SOUTH EPO SWORDFISH ASSESSMENT (SAC-14-15)

Carolina Minte-Vera, Mark N. Maunder, Haikun Xu, Cleridy E. Lennert-Cody, Juan L. Valero, and Alexandre Aires-da-Silva

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Outline

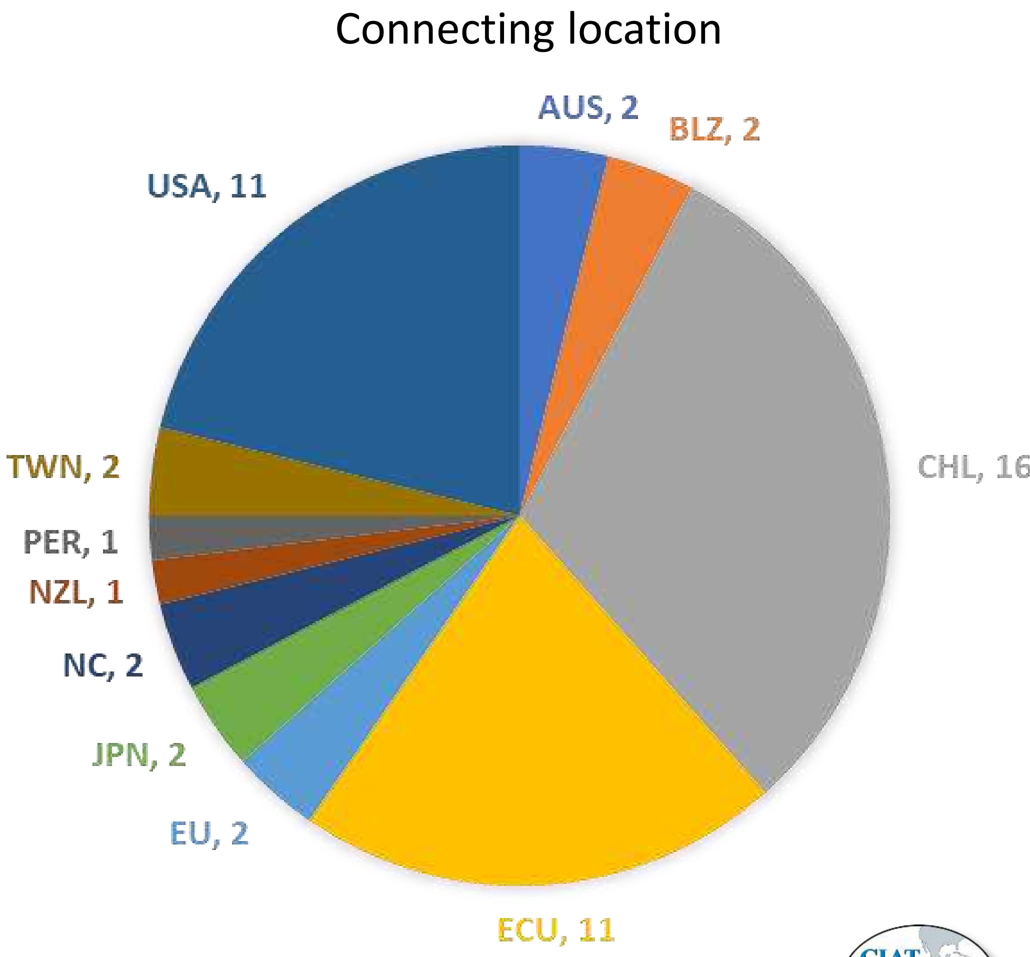
- Timeline
- Conceptual model
  - Tagging studies
- Data
- Stock assessment
  - Assumptions
  - Results
- Research recommendations

Timeline: it takes a planet…

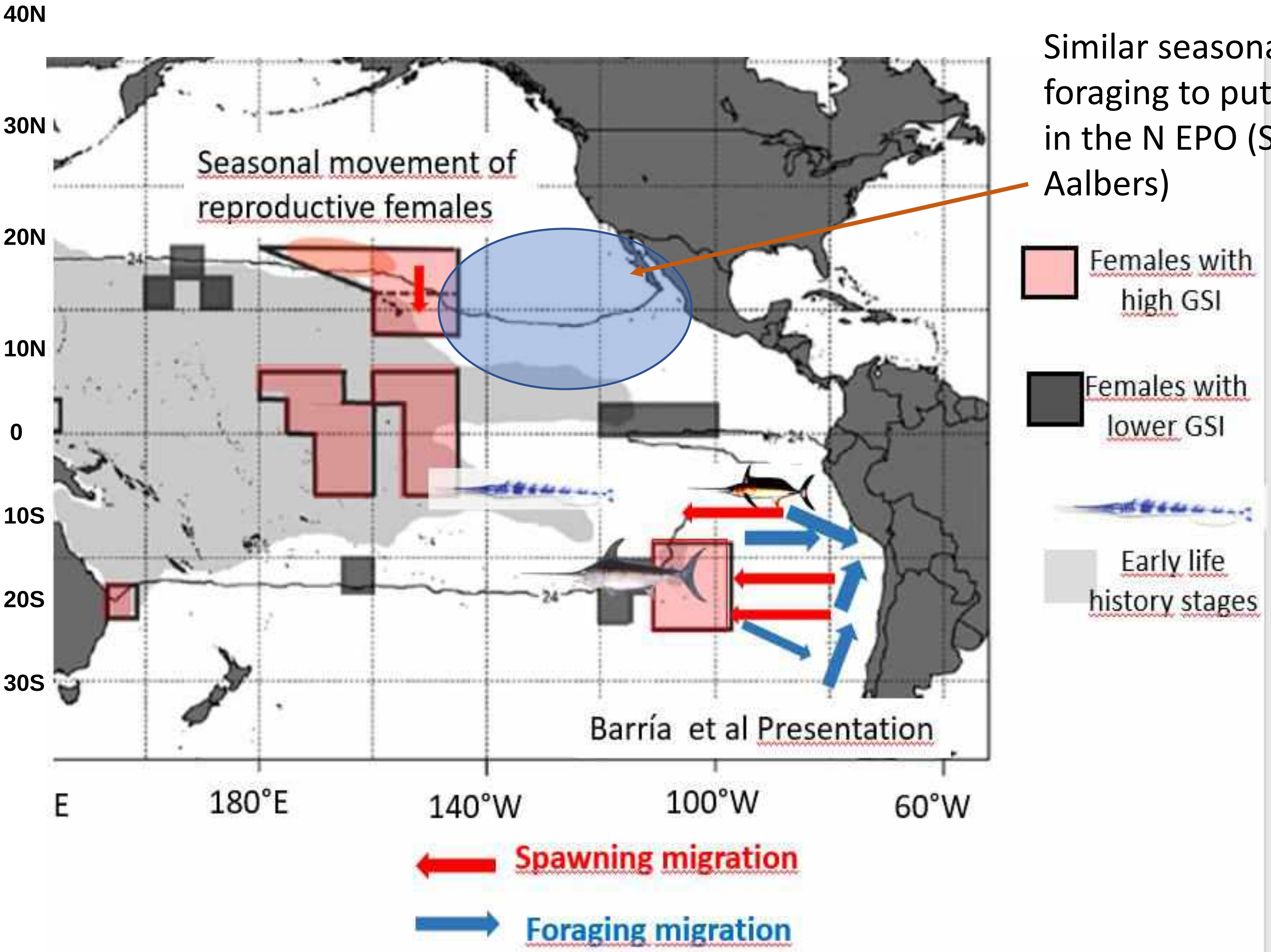
- Previous assessment 2011 (SAC-02-07)
- The commission requested the staff to work on a new assessment
- 2018: included in the Scientific Strategic plan
- **2020: 1th technical workshop on S EPO swordfish (SWO-01-Report) – videoconference**
- 2021: ISC BILL WG presentation on the workshop
- 2021: data assembly and exploratory data analysis
- 2022: assessment

Number of external participants: 52

IATTC staff: 22



Conceptual model for S EPO

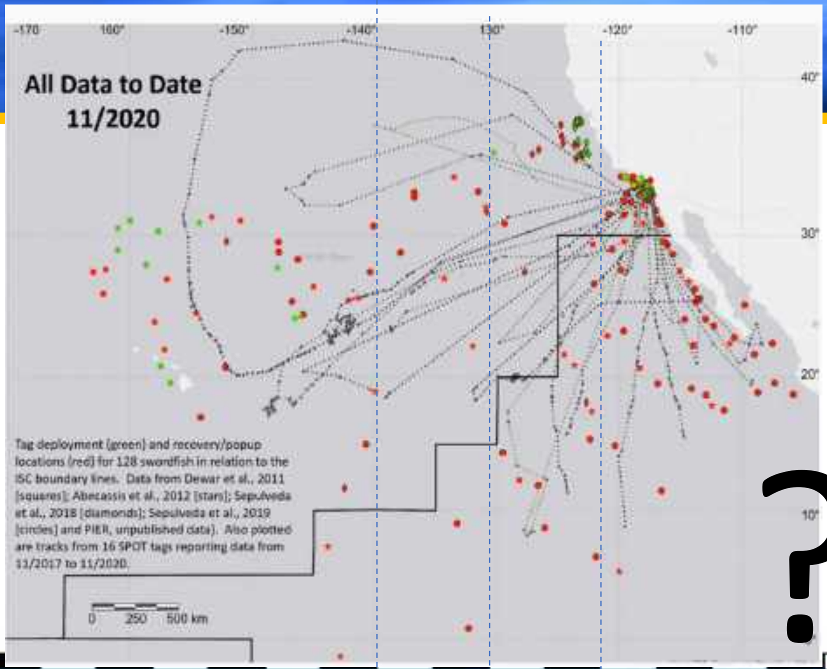


Similar seasonal movement from foraging to putative spawning areas in the N EPO (Sepulveda and Aalbers)

Conceptual model

Sepulveda and Aalbert (2020 SWO-01)

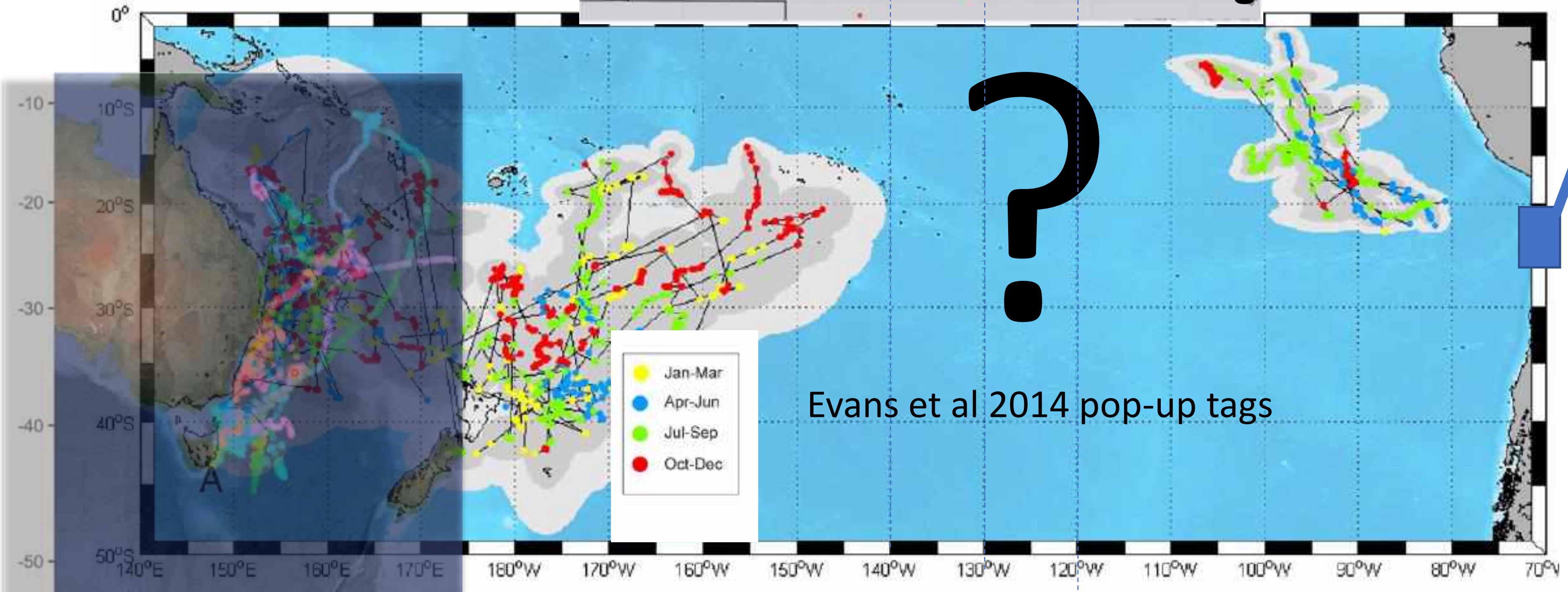
Tracey and Pepperell (2018) in Moore (2020 SWO-01)



Zárate et al (SWO-01)

Tagging in the coast of Chile

?



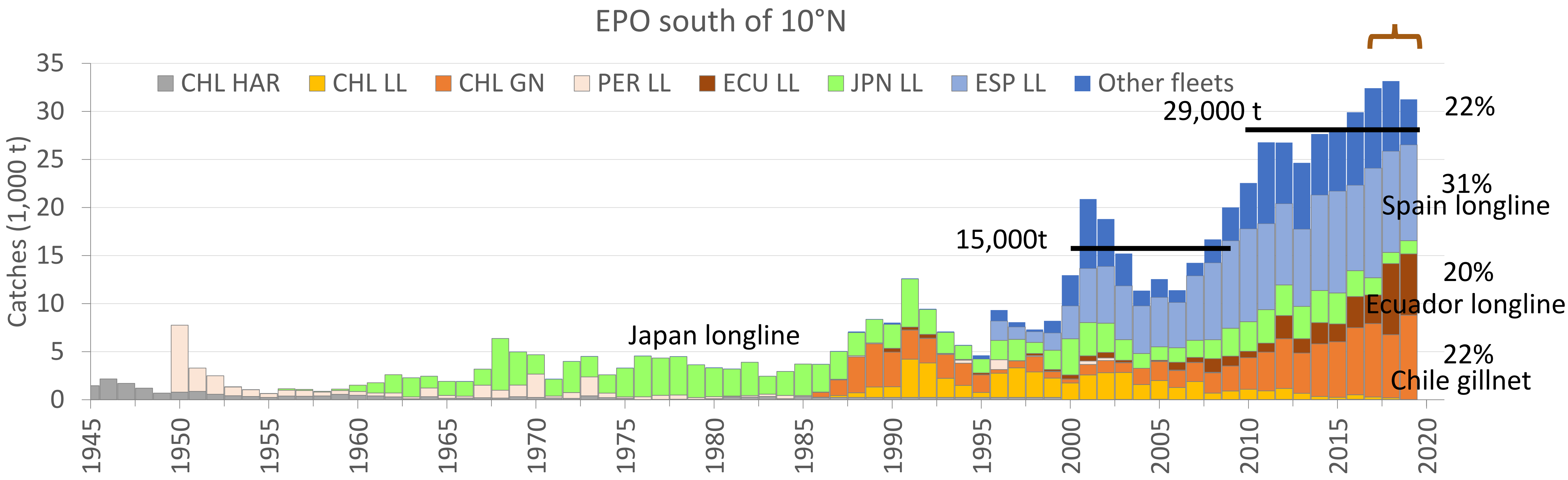
Evans et al 2014 pop-up tags

Data

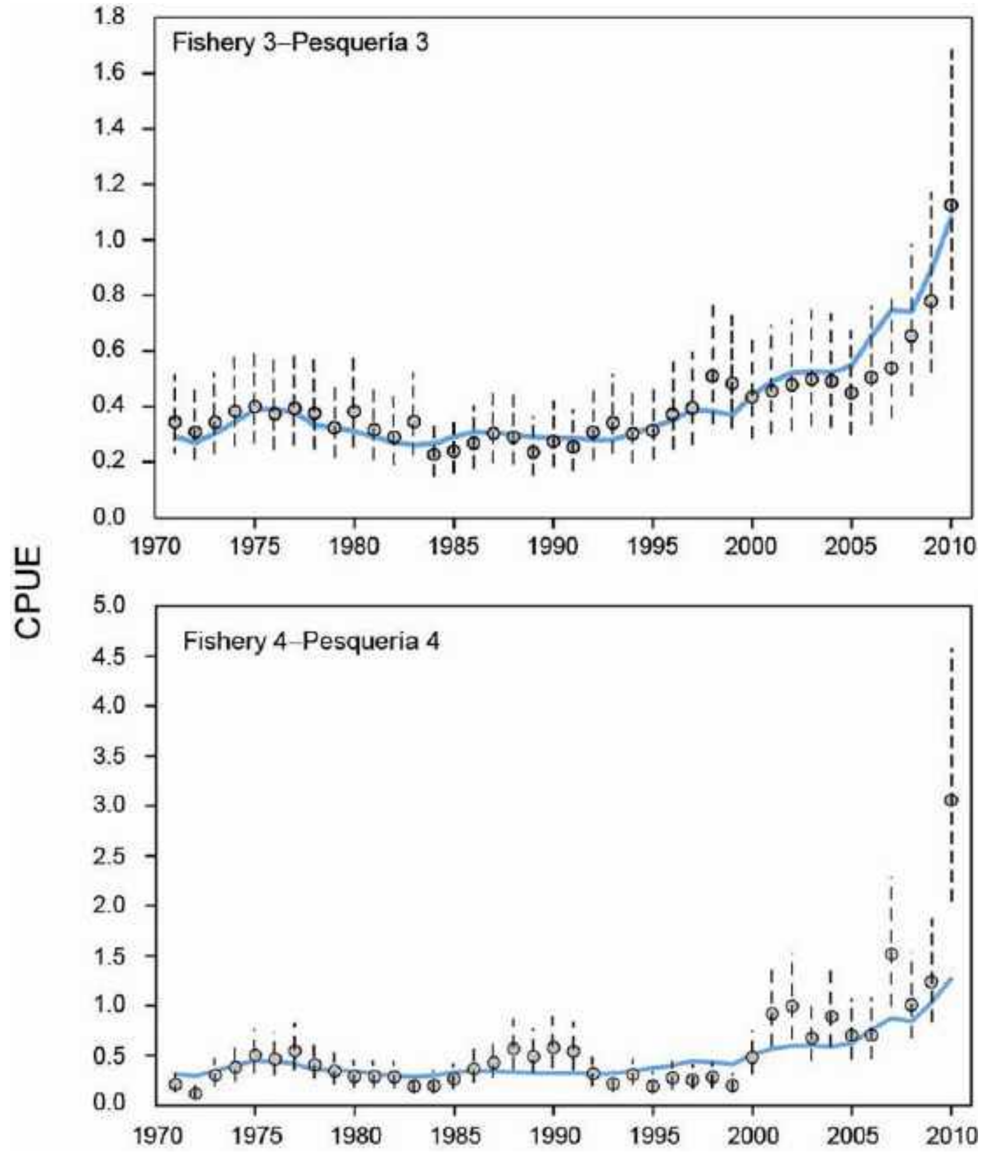
- Catches
  - Submission in compliance with Resolution C-03-05
  - Special submission by **Chile** catches by quarter
  - Special submission by **Ecuador** catches by trip
  - FAO database
  - Literature search
- Indices of abundance
  - Special submission by **Chile** of 2° by 2° data and estimation of indices by Chilean colleagues (2000-2019)
  - Collaboration with **Japan** to analyze set-by-set operational level data (1975-2019)
  - Submission in compliance with Resolution C-03-05 for Japan (level 2 data)
  - Memorandum of understanding with **Korea** - set-by-set operational level data (1976-2018)
  - Special submission by **Spain** of set-by-set data with positive catches of swordfish (2006 -2019)
- Composition data
  - Age composition data by sex for **Chile** (gillnets and longline) (2000-2019)
  - Length composition data for **Chile** (2000-2019)
  - Length composition data for **Ecuador** (2016-2020)
  - Length composition for distant water fleets in compliance with Resolution C-03-05
- Standardized average weight
  - Collaboration with **Japan**

Catch estimation

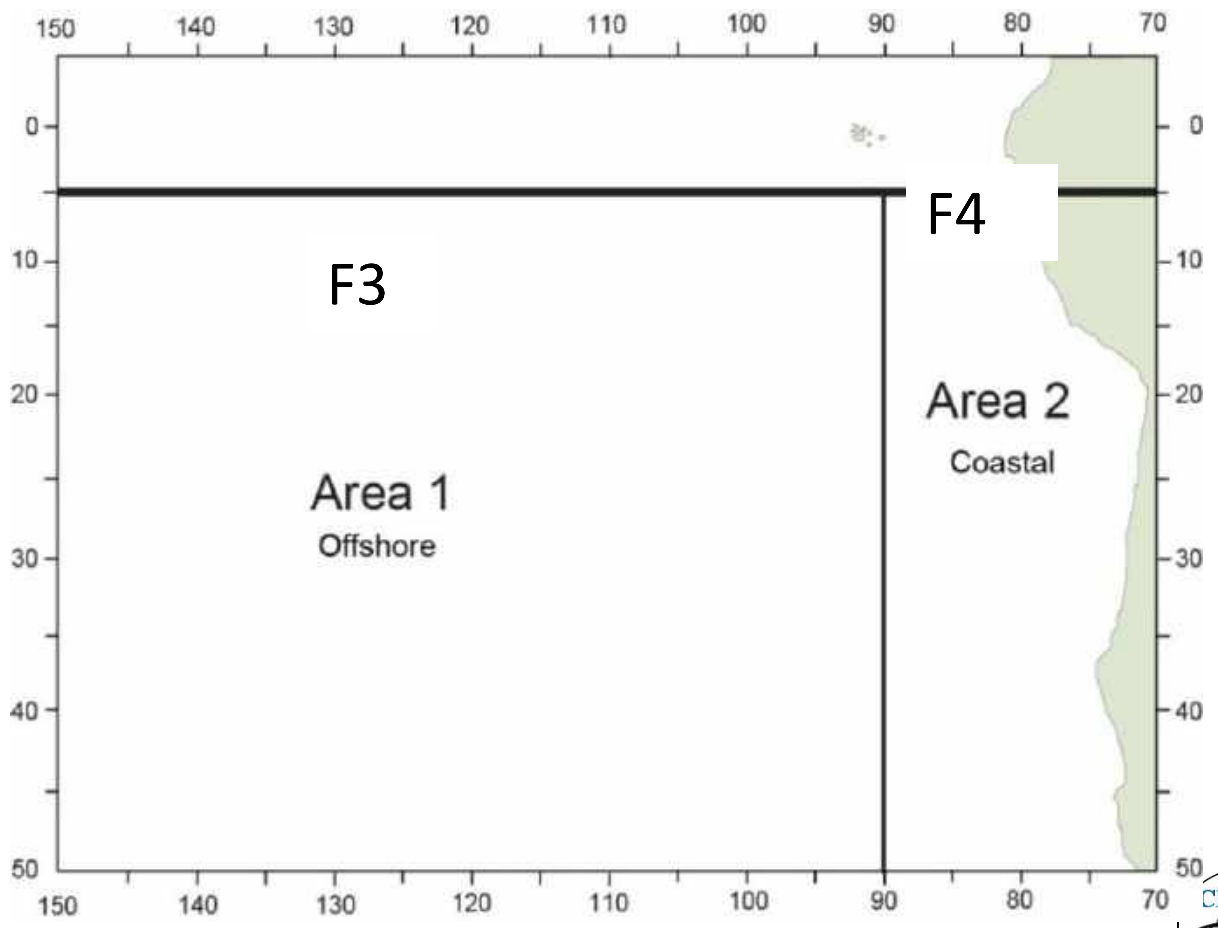
Annual catches of swordfish in the EPO south of 10° N in weight by fishing gear and CPC



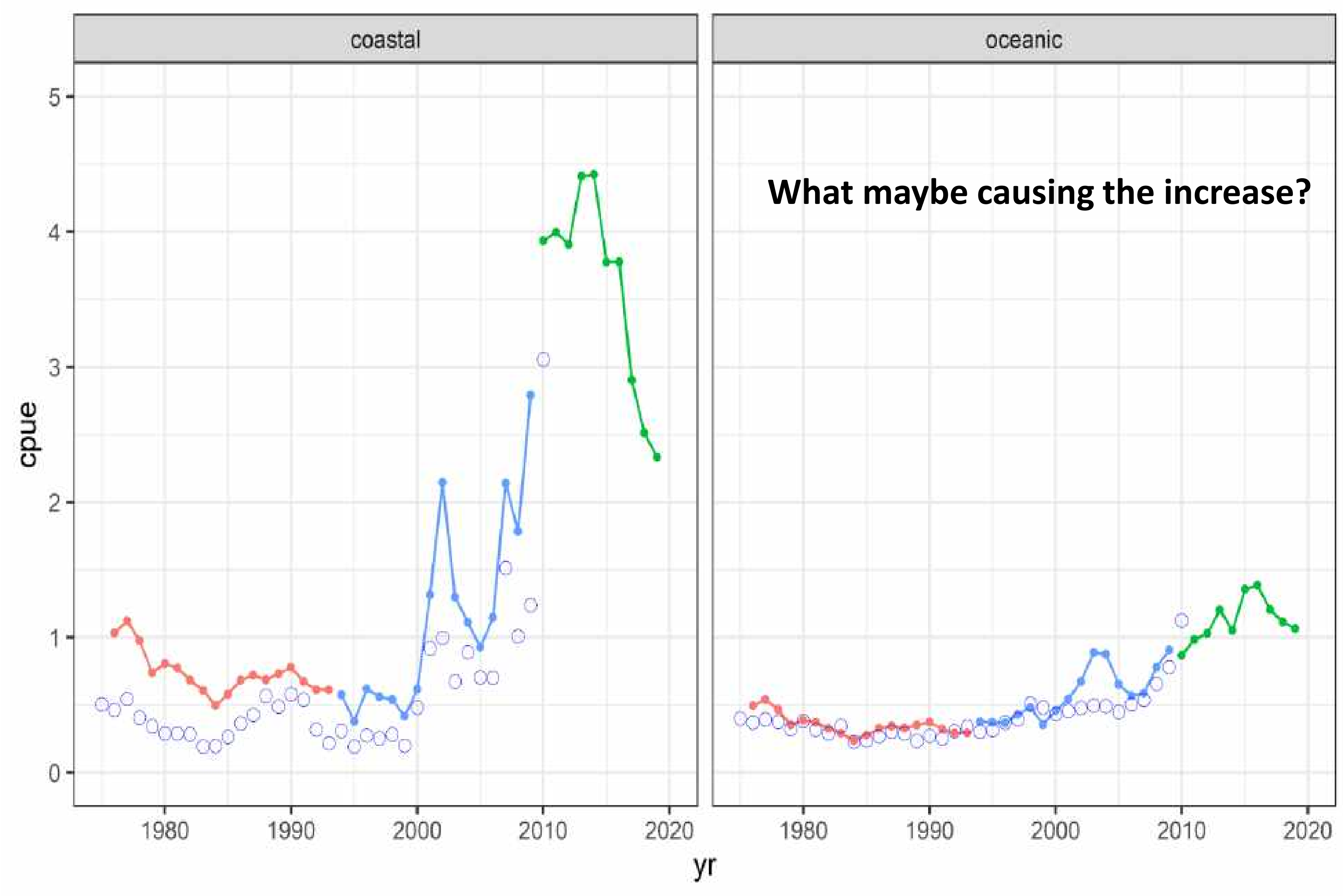
Indices of abundance: 2011 assessment



Japanese longline CPUE



Updated indices from Japanese fleet SAC-13-INF-N



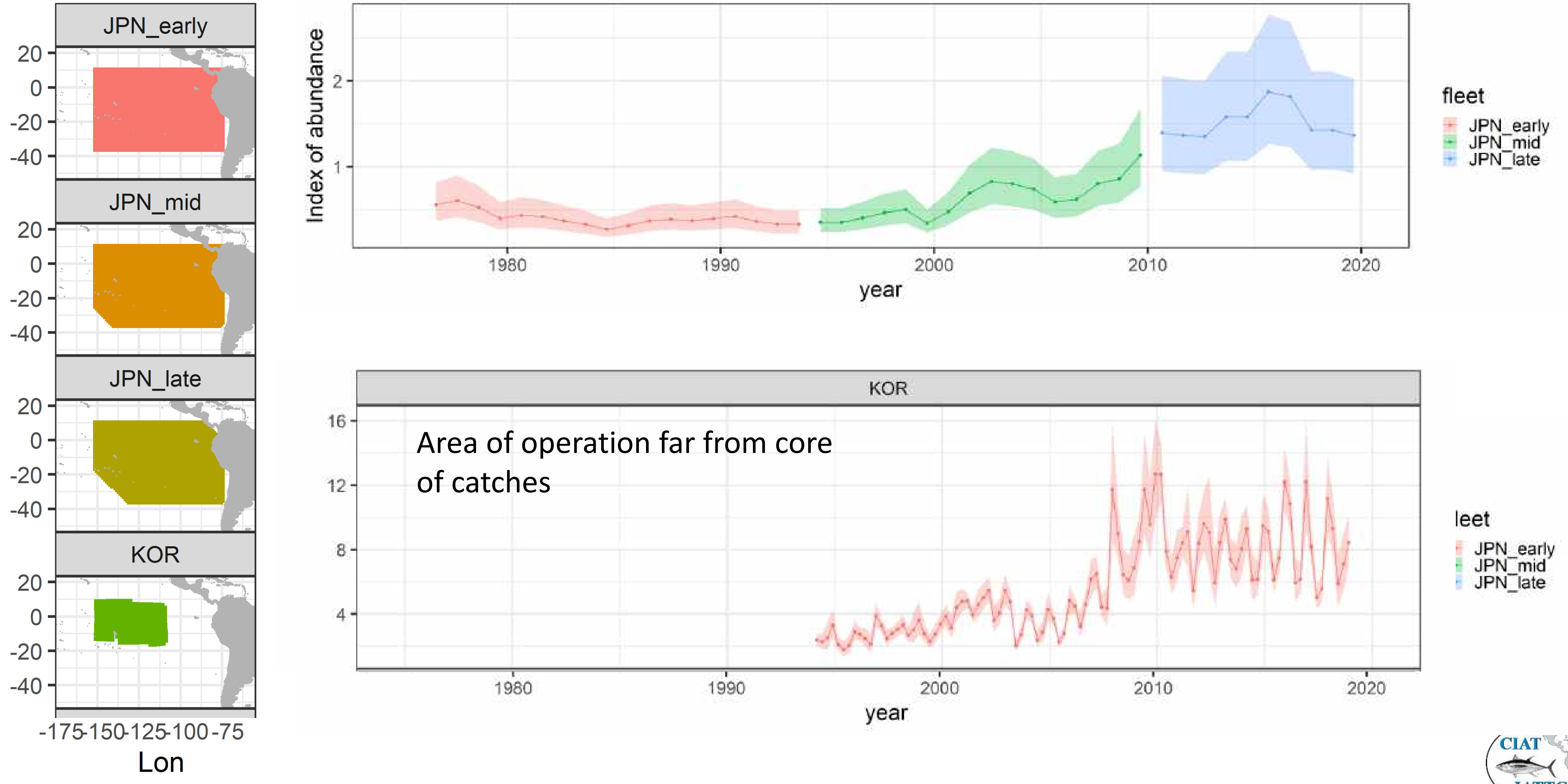
New indices:

- early
- late
- mid

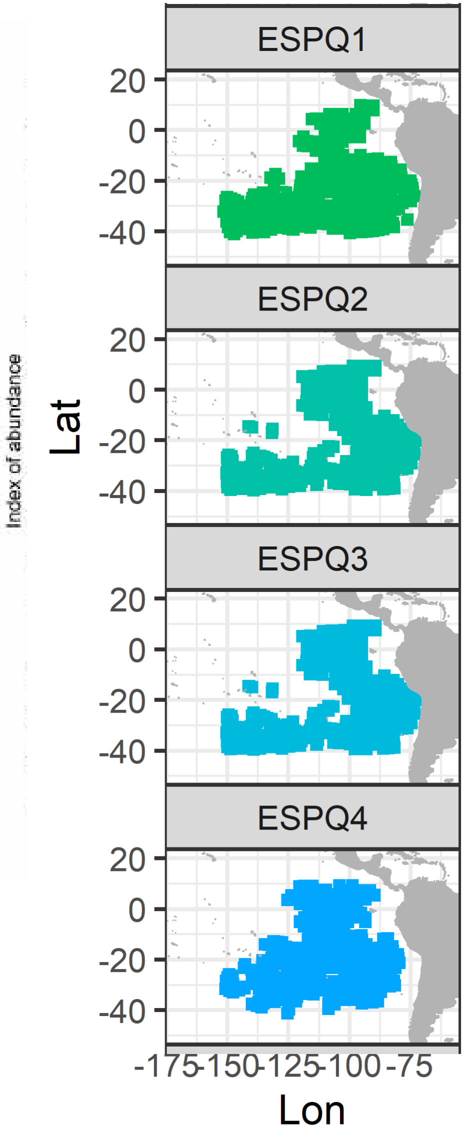
2011 indices:

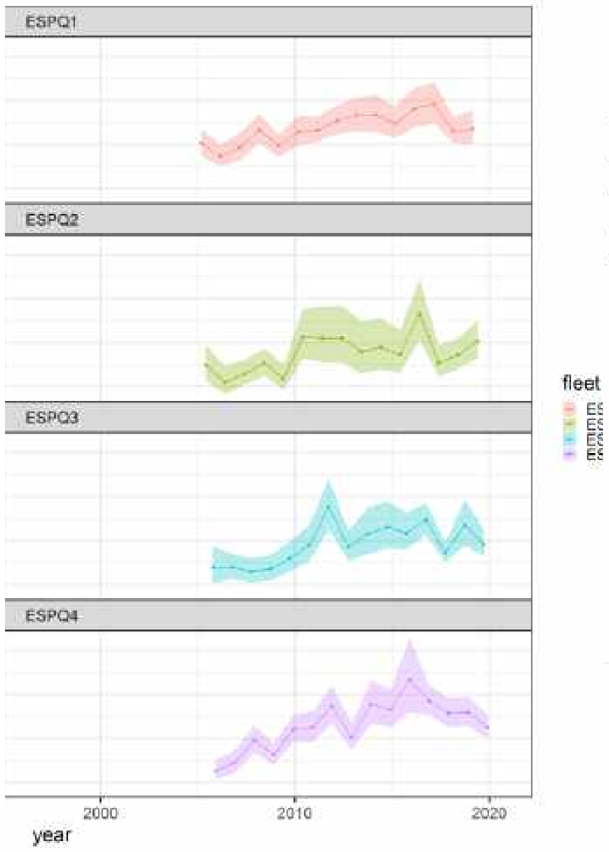
O

Indices of abundance

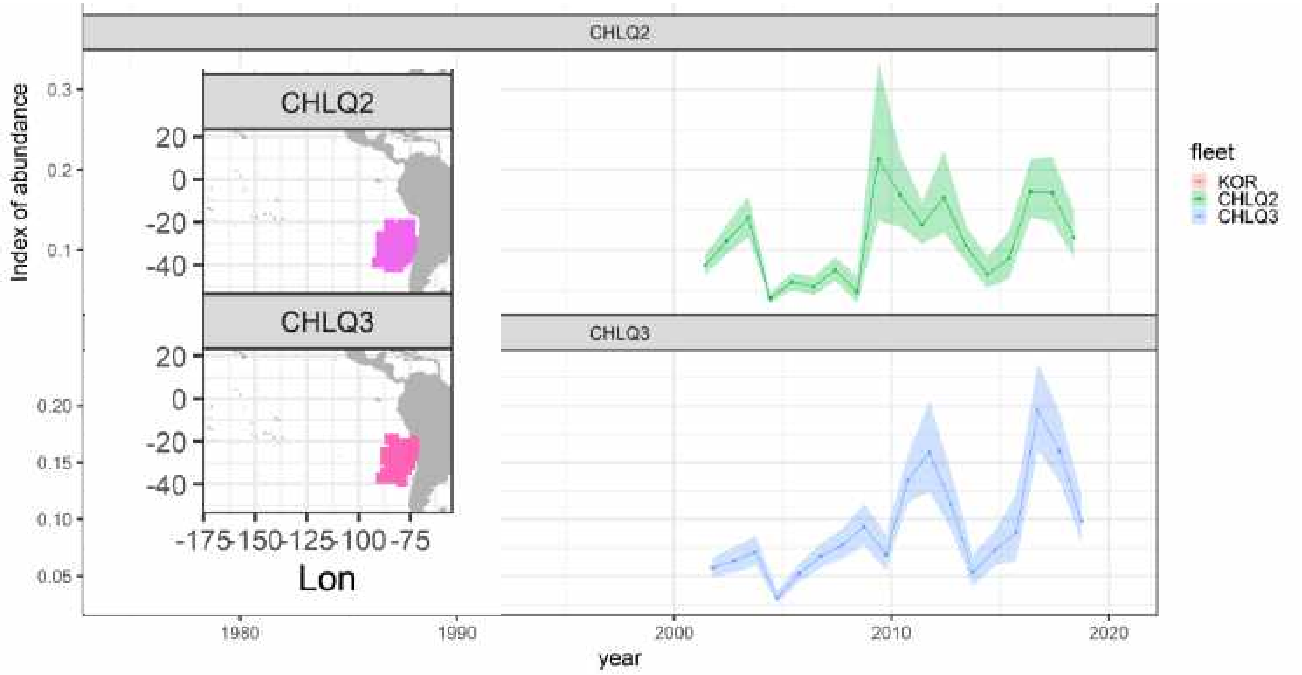


Indices of abundance



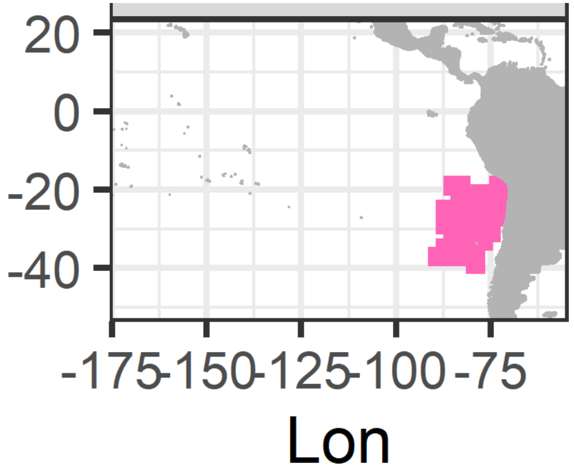


Only positive catches
(no sets with zero catches)

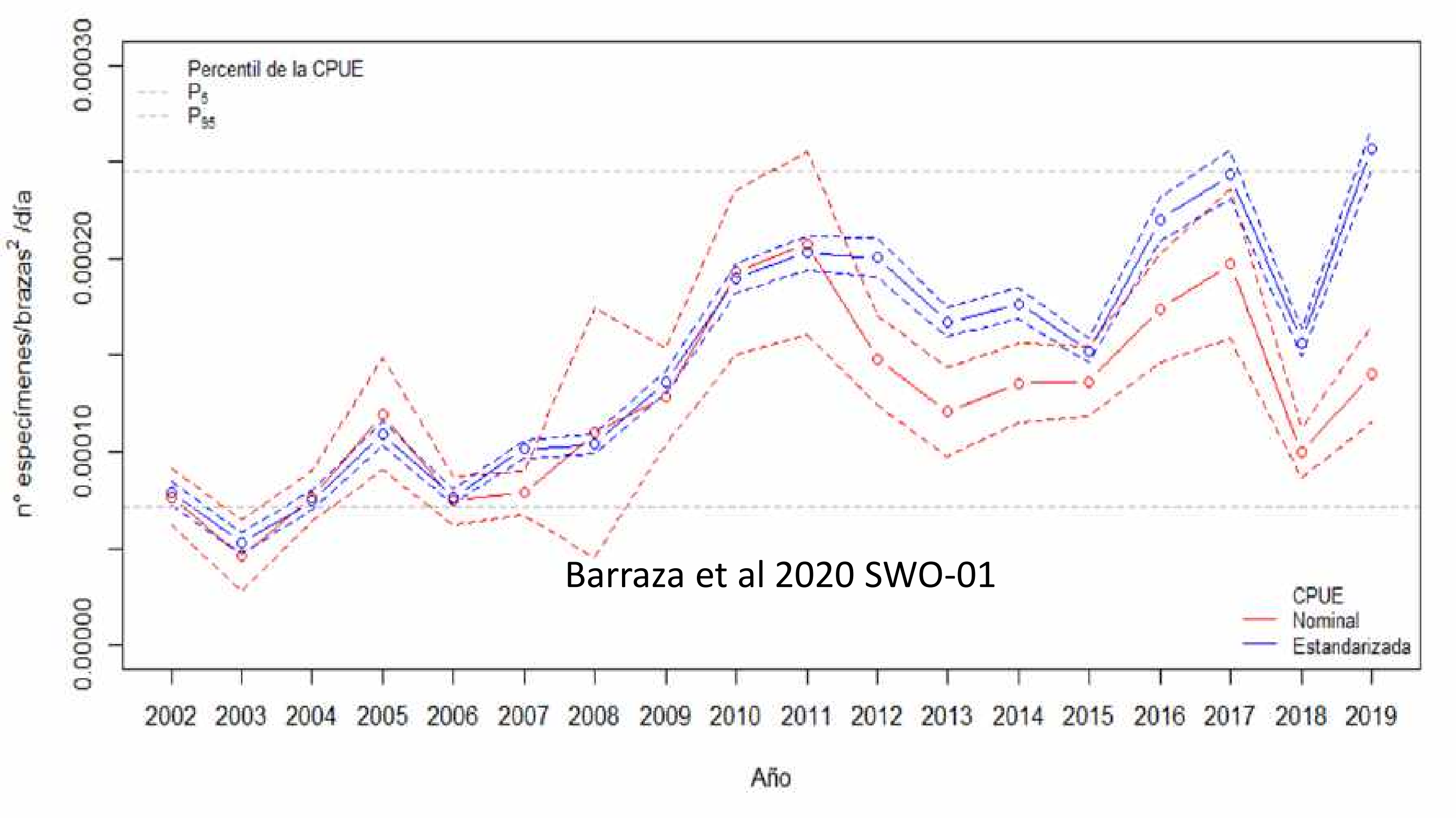


Restricted area

Indices of abundance



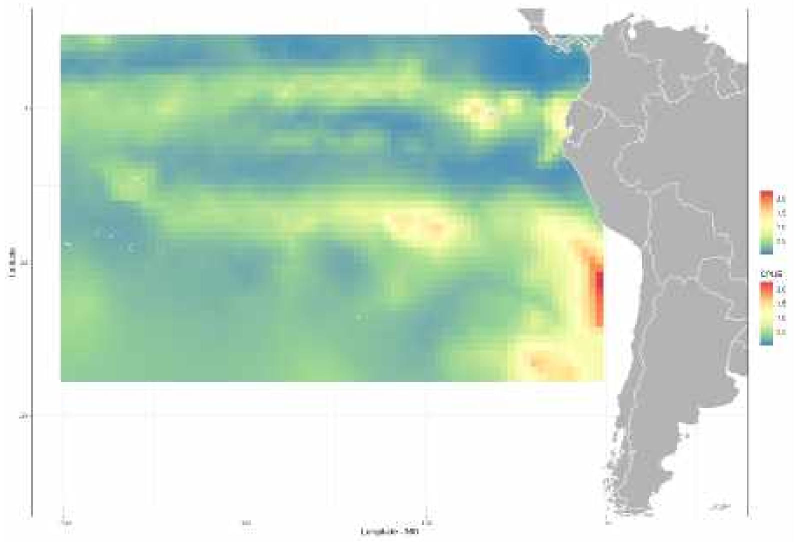
CHL Driftnet



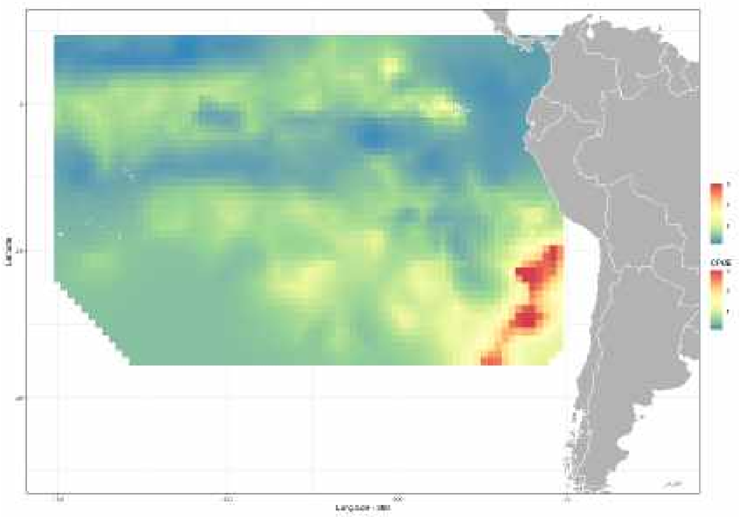
Indices of abundance: Japanese longline CPUE

Average density estimated from spatio-temporal model (SAC-13-INF-N)

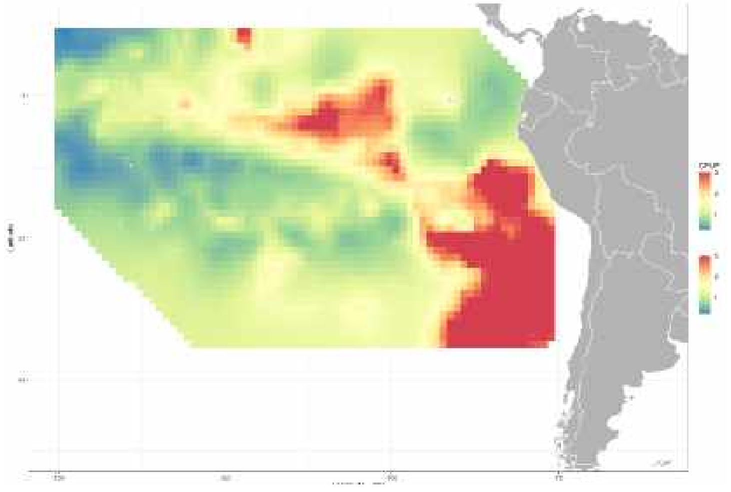
Early: 1975 to 1993



Mid: 1994 – 2009



Late: 2010 on

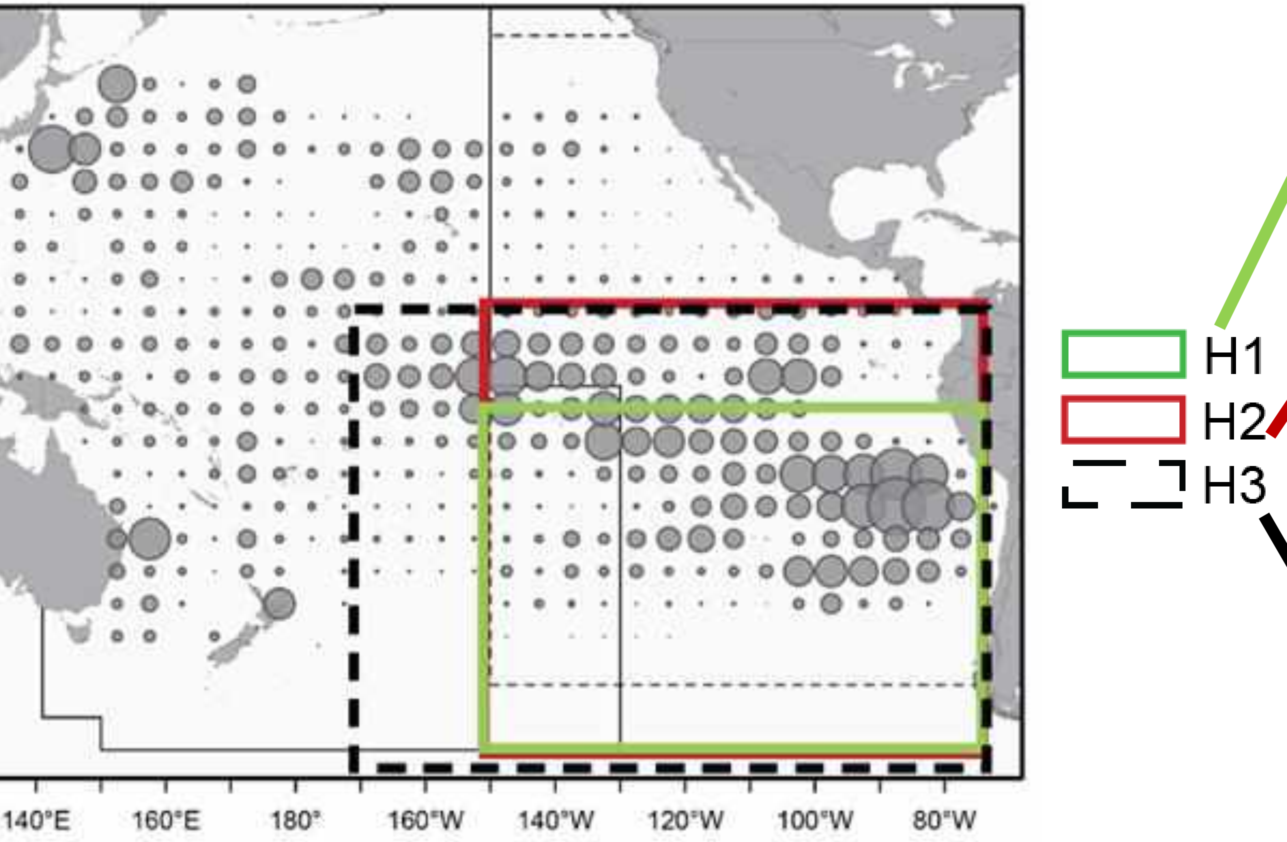


Increase in connectivity in areas of high density

Models: reflect the hypotheses about the stock

Stock structure hypotheses

2009 – 2018 Distribution of industrial longline catches



Model H1 – Updates the 2011 assessment

Hypotheses that explain Increase in catches and indices

Model 1 – Productivity: Abundance increase is real, there was increase in productivity

Model 2 – Availability: Abundance is not increasing, increase in index is due to change in catchability

Model 3 – Both: factors that increased abundance also contributed to increase in availability

Model 4 – Stock structure: the stock is in a larger area

Maps from Moore (2021)

Stock assessment models – main assumptions

- Model period 1945 – 2019, starts from virgin
- Annual model with 4 seasons
- Recruitment in seasons 1 and 2
- Beverton-Holt recruitment function (steepness h = 1, sensivity h=0.75)
- Natural mortality 0.4 $year^{-1}$
- Fisheries:
  - H1 – as 2011 assessment
  - Models 0 to 4: 21 fisheries defined by area, gear, fleet origin (coastal, Spain, other distant water fleets)
- Selectivities (logistic, double normal, splines)
- Fit to indices, age and length composition data
- Data reweighting using Francis approach

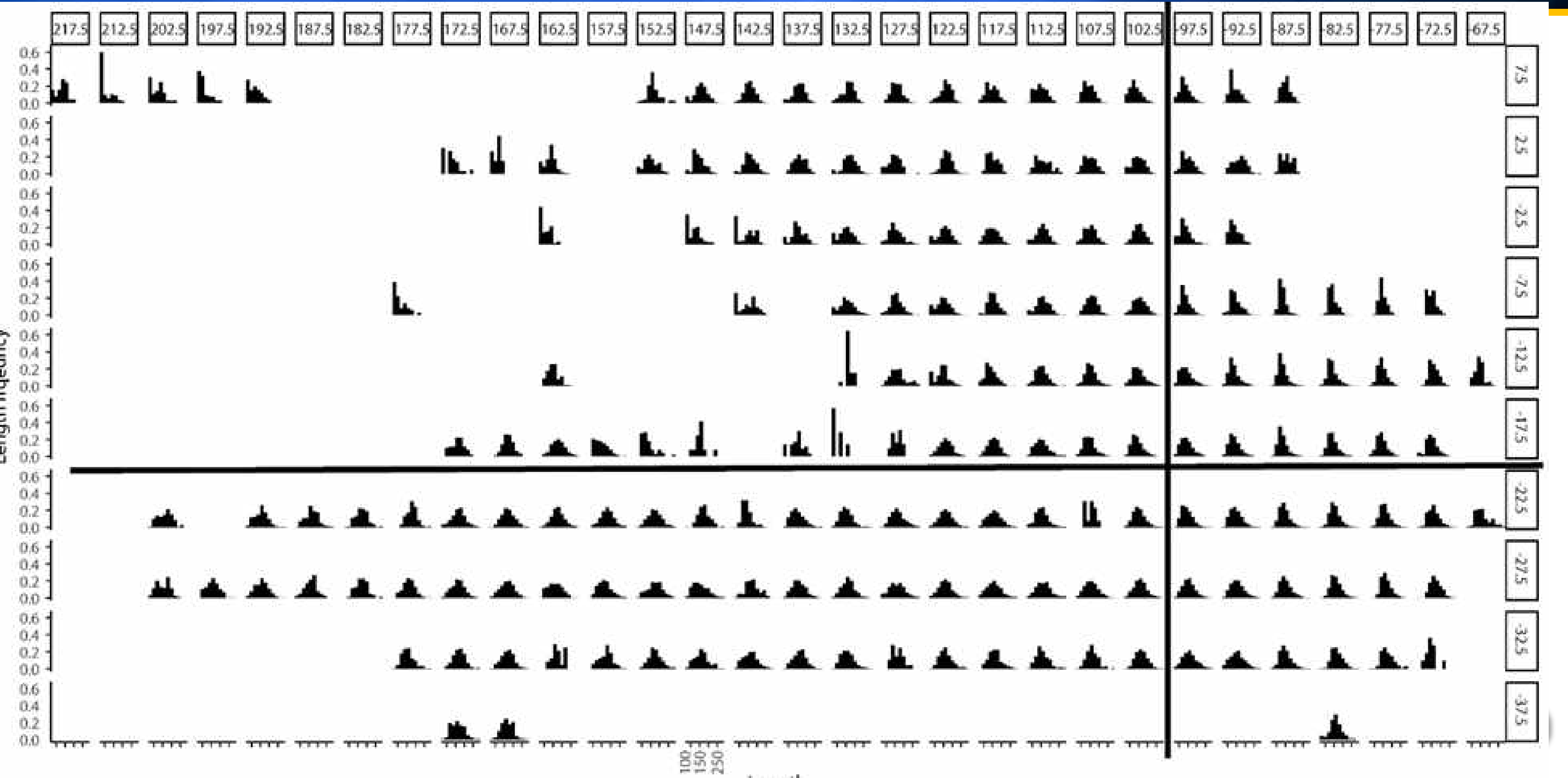
Model implementation

Hypothesis	Model	Fisheries	Catches	Indices	Recruitment
Updates 2011	H1	= 2011	EPO, south of 5°S	JPN	R0 + deviations
“base model” used to derive M1 to M4	M0	Tree analysis	EPO, south of 10°N	JPN, SPN, CHL	R0 + deviations
Productivity	M1	Tree analysis	EPO, south of 10°N	JPN, SPN, CHL	R0*trend + deviations
Availability	M2	Tree analysis	EPO, south of 10°N	none	R0 + deviations
Both	M3	Tree analysis	EPO, south of 10°N	JPN, SPN, CHL	R0*trend + deviations
Stock structure	M4	Tree analysis	East of 170W, South of 10°N	JPN, SPN, CHL	R0 + deviations

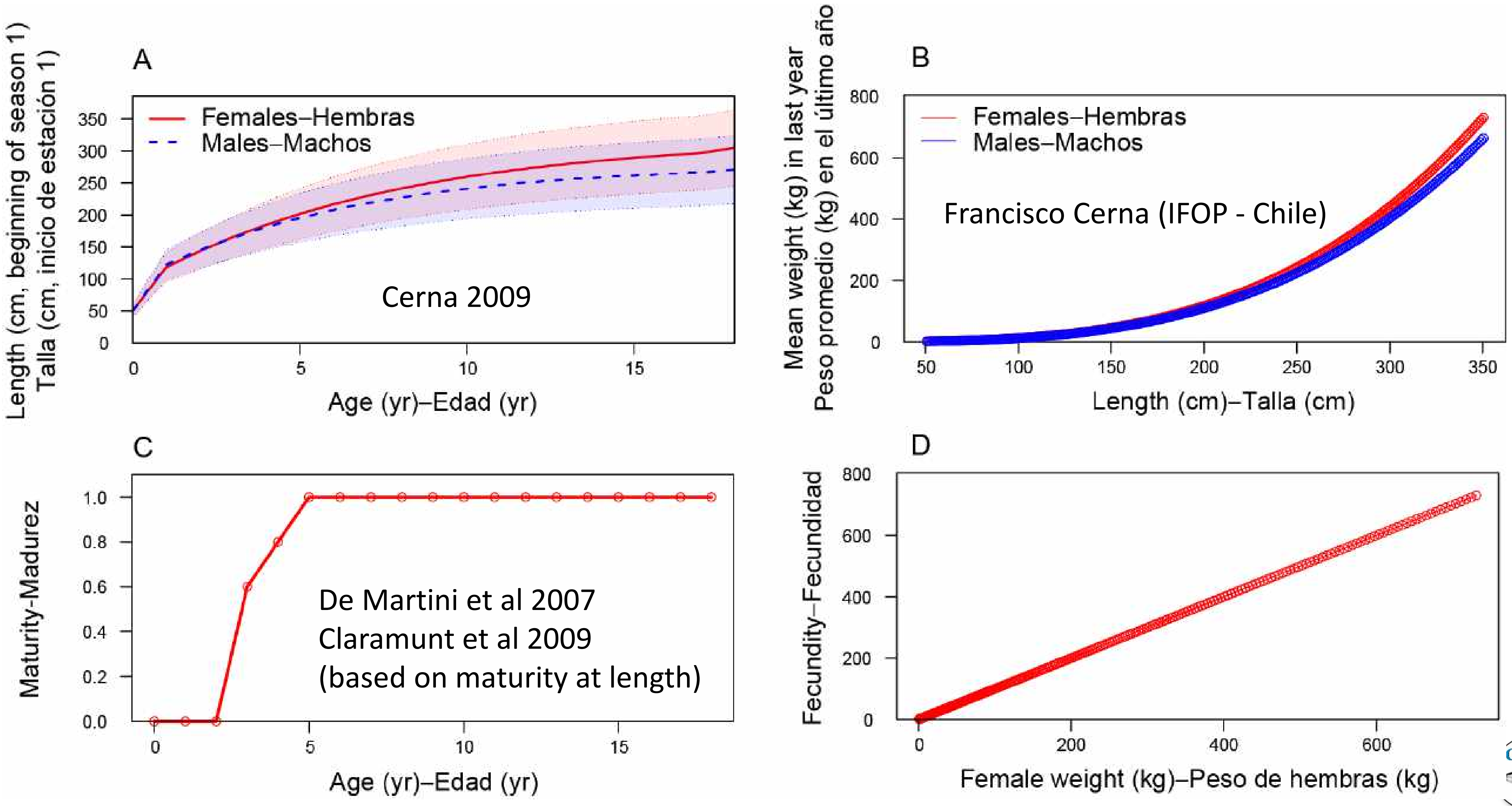
Fishery definitions: Tree analysis (Models 0 to 4)

- Analysis
  - Length-composition data from Japan, Spain, Chile, Ecuador
  - Regression tree methods
  - Latitude, longitude, quarter, and cyclic quarter
  - Compromise between explaining data and number of fisheries
- Results
  - **First split 100°W**
  - **Second split at 20°S, east and west of 100 °W**
  - 4 areas
  - 21 Fisheries defined by area, gear, fleet origin (coastal, Spain, other distant water fleets)

Tree analysis: results consistent with conceptual model



Biological assumptions – all models



Results

All model input files and output results for this assessment are available in html and pdf formats.

https://www.iattc.org/StockAssessments/2022/SWOWebsite/SWO_South_EPO_2022.htm

Benchmark assessment of swordfish in the South EPO 2022

SS3 plots, input and output files for the models that compose the stock assessment

Model	Stock structure hypothesis	Productivity/Availability hypothesis	Label in figures	Interpretation	Model description
H1	H1: The stock is distributed south of 5°S and east of 150°W	Updates the 2011 assessment model: shows an increasing trend in recruitment	H1	Increase in catches with increase in indices are explained by increase in recruitment deviations	This model makes similar assumptions than the 2011 assessment model (Hinton and Maunder 2011), with similar fishery definitions and indices
Model 0	H2: The stock is distributed south of 10°N and east of 150°W. This hypothesis is considered as the reference case	Initial Reference Model: shows an increasing trend in recruitment	M0	Increase in catches with increase in indices are explained by increase in recruitment deviations)	New fishery definitions based on tree analyses, new indices of abundance obtained using spatiotemporal models. This model is modified to produce Models 1 to 4
Model 1	H2	1.Real increase in abundance	M1_Productivity	There is an increasing trend in productivity due to increasing recruitment.	A regime shift in lnRo is estimated, as a trend starting in a fixed lower productivity value (lnRo for a model for 1945 to 1993)
Model 2	H2	2.Increased catchability (availability)	M2_Availability	Increasing indices may be due to a general increase in availability of the fish to all the gear. The indices do not represent the abundance of the population.	The catch curve model based on M0 is estimated: The model is fit only to mean weight, age, length, and generalized size-composition data. The change in availability to the indices is computed as the difference from the expected values for the indices and the observed indices
Model 3	H2	3.Increase both in abundance and availability	M3_Productivity and availability	Factors that increase availability may also increase abundance	A model like M0 is estimated, the changes in availability are obtained by estimating time-varying catchability parameters for all indices except
Model 4	H3: The stock is distributed south of 10°N and east of 170°W	4. Stock structure and connectivity	M4_Connectivity	Connectivity from the equatorial area and the southern EPO seems to have increased after 2010, perhaps connectivity between WCPO and EPO also increased.	Like M0 but include the catches in the CPO (areas 6 and 7 in Figure 2 stock structure hypothesis H3)

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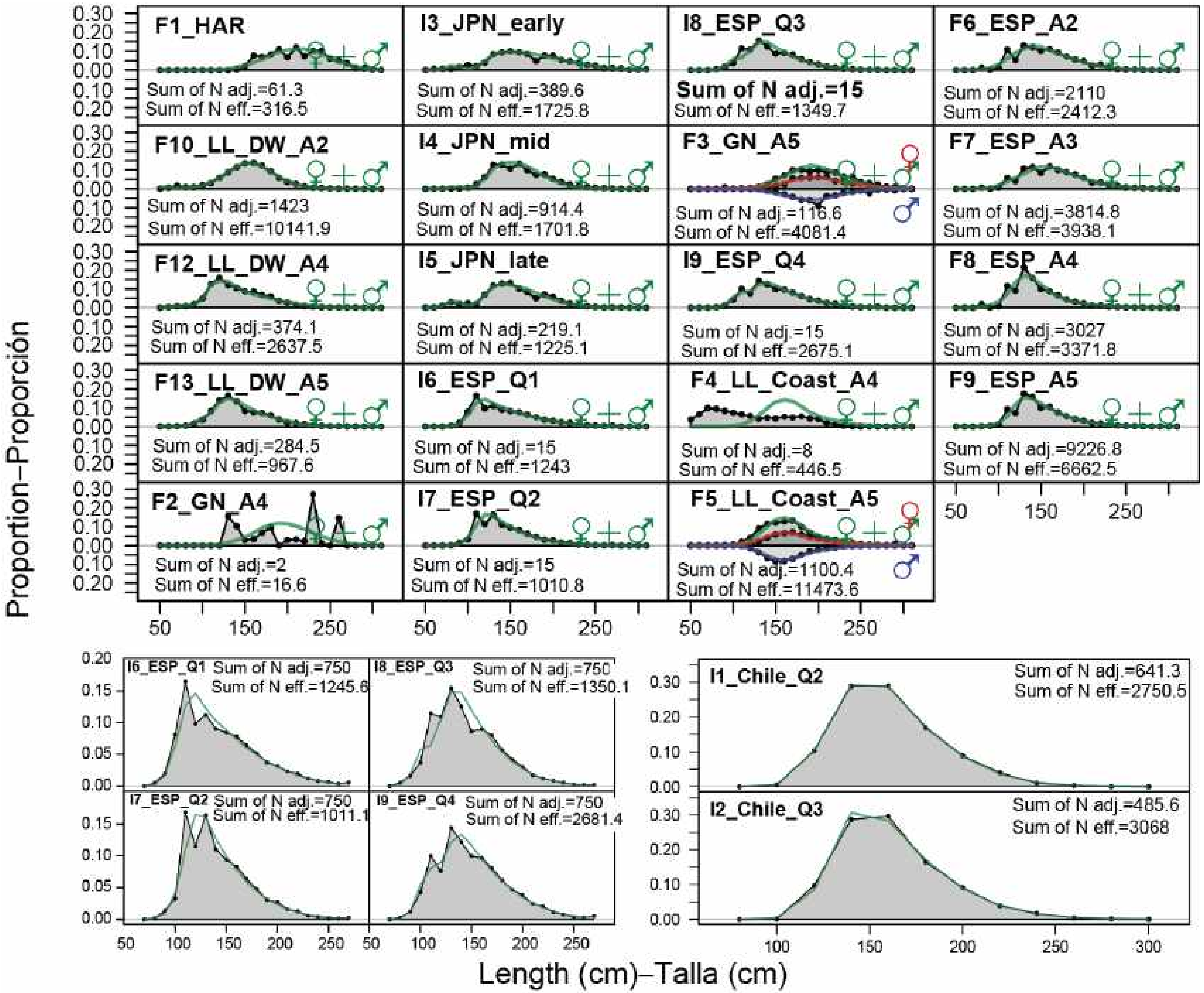
Fits to composition data

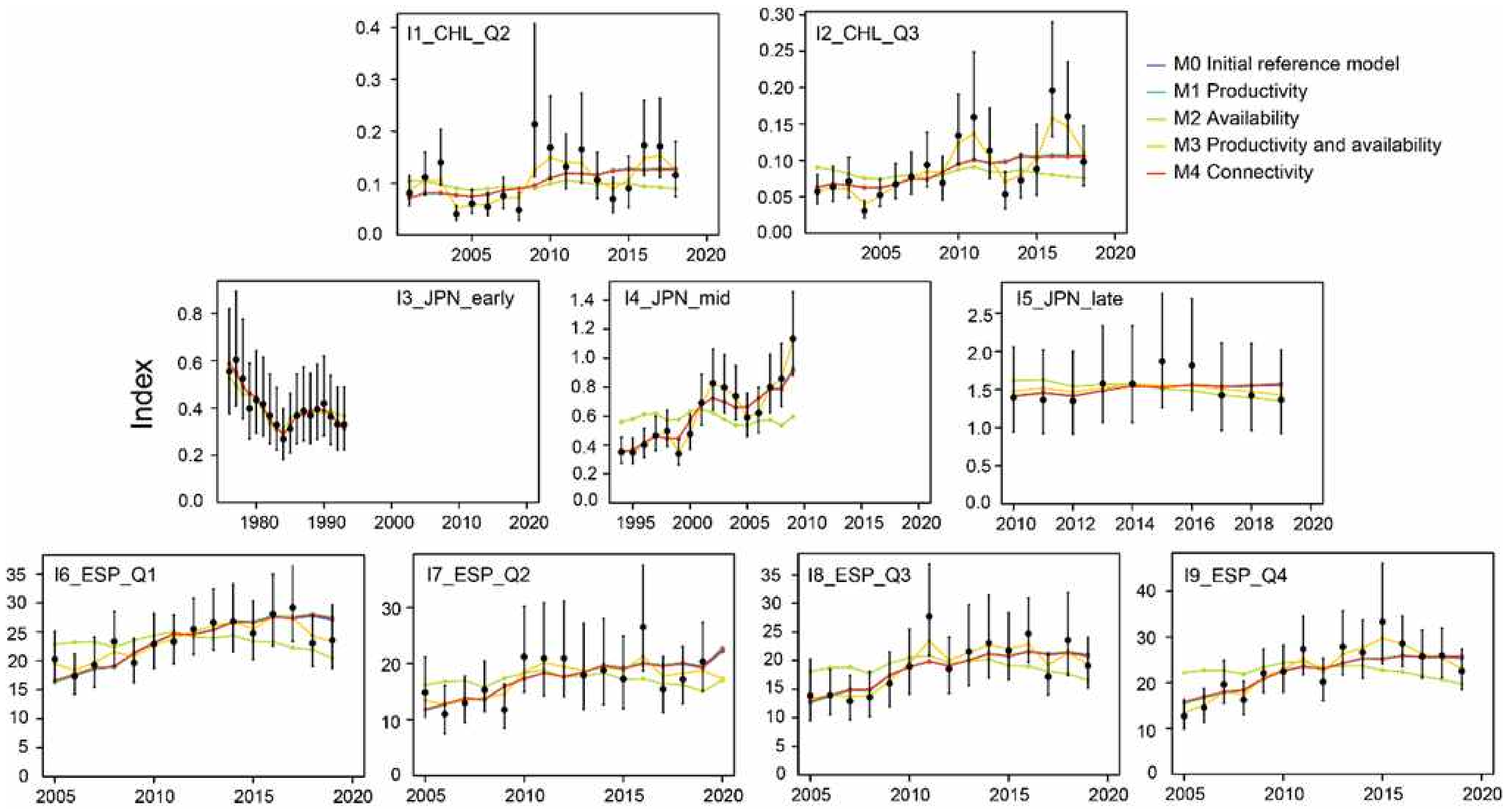


Model 0

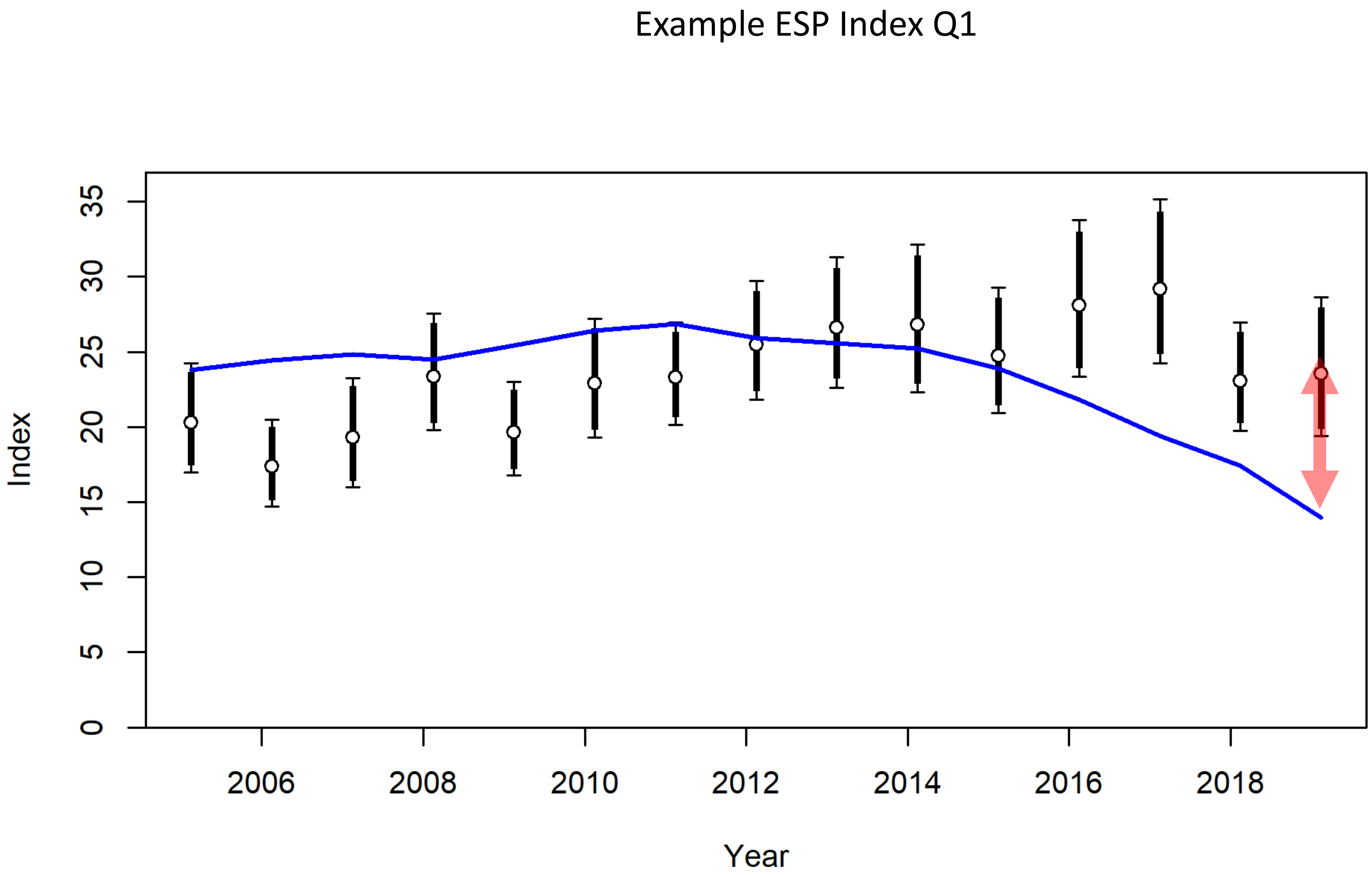
Fisheries

Indices of abundance

Fit to indices of abundance



Model 2 - Availability



Observed index

-

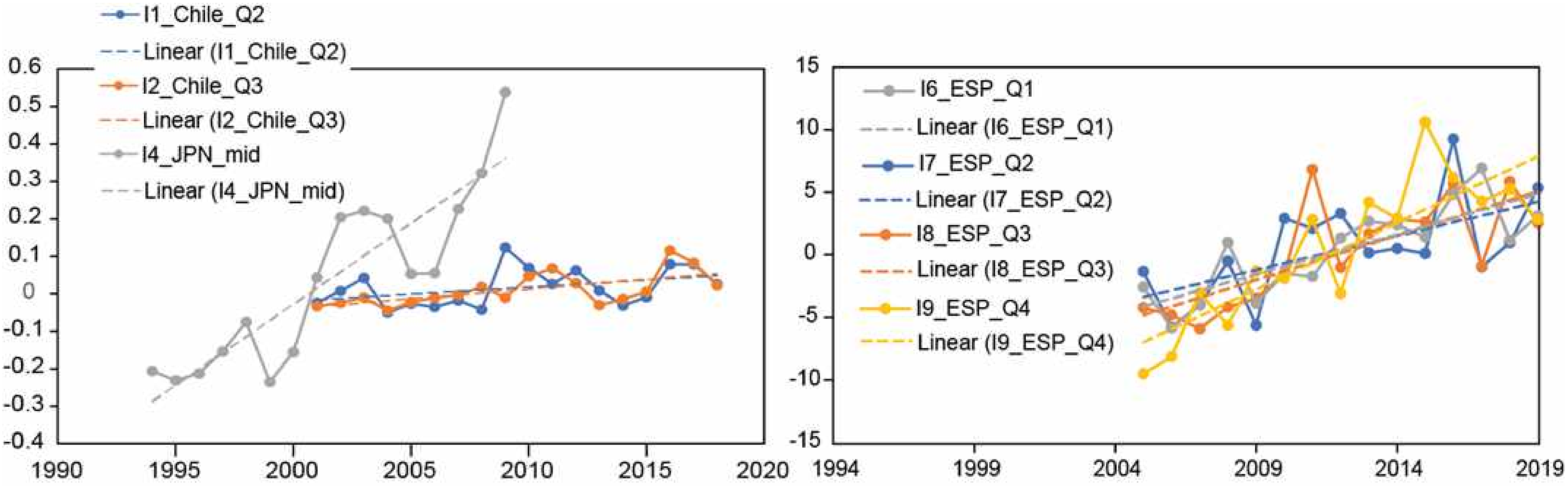
Expected value from model 2

=

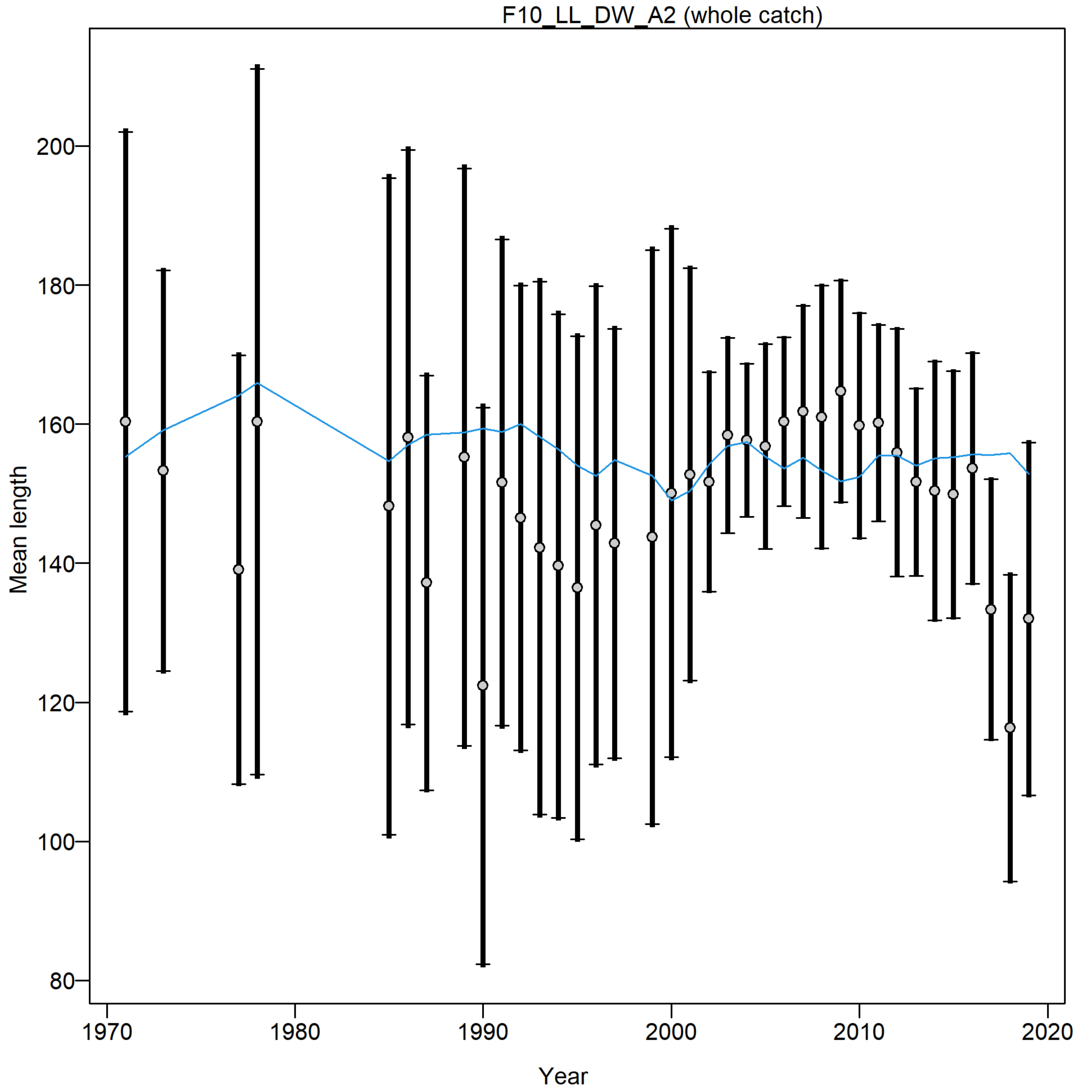
catchability

Trends in catchability (Model 2)

Catchability = expected index – observed index



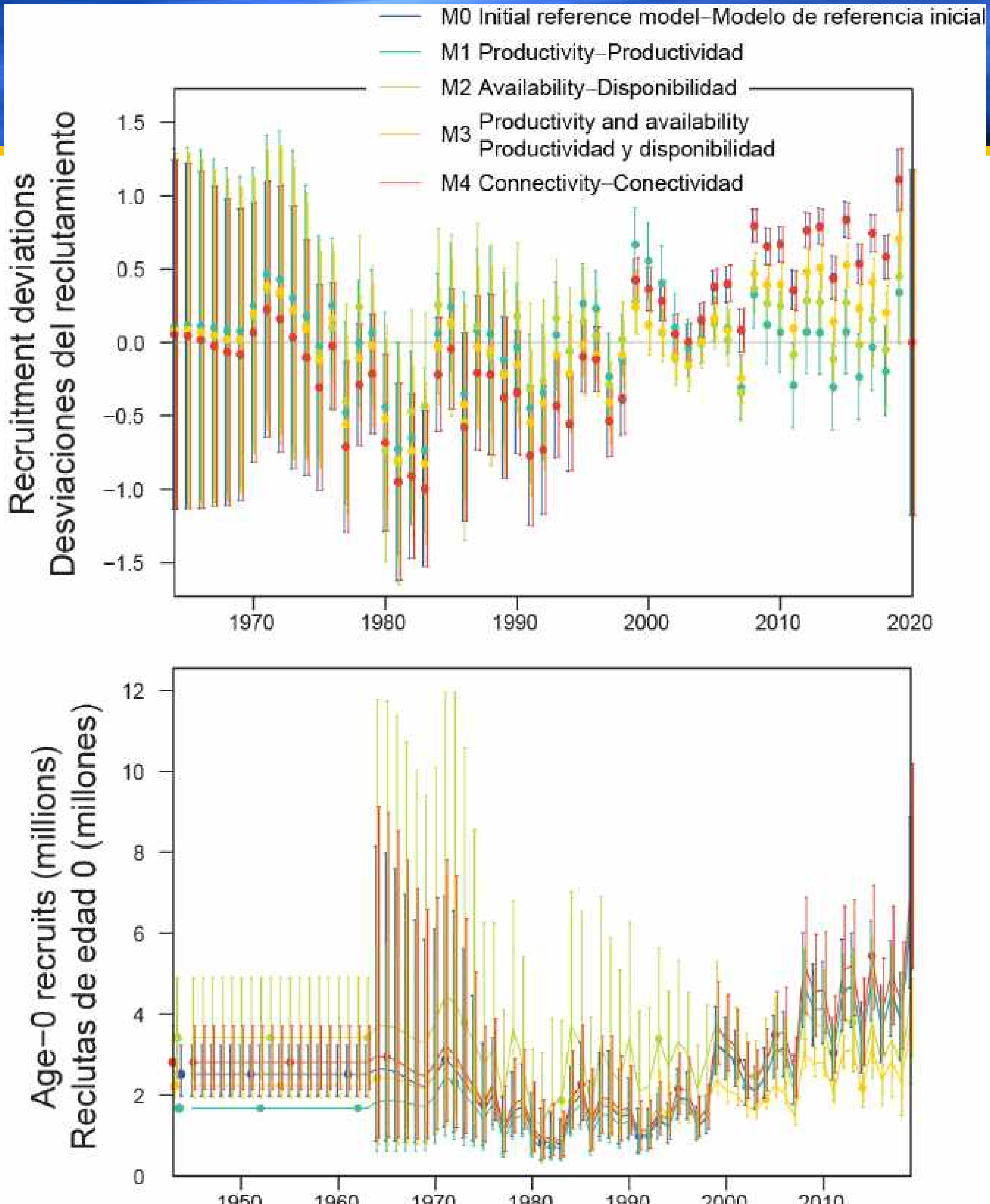
Fits to composition data



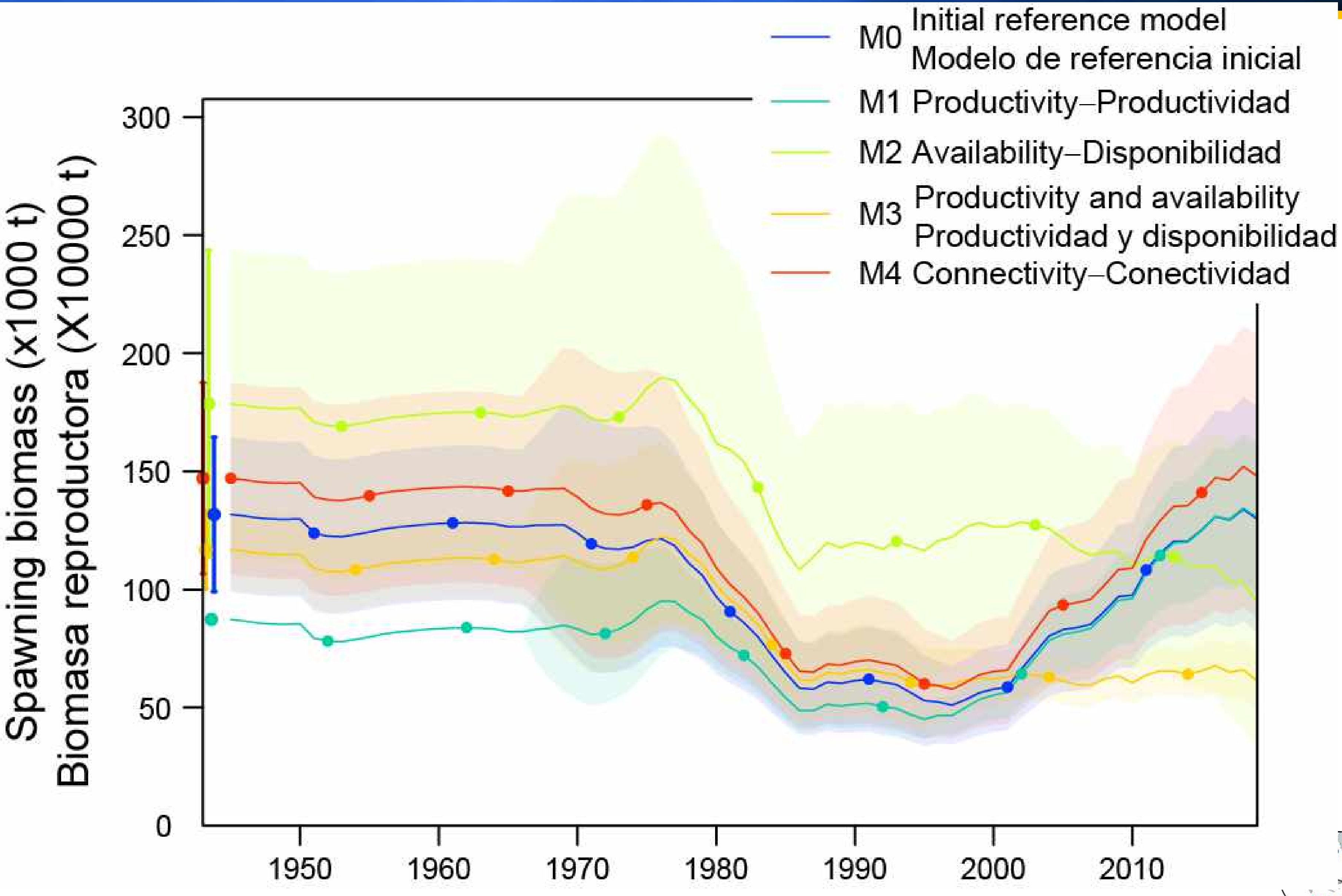
Model 1 – increase in abundance

Some size composition data is not consistent with this hypothesis

Results - recruitment



Results0 – spawning biomass



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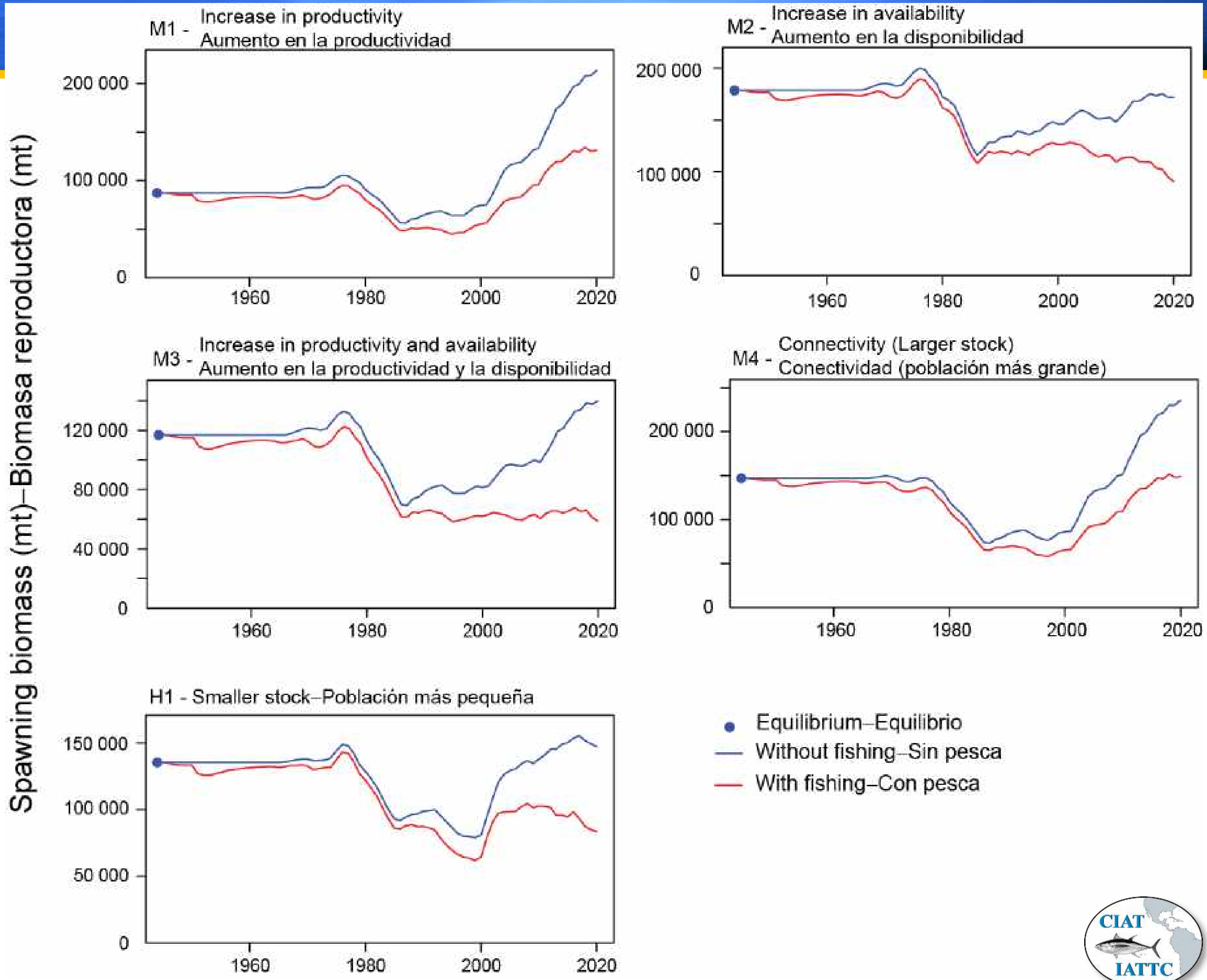
Fisheries impact



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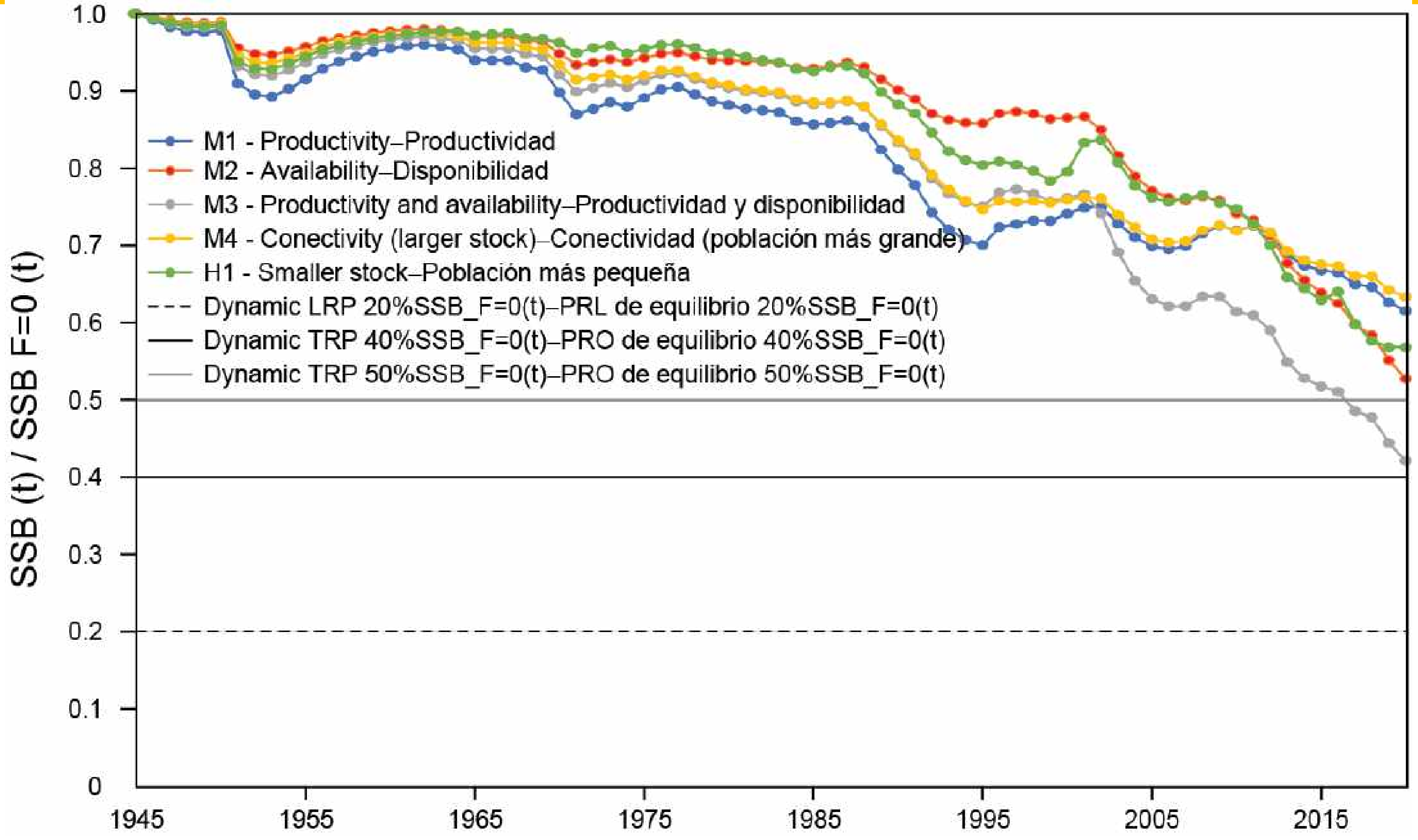
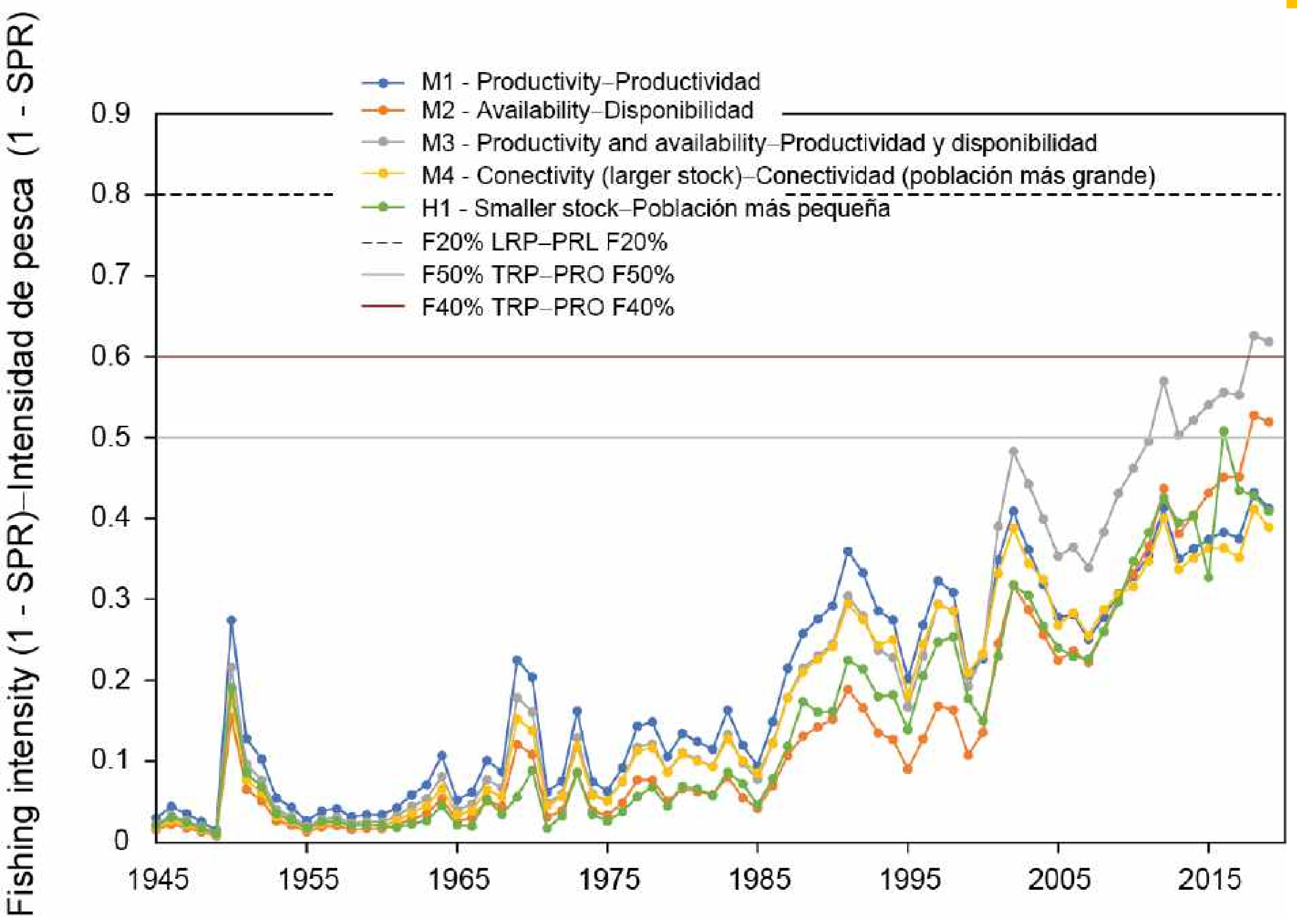
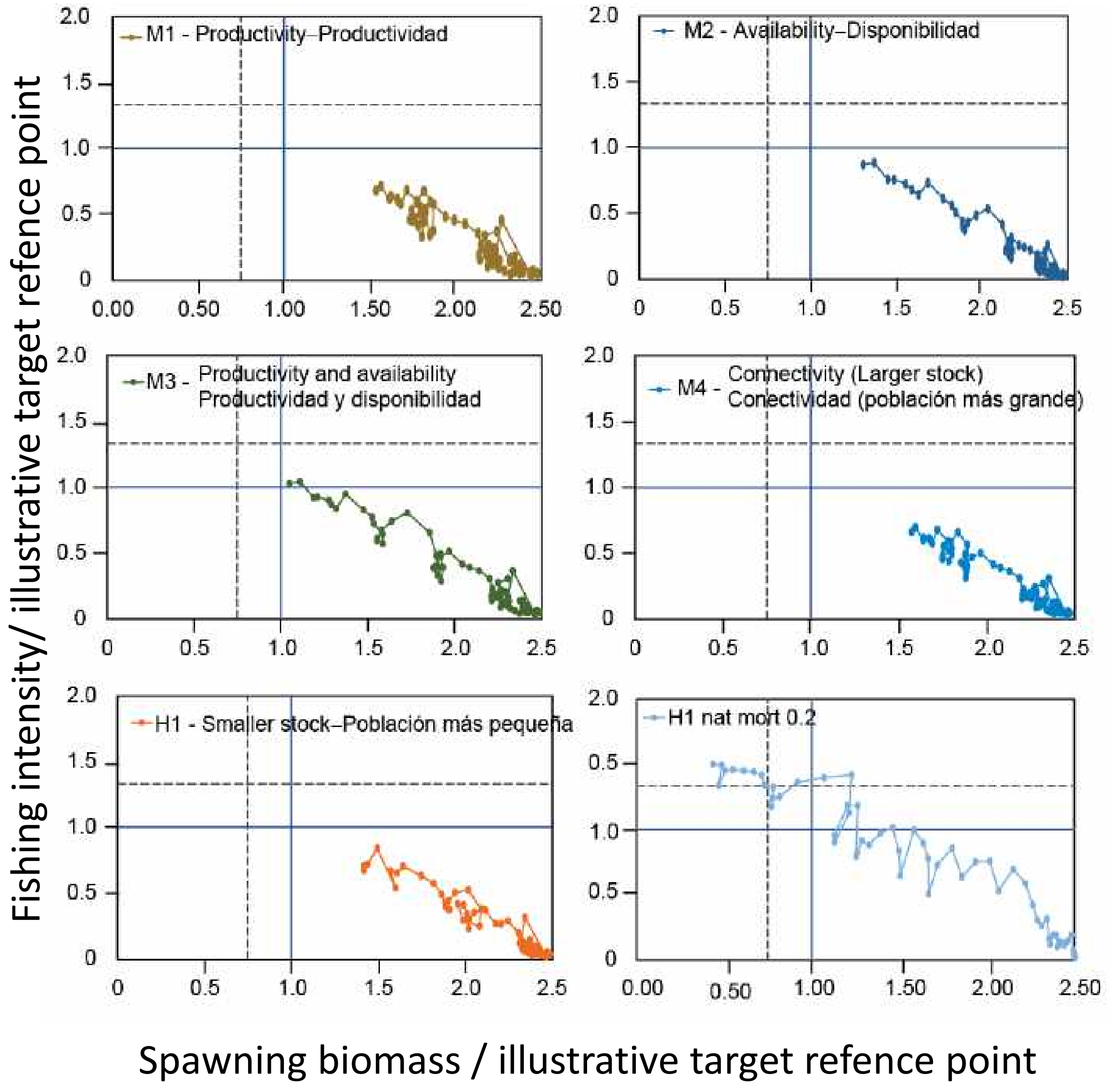
Results: depletion



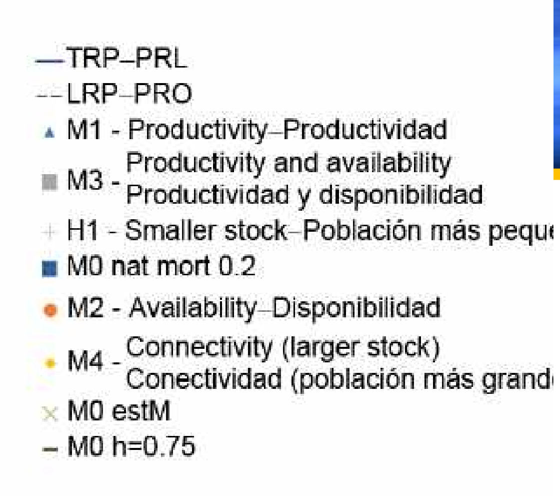
Results: fishing intensity



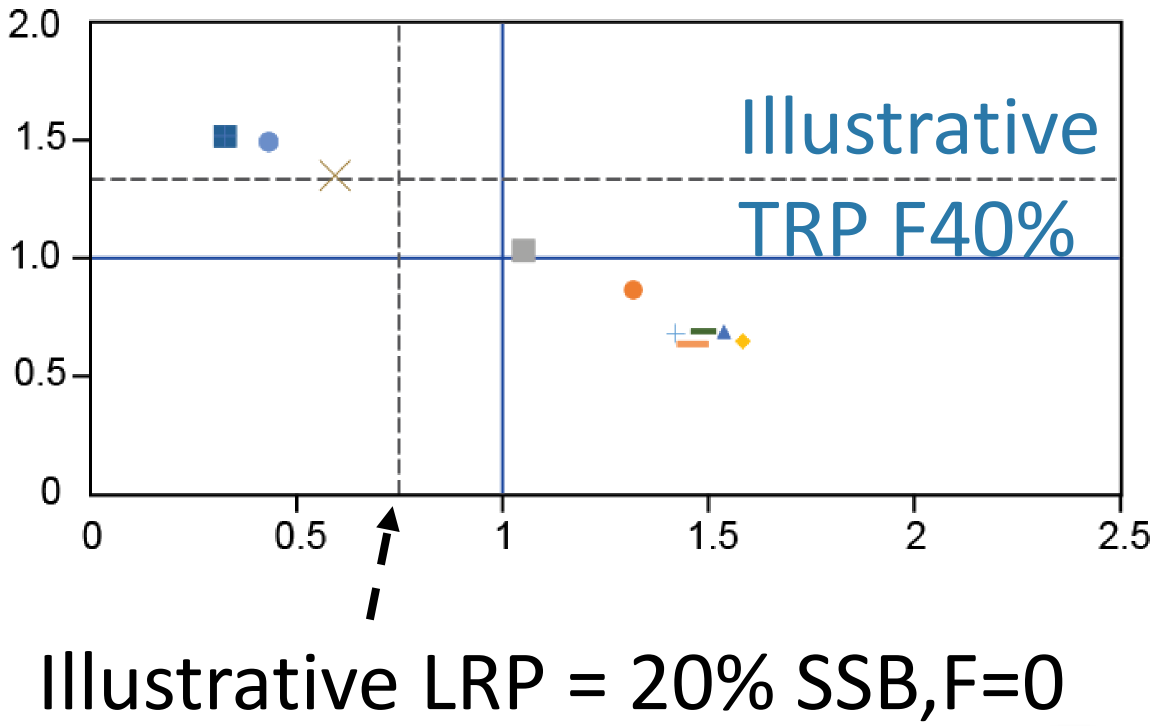
Phase plots



M1 - Productivity–Productividad
M2 - Availability–Disponibilidad
M3 - Productivity and availability
Productividad y disponibilidad
M4 - Connectivity (Larger stock)
Conectividad (población más grande)
H1 - Smaller stock–Población más pequeña
H1 nat mort 0.2
Fishing intensity/ illustrative target refence point
Spawning biomass / illustrative target refence point



TRP–PRL
LRP–PRO
M1 - Productivity–Productividad
M3 - Productivity and availability
Productividad y disponibilidad
H1 - Smaller stock–Población más peque
M0 nat mort 0.2
M2 - Availability–Disponibilidad
M4 - Connectivity (larger stock)
Conectividad (población más grand
M0 estM
M0 h=0.75



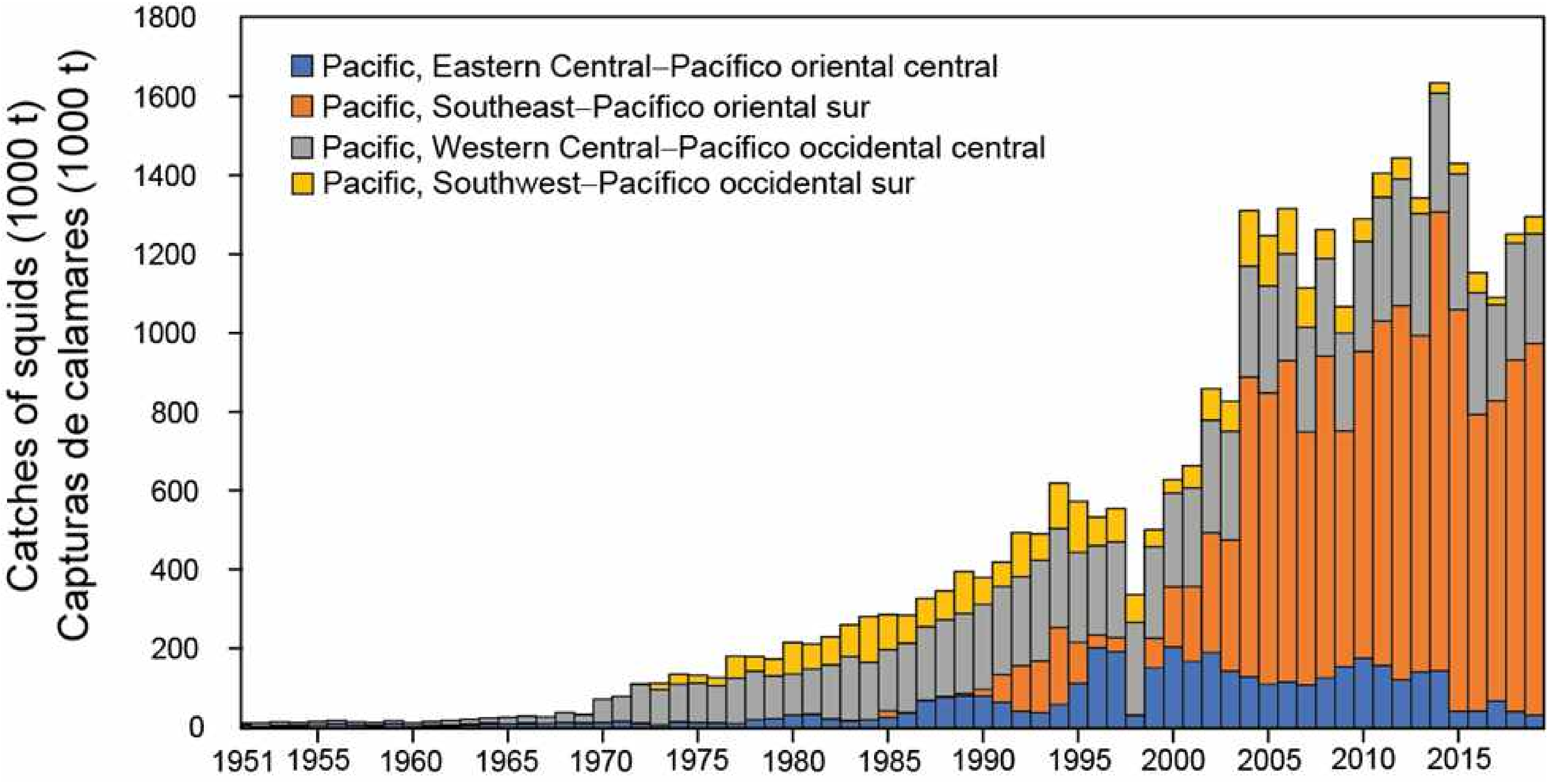
Illustrative
TRP F40%
Illustrative LRP = 20% SSB,F=0

Discussion

The increases in recruitment and subsequent increase in biomass estimated by the integrated model maybe due to:

- Real increase in abundance
  - Increase in prey

Discussion: support for increase in abundance - increase in preys



Discussion

The increases in recruitment and subsequent increase in biomass estimated by the integrated model maybe due to:

- Real increase in abundance
  - Increase in prey
- Increase in availability
  - Indices derived from different fleets and gear show increase in density: environment (warm-core eddies and frontal zones)? Fishing technology (e.g. oceanographic analysis)?
- Increase both in abundance and availability
- Stock structure and connectivity
  - Connectivity from the equatorial area and the south sub tropical EPO seems to have increased after 2010, perhaps movement from WCPO to the EPO
  - Indices derived from fleet in the WCPO show increase in density at similar times that the indices in the EPO

Conclusion

- The pattern of increase in indices of abundance an increase in catches dominated the assessment
- The increase in productivity hypothesis is not supported by some of the composition data, but it cannot be discarded.
- This can be the result of model misspecification which, if addressed and once resolved, may reconcile the data components.
- Regardless of the high uncertainty, all the models estimated that the stock did not breach the illustrative biomass and fishing limit reference points but may be approaching the target reference points.
- The stock should be closely monitored

Future work, research recommendations and data submission

Catch: report data by gear, quarter, with indication of the area of origin and in the original unit they were recorded (weight , numbers , or both)

Composition data: Add information on sample size and spatial distribution of samples. Obtain size and sex information. The only sex-specific data available for this assessment were the data for the Chilean fleet.

Indices of abundance: Include catchability variables (e.g., light stick, use oceanographic interpretation services) and changes in target

Spatiotemporal models: include the western and central Pacific Ocean

Future work, research recommendations and data submission

Stock structure: implement a well-designed collaborative electronic tagging study associated with tissue sampling for genomic analysis , which should tag fish between longitudes 150°W to 130°W, both in the equatorial areas and in the temperate areas around 35°S to 40°

hypotheses could be modelled more adequately.

Habitat and preys: identify favorable oceanographic conditions for high swordfish abundance and CPUE (e.g warm-core eddies) and track changes of those conditions over time should be done to evaluate if the hypothesis of increase in availability is plausible.

Modelling: Multispecies models to investigate predator-prey dynamic maybe useful

Name	Affiliation
Aalbers, Scott	Pier
Aguila, Roselyn	Texas A&M University at Galveston
Alcivar, John	Pacific Marines Services SERMAPAC
Alegre, Ana	IMARPE
Alvarado-Bremer, Jaime	Texas A&M University at Galveston
Ambrosio, Lui	Tunacons
Barraza-Saez, Alana	Instituto de Fomento Pesquero
Barría, Patricio	Instituto de Fomento Pesquero
Bellquist, Lyall	The Nature Conservancy
Bravo, Karla	Subsecretaría de Recursos Pesqueros
Bustos Molina, Lezlie C.	Subsecretaria de Pesca y Acuicultura
Cari, Ilia	Instituto de Fomento Pesquero
Cerna, José	Instituto de Fomento Pesquero
Clavijo, Ljubitza	Instituto de Fomento Pesquero
Costain, Jorge	Transmarina
Delgado, Jorge	Subsecretaría de Recursos Pesqueros
Delgado, Luciano	Subsecretaría de Recursos Pesqueros
Devia, Daniel	Instituto de Fomento Pesquero
Ducharme-Barth, Nicholas	South Pacific Community
Espíndola, Fernando	Instituto de Fomento Pesquero
Evans, Karen	CSIRO
Farley, Jessica	CSIRO
Flores, Gabriela	Subsecretaría de Recursos Pesqueros
González, Andres	Instituto de Fomento Pesquero
González, Fidelina	Universidad de Concepción
Hamer, Paul	South Pacific Community
Howe, Ernie	Ministry of Finance
Ijima, Hirotaka	Japan Fisheries Research and Education Agency
Jackson, Alexis	The Nature Conservancy
Lazo, Jorge	Universidad Católica
Lee, Huihua	NOAA/National Marine Fisheries Service
Lu, Ching-Ping	National Taiwan Ocean University
Moore, Brad	National Institute of Water and Atmospheric Research (NIWA) Ltd
Mora, Sergio	Instituto de Fomento Pesquero
Morán, Guillermo	Empresa Privada
Ortega, Juan	Instituto de Fomento Pesquero
Pincay, Jonathan	Subsecretaria de Recursos Pesqueros

Piner, Kevin	NOAA/National Marine Fisheries Service
Pinkard, Delice	Ministry of Finance
Ponce, Francisco	Consultor Privado
Rivadeneira, Yuli	Subsecretaría de Recursos Pesqueros
Runcie, Rosa	Southwestern College
Santiago, Josu	Azti
Sarricolea, Lucia	Secretaría General de Pesca
Sculley, Michelle	NOAA/National Marine Fisheries Service
Sepulveda, Chugey	Pfleger Institute of Environmental Research
Teo, Steve	NOAA/National Marine Fisheries Service
Tigrero, Walter	Ministerio de Economía y Finanzas
Uozumi, Yuji	Japan Tuna Fisheries Co-operative Association
Urzúa, Ángel	Universidad Católica
Wang, Sheng-Ping	National Taiwan Ocean University
Zarate, Patricia	Instituto de Fo
Minte-Vera, Carolina	IATTC
Aguilar, Marisol	IATTC
Aires da Silva, Alex	IATTC
Cullingford, Barbara	IATTC
Fuller, Daniel	IATTC
Galvan, Monica	IATTC
Griffiths, Shane	IATTC
Hall, Martin	IATTC
Hinton, Michael	IATTC
Kang, Geoyoung	IATTC
Lennert, Cleridy	IATTC
Lopez, Jon	IATTC
Maunder, Mark	IATTC
Morgan, Jeff	IATTC
Parraga, Jorge	IATTC
Pulvenis, Jean-Francois	IATTC
Romero, Andres	IATTC
Ureña,Enrique	IATTC
Valero, Juan	IATTC
Xu, Haikun	IATTC
Zuñiga, Alejandro	IATTC

It takes a planet!
Thank you!

Instituto de Fomento Pesquero, Subsecretaria de Recursos Pesqueros – Chile
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Questions