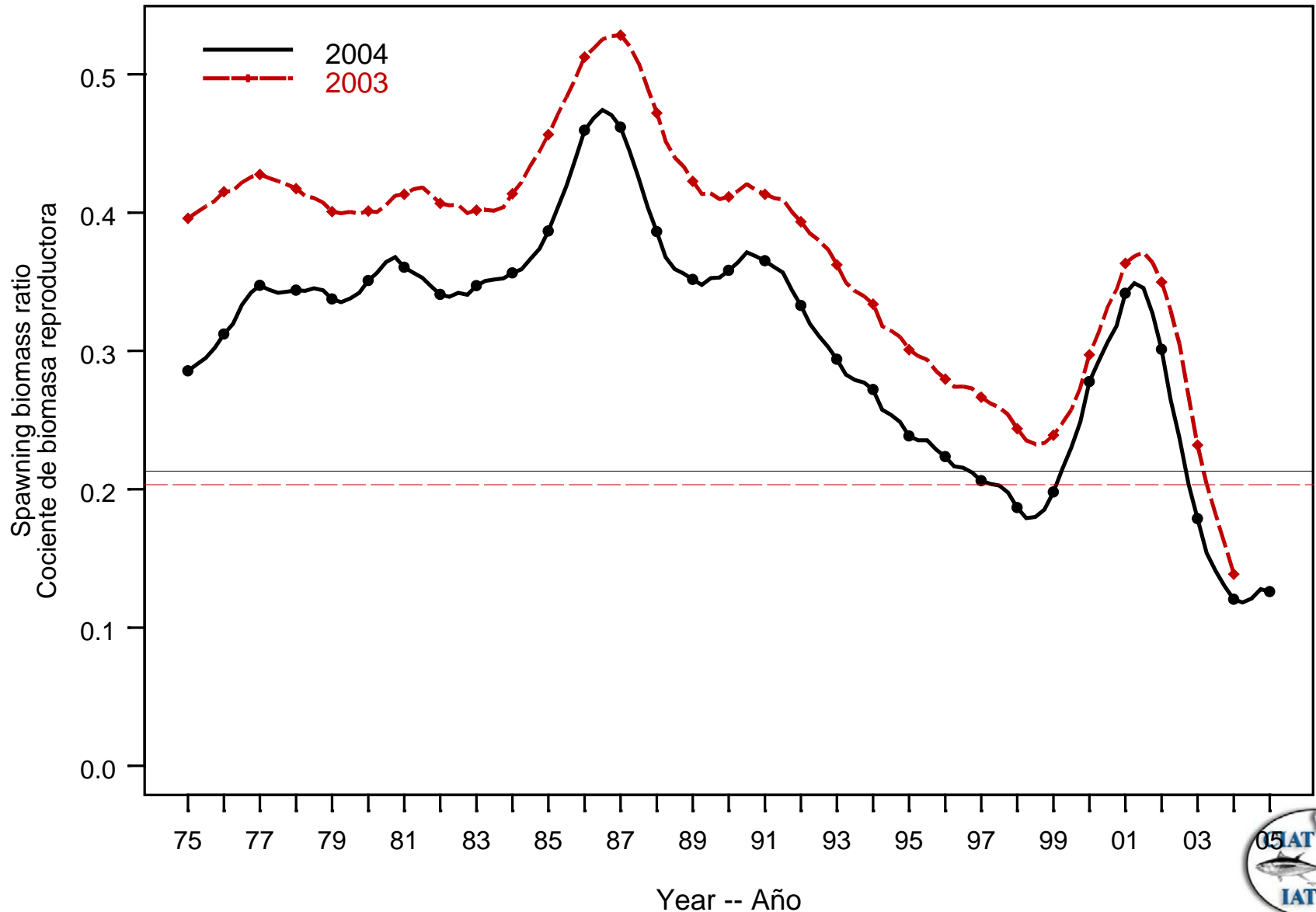
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- Spawning biomass depletion
- Yield curve
- Critical weight
- Lifetime fecundity
- MSY ref

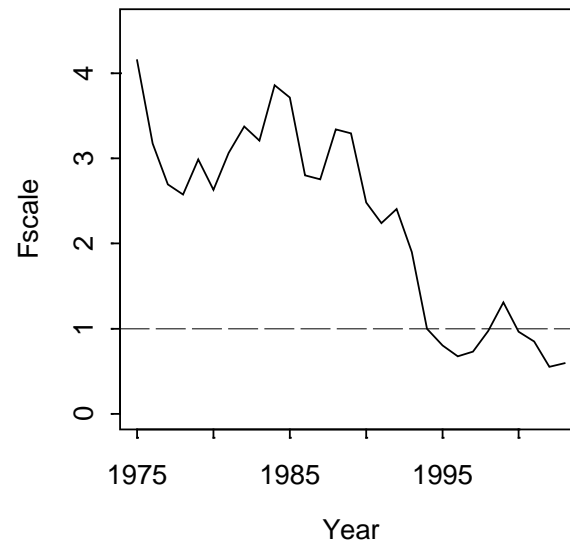
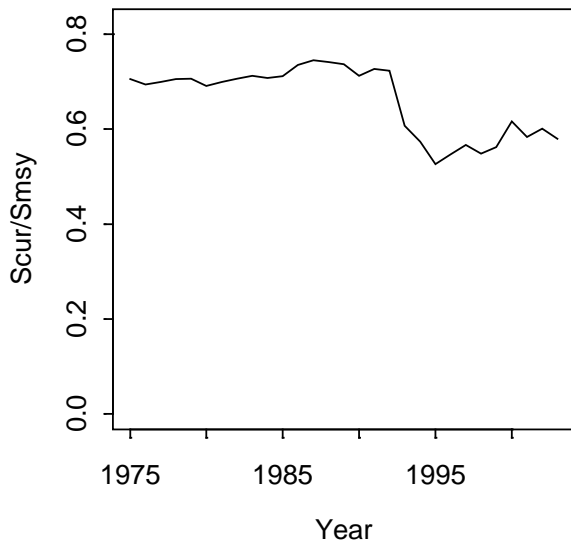
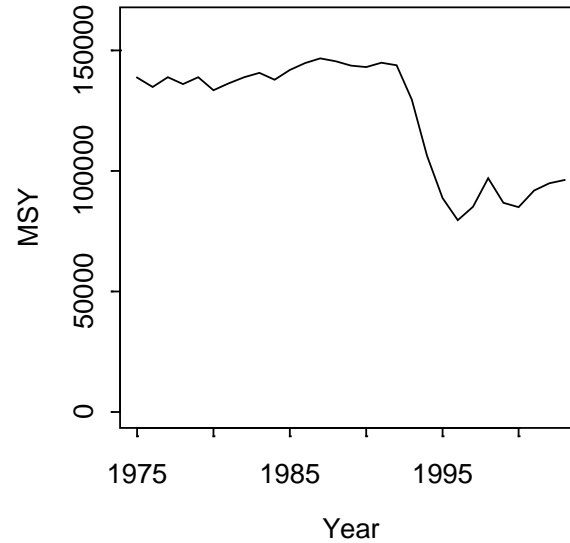
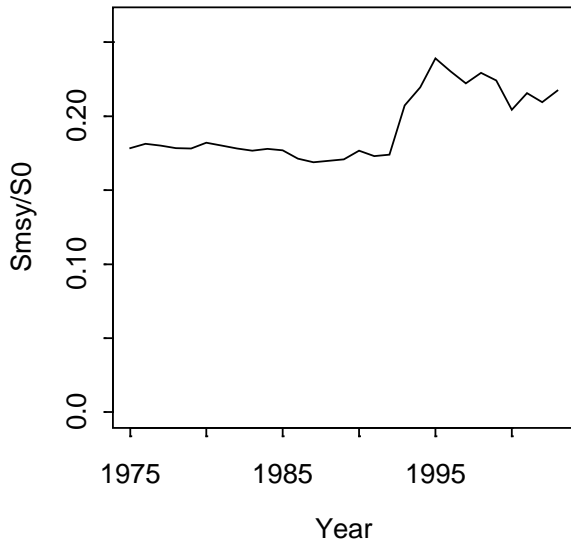
# Spawning biomass ratio



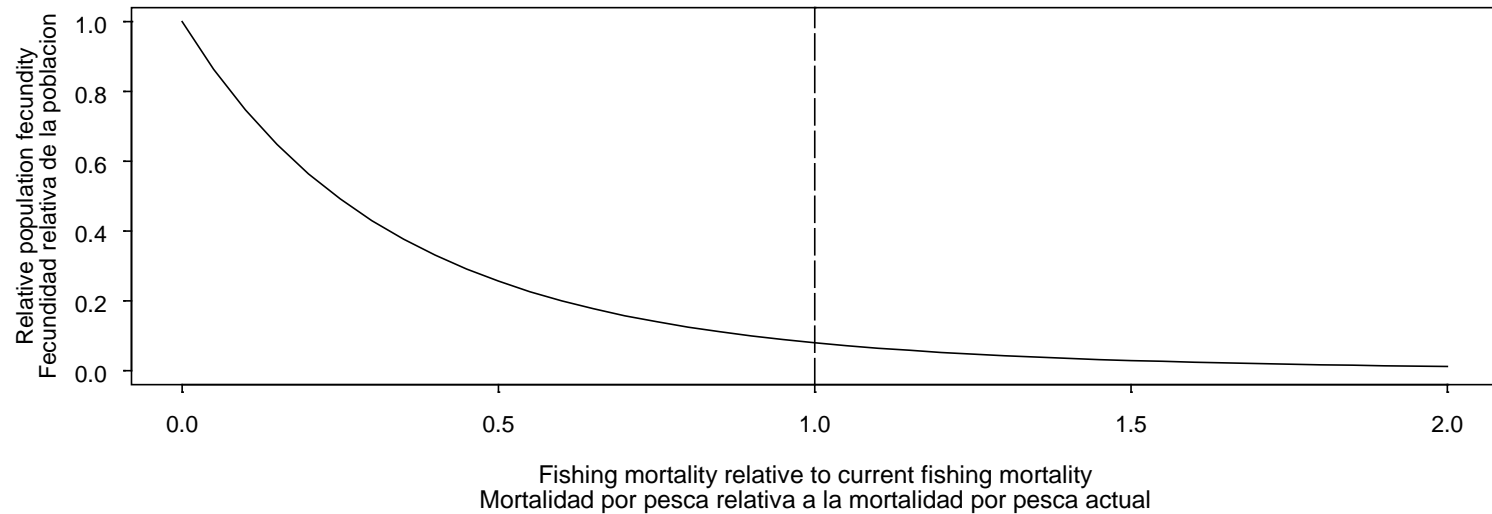
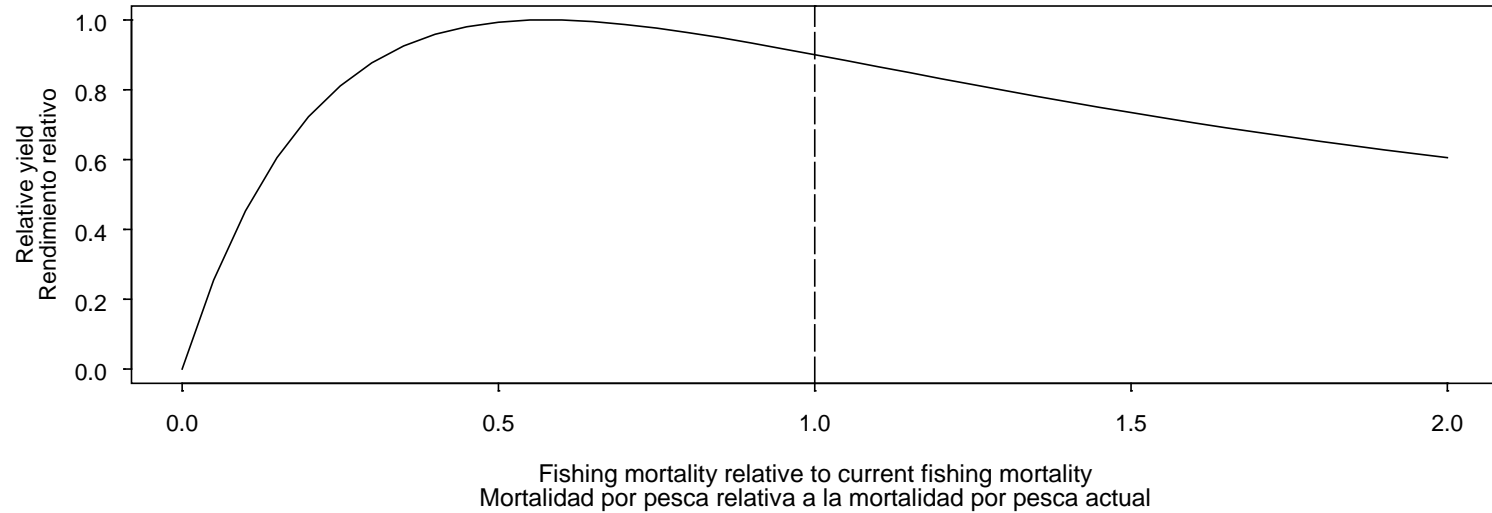
# SBR comparison with last year



# Time varying indicators



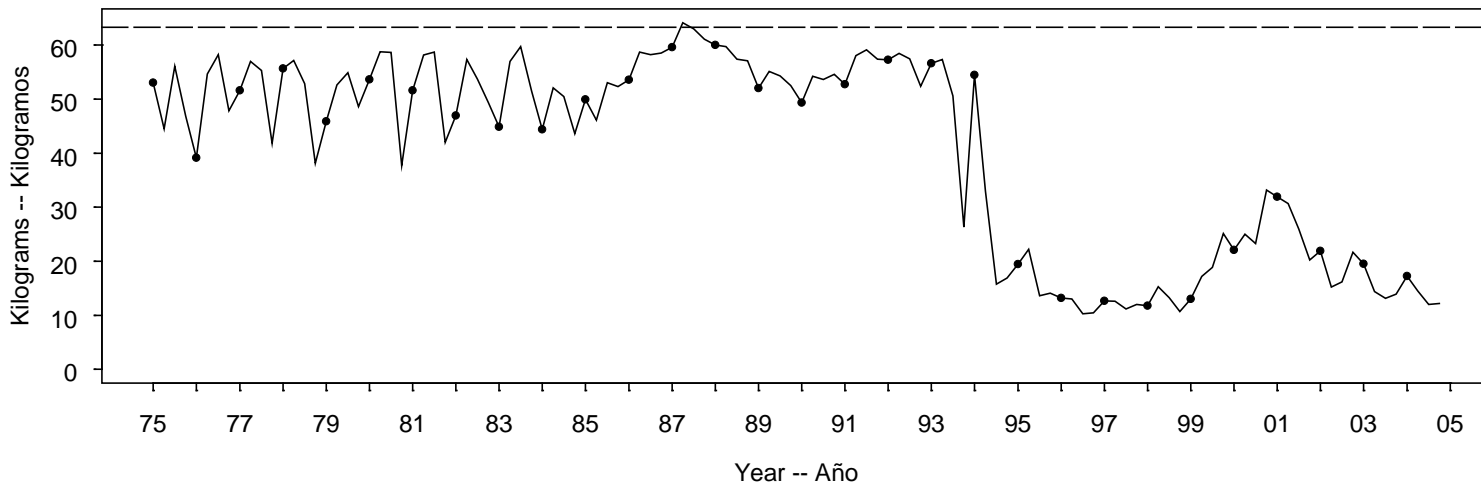
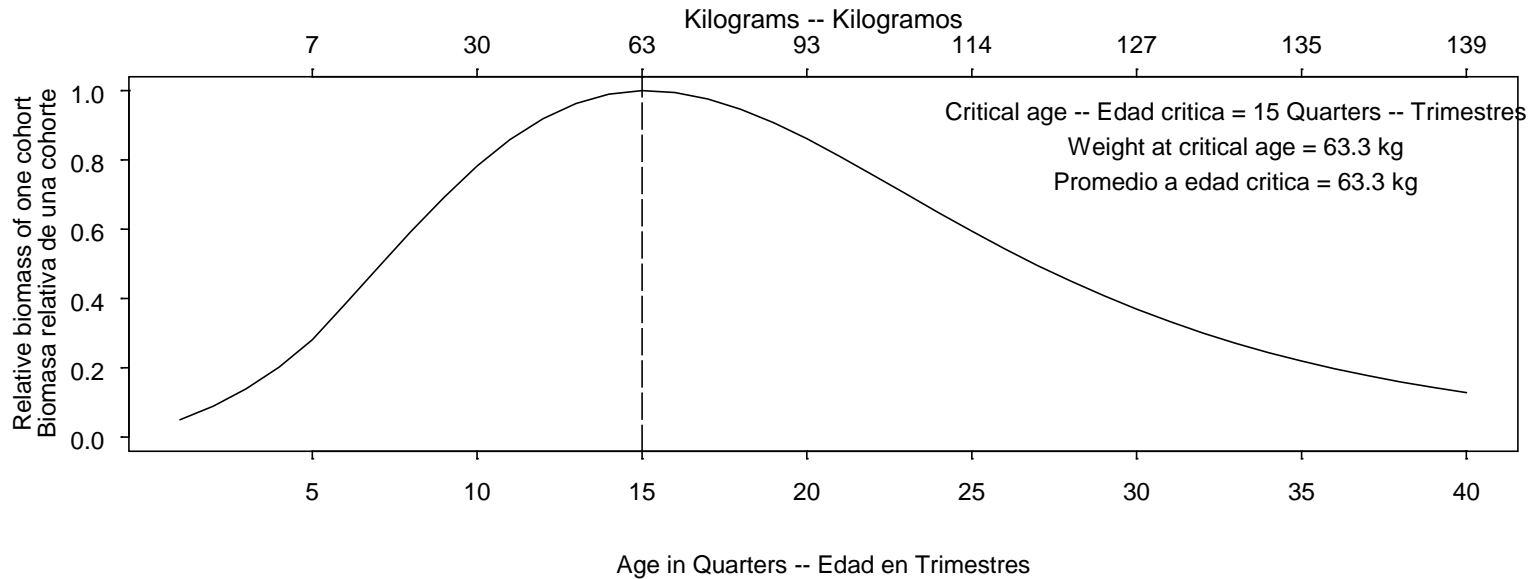
# Yield curve



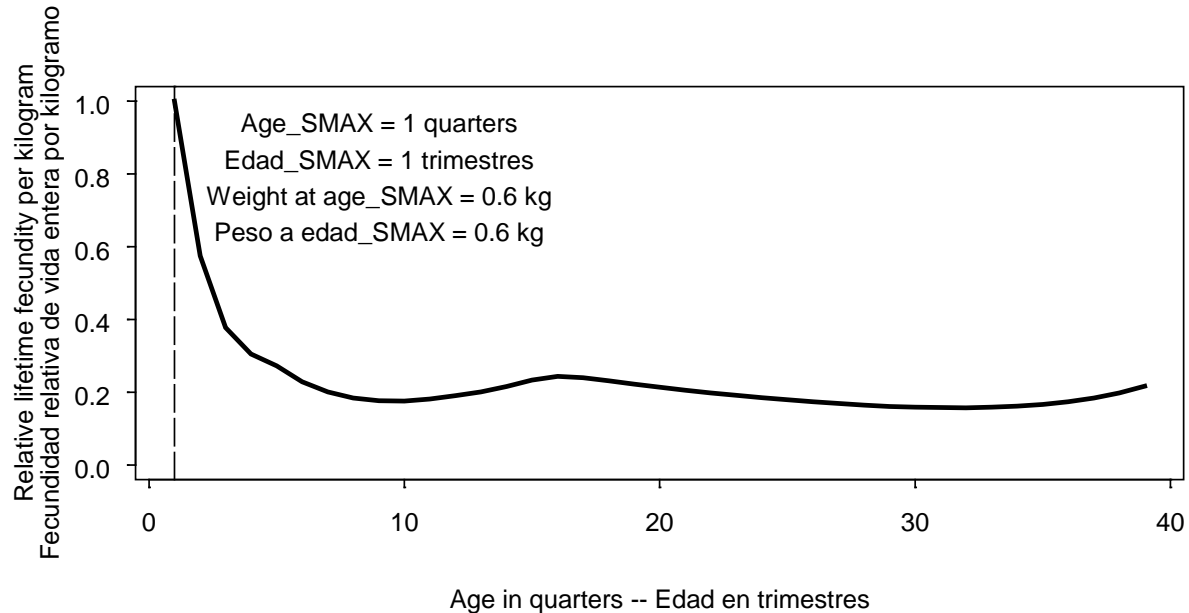
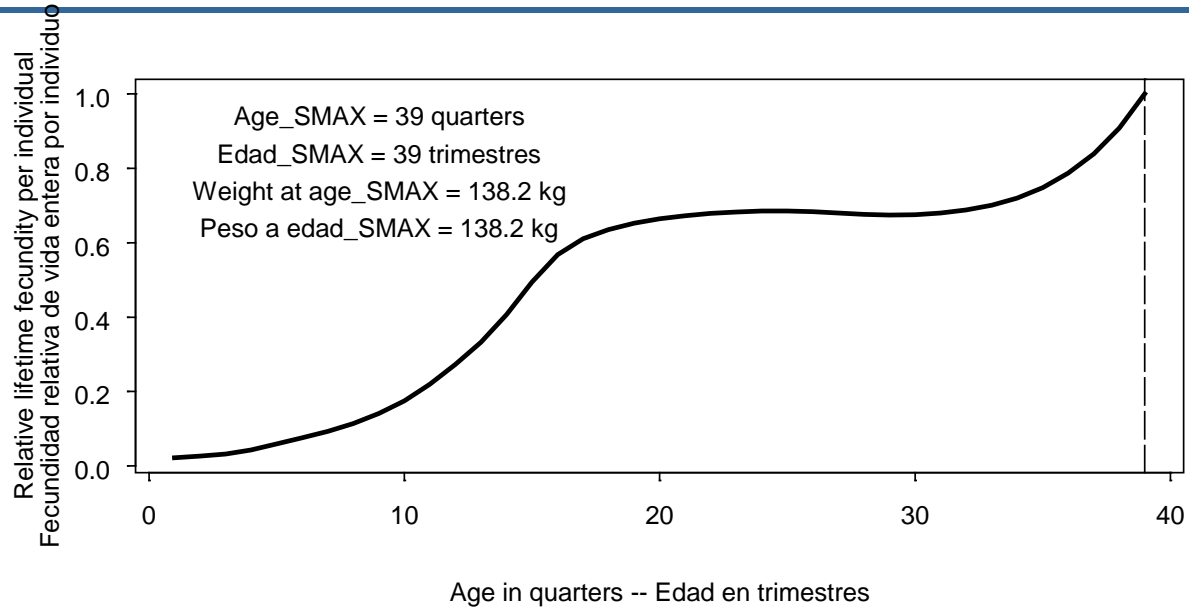
# AMSY-quantities

	<b>Base case</b>
AMSY (mt)	95572
<i>B</i> AMSY (mt)	292504
<i>S</i> AMSY	482
<i>B</i> AMSY/ <i>B</i> 0	0.29
<i>S</i> AMSY/ <i>S</i> 0	0.21
<i>C</i> recent/AMSY	1.05
<i>B</i> recent/ <i>B</i> AMSY	0.76
<i>S</i> recent/ <i>S</i> AMSY	0.59
<i>F</i> multiplier	0.57

# Critical weight

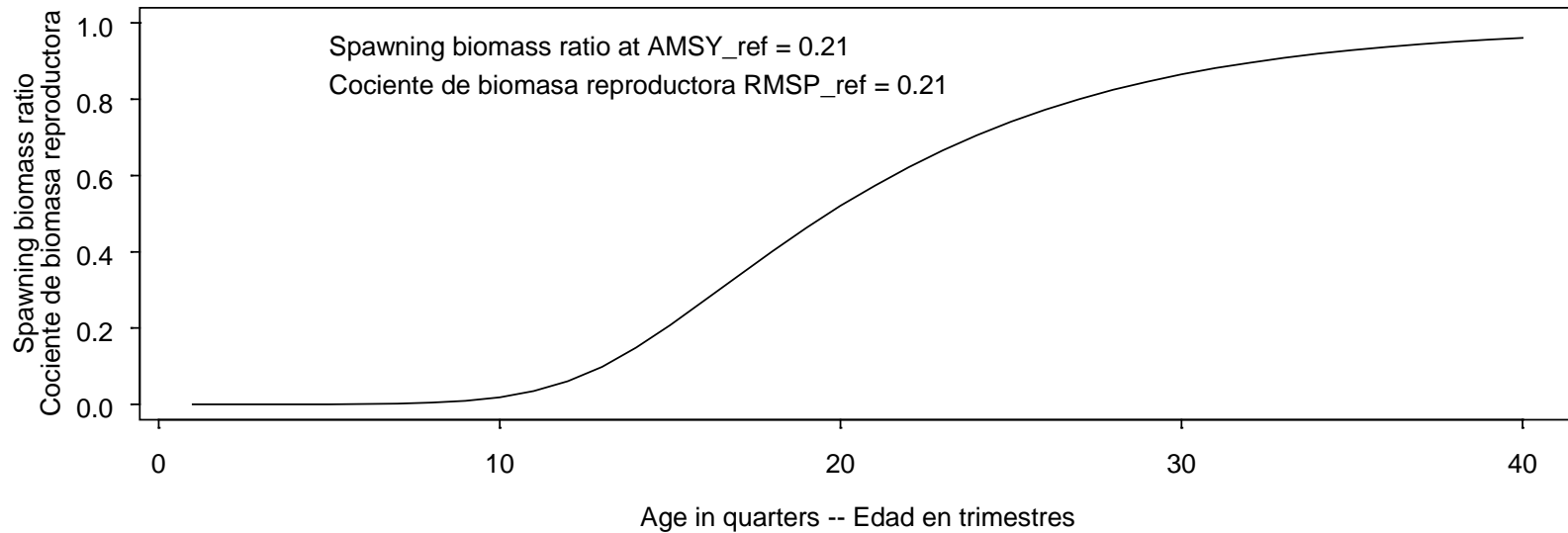
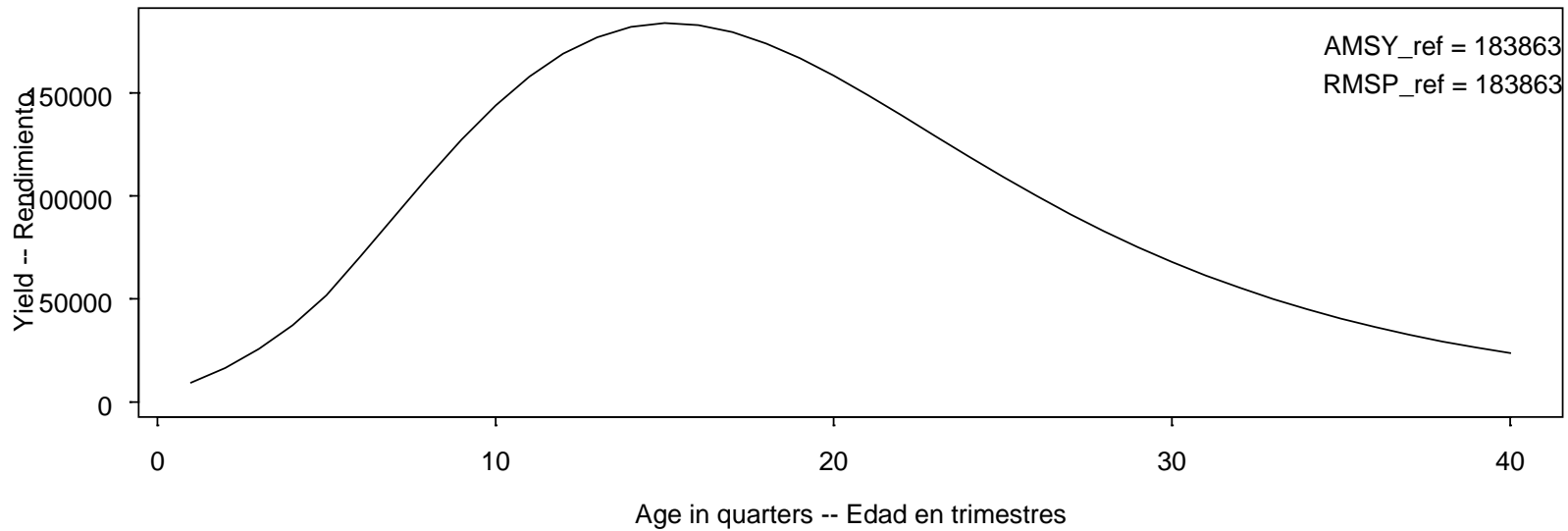


# Lifetime fecundity





# MSY<sub>ref</sub>



# AMSY-quantities -- sensitivity analysis

	Base case	Steepness = 0.75
AMSY	95572	91270
$B_{\text{AMSY}}$	292504	462975
$S_{\text{AMSY}}$	482	879
$B_{\text{AMSY}}/B_0$	0.29	0.36
$S_{\text{AMSY}}/S_0$	0.21	0.30
$C_{\text{recent}}/\text{AMSY}$	1.05	1.13
$B_{\text{recent}}/B_{\text{AMSY}}$	0.76	0.54
$S_{\text{recent}}/S_{\text{AMSY}}$	0.59	0.41
$F$ multiplier	0.57	0.41

# AMSY-quantities -- assumed F

	F's 2002 & 2003 – Base case	F's 2001 & 2002	F's 2003 & 2004
<b>AMSY (mt)</b>	95572	93697	93461
<b>BAMSY (mt)</b>	292504	289606	292145
<b>SAMSY</b>	482	480	486
<b>BAMSY/B<sub>0</sub></b>	0.29	0.29	0.29
<b>SAMSY/S<sub>0</sub></b>	0.21	0.21	0.21
<b>Crecent/AMSY</b>	1.05	1.08	1.08
<b>Brecent/BAMSY</b>	0.76	0.77	0.76
<b>Srecent/SAMSY</b>	0.59	0.59	0.59
<b>F multiplier</b>	0.57	0.67	0.64

# AMSY-quantities – by fishery

---

	Base case	Purse-seine	Longline
AMSY (mt)	95572	61394	147214
<i>BAMSY</i> (mt)	292504	230123	307548
<i>SAMSY</i>	482	397	377
<i>BAMSY/B0</i>	0.29	0.23	0.30
<i>SAMSY/S0</i>	0.21	0.18	0.17
<i>F</i> multiplier	0.57	1.13	2.06

# AMSY by fishery: Steepness sensitivity

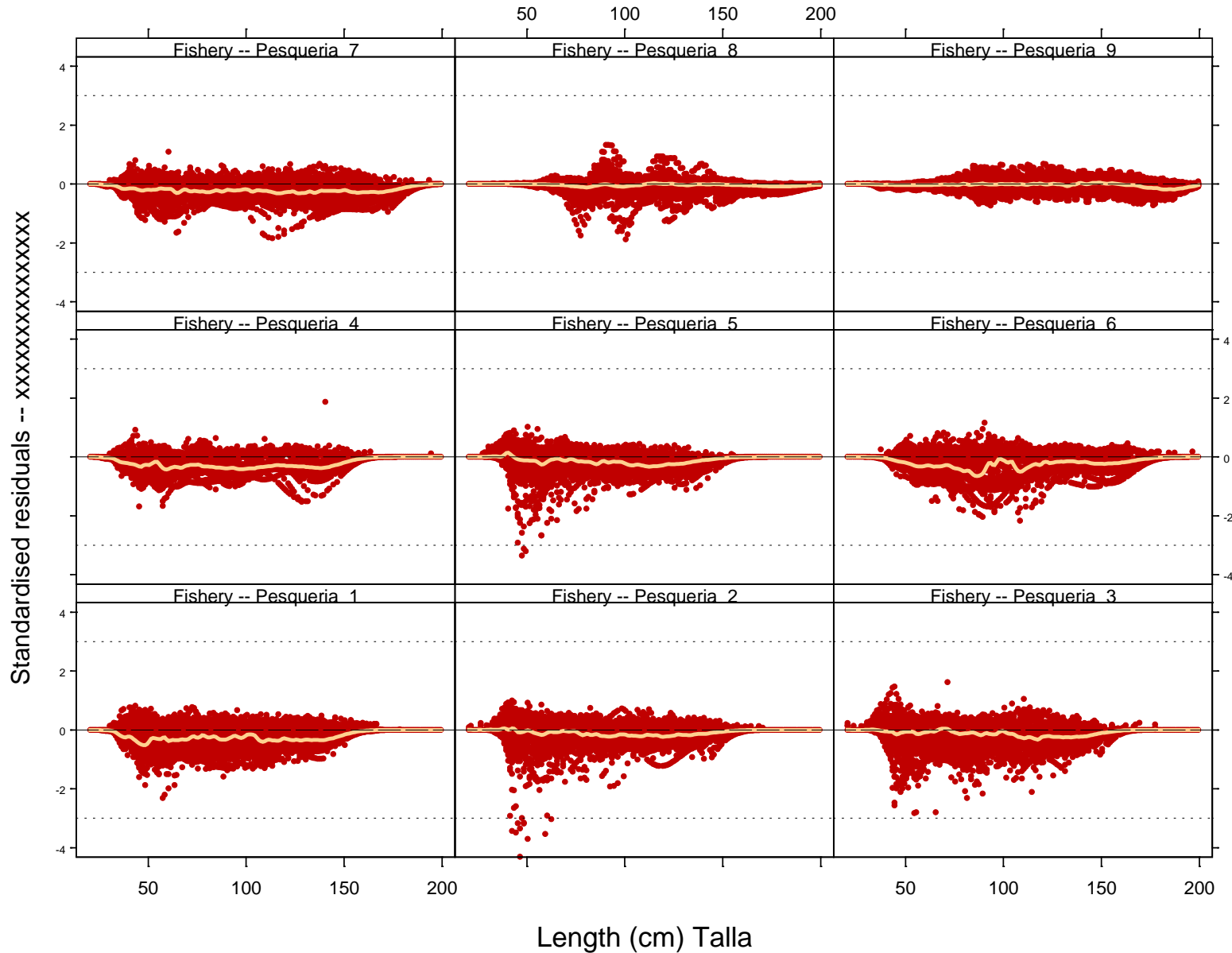
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	Base case	Purse-seine	Longline
AMSY (mt)	91270	57879	141237
<i>BAMSY</i> (mt)	462975	421950	490544
<i>SAMSY</i>	879	828	844
<i>BAMSY/B0</i>	0.36	0.33	0.38
<i>SAMSY/S0</i>	0.30	0.29	0.29
<i>F</i> multiplier	0.41	0.73	1.19

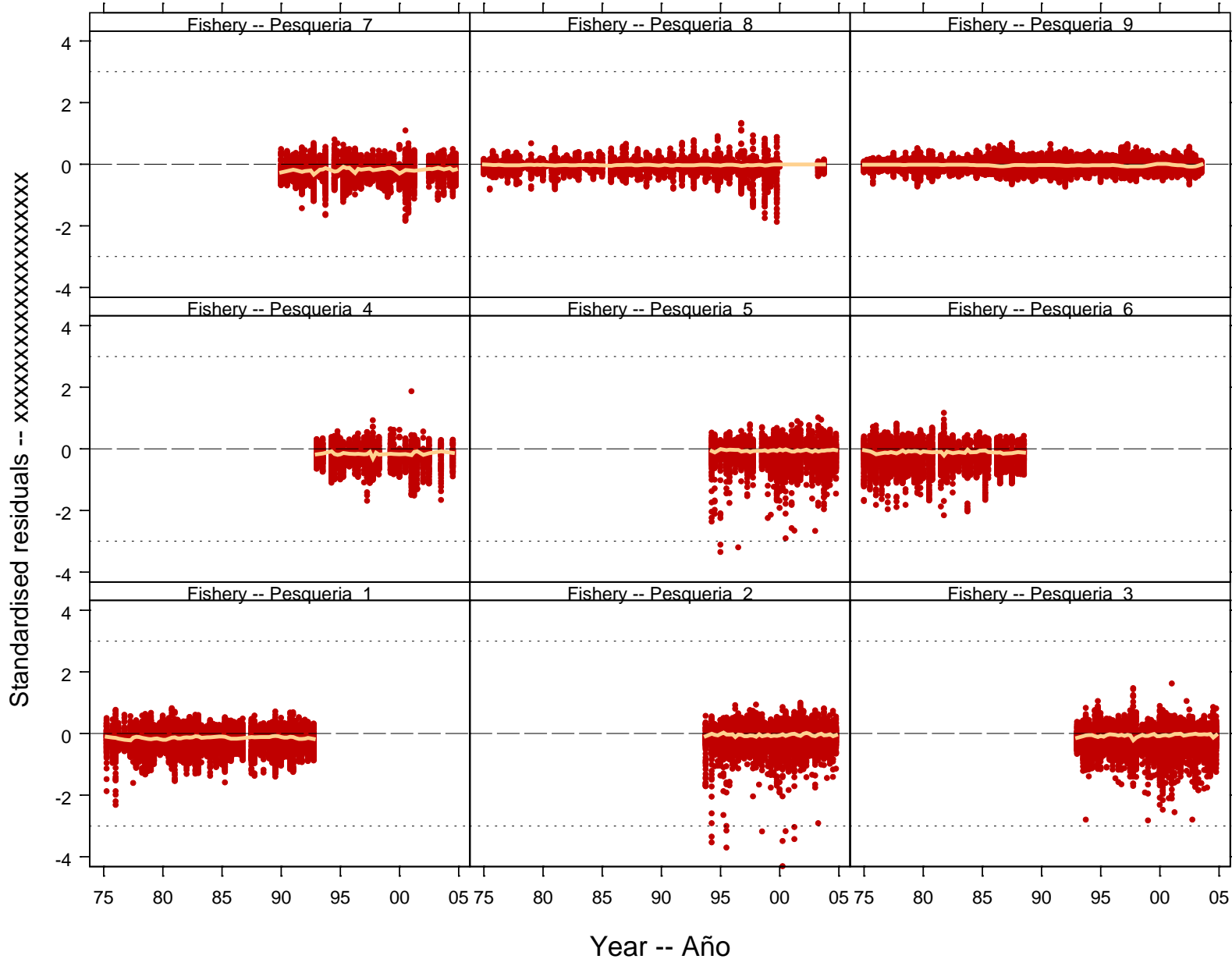
# Diagnosics



# LF residuals - by length

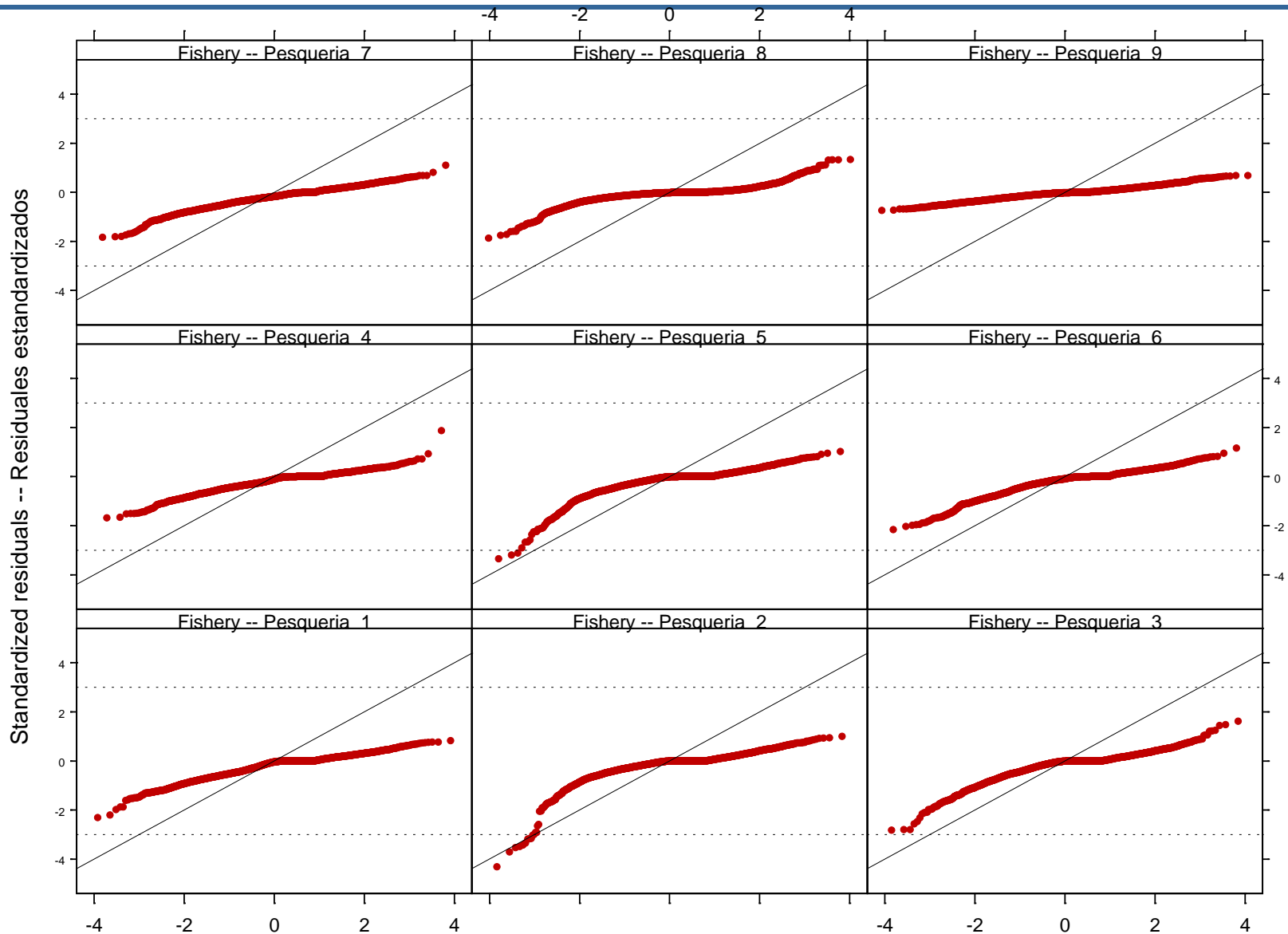


# LF residuals - by year





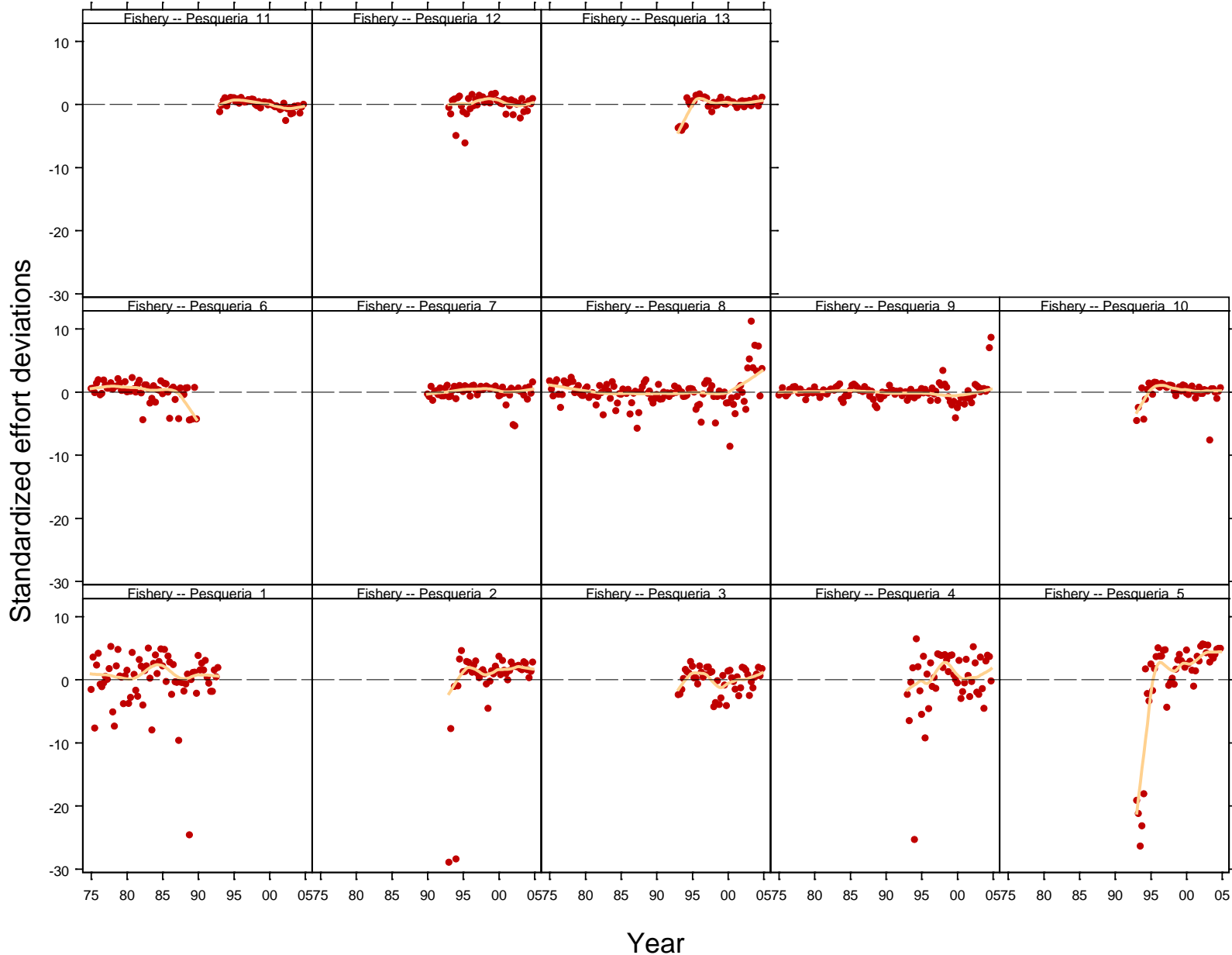
# QQ-normal plot of LF residuals



Quantiles of standard normal -- Cuantiles de la distribución normal estándar



# Effort deviates

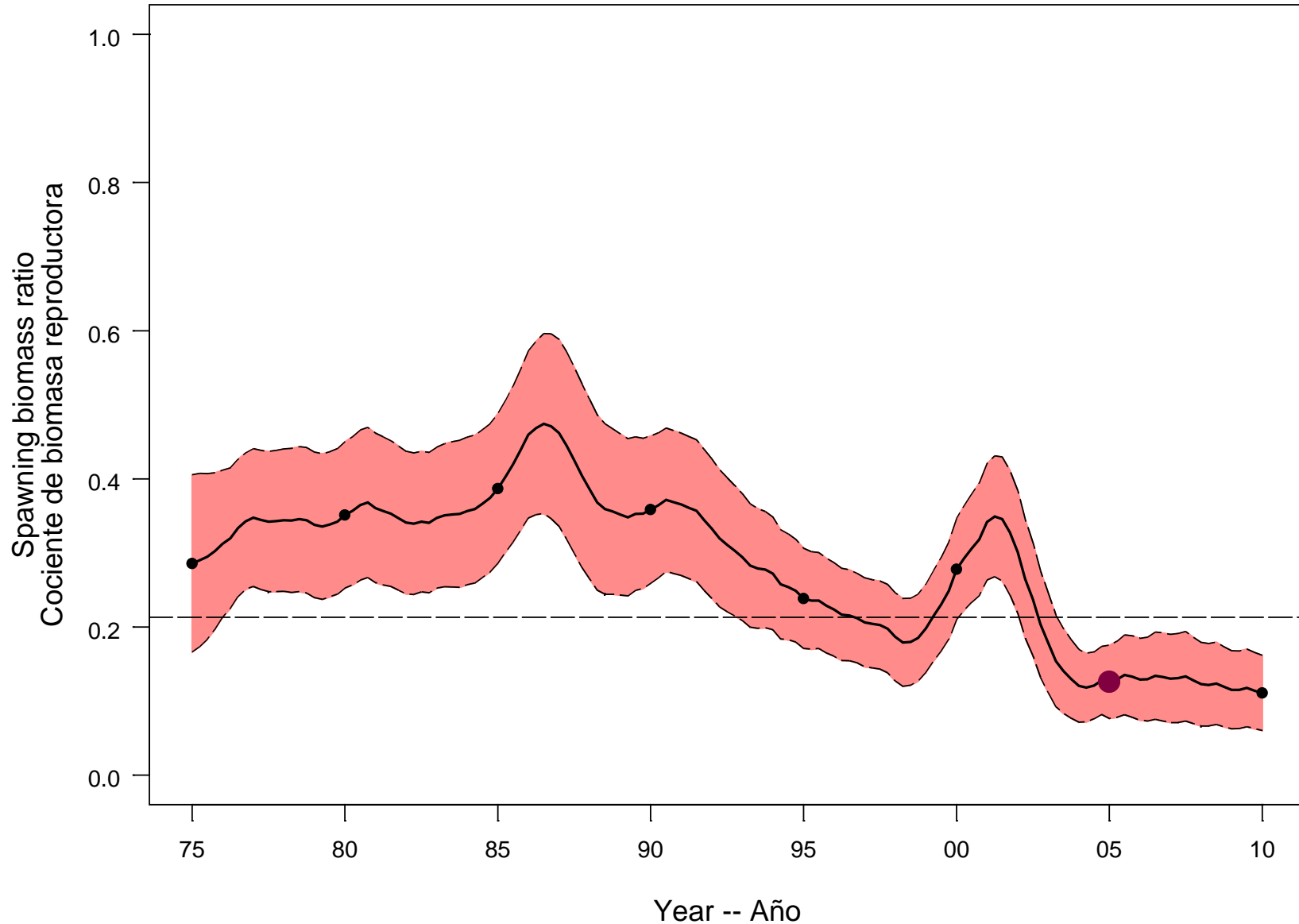


# Forward simulations

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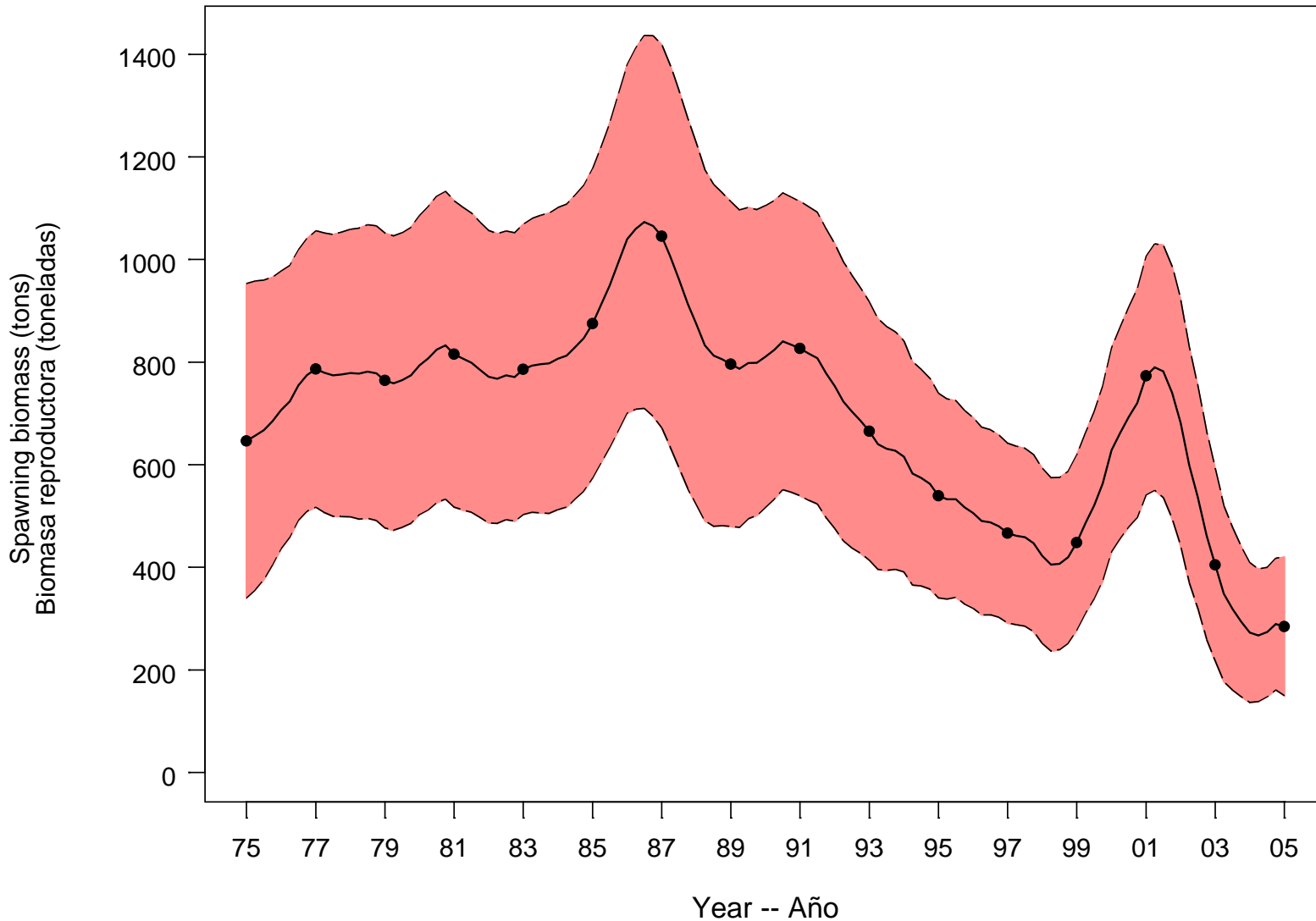
- Spawning biomass depletion
- Biomass
- Surface fishery catch
- Longline catch
- Average catchability for 2001 and 2002
- Alternative effort scenarios
  - 2004 effort levels
  - No restrictions
  - $F_{AMSY}$

# Spawning biomass ratio



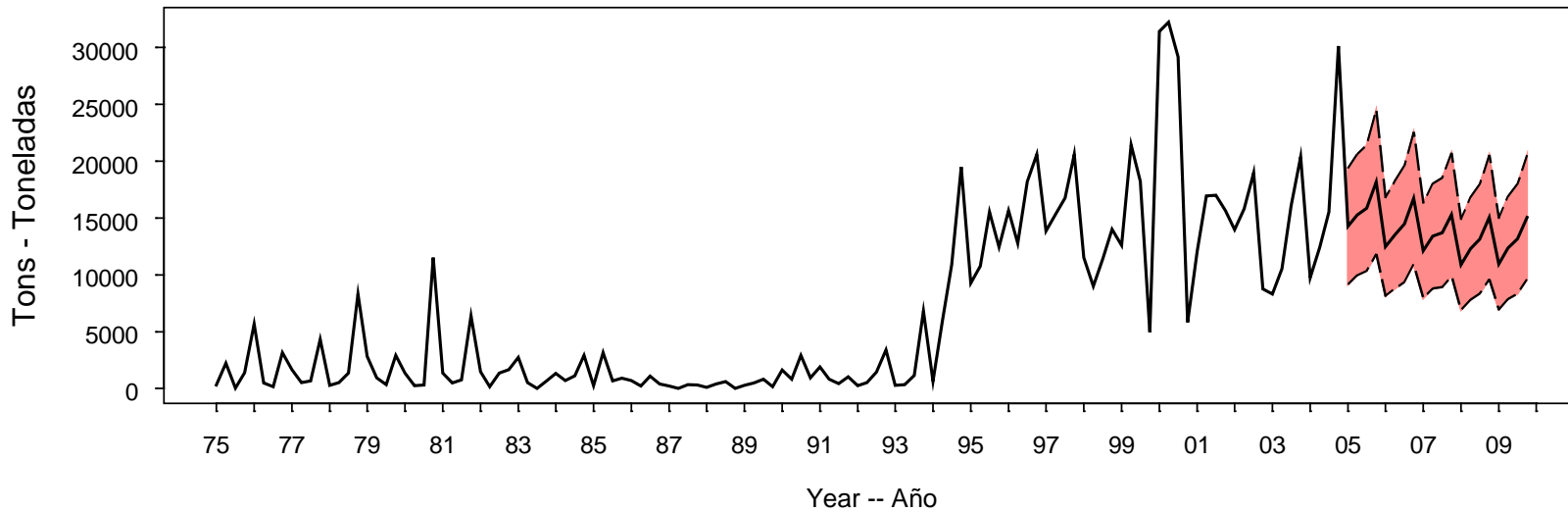
# Biomass

Population fecundity -- Fecundidad de la poblacion

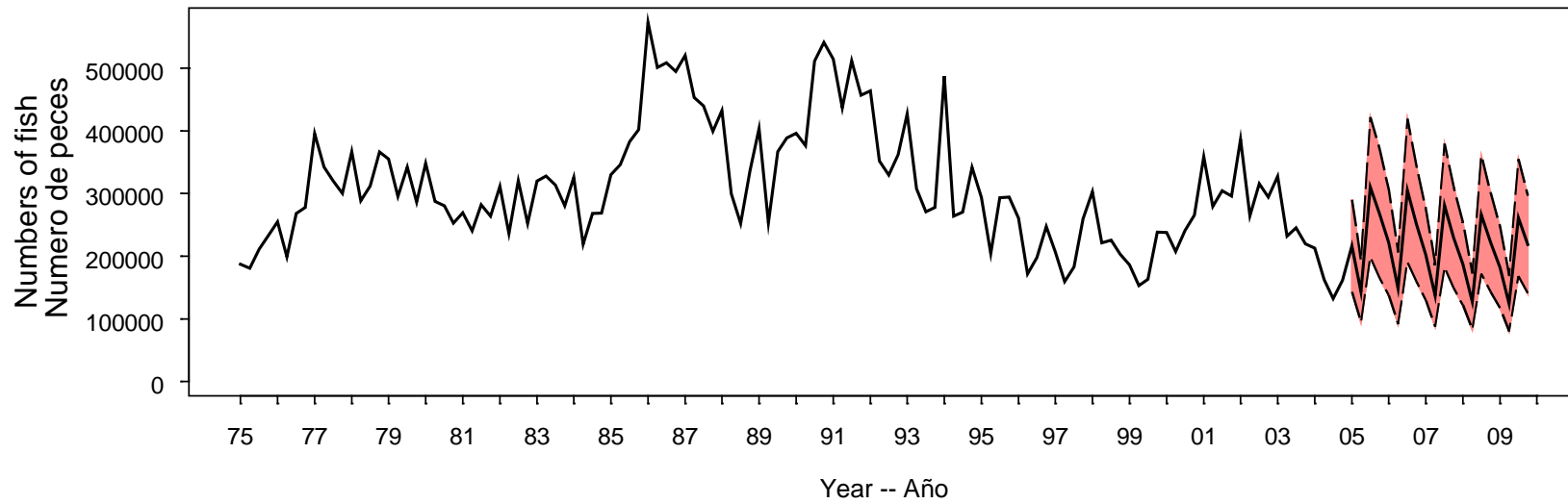


# Predicted catches

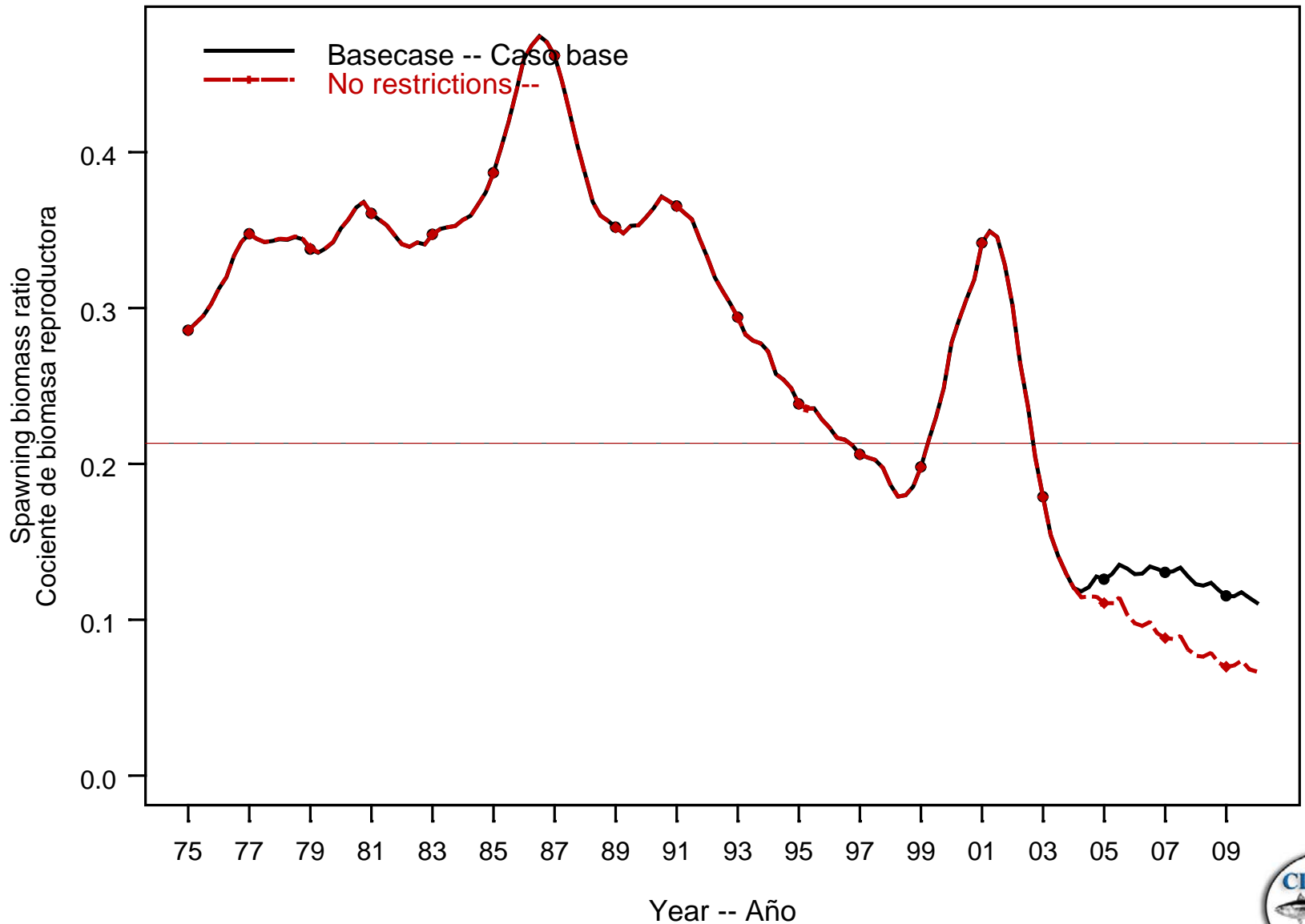
## Predicted purse-seine catches



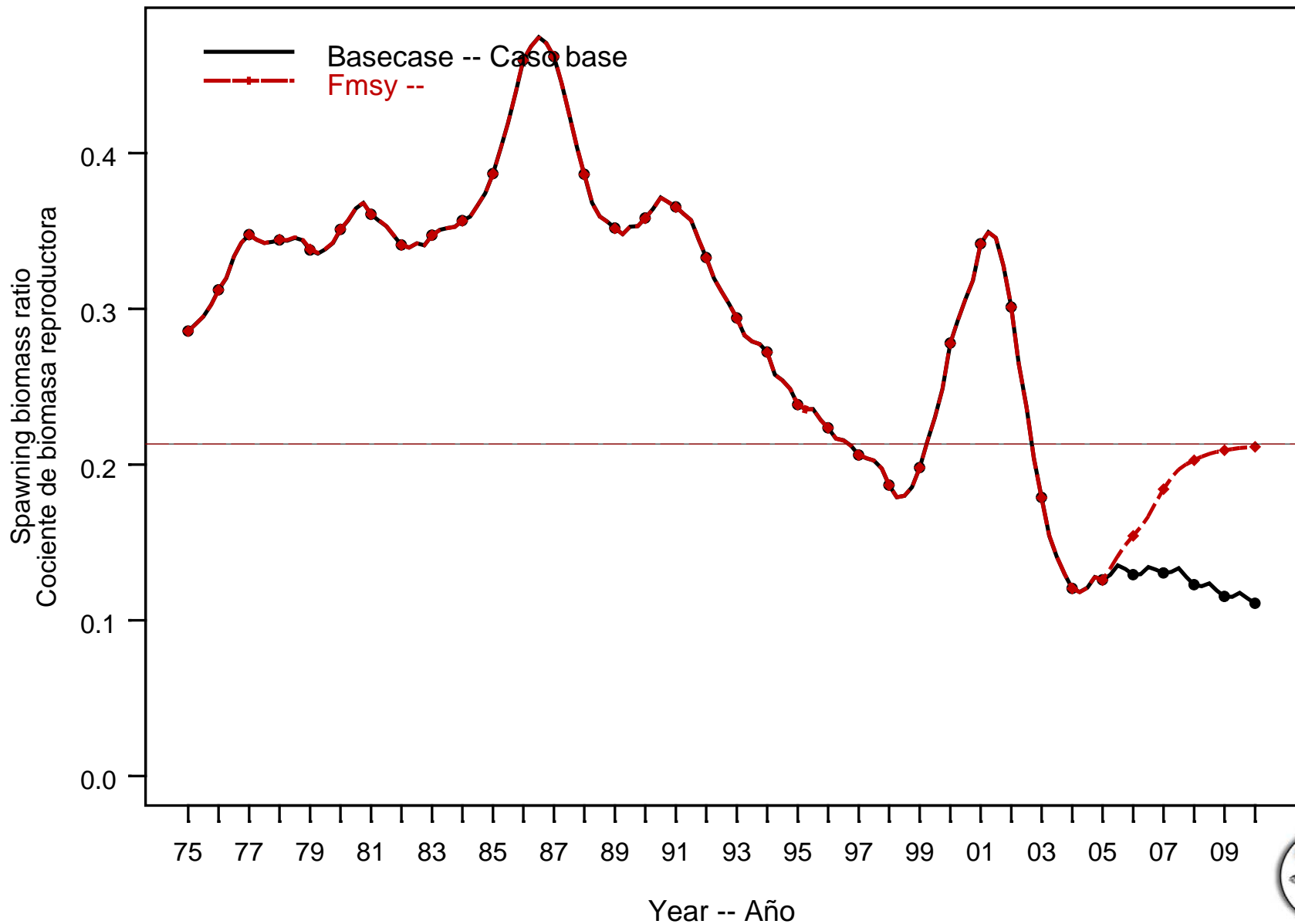
## Predicted longline catches



# Spawning biomass ratio – No restrictions



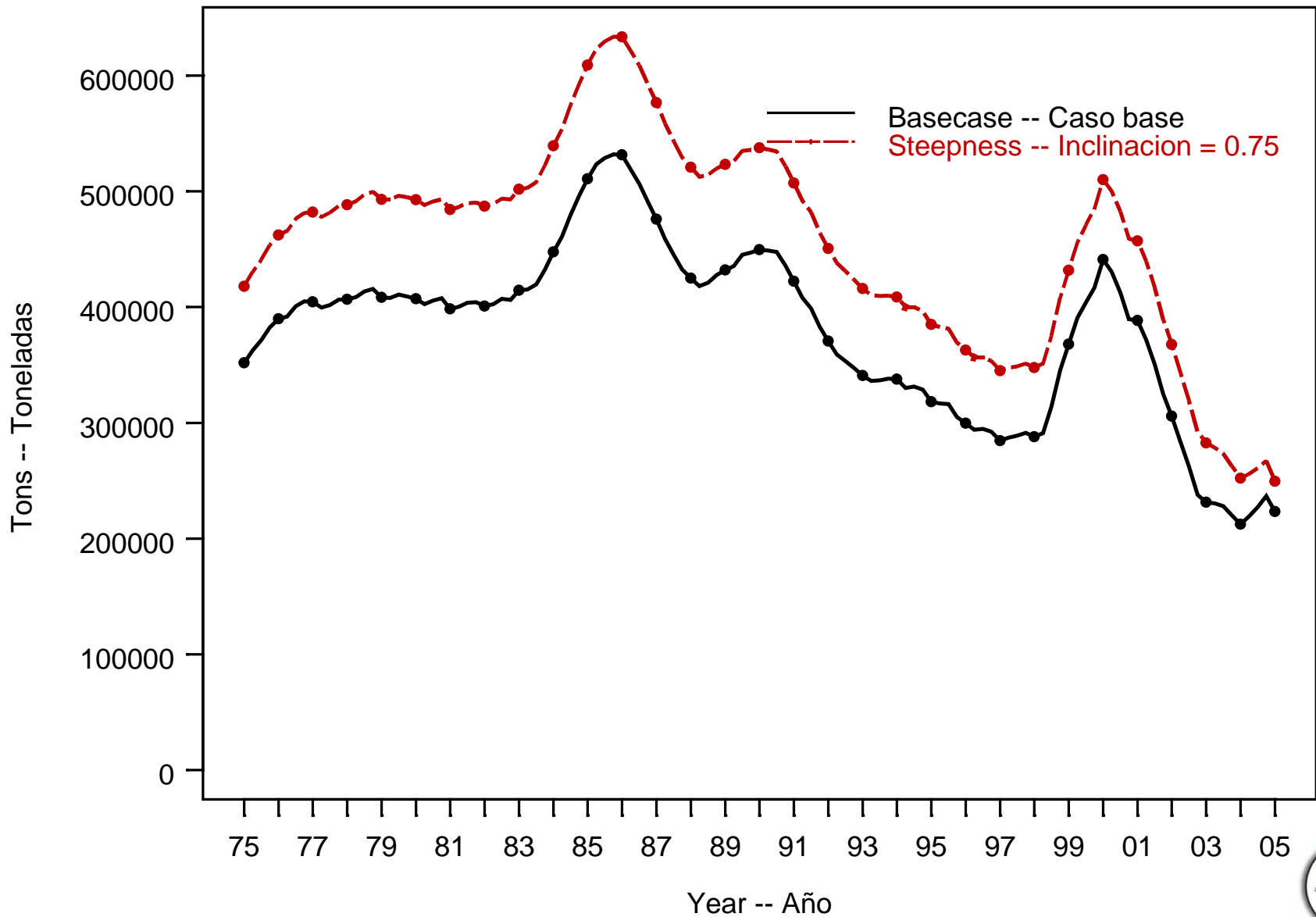
# Spawning biomass ratio - $F_{AMSY}$



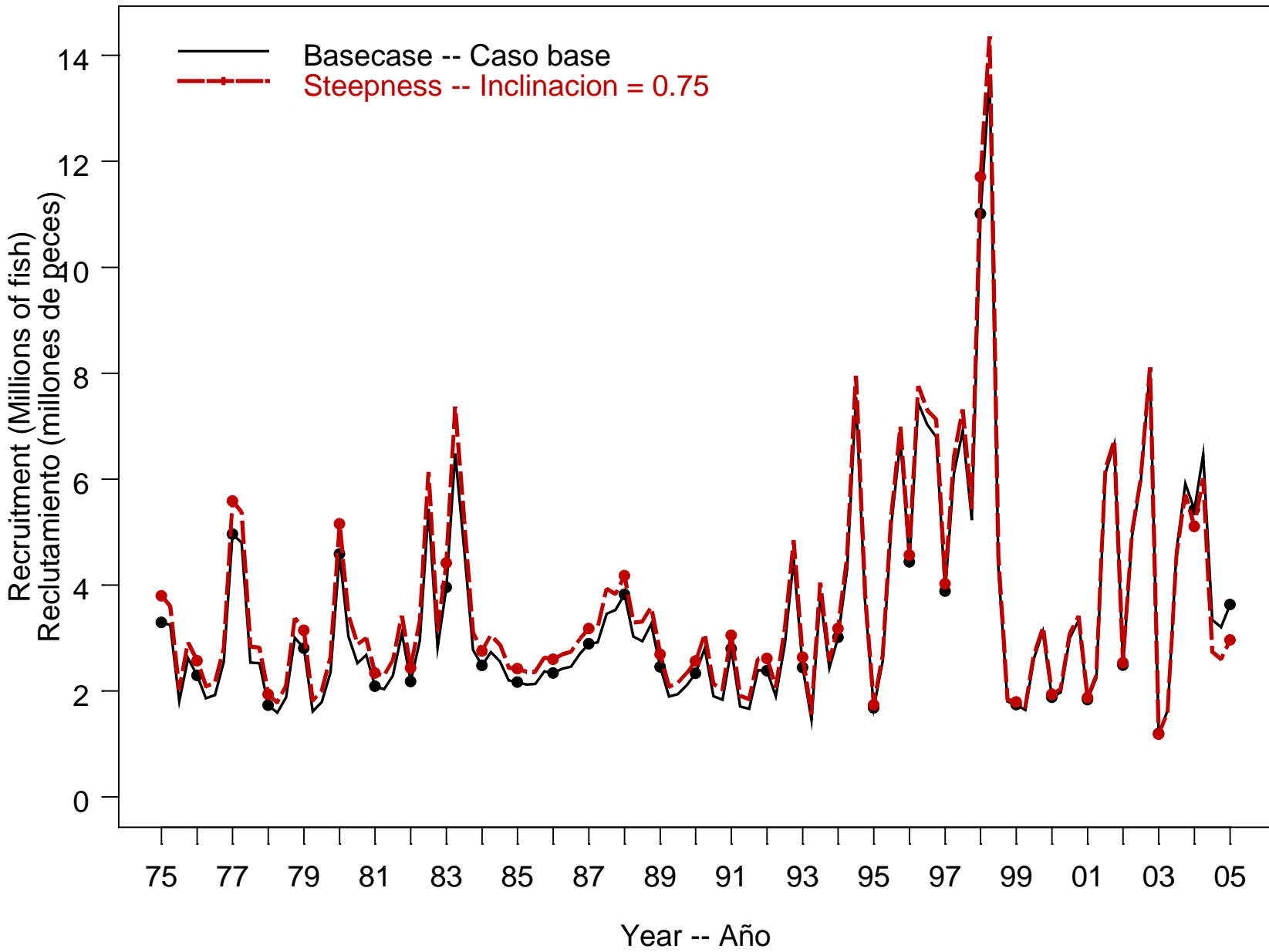


# Stock-recruitment relationship ( $h = 0.75$ )

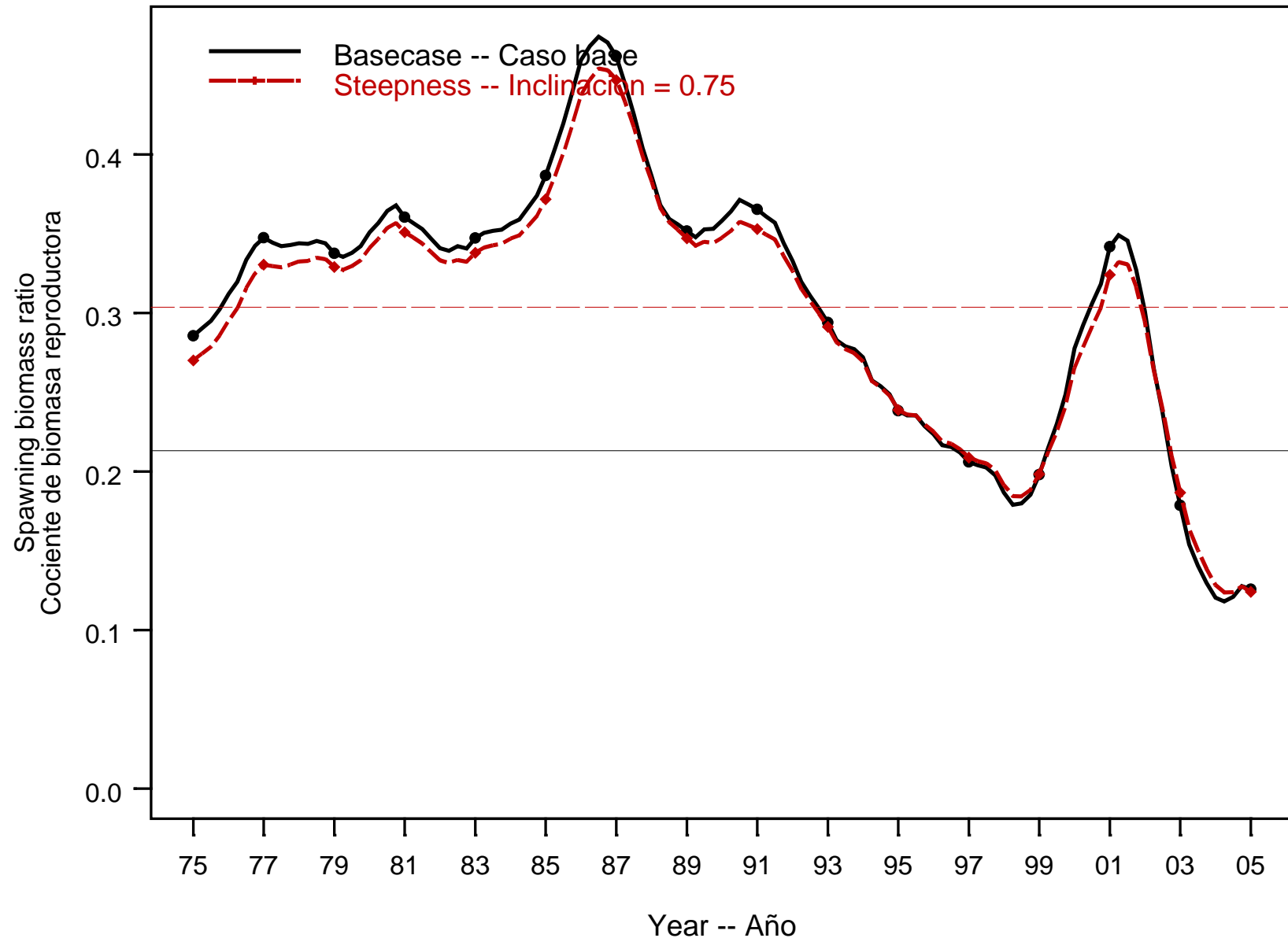
# Biomass



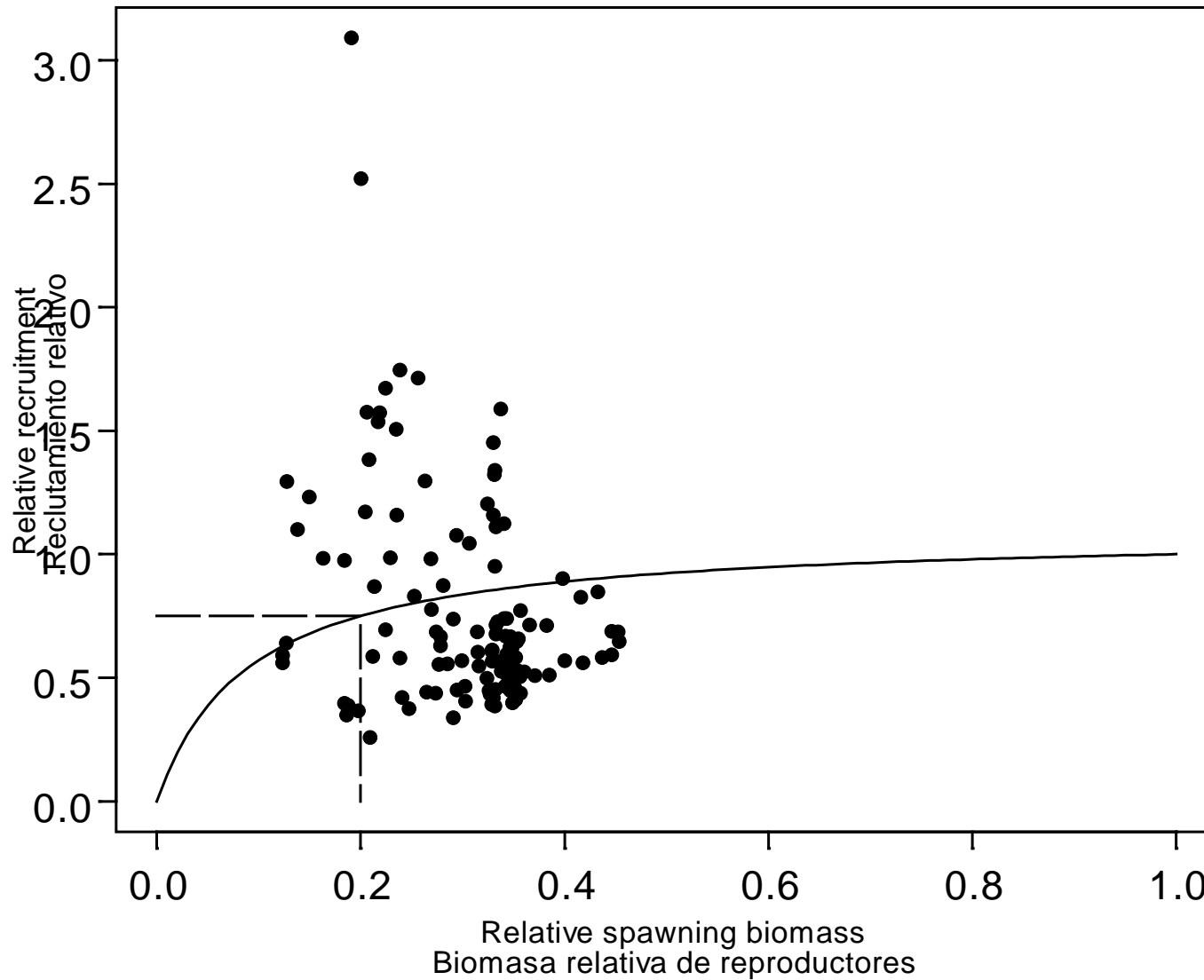
# Recruitment



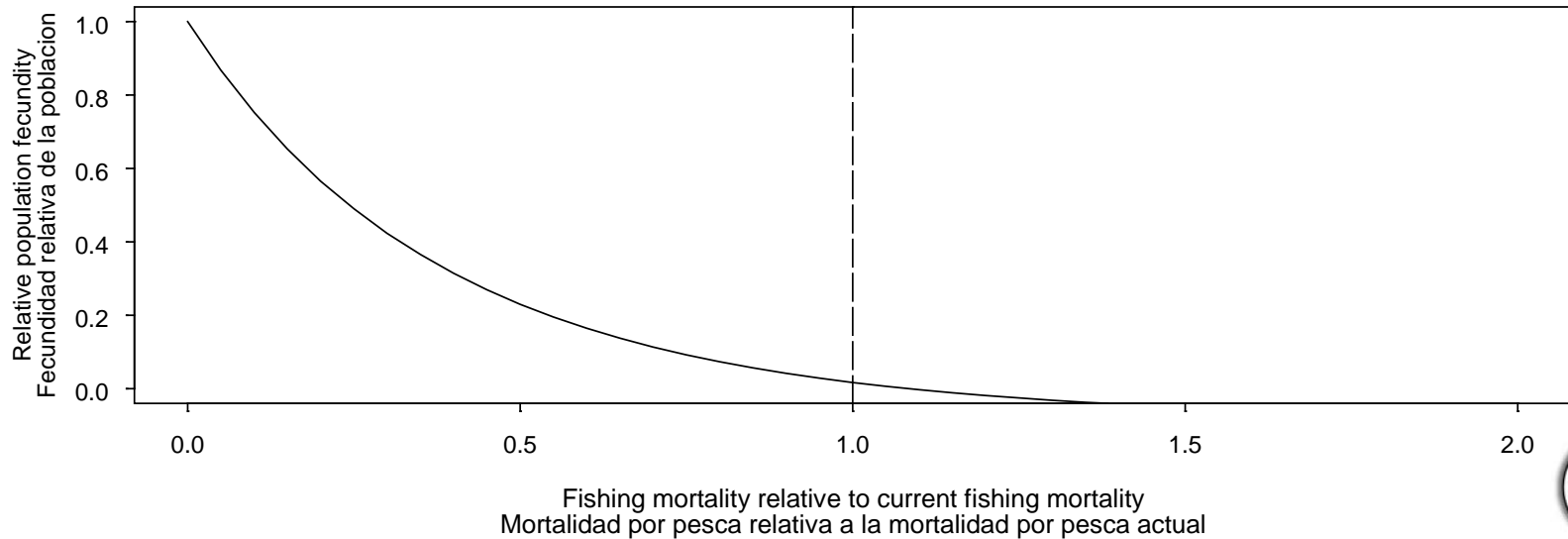
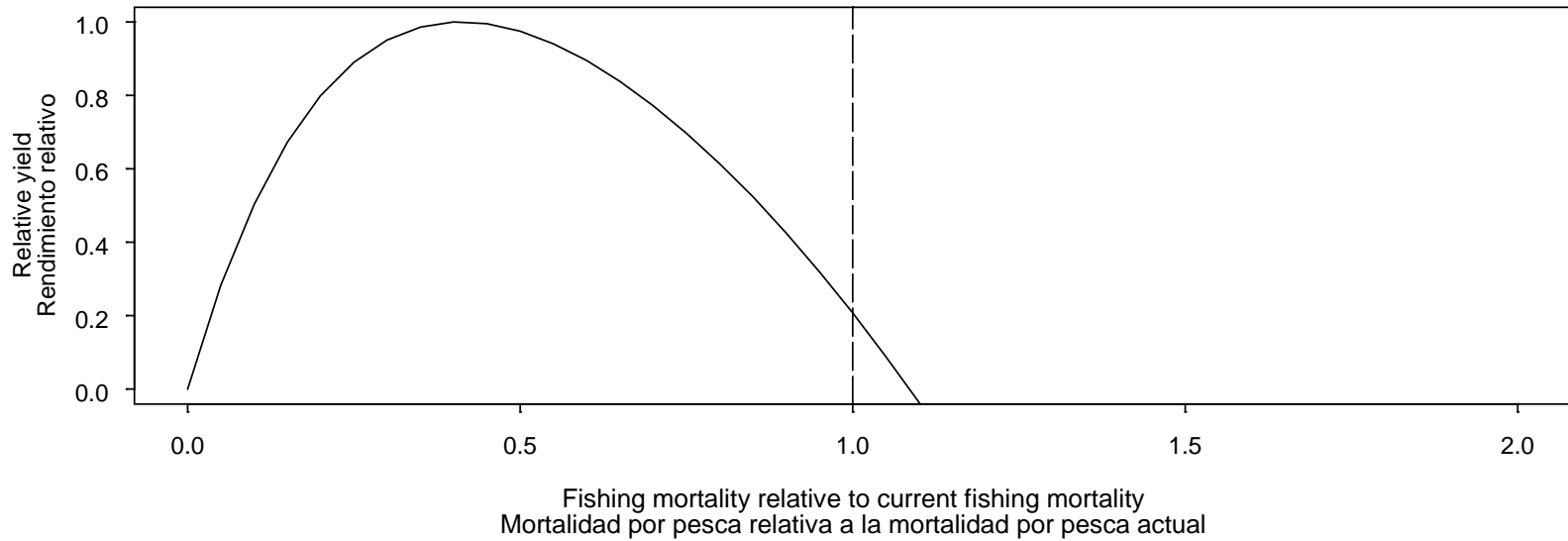
# Spawning biomass ratio



# Spawner-recruitment curve



# Yield curve



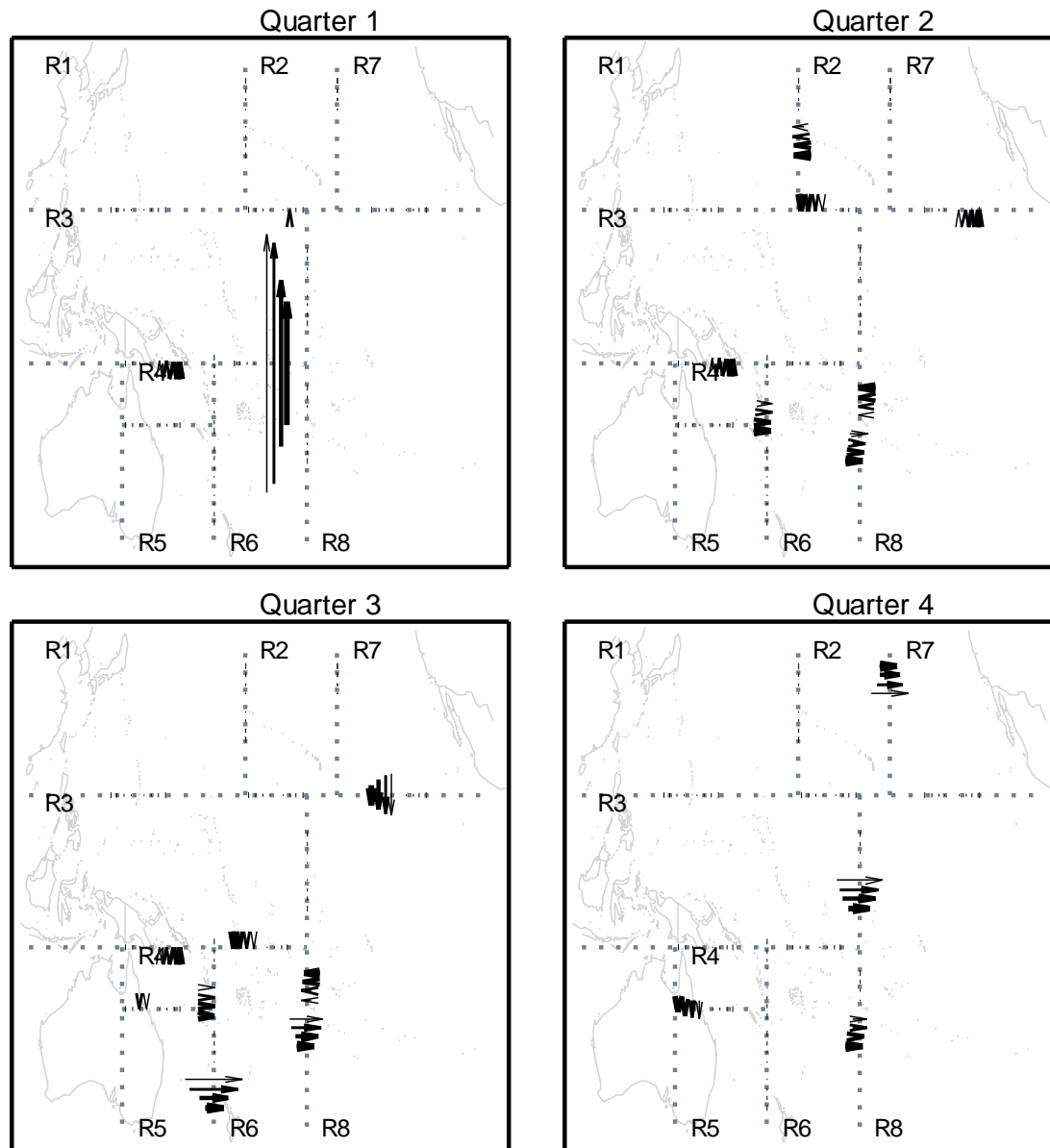
# Pacific-wide assessment

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- Collaboration with the Secretariat of the Pacific Community and National Research Institute of Far Seas Fisheries of Japan.
- Model bigeye tuna in the Pacific Ocean as a single stock with a number of subregions.
- Fish can move between subregions.
- Analysis uses available tagging data from studies in the WCPO and the EPO.

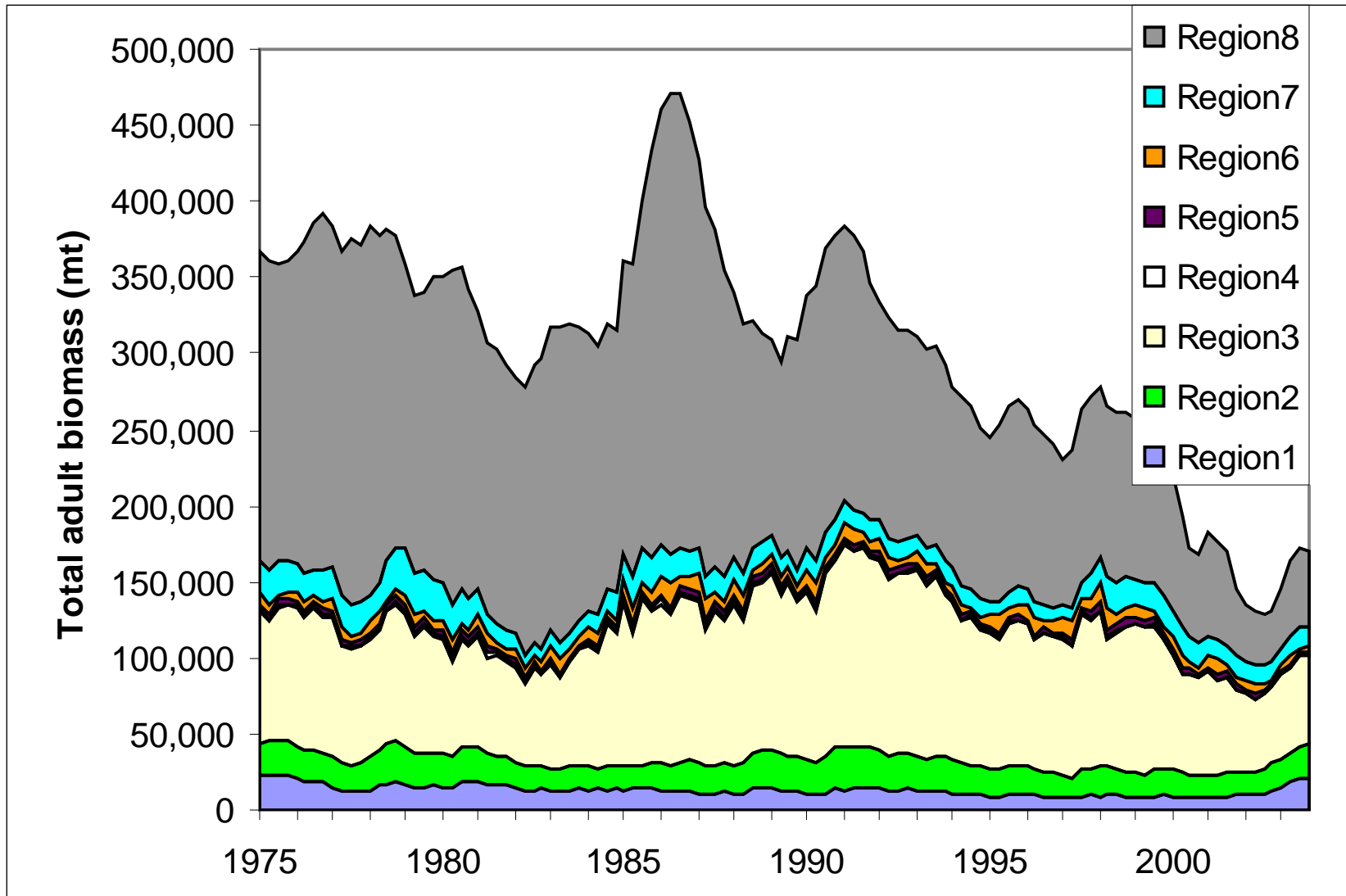


# Pacific-wide versus EPO assessments

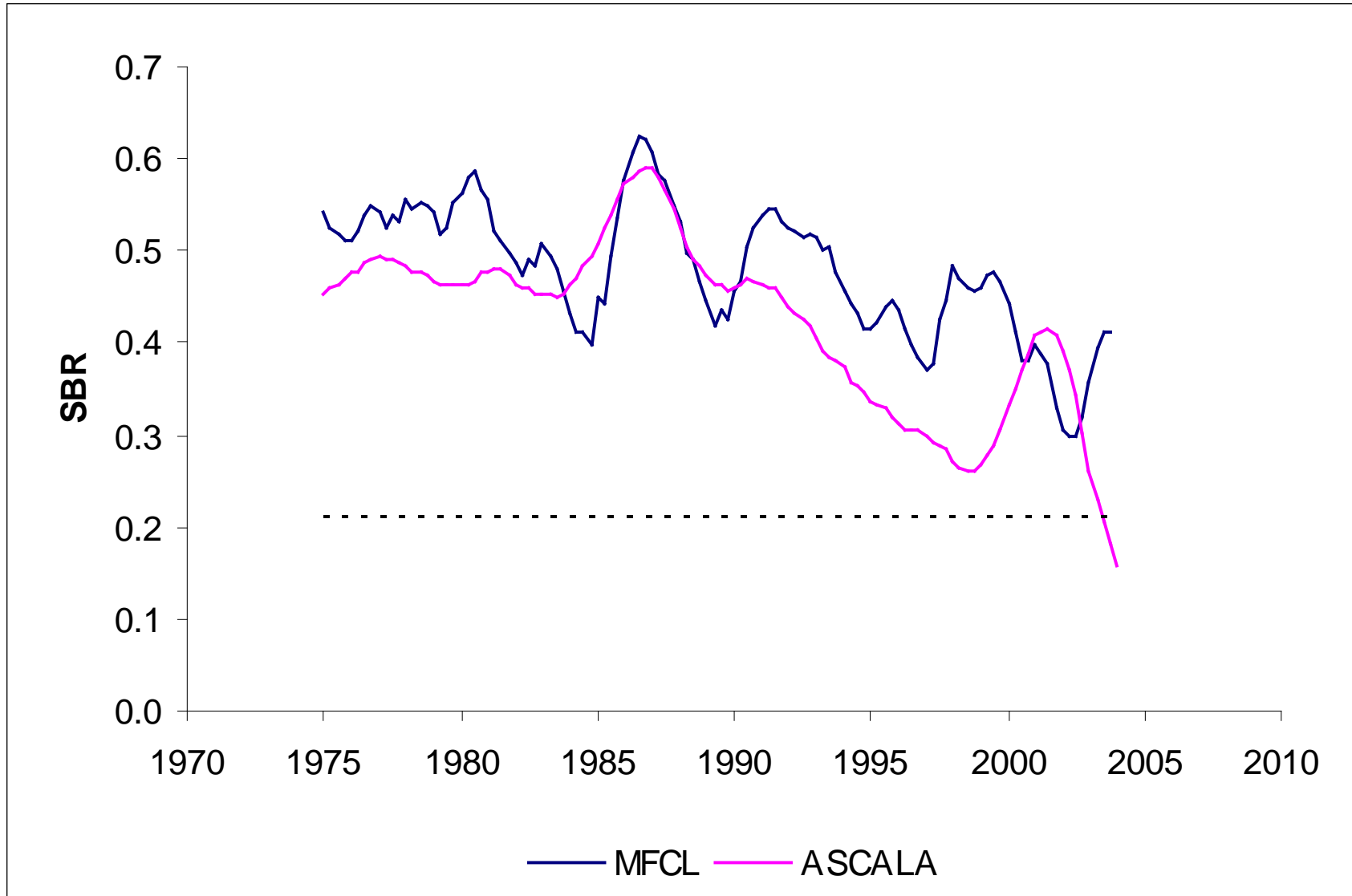




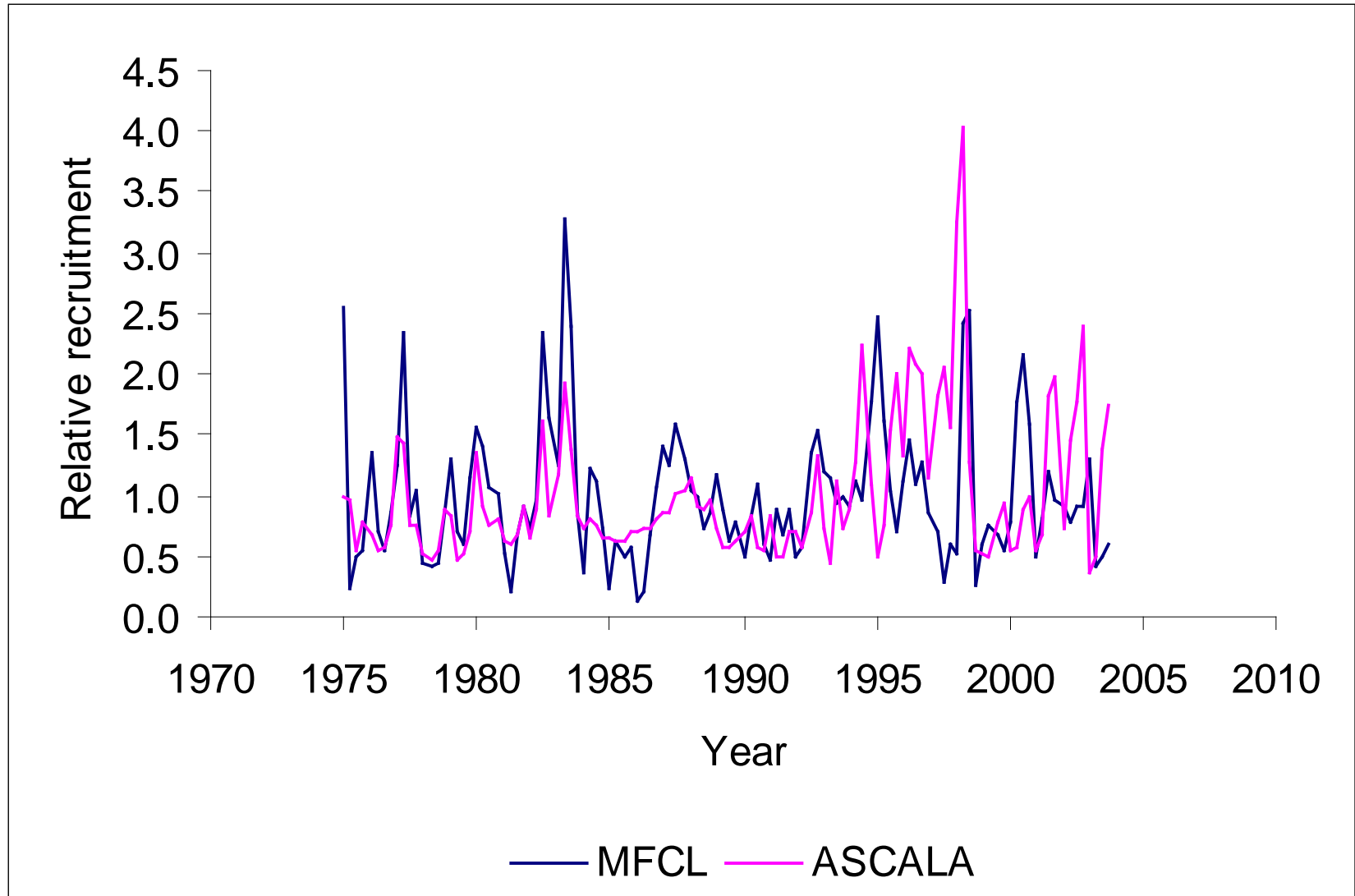
# Pacific-wide versus EPO assessments



# Pacific-wide versus EPO assessments



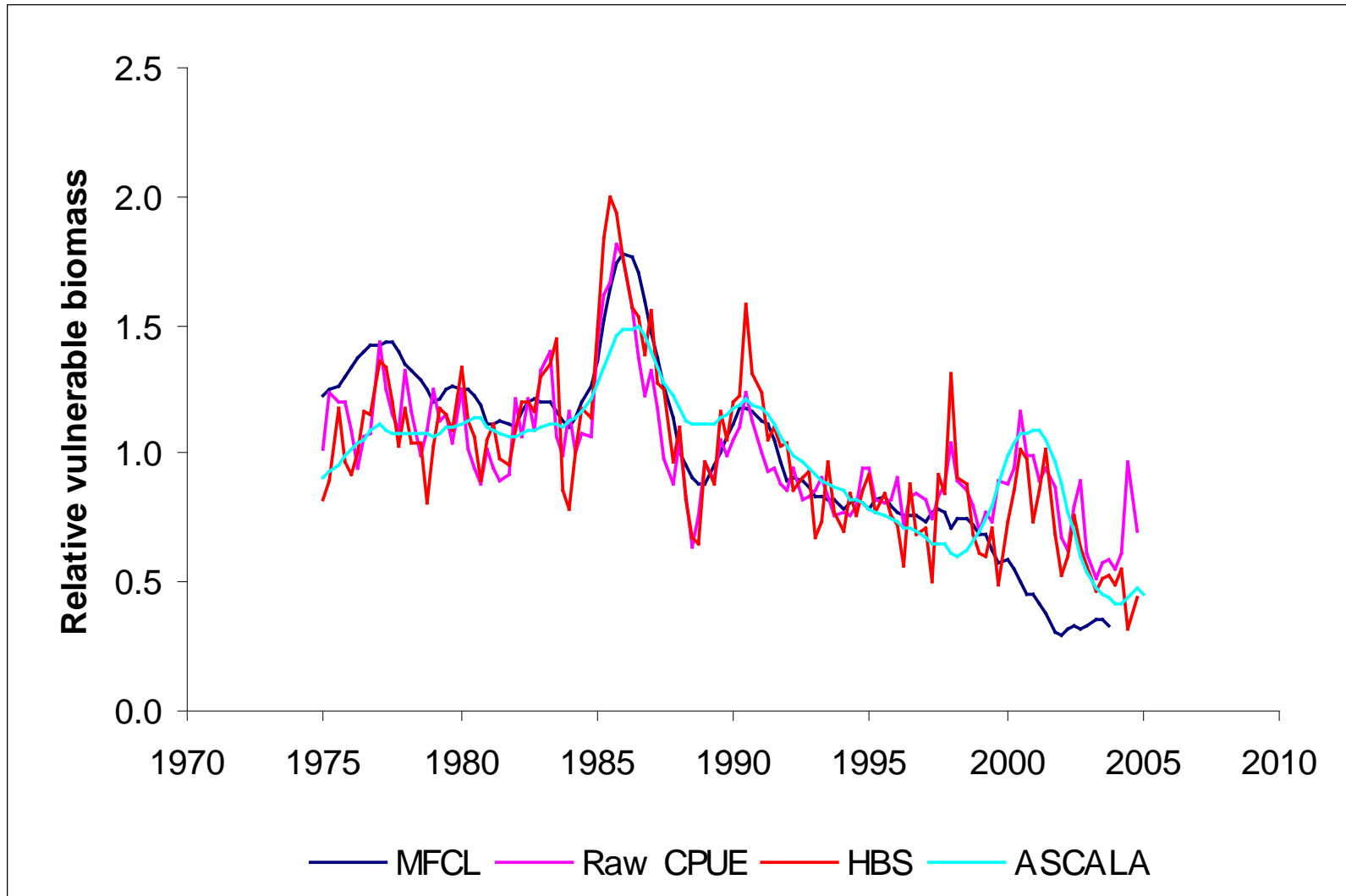
# Pacific-wide versus EPO assessments



— MFCL — ASCALA



# Pacific-wide versus EPO assessments



# Summary: Main results

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- Biomass trends are similar to those estimated (and predicted) in previous assessments
- Both total and spawning biomass is estimated to have substantially declined since 2000
- Current biomass level is low compared to average unexploited conditions
- The current effort restrictions are not enough to allow the population to reach a level that will support AMSY

# What is robust

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- Current SBR being below that required to produce AMSY.
- Fishing mortality levels are greater than that necessary to achieve the maximum sustainable yield.

# Plausible Sensitivities and Uncertainties

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- Results are more pessimistic with the inclusion of a stock-recruitment relationship
- Biomass trends are strongly related to longline CPUE

# Conclusions

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- Current spawning biomass is below the level required to produce AMSY.
- In the most recent years the fishing mortality is greater than that required to produce AMSY.
- Under average recruitment, the stock is not predicted to rebuild unless fishing mortality levels are reduced further than the current restrictions.