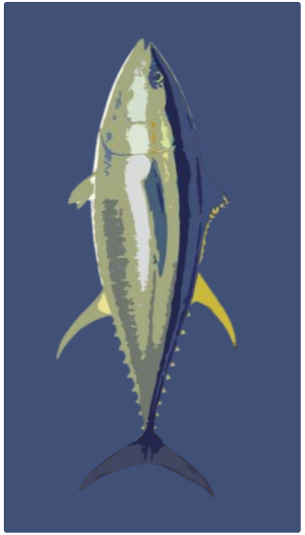
12/12/2022



Yellowfin tuna

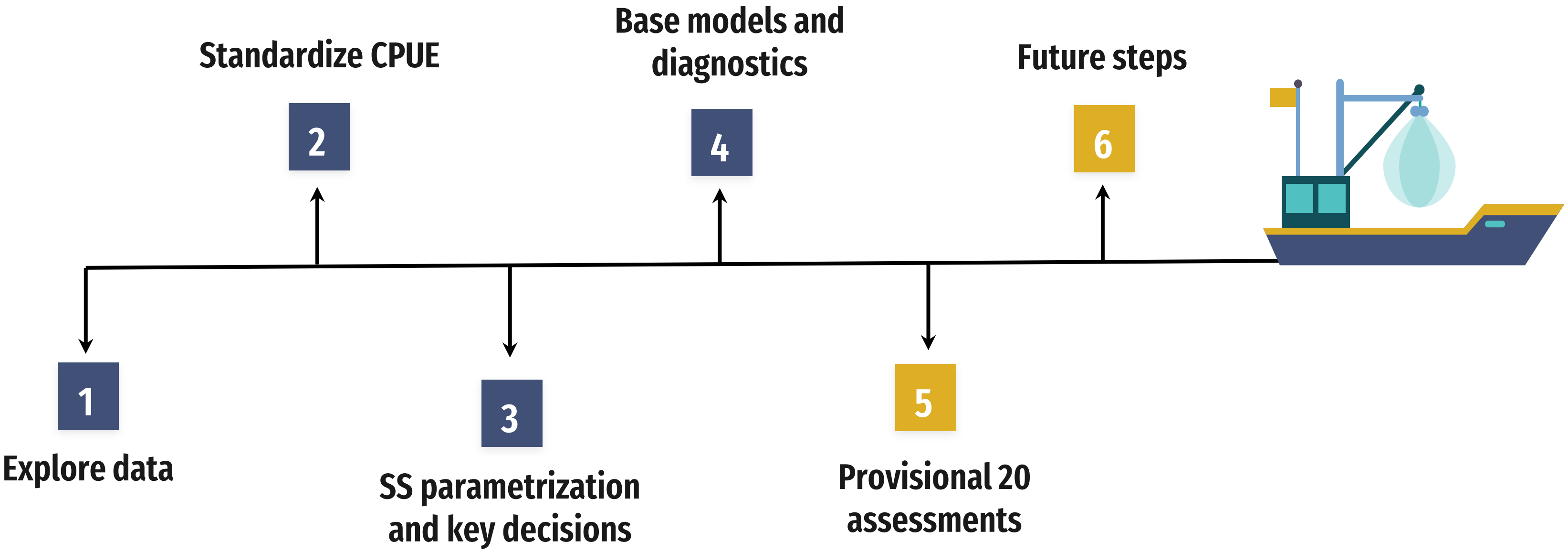
Spatial assessment modelling workshop

Stock Synthesis (SS)

Francisco Izquierdo, Marta Cousido, Giancarlo M. Correa, Maria Grazia Pennino, Santiago Cerviño

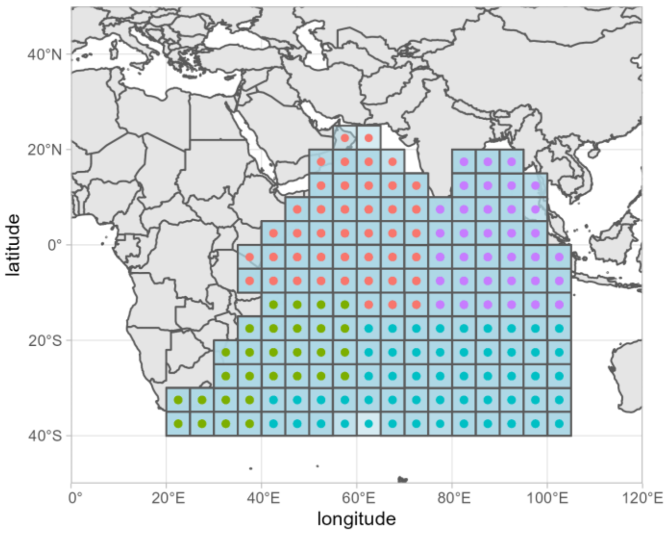
GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN
CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS
INSTITUTO ESPAÑOL DE OCEANOGRAFÍA 1914

IEO Team modeling approach



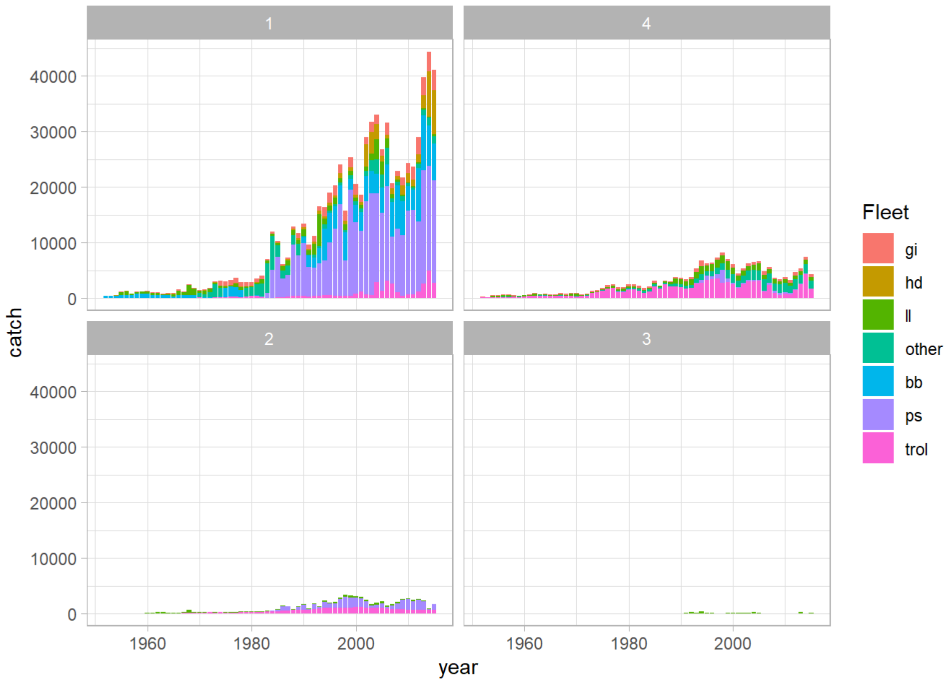
1. Explore data

4 areas



1 and 4 spatial areas

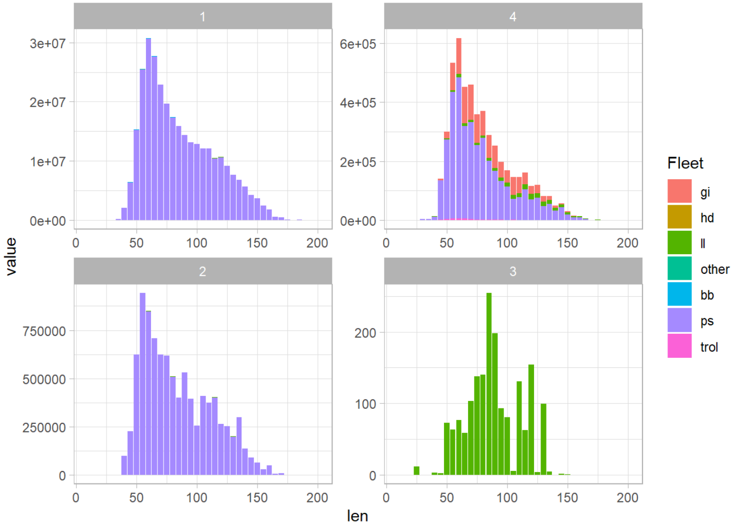
Catch by fleet



Catch by area: 1>4>2>3
Catch by fleet: ps>trol>bb>other>ll>gi>hd

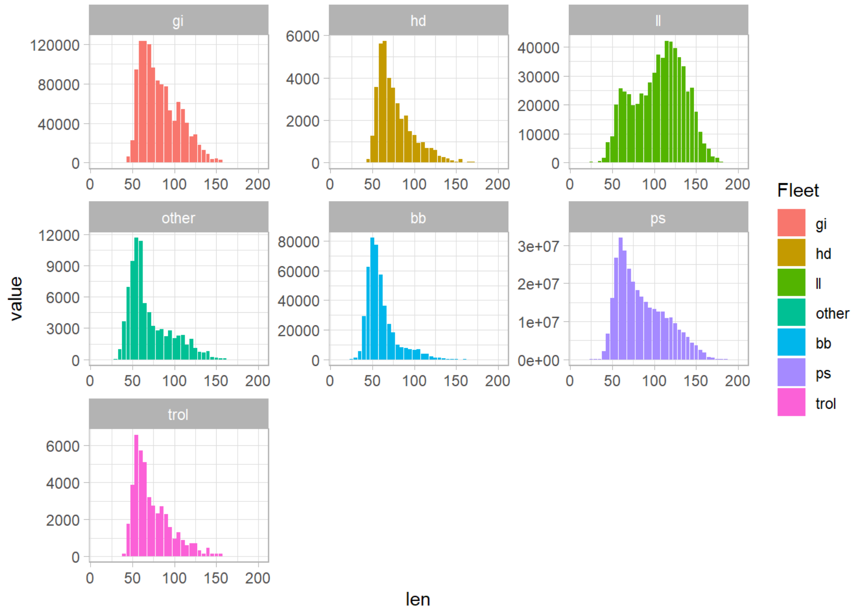
1. Explore data

LFD's by area (no scaled)



LFD by area: 1>4>2>3
LFD by fleet: ps>gi>ll>bb>trol>hd>other

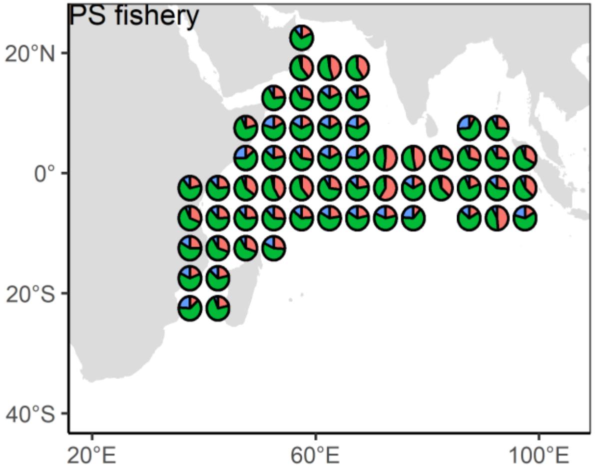
LFD's by fleet (no scaled)

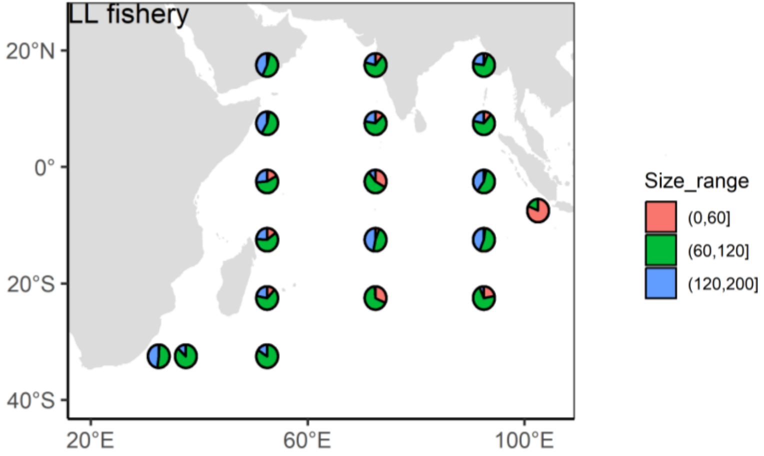


Sizes range around 50 – 150 for all fleets
LL catching bigger fish

1. Explore data

Fish size by fleet



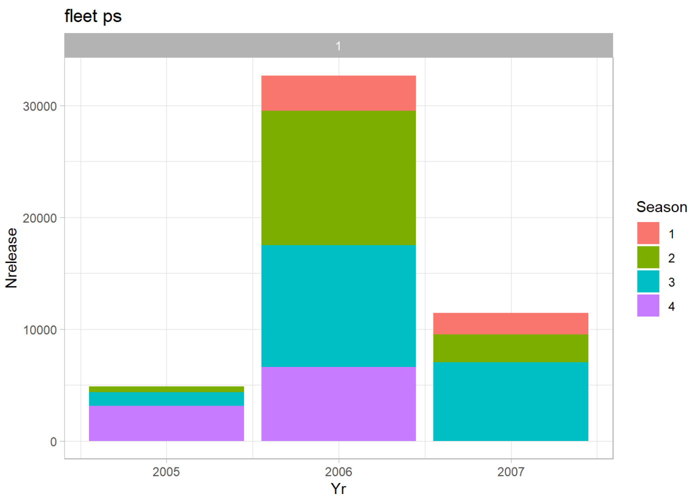


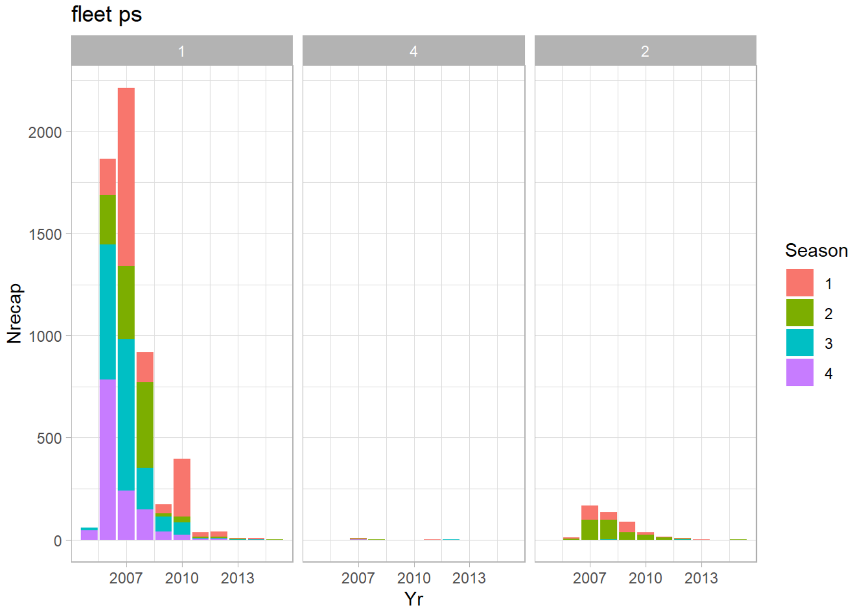
Smaller individuals targeted by PS (the one used to define recruitment)

Bigger individuals targeted by longline distributed in mainly in área 1, 2, & 4

1. Explore data

Tagging data



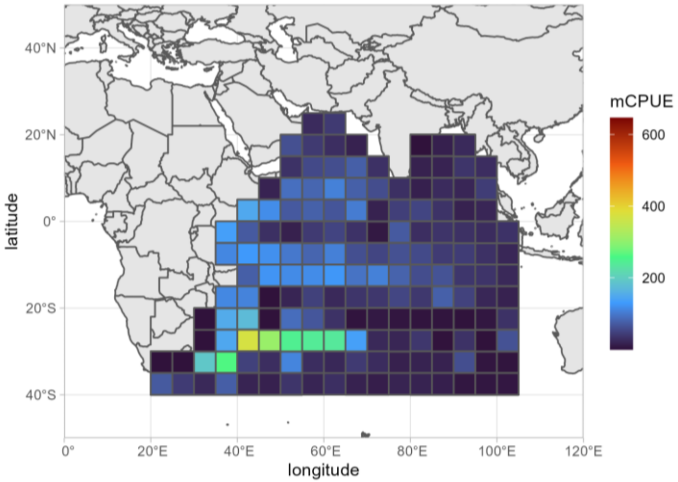


All tag releases made in A1

Recaptures by PS in A1>A2>A4
None in area 3

2. Standardize CPUE

*"The **provided CPUE** is calculated as the number of fish caught by the longline fishery divided by the number of hooks in each cell (as such units for each CPUE index are in N/hooks)"*



We fit a Bayesian spatio-temporal models for lattice data with R-**INLA**.

Continuous response variable: non standardized CPUE (no 0's).

We model the **relative abundance CPUE**, **Zst**.

$$Z_{st} \sim \text{Gamma}\ (\mu_{st}, \phi)$$

1) **iid**: $\log(\mu_{st}) = \alpha + a_s + g(t)\ ;\ a_s \sim N(0,\sigma_a^2)$ & g RW2

2) **besag**: $\log(\mu_{st}) = \alpha + U_s + g(t)\ ;\ U_s \sim N(0,\Sigma)$ & g RW2

3) **besag st**: $\log(\mu_{st}) = \alpha + U_{st} + g(t)\ ;\ U_{st} = W_{st} + \rho\, U_{st-1},$

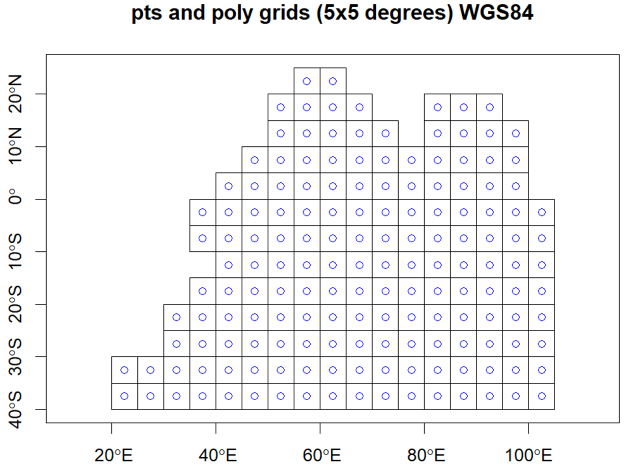
$$W_{st} \sim N(0, \Sigma)\ \&\ g\ \text{RW2}$$

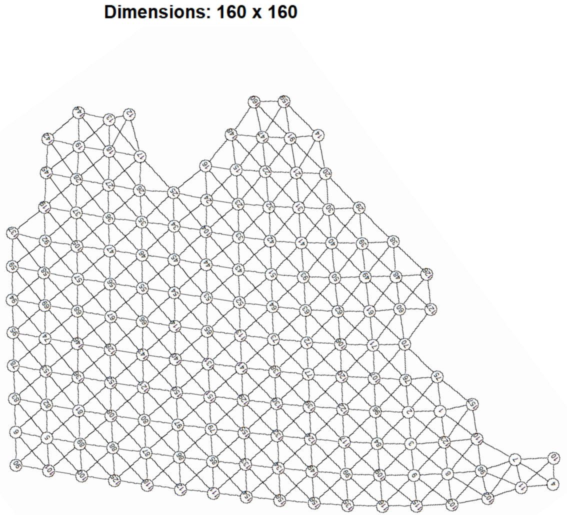
R Scripts on **Github**:
https://github.com/FranIzquierdo/YFT-lattice-st-CPUE-models

2. Standardize CPUE

2) Besag spatial effect implies that nearby things are similar

We construct the neighbor **matrix** by polygon contiguity in order to create the spatial (matrix correlation) structure: xi—xj ~N (0, sigma2) if i and j are neighbours

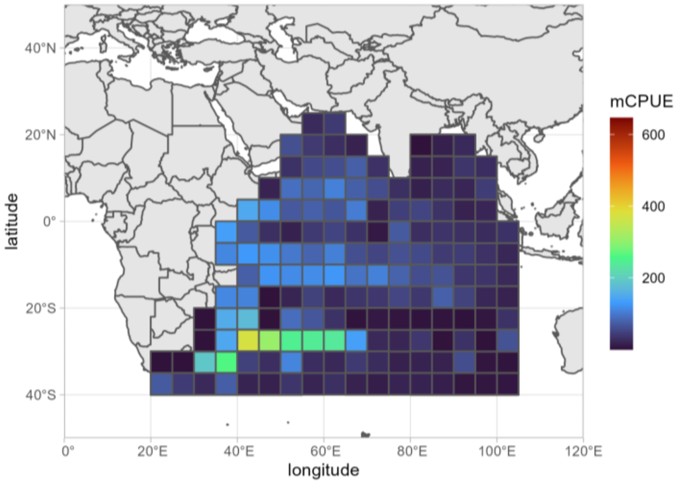




Besag spatial and spatio-temporal models **SPDE book**:
https://becarioprecario.bitbucket.io/inla-gitbook/ch-spatial.html#sec:lattice

2. Standardize CPUE

*"The **unstandardized CPUE** is calculated as the number of fish caught by the longline fishery divided by the number of hooks in each cell (as such units for each CPUE index are in N/hooks)"*



We fit **INLA** spatio-temporal models for lattice data.

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$W_{st} \sim N(0, \Sigma)$ & g RW2

R Scripts on **Github**:
https://github.com/FranIzquierdo/YFT-lattice-st-CPUE-models

2. Standardize CPUE

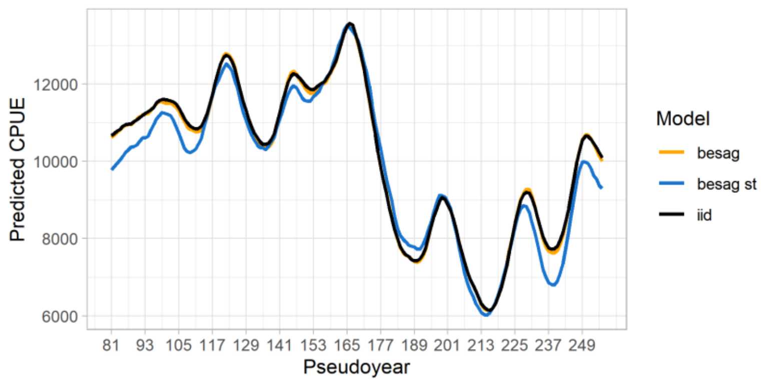
Model selection

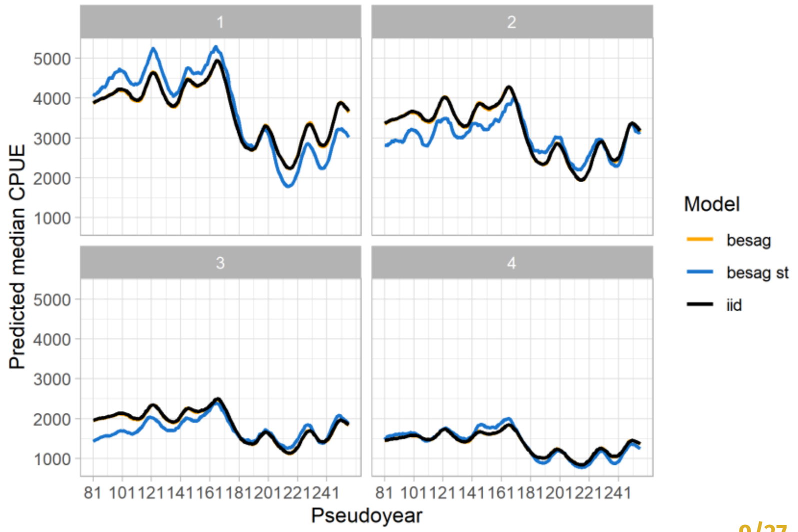
model	dic	waic	lcpo	time
iid	70283.08	70301.38	3.20	203.63
besag	70294.30	70328.79	3.20	181.10
besag st	**68204.39**	**68142.56**	**3.11**	**8276.21**

The **best model** in terms of godness of fit is the **besag spatio-temporal model**

Predicted CPUE: sum of predicted values in the cells by area in each pseudoyear (scaled indices)

Uncertainty of the model obtained by taking 100 random samples of the posterior distributions (not displayed here)

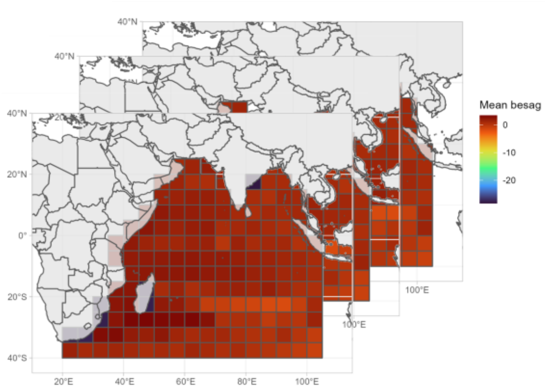




2. Standardize CPUE

Besag spatio-temporal model: the progressive **spatio-temporal structure** catches the spatial correlation among neighbour polygons along the time

- The spatial polygons evolve differently along time
- Not all time steps have the same spatial distribution



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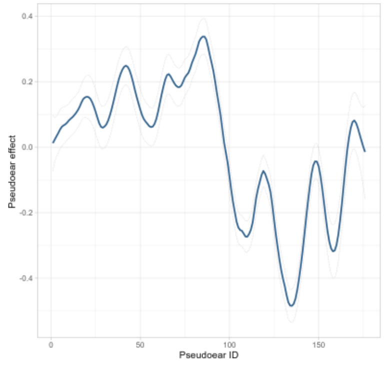

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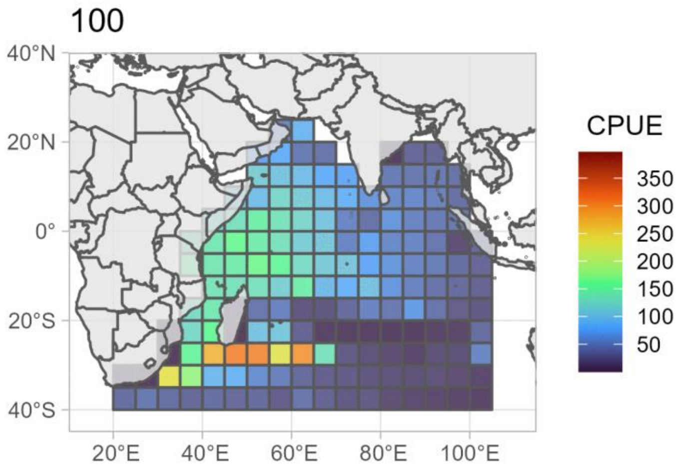
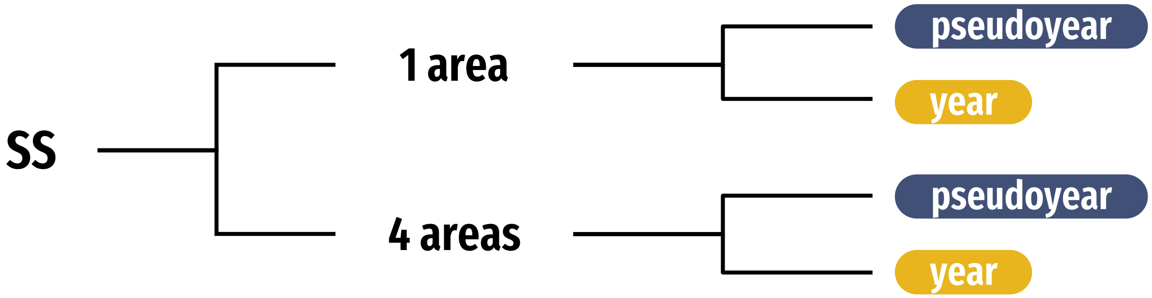


Mean besag spatial effect by year (AR1 time correlation)

Time smoothed (RW2) trend

3. SS parametrization and key decisions



- Build a fine scale model configuration with all provided data (**0 to 28+ pseudoyears**, k seasonal dev., M each quarter)
- Build a model with parameter inputs that we would have in a real case situation (**0 to 7+ years**, k base, M at age)

3.1. Parametrization

Biology

pseudoyear

- Input parameters as provided in the experiment

Age (pseudo-year)	Age (year)	M	L	Mat	k
1	0.25	0.3358	22	0	0.5
2	0.5	0.2955	35.2865	0	0.75
3	0.75	0.2552	41.384	0	1
4	1	0.2149	45.7348	0	1
5	1.25	0.1746	49.904	0.1	1
6	1.5	0.1343	53.8991	0.15	1.8
7	1.75	0.1343	57.7273	0.2	1.8
8	2	0.1343	64.2198	0.3	1.2
9	2.25	0.1343	74.721	0.5	1.2
10	2.5	0.1343	85.5489	0.7	1

year

- **Natural mortality (M):** summed across seasons for each age
- **Maturity:** values averaged across seasons
- **K Von Bert.:** k base = 0.45

	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7
M	1.23	0.66	0.54	0.73	0.76	0.56	0.54	0.54
Mat.	0	0.12	0.6	1	1	1	1	1

3.1. Parametrization

pseudoyear and year

Spawner-Recruitment

LN(R0)	BH steep	sigmaR	SR regime	SR autocorr
0.68	0.8	0.6	0	0

- We **fixed all parameters unless R0**

Growth

L_{inf}	145 cm
L_{min}	22 cm
k (base)	0.455
Length of weight: a	$2.459e^{-5}$
Length of weight: b	2.9667

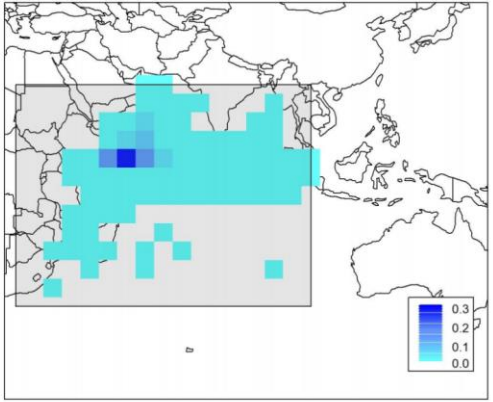
- All parameters were set fixed as provided by the experiment
- CV_Young and CV_old set to 0.1

3.2. Key decisions

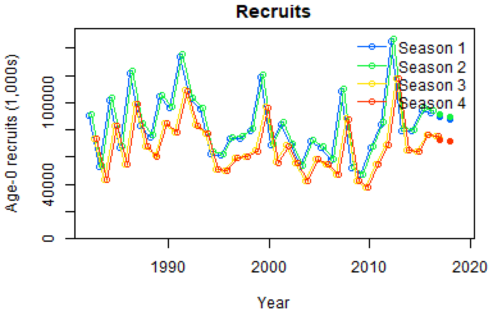
Recruitment

pseudoyear

- **1A y 4A**, recruitment into the population established in each pseudoyear.



year



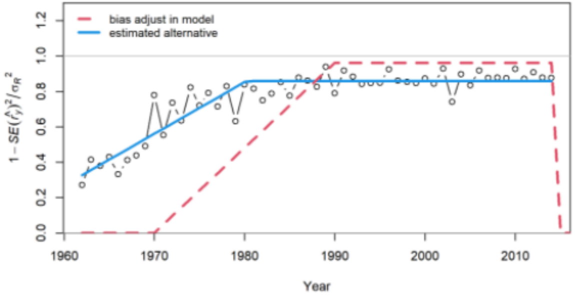
- **1A** recruitment settlements in months **1, 4, 7 & 10**
- **4A** recruitment settlements in area 1, months **1 & 7** (time-varying effect)

3.2. Key decisions

Recruitment deviations

pseudoyear and year

- We run the model with hessian in order to get the recruitment deviation **suggested from SS**
- Run the model again with these values
- Afterthat, we changed **the last early year no bias adjustment** from 1950 to **1970** (same in pseudoyears) for being the period which started to have good information about LFDs



Points are transformed variances. Red line shows current settings for bias adjustment
(which may or may not be an improvement. For more information, see

Methot, R.D. and Taylor, I.G., 2011. Adjusting for bias due to variability of estim

Estimated alternative inputs to SS control file associated with blue line in figure:

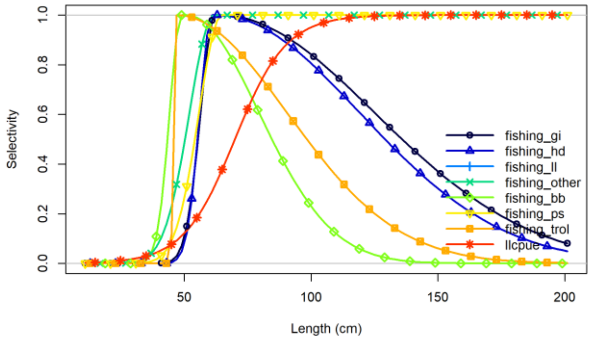
```
1950.8   #_last_early_yr_nobias_adj_in_MPD
1980.2   #_first_yr_fullbias_adj_in_MPD
2014.0   #_last_yr_fullbias_adj_in_MPD
2021.7   #_first_recent_yr_nobias_adj_in_MPD
0.8592  #_max_bias_adj_in_MPD (1.0 to mimic pre-2009 models)
```

3.2. Key decisions

Fleet's selectivity

pseudoyear and year

- We tried selex at age & selex at length configurations for year and pseudoyear models
- Hypothesis: selex at age may work better in the pseudoyear model because there is not a big difference in growth across pseudo-ages
- Finally, **selex at age** was selected for pseudoyear and **selex at length** was the best option for year

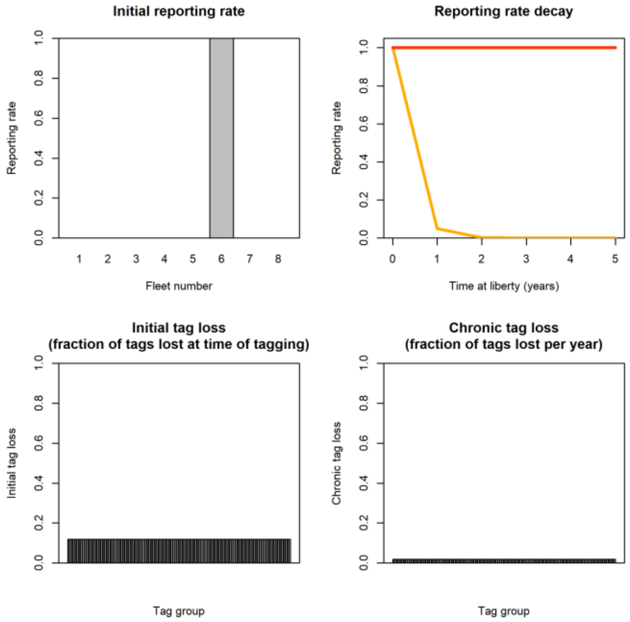


- **1A,** set all fleets DN unless LL
- **4A,** set all fleets DN unless LL.

As a first approach, we mirrored selectivity parameters of the same fleets across areas

3.2 Key decisions

Tagging data



pseudoyear and year

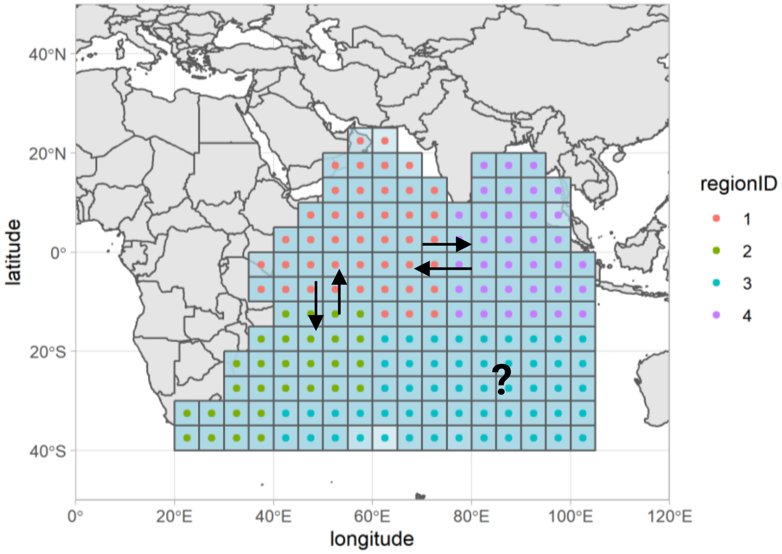
For **1A** and **4A**, we **auto-generated** tag parameters

Some information taken from **report** references:

- Reporting rate only for PS
- Initial tag loss fixed around 10%
- Tag chronic loss fixed around 3%
- Mixing latency period = 3 (values explored)

3. 2 Key decisions

Movement



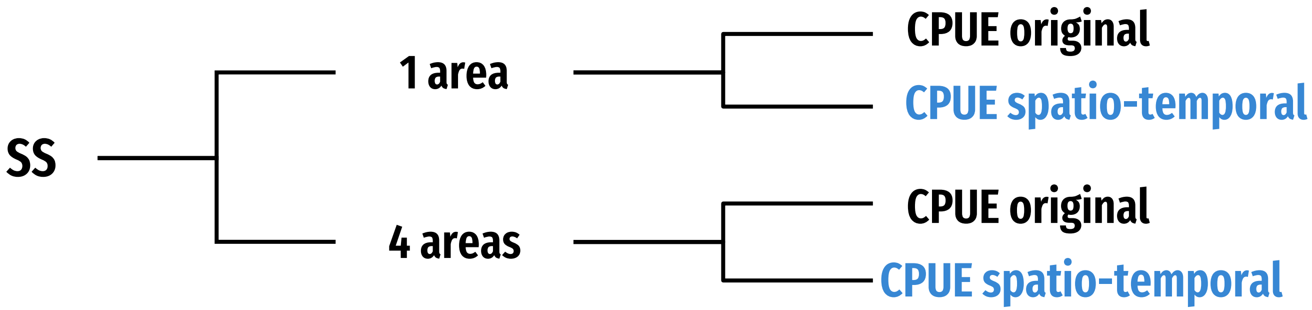
Information from taging: **A1→A1, A1→A2, A1→A4**

What about A3?

- CPUE st maps indicate area 3 and 4 are similar
- The CPUE st is scaling the relative abundance by area, so we assumed that the 4 areas have **constant catchability (Q)**
- We think big individuals must come back to A1 for reproduction

We defined the **movements** between areas:
A1→A1, A2→A2, A3→A3, A4→A4, A1→A2, A2→A1, A1→A4, A4→A1, A3→A4, A4→A3

4. Base models and diagnostics

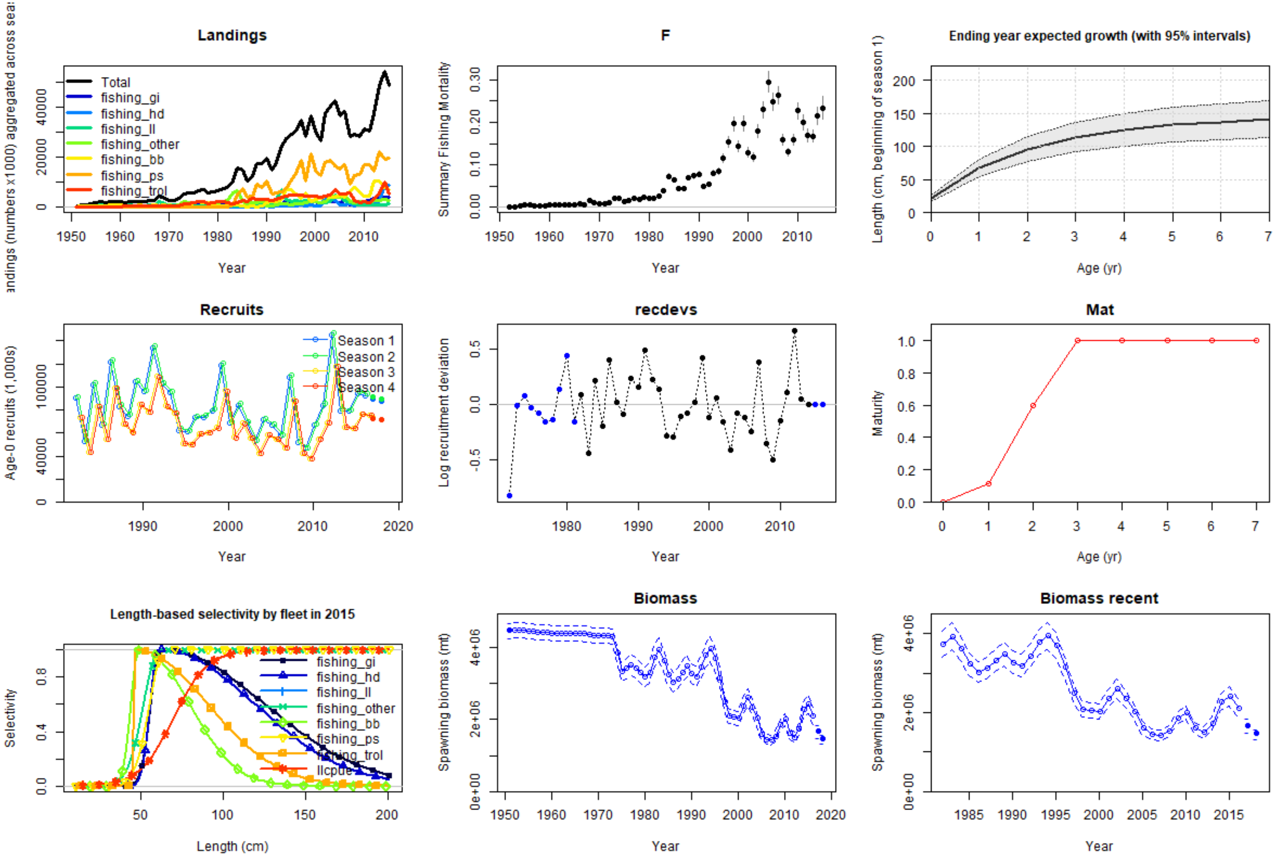


Both CPUEs showed a good performance across the different configurations

We decided to **select CPUE spatio-temporal** models because they take into account the spatio-temporal autocorrelation

4.1 Base model 1 area

year

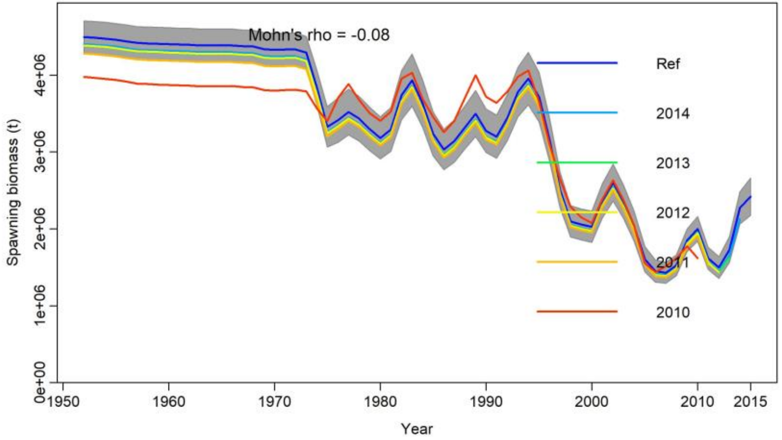


Settings:

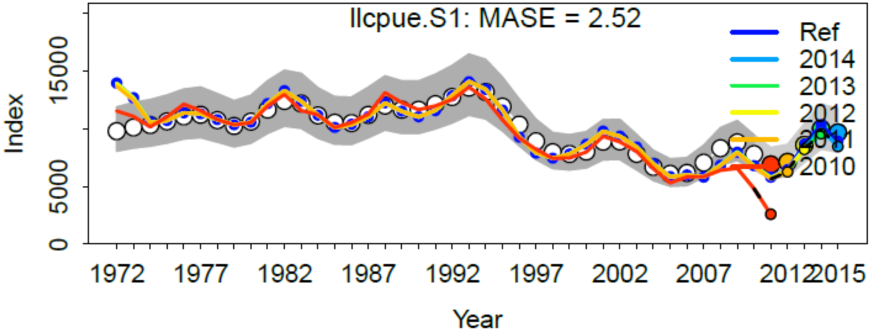
- CPUE besag st
- Tagging data (*Latency period bias*)
- 4 settlements
- LFD ESS 25
- PS, LL & OTHER estimated as logistic

4.1 Base model 1 area year

Retros and diags

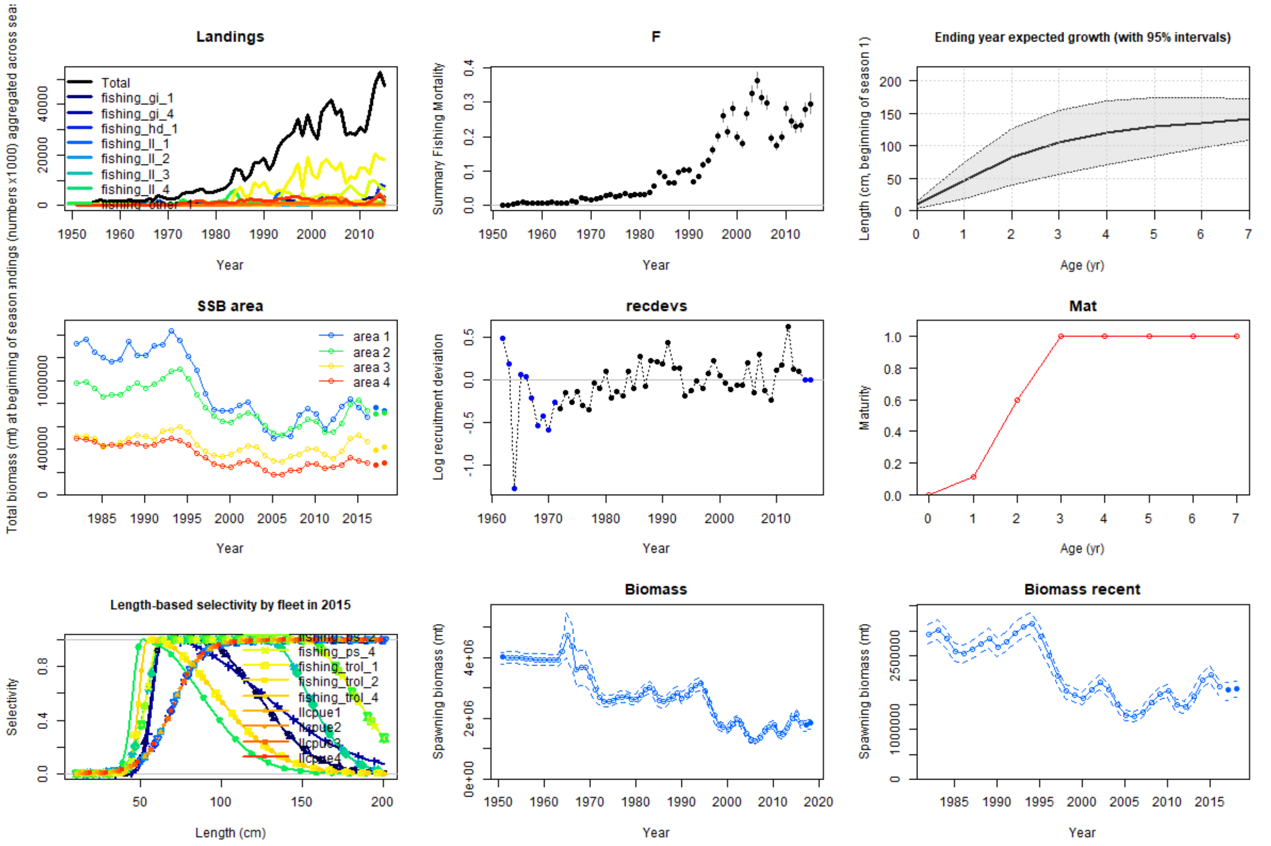


Retrospective pattern of SSB seems fine unless the retro-5



Retrospective pattern of index seems correct unless the retro-5

4. 2 Base model 4 areas year



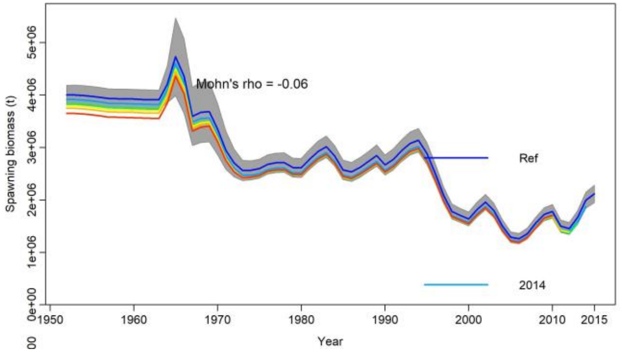
Settings:

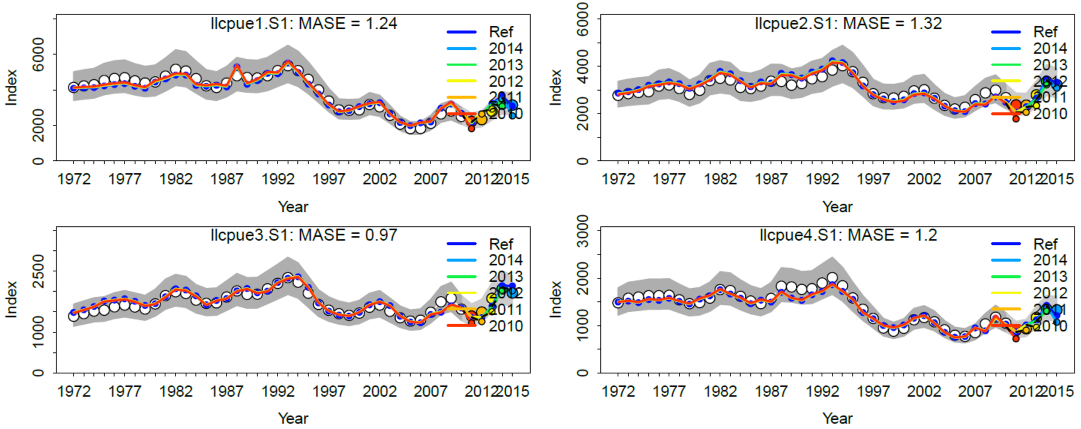
- CPUE besag st
- Shared Q
- LFD ESS 25
- Settlements 1,7 in A1
- Movement defs
- Tagging data

4. 2 Base model 4 areas

year

Retros and diags

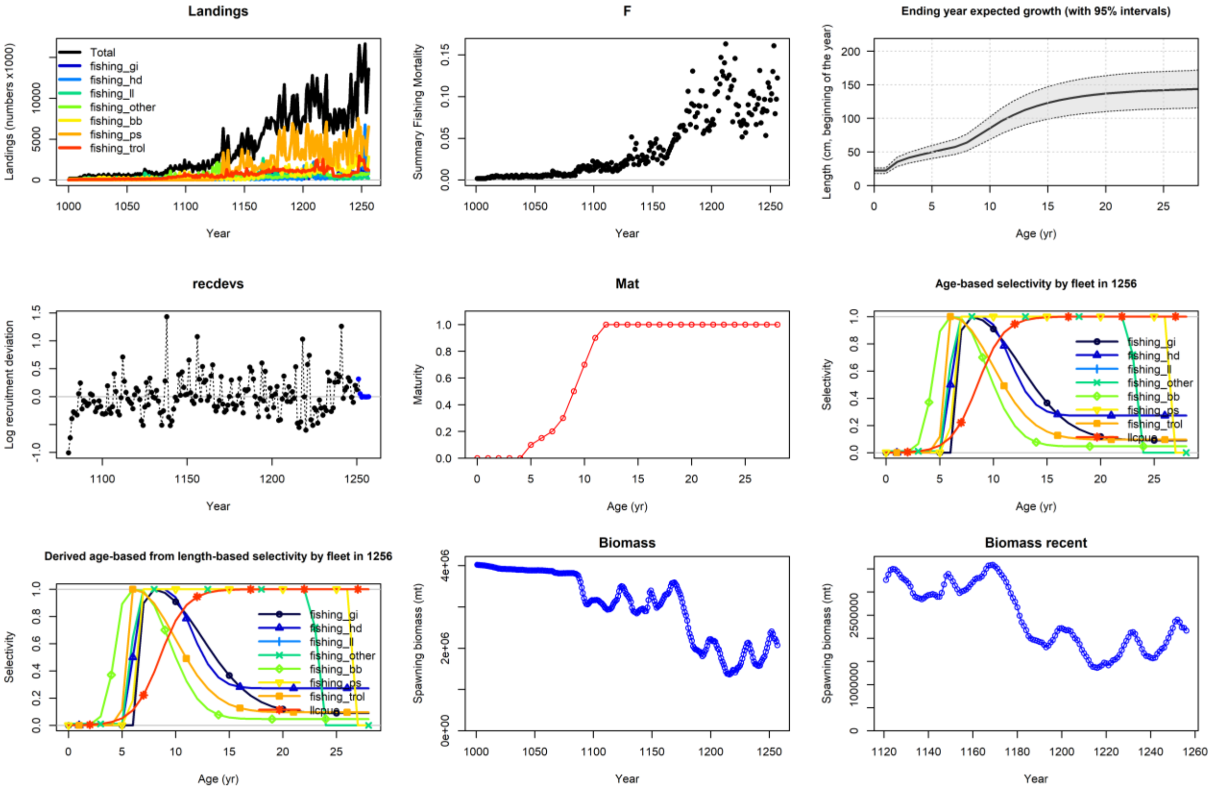




Retrospective pattern of SSB and index seems correct

4.3 Base model 1 area

pseudoyear



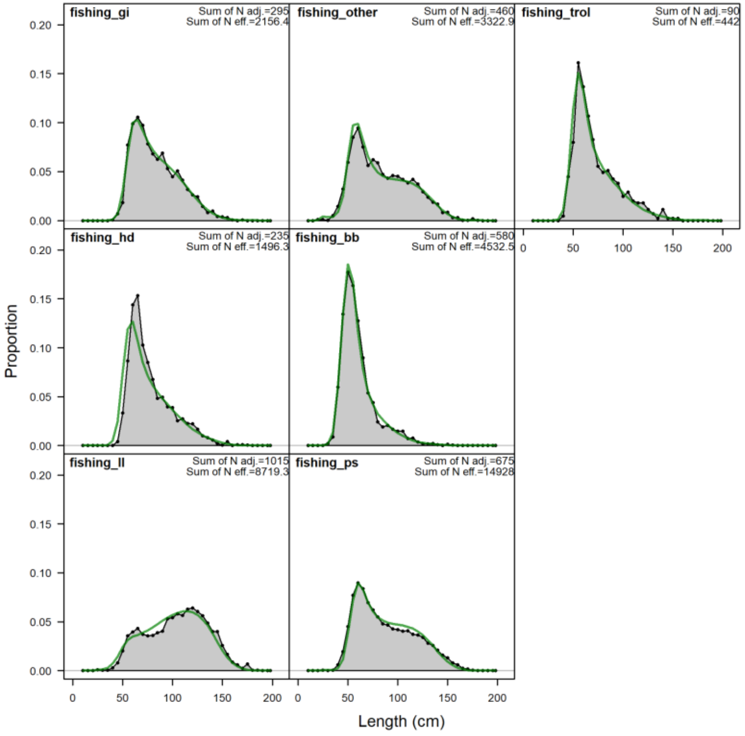
Includes:

- CPUE besag st
- Tagging data
- LFD ESS 25
- PS, LL & OTHER estimated as logistic

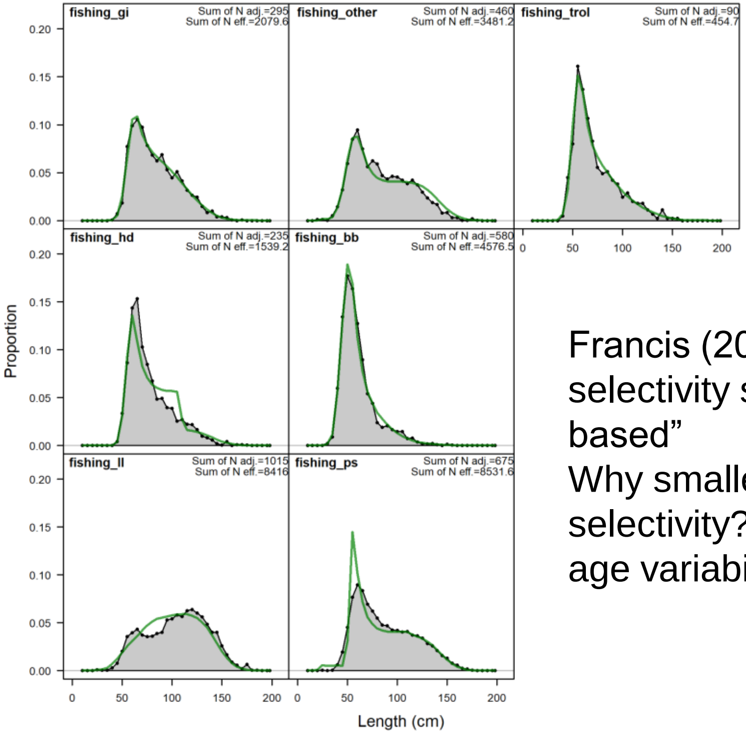
4.3 Base model 1 area

pseudoyear

Age-selectivity:



Length-selectivity:

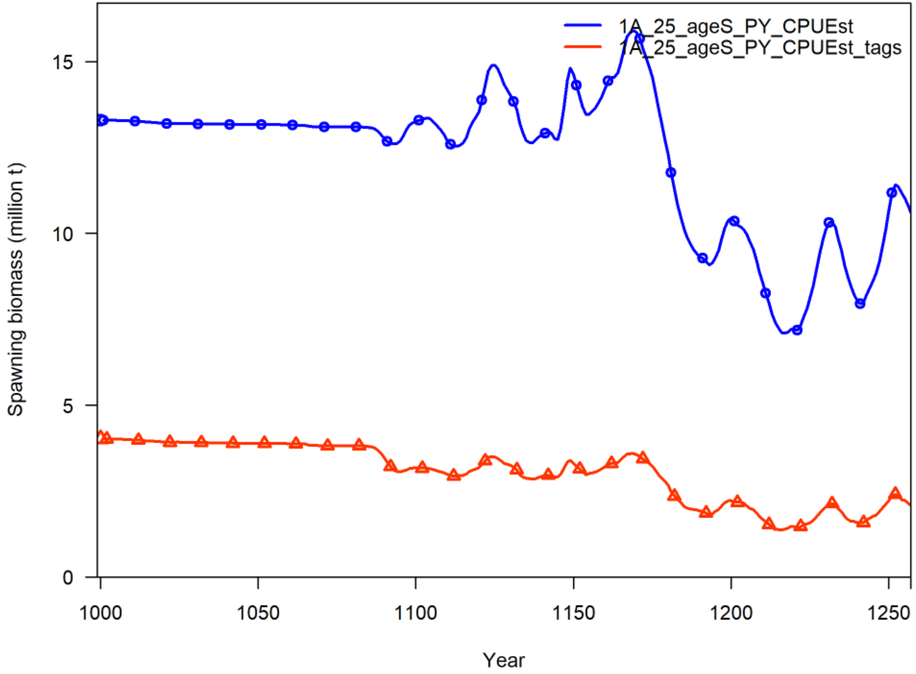


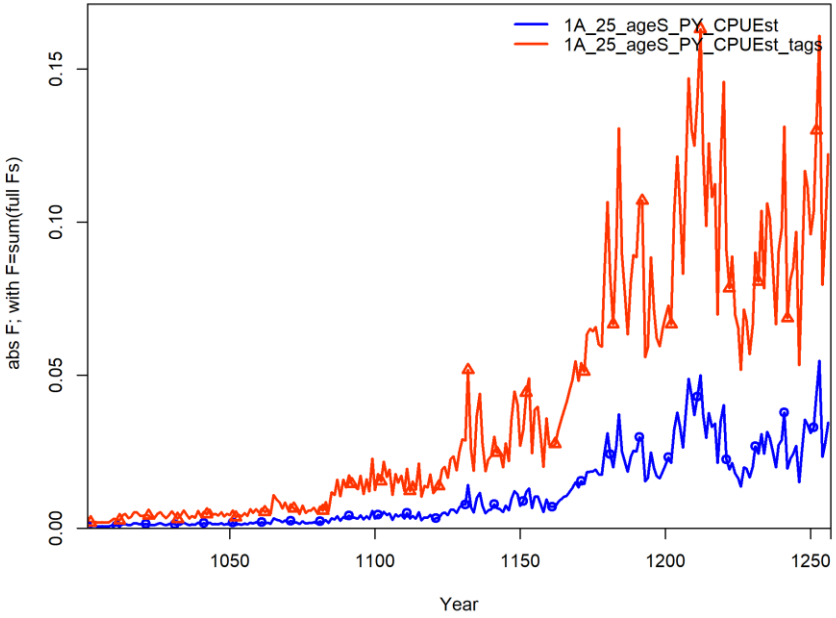
Francis (2016): “In most cases, selectivity should be length-based”

Why smaller residuals of age-selectivity?: effects of length-at-age variability?

4.3 Base model 1 area

pseudoyear



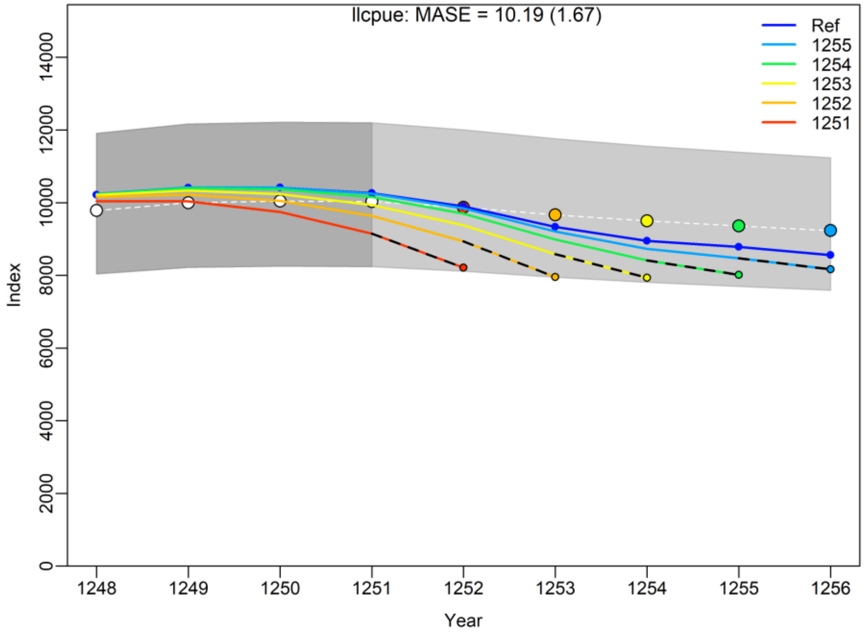


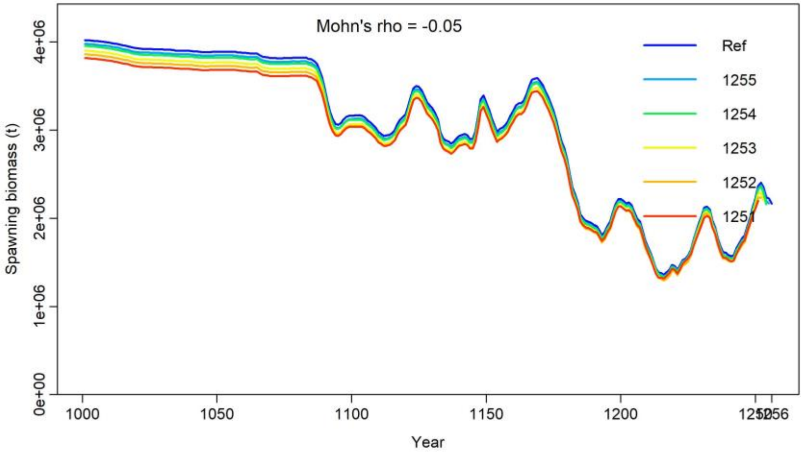
What information provides tagging data in a 1A model?

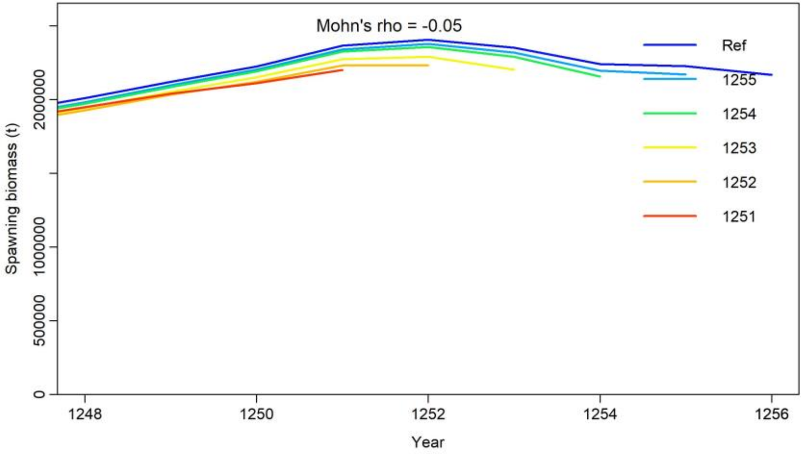
4.3 Base model 1 area

pseudoyear

Retros:







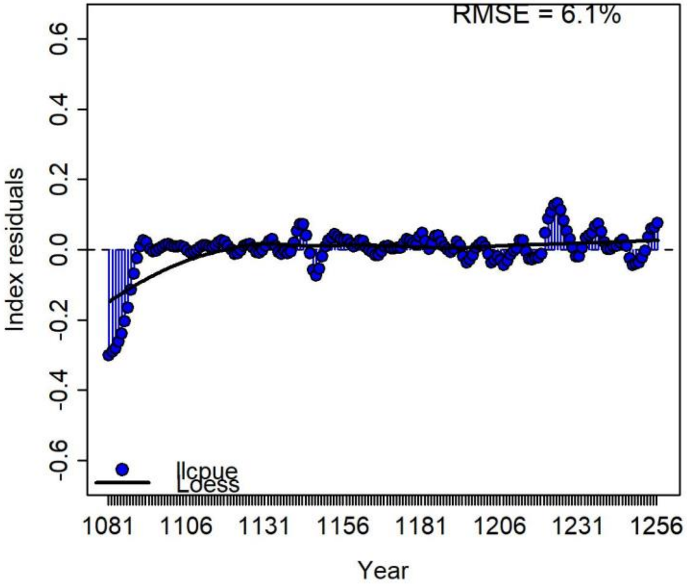
Retrospective SSB pattern looks fine.

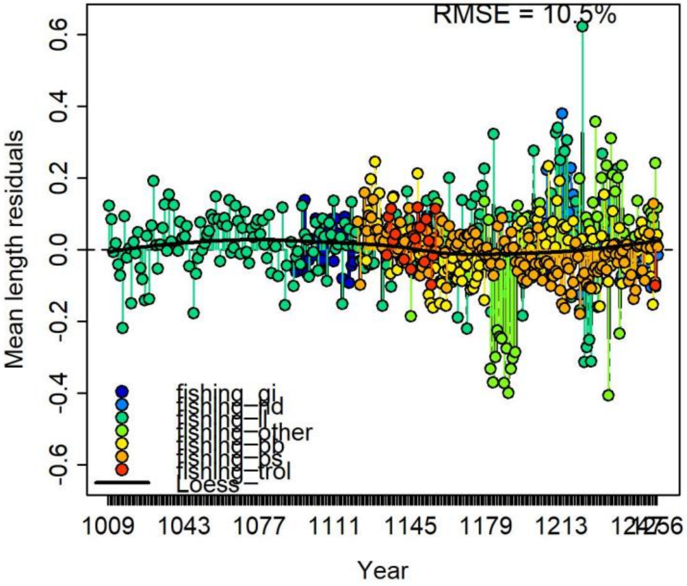
4.3 Base model 1 area

pseudoyear

CPUE: Negative residuals for early years.
Mean length: Some fisheries did not pass test.

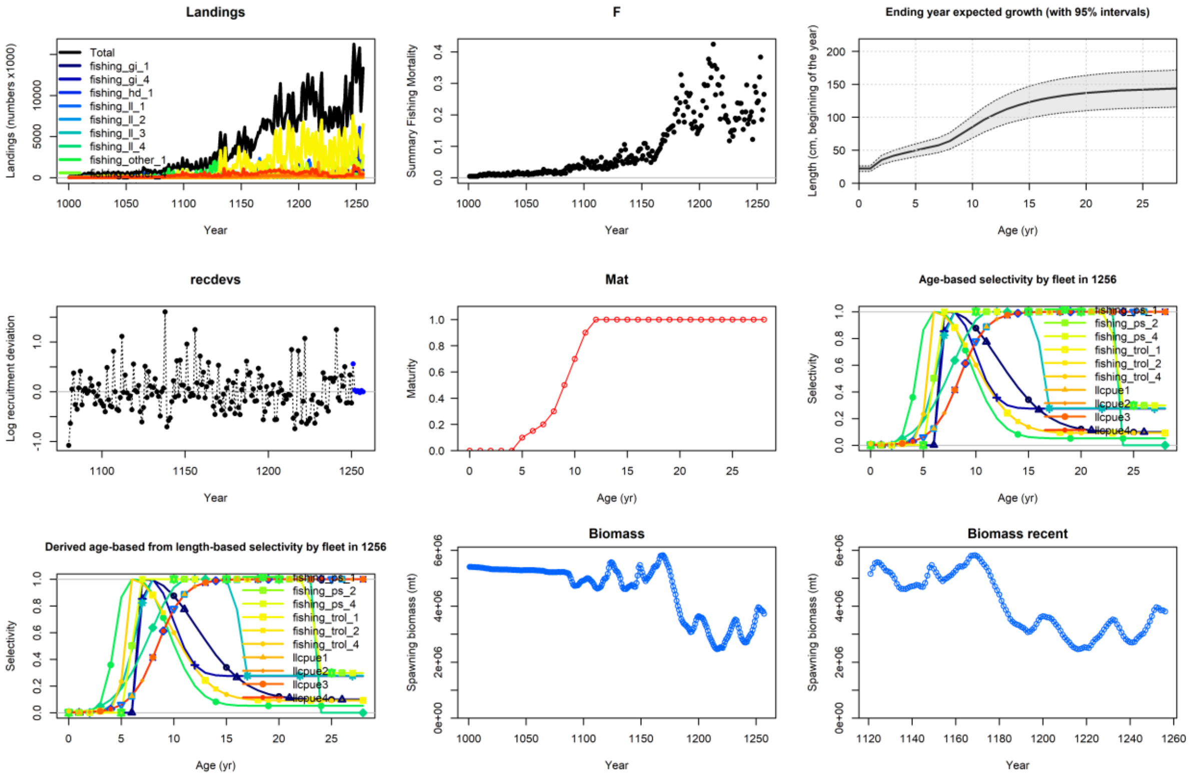
Diagnostics:





4. 4 Base model 4 areas

pseudoyear



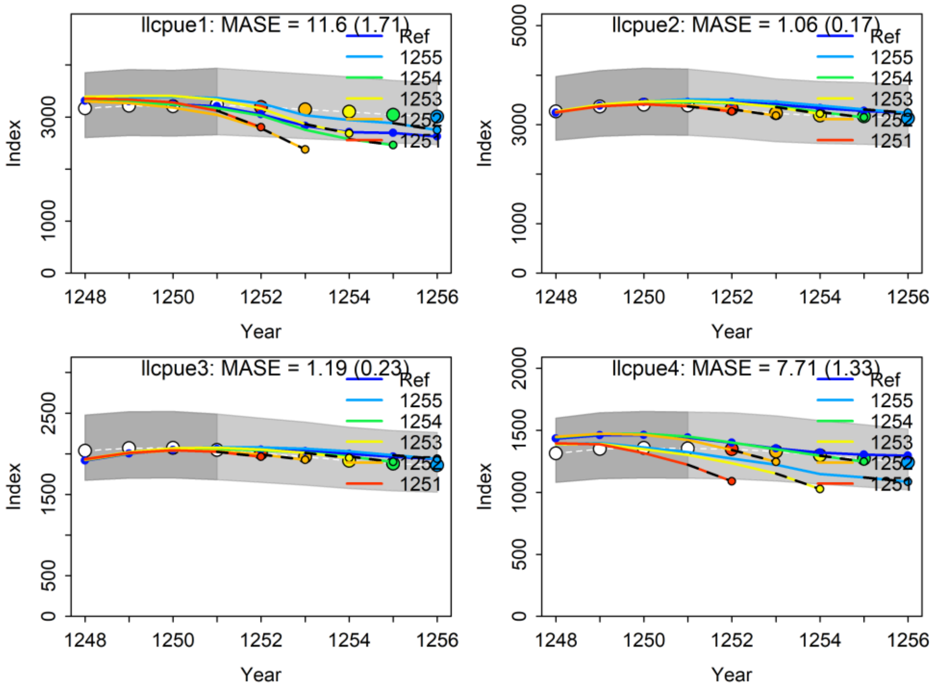
Includes:

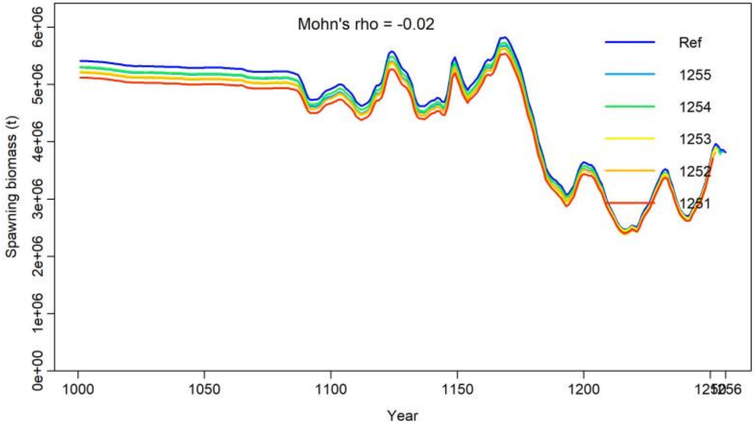
- CPUE besag st
- Shared Q
- LFD ESS 25
- Tagging data

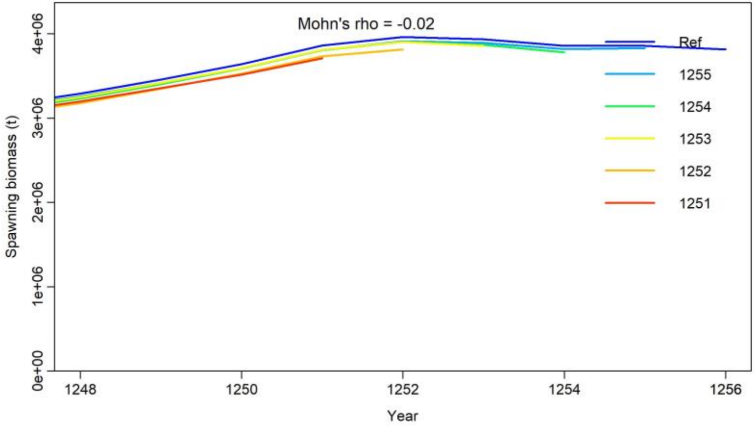
4. 4 Base model 4 areas

pseudoyear

Retros:







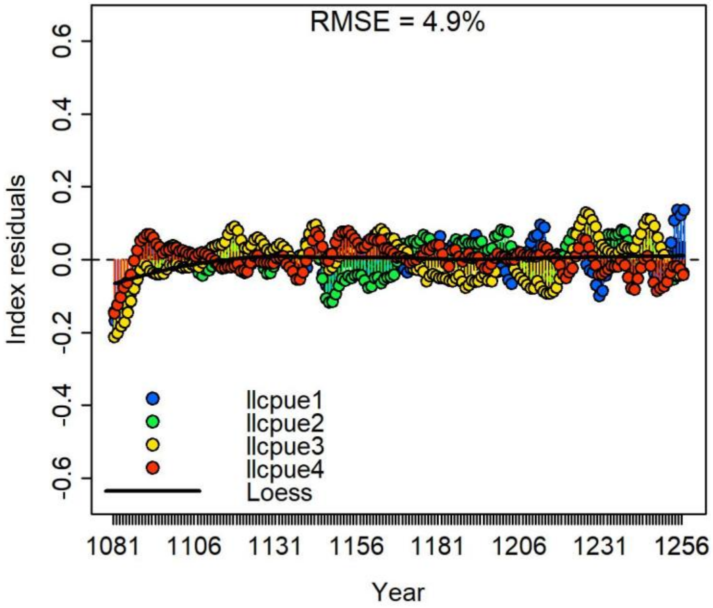
Retrospective pattern of SSB and index seems correct

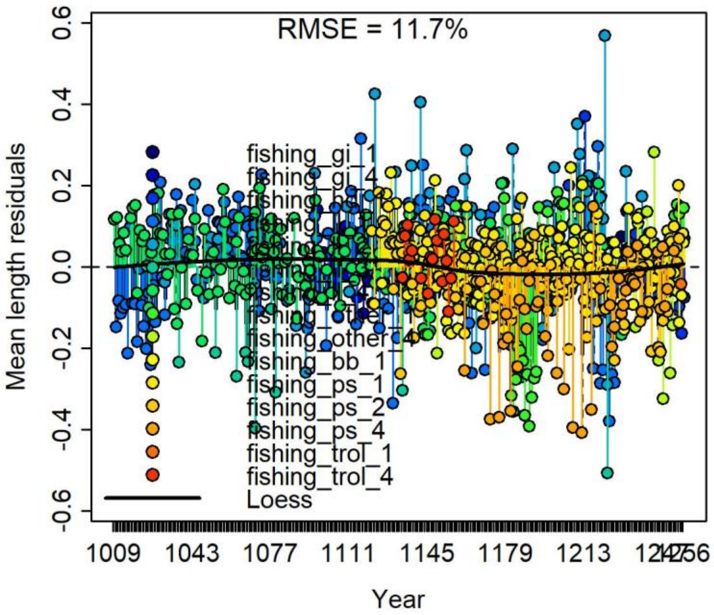
4.3 Base model 4 area

pseudoyear

CPUE: Negative residuals for early years.
Mean length: Some fisheries did not pass test.

Diagnostics:





4.5. SPiCT model

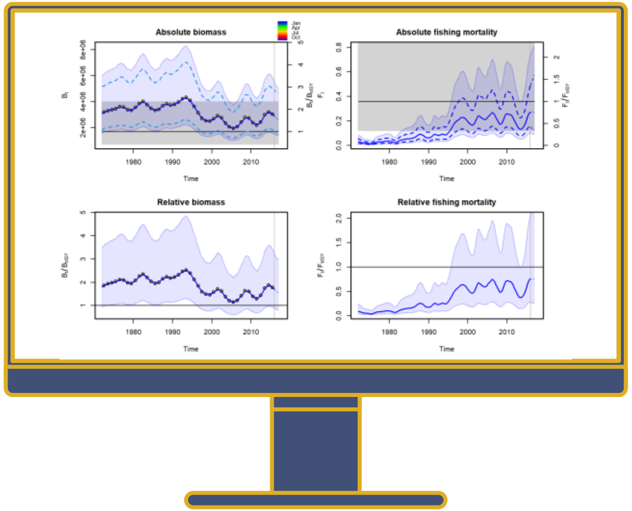
Cross-check: Surplus Production model

Data-moderate model: A stochastic surplus production model in continuous time (**SPiCT**; Pedersen and Berg, 2017)

Input data: catch data in tonnes (transformation catch numbers using length frequency distributions)

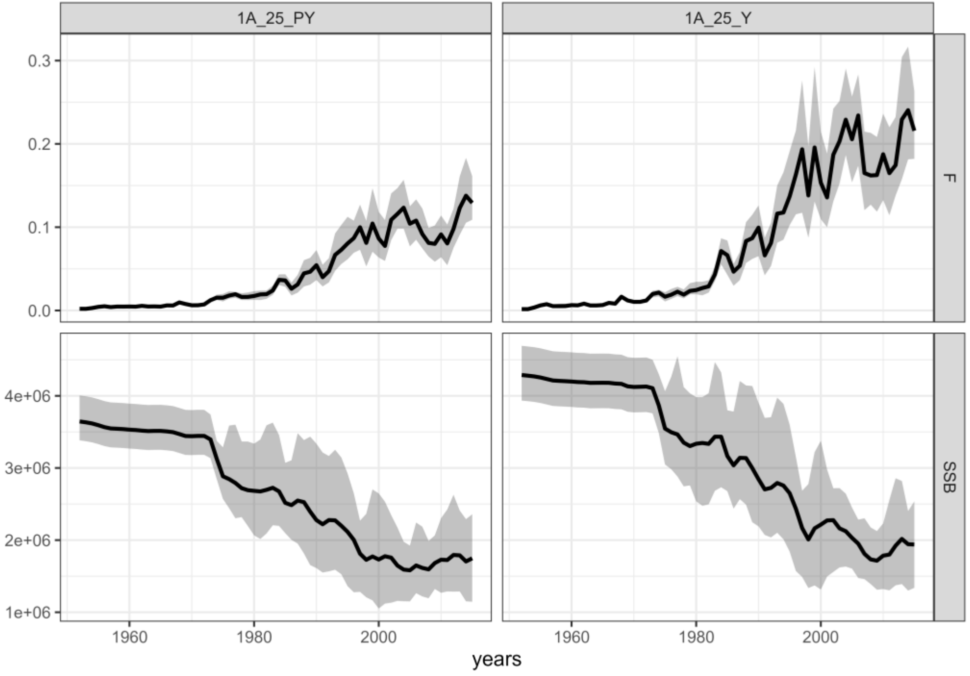
Different trials for **annual** data:

a) catch and original CPUE
b) catch and spatio-temporal CPUE



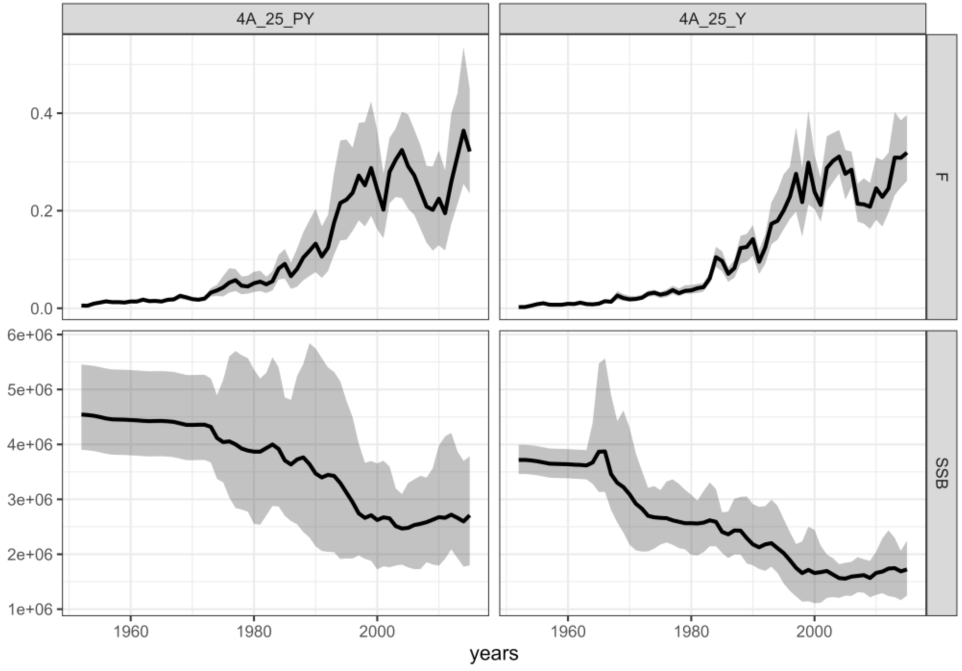
Convergence problems using catch from 1954 → Start catch time series at 1972 (first year of CPUE).

5.1 Provisional 20 assessments 1A



	year	pseudoyear
% Convergents	0.85	0.95
Catch RMSE mean	0	0
Catch MAPE mean	0	0
Catch RMSE sd	0	0
Catch MAPE sd	0	0
CV SSB mean	12.37	13.6
Cv F mean	15.89	13.6
CV rec mean	20.04	23.6
CV ssb sd	5.74	6.6
Cv F sd	5.05	5.1
Cv rec sd	11.05	15

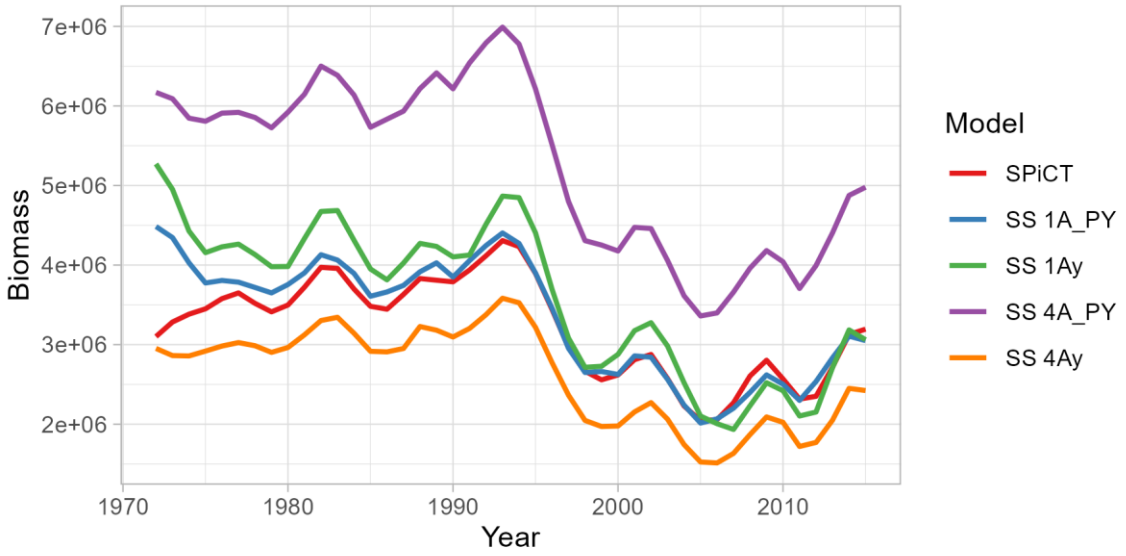
5.2 Provisional 20 assessments 4A



	year	pseudoyear
% Convergents	0.75	0.9
Catch RMSE mean	0	0
Catch MAPE mean	0	0
Catch RMSE sd	0	0
Catch MAPE sd	0	0
CV SSB mean	12.72	19.4
Cv F mean	12.29	22.1
CV rec mean	17.53	32.5
CV ssb sd	5.19	5.6
Cv F sd	4.62	4.8
Cv rec sd	9.68	17.4

4.5. SPiCT model

Cross-check: Surplus Production model

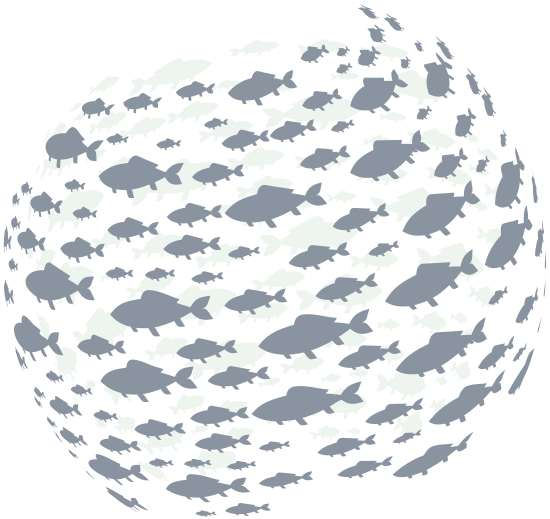


Diagnostic

- SPiCT estimates have same trends as 1A and 4A models for both configurations
- SS 4A_PY for a single replicate*

6. Future steps

- Keep exploring trials without tagging data
- Try different recruitment settlement settings in **4A models**
- Explore different movement settings in **4A**
- Compare and discuss **pseudoyear and year differences (i.e., recruitment settlements)**
- Compare and discuss **1A** and **4A** configurations



THANKS!

francisco.izquierdo@ieo.csic.es
marta.cousido@ieo.csic.es
gcorrea@uw.edu

https://github.com/FranIzquierdo/NOAA-YFT-workshop-IEO-team
https://github.com/gmoroncorrea/SpatialStockAssessment_SpanishGroup