Stock Assessment of Swordfish in the Southwest Pacific Ocean: 2025

WCPFC-SC21-2025/SA-WP-05
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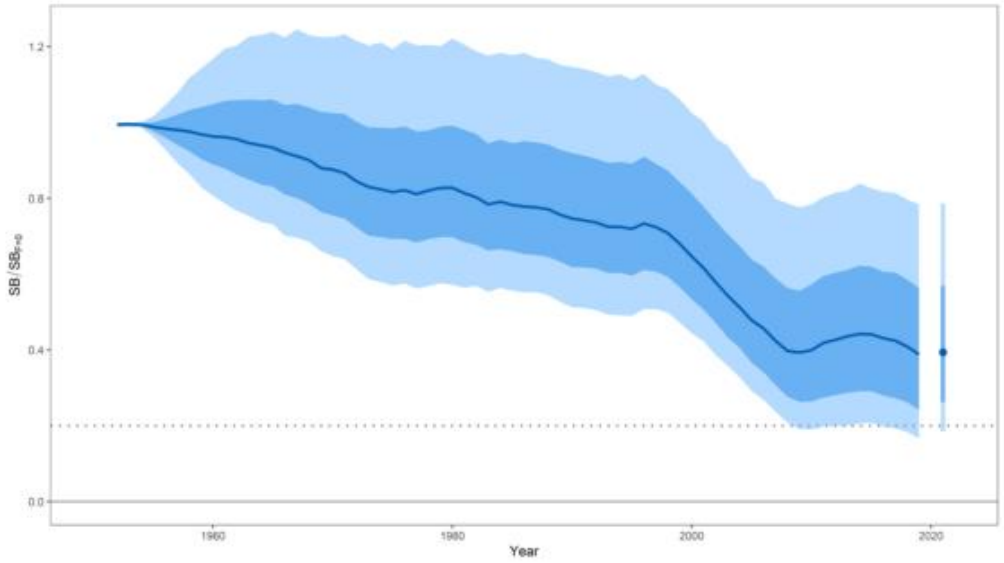
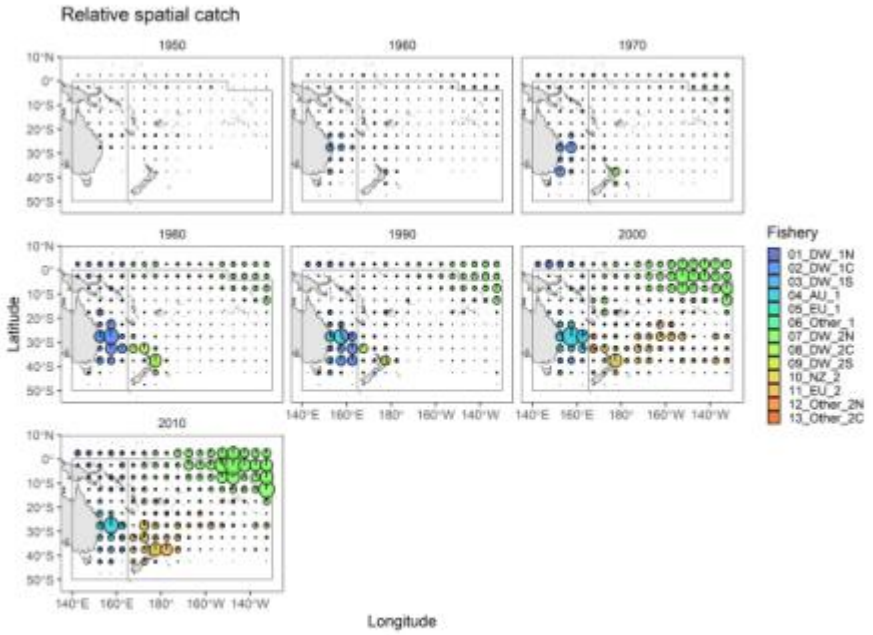
Jemery Day, Claudio Castillo-Jordán, Arni Magnusson, Kyuhan Kim, Thom Teears, Nick Davies, John Hampton, Sam McKechnie, Tom Peatman, Tiffany Vidal, Paul Hamer

SWO2021 in a nutshell (Ducharme-Barth et al. 2021)



- 20% risk of overfishing
- 13% risk overfished

	Median	10th %ile	90th %ile
F_{recent}/F_{MSY}	**0.47**	**0.25**	**1.29**
SB_{recent}/SB_{MSY}	**3.61**	**1.23**	**7.39**
$SB_{latest}/SB_{F=0}$	0.39	0.18	0.79



(a) Relative spatial catch by fishery.

Most influential axes:

- movement
- natural mortality

Others: DWFN index, data weight (length), data weight (AU CPUE)

SWO: The real journey

- Stubborn
- Strong-willed
- Tenacious
- Pragmatic
- Bloody-minded

- Some say stock assessment is an art, not a science
- Some even say it is a dark art?
- All models are wrong. Some models are useful.
- My job today? Transform the journey to performance art?

Elders: past, present and emerging

- Dale Kolody: 1st revolution, foundational work – pushed spatial billfish models to the limits; 7 regions, 6 regions, 4 regions
- Nick Davies: Fixed the 4-region problem (made it only 2), identified growth as a key uncertainty
- Yukio Takeuchi: Fixed growth (CSIRO otolith work), tried a 2-sex model
- Rich Hillary (imposter?): Fiddled with movement, said wise things, worked quietly on the next revolution (CKMR), unfortunately for white sharks and SBT
- Nicholas Ducharme-Barth: The real revolutionary – uncertainty ensemble (but couldn't quite fix 2-sex problem, but gave it a red-hot go)

Elders: past, present and emerging

2.2 Historical SWPO swordfish assessments

The first assessment of swordfish in the south western Pacific region (Kolody et al., 2006) was conducted in 2006 using MULTIFAN-CL and focused on the area 140°E – 175°W. This first assessment noted the considerable uncertainty in stock status and that the assessment uncertainty will not be substantially reduced until there is considerable additional data collected, ideally including improved interpretation of catch rates, direct observations of movement from tagging (conventional, electronic or genetic), direct aging from hard parts, and improved size data and sex sampling. The general conclusion was that the biomass (total and spawning) are probably above levels that would sustain MSY and fishing mortality is probably below F_{MSY}. This initial assessment was updated in 2008 by Kolody et al. (2008), again using MULTIFAN-CL, and drew similar conclusions, with some reduction in the uncertainty compared to the 2006 assessment. In the same year, an alternative assessment (Davies et al., 2008) was also conducted using CASAL (Bull et al., 2012), focusing on the south-central Pacific area alone (140°E – 130°W). The 2008 CASAL assessment produced quite different outcomes to the 2008 MULTIFAN-CL assessment, and concluded there was insufficient information available to estimate population abundance. Consequently, the status of the swordfish stocks in the south-central Pacific Ocean could not be determined from this assessment.

SWO2025: Statistical tests

- Pub test (Can you explain it to your mates over kava?)
- Intra-ocular test (Does it hit you between the eyes?)

- Assessment is simple – some assumptions + some data
- Best fit to the data given those assumptions
- But is it realistic? (the dark art?)

- Little contrast in CPUE (not severely depleted)
- Catches increase in late 1990s and stayed relatively stable ever since
- Nothing much to see here probably – no red flags?

SWO2025: Lowlights

- The data to ~~fight~~ work with
- Catch data in: numbers vs **weight**
- Composition data: weight vs **length** frequency data
- Different measurement standards
  - **Lower jaw-fork length (LJFL)** / Eye orbital-fork length, and the rest
  - **Whole weight** / Processed weight (with varied processing approaches)
- Never enough age data (spatial and temporal limitations on collection of age data)
- The struggle to **simultaneously fit the data** (CPUE, comp data, age data) and **produce plausible model results**
- Spatial structure (how to deal with the NE corner and boundary catches?)
- Some diagnostics (ASPM, likelihood profiles, retrospectives)
- No growth uncertainty in the grid
- No stepwise model development to present
- **Population scale**: Can we really estimate this?

SWO2025: Highlights

- Always the people – the assessment team
- Collaborative approach to assessment
- Patience shown by many in allowing me to keep pushing this model to the limit – or at least to a place reflecting some sanity
- Simpler model with only 74 parameters estimated (53 recruitment)
- Managing to run an uncertainty grid and process results under time pressure, albeit at the cost of an uncertainty ensemble
- Jitter analysis – great stability
- Positive definite Hessians galore (all 360 grid models with PDH!)

Other Elders: emerging?

- Ash Williams: Australian CPUE and data issues (discarding)
- Brad Moore: NZ CPUE
- Paige Eveson and Jess Farley: Otolith data
- **Mark Maunder**: Led the revolution? Encouraged further downweighting, fully beheaded F-Ballpark
- **Simon Hoyle**: NZ fisheries knowledge, encouraged subregional split, advice on Lorenzen M, (seasonal selectivity)
- Rick Methot: Stock Synthesis technical advice
- Michael Schirripa: ICCAT swordfish
- Rich Hillary: Moral support (data limitations, movement, CKMR insights, vibe)
- Dale Kolody: Legacy of enduring words and open approach, perspective
- Nicholas Ducharme-Barth: Last assessment detail, chewing the fat
- Meg Oshima: Ran the ASPM analysis for me (at the last minute)

SWO2025: The revolution?

1. Downweight the length composition data a lot (subjectively)
2. Group and share selectivity and estimate it
3. Then fix selectivity for most groups (all except the southern ones – and leave only a single season for these fisheries)
4. Downweight most comp data even more (sometimes to zero) and upweight others
5. Francis/Punt weighting to remaining data (length, weight and age data)
6. Bob's your uncle!
7. F_Ballpark – certainly had its head cut off

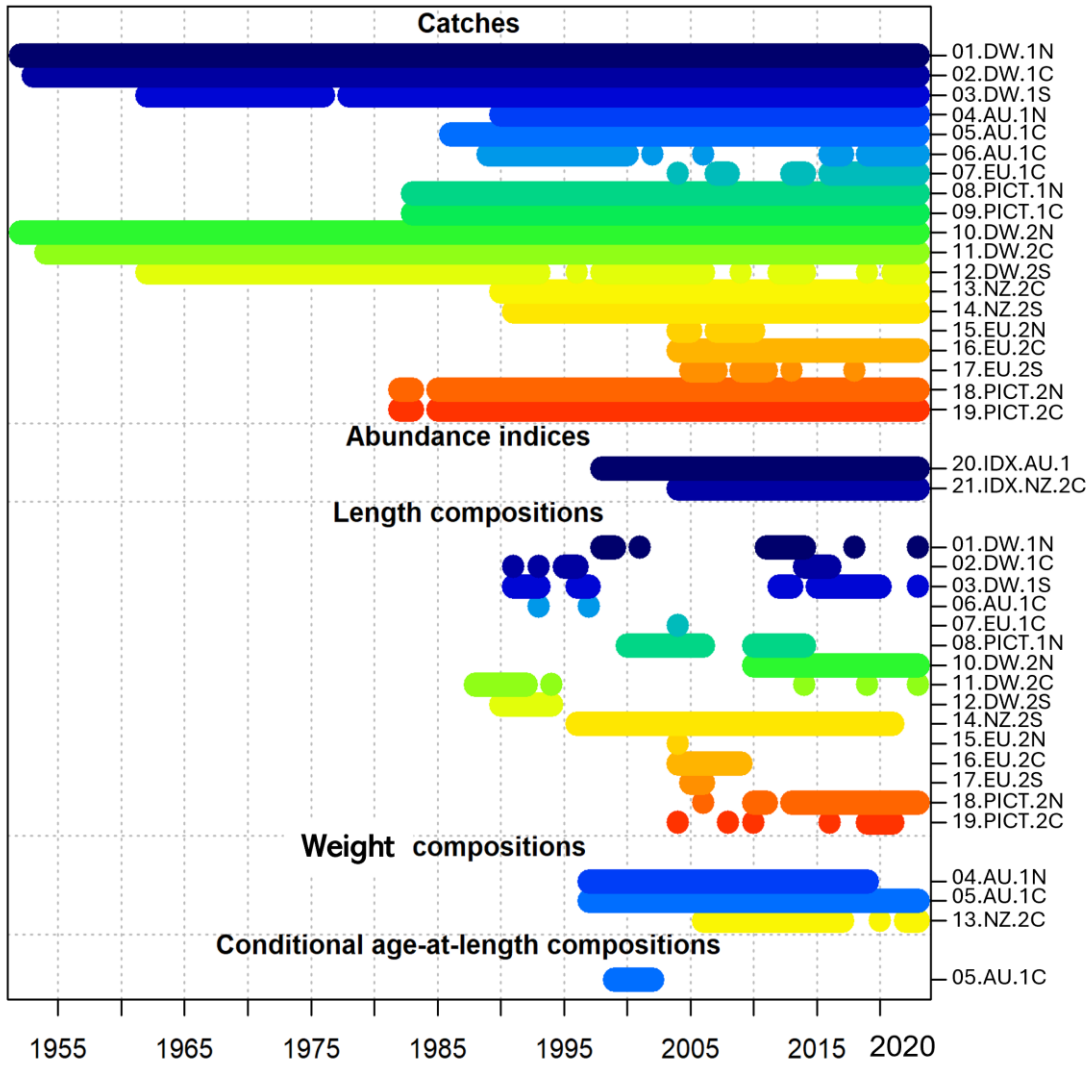
Without the revolution, the model estimated ENORMOUS biomass

Interesting fact – this all came to a head on Bastille Day

2025 assessment: The press response?

1. In true revolutionary style, some had their heads cut off, and these either needed to be put back on, or appropriate conversion factors used to convert such headless fish to standard weights and lengths
2. It is a dubious model overall, but probably better than the last one
3. You basically have a length-based data poor method that assumes asymptotic selectivity. With some tweaks to make it non-equilibrium and take account for catch. But not unlike a lot of tuna assessments
4. As with any change, there was a certain amount of associated chaos
5. It wasn't clear that a viable model would emerge at the end
6. It was important to present a model that was robust and could stand up to the post-revolutionary times at hand
7. Fortunately, the assessment team kept their heads on
8. Apologies are owed for the late delivery of this assessment. Sorry!

Data overview: Catch, CPUE, length, weight, age



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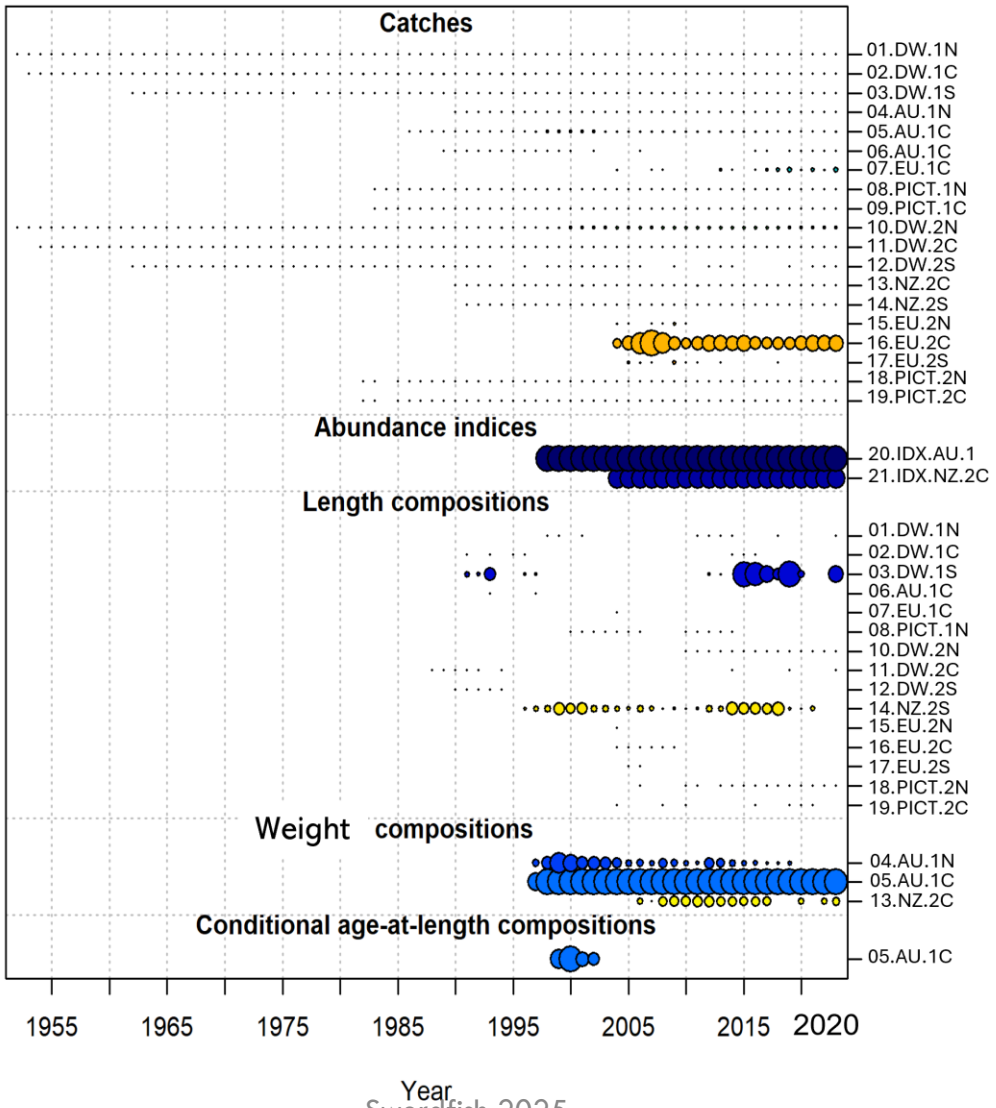
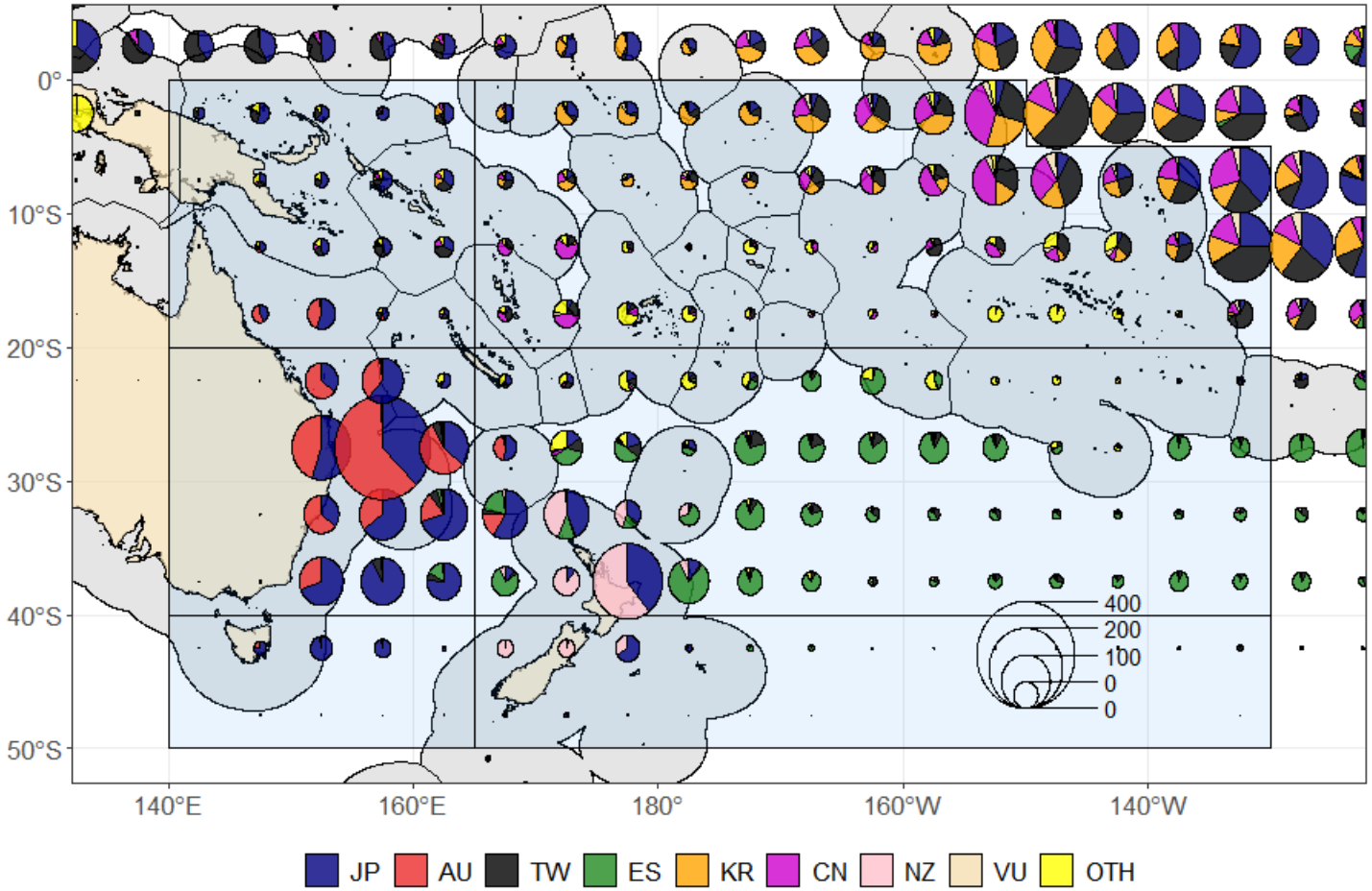
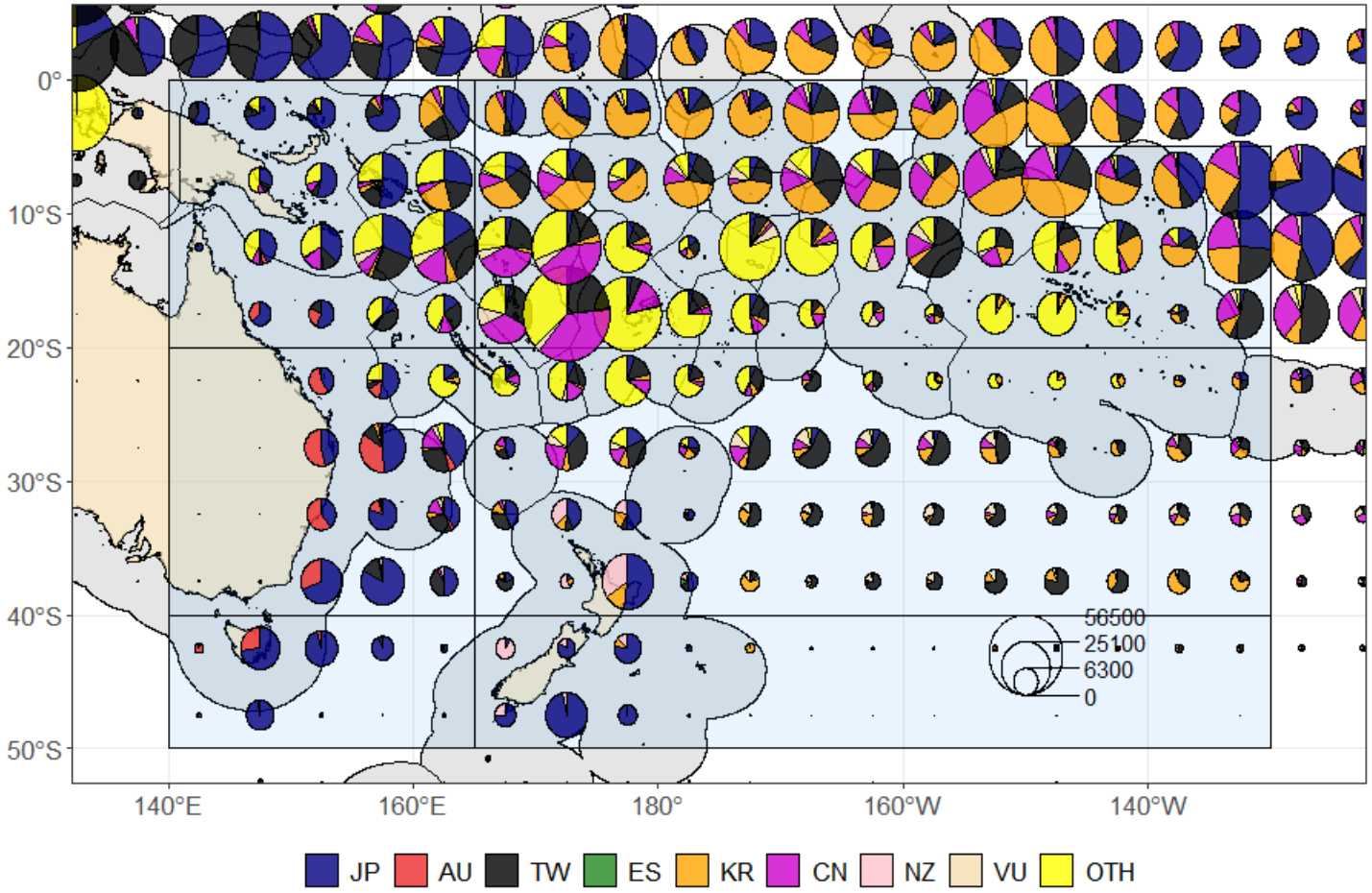


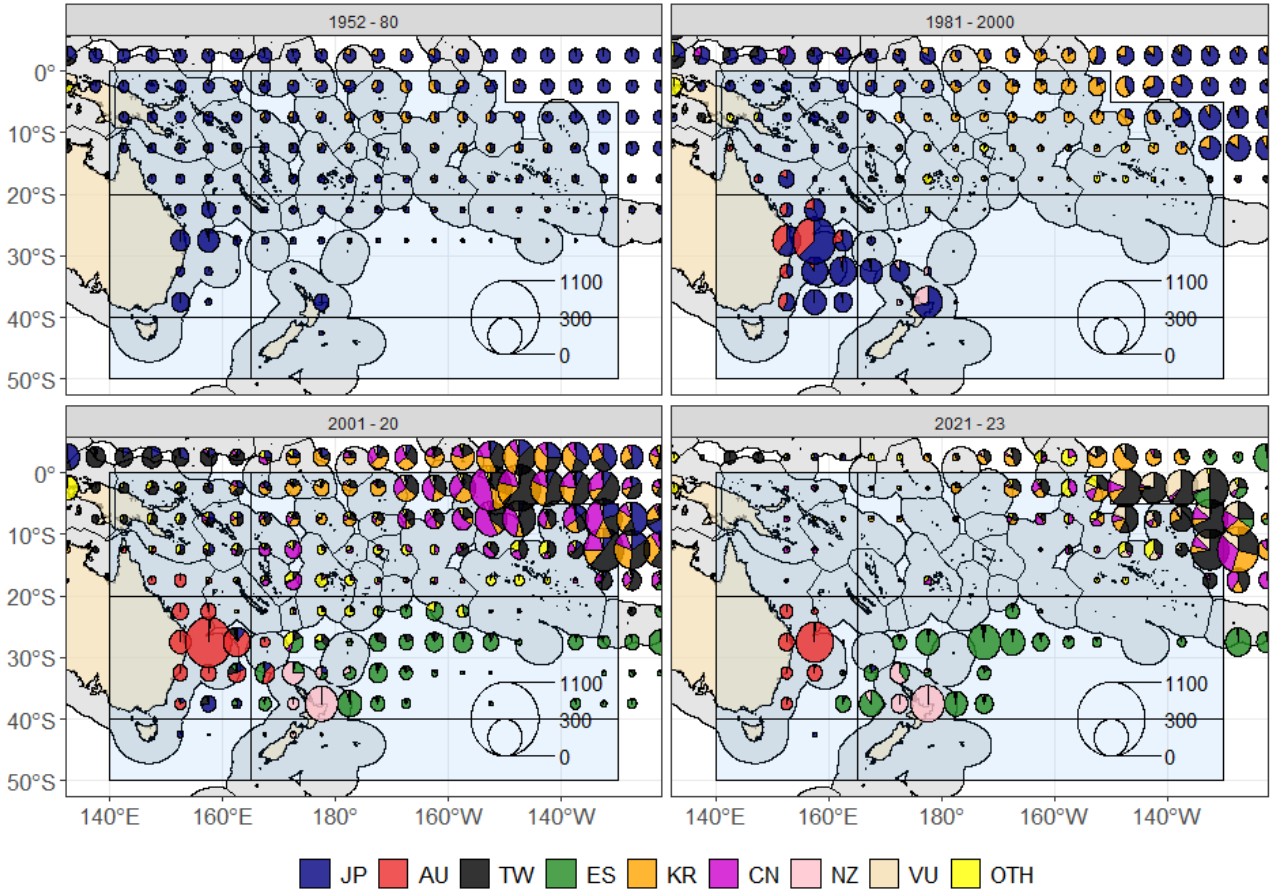
Data overview: Spatial catch by flag (single stock, 2 regions)



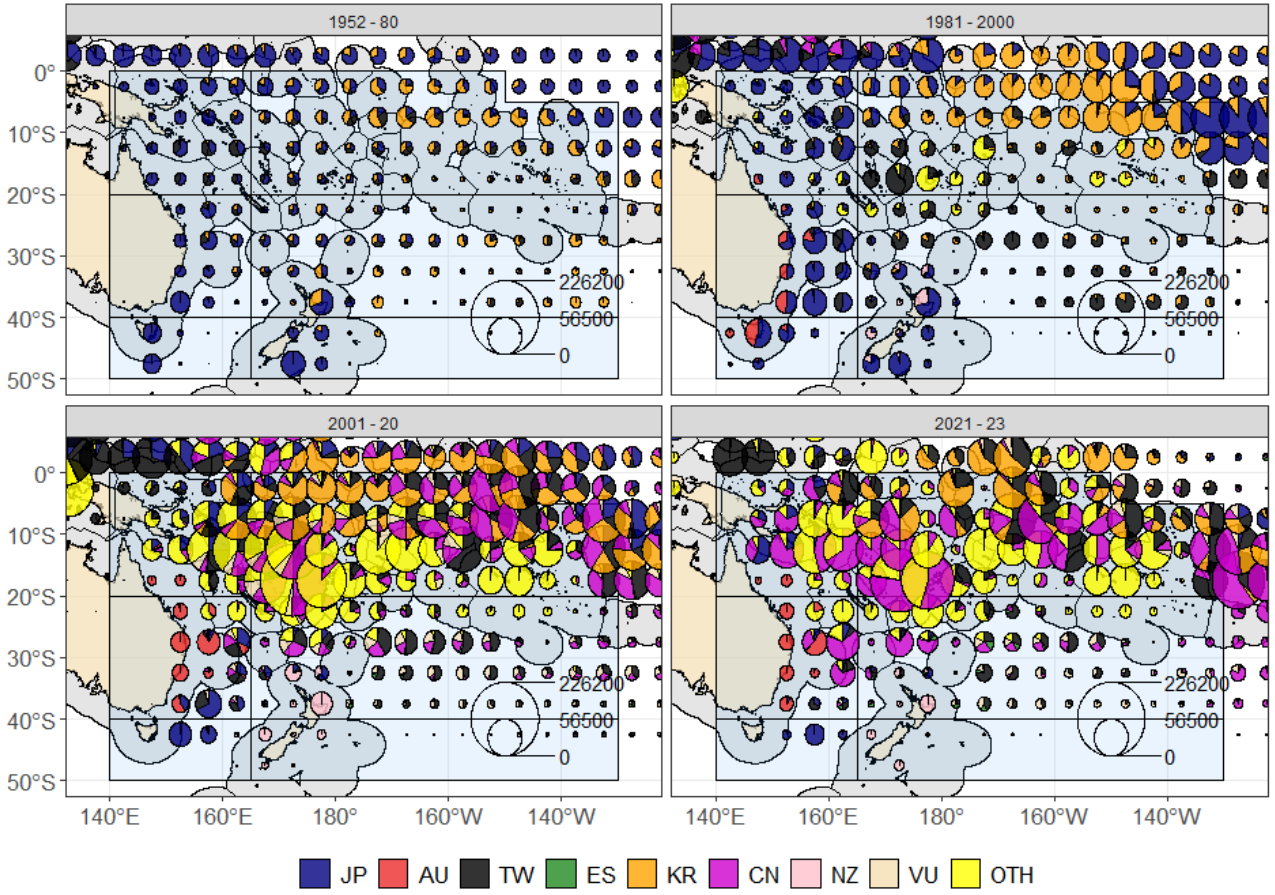
Data overview: Spatial effort by flag



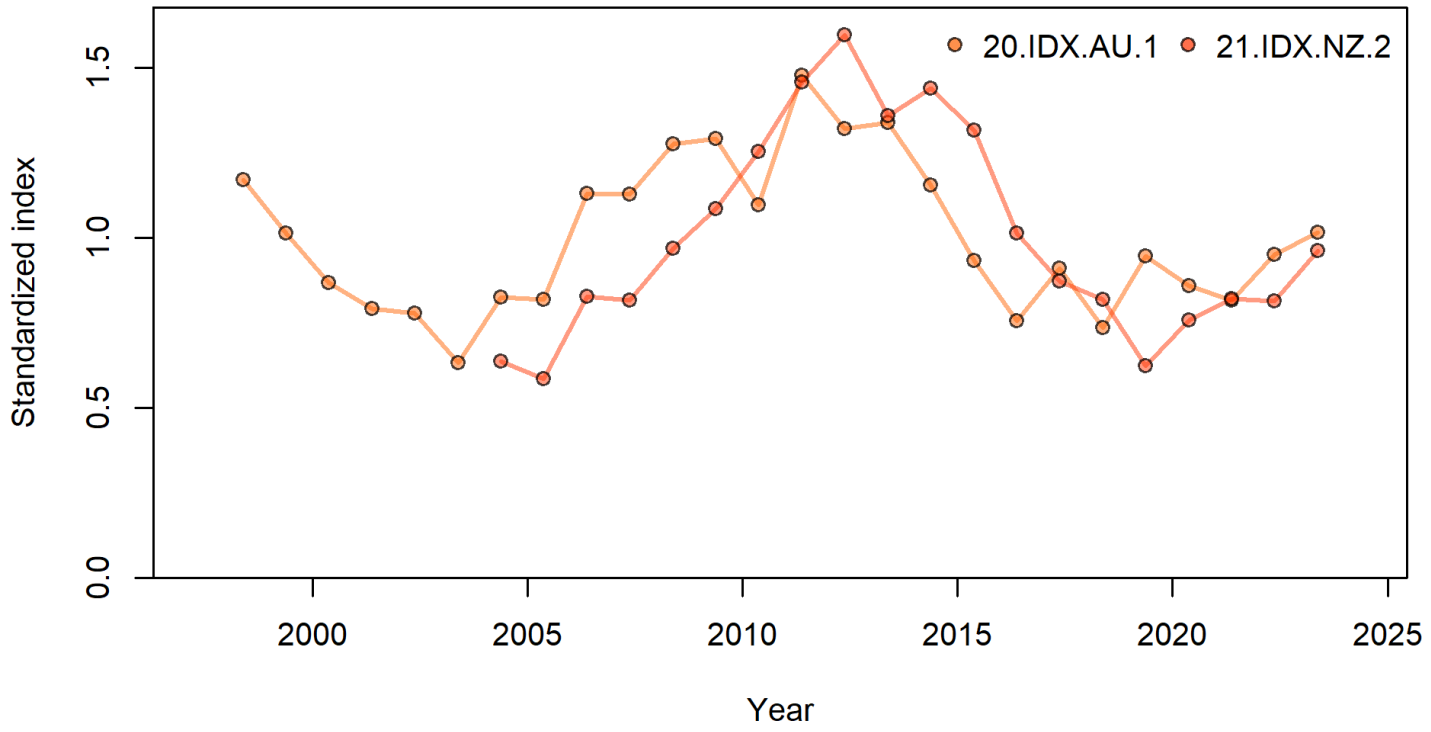
Data overview: Spatial catch by time period and by flag



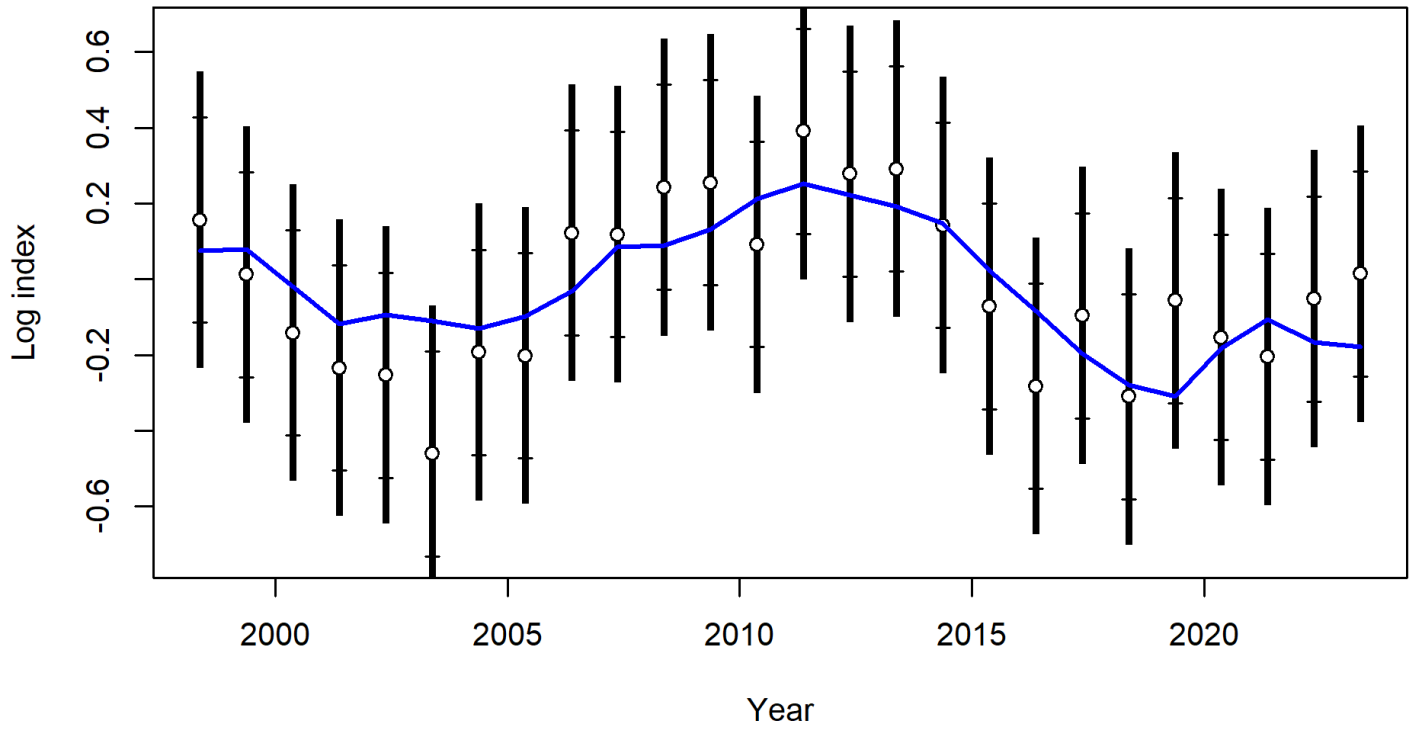
Data overview: Spatial effort by time period and by flag



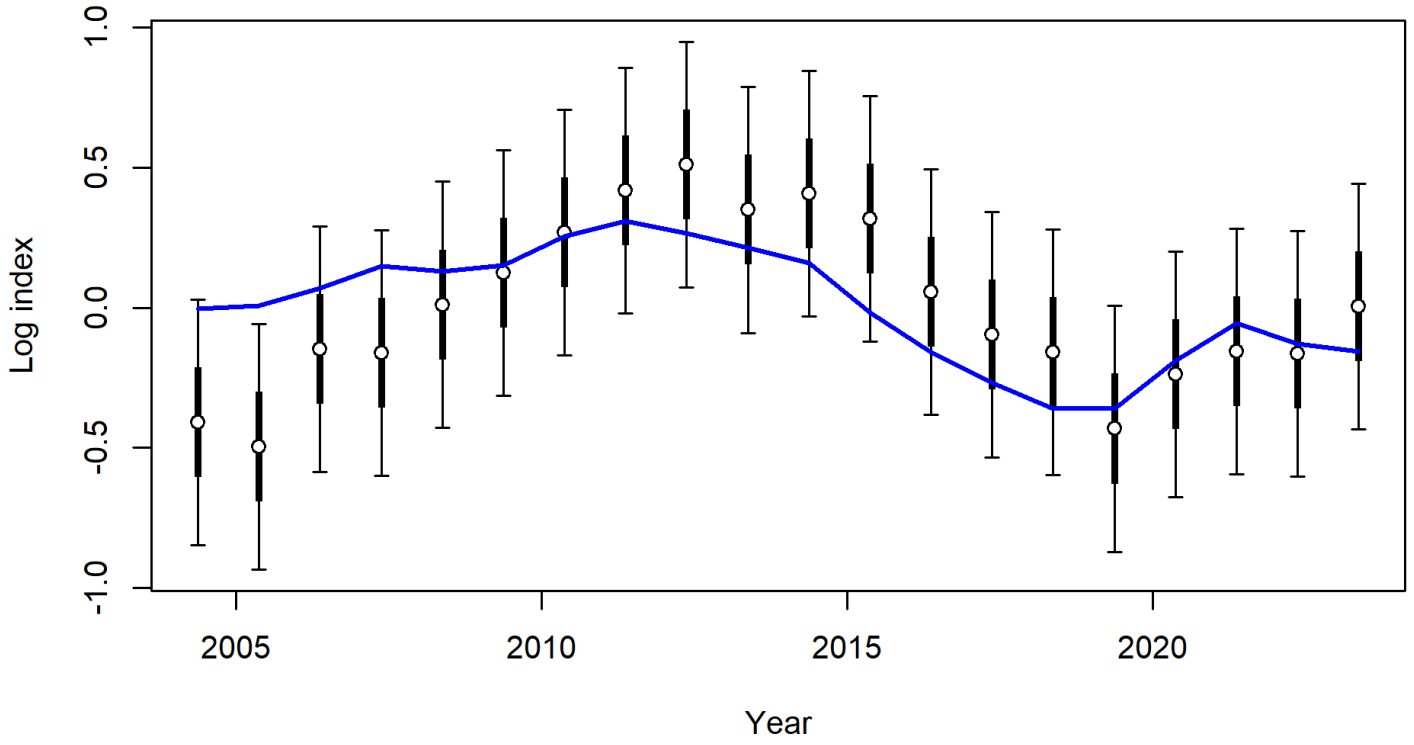
CPUE: Diagnostic model indices (AU + NZ)



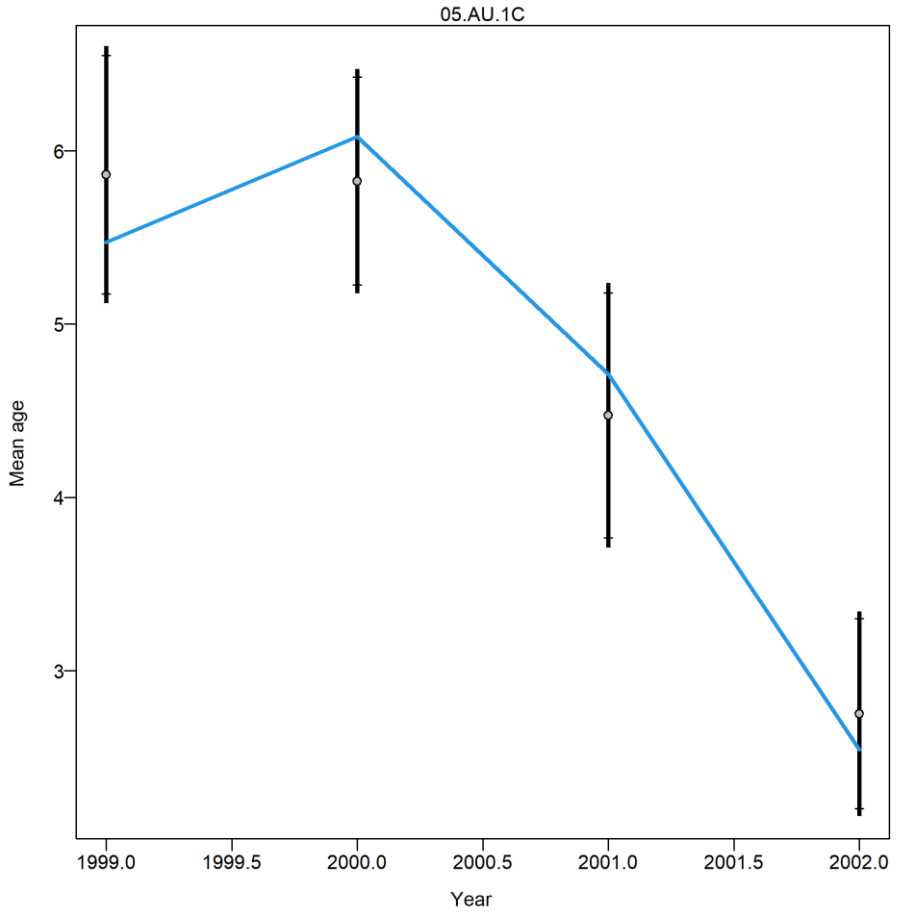
Fit to CPUE: Australian Index



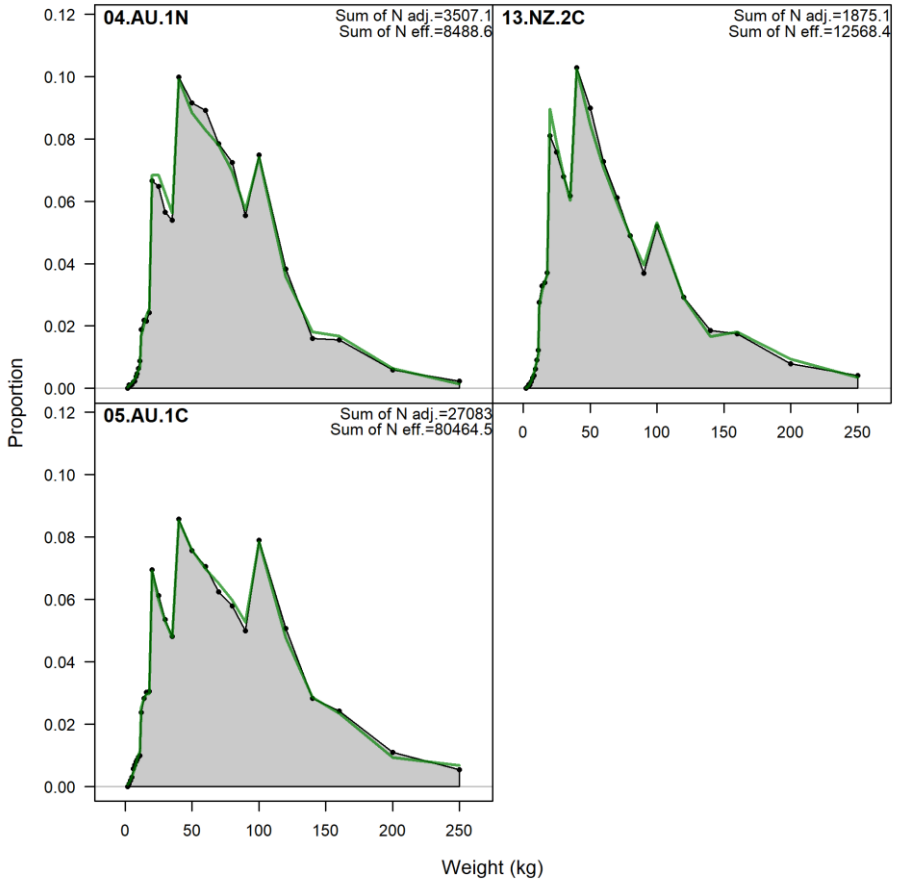
Fit to CPUE: New Zealand Index



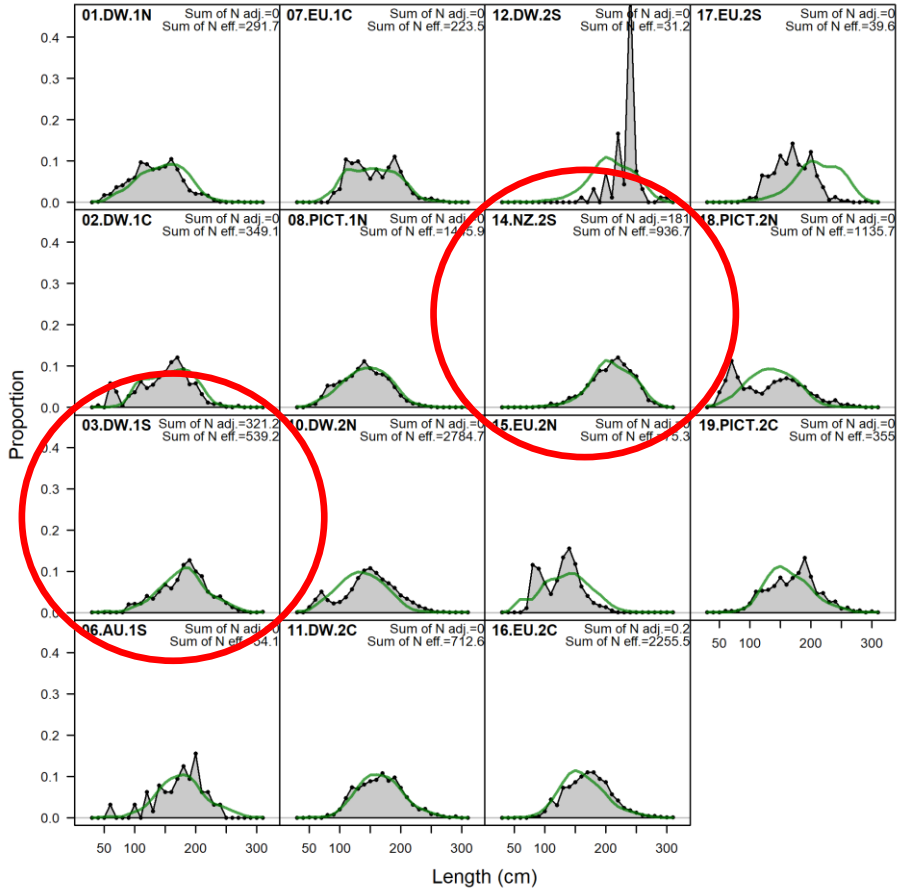
Fit to age data: Fishery 05.AU.1C



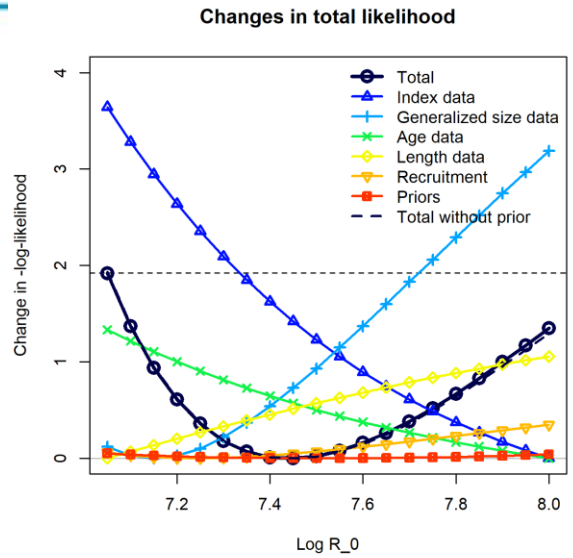
Fit to weight data: AU and NZ (a little punk)

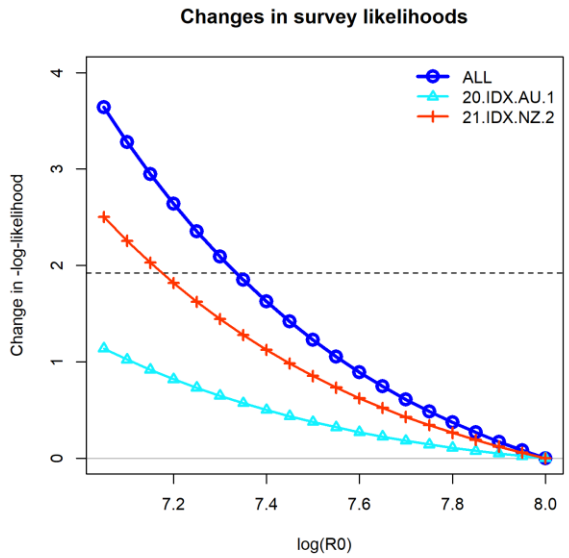


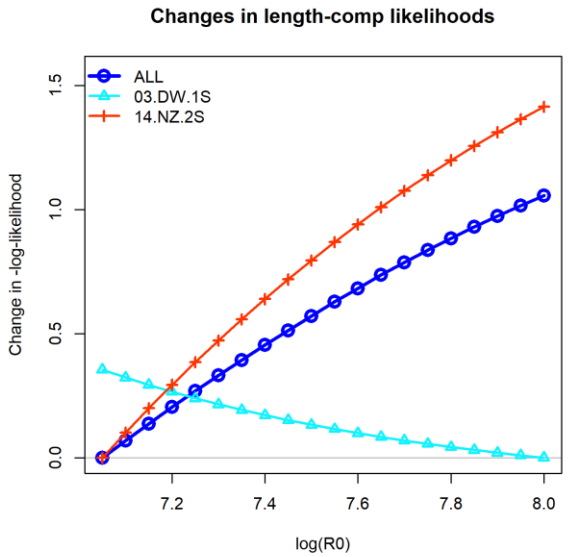
Fit to length data: Southern fisheries (1S and 2S)

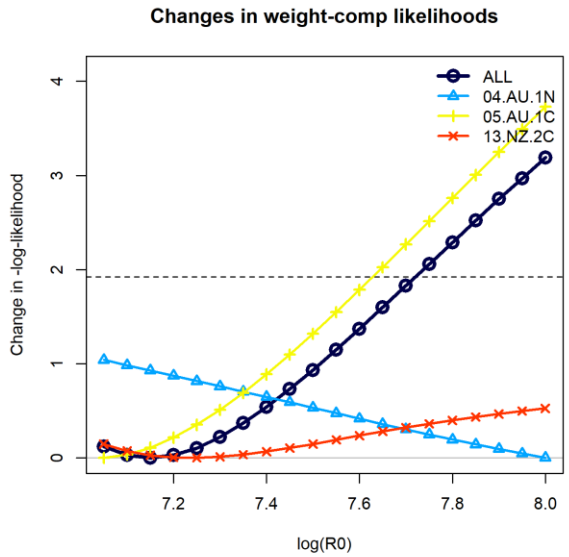


Likelihood profile: log (R_0)

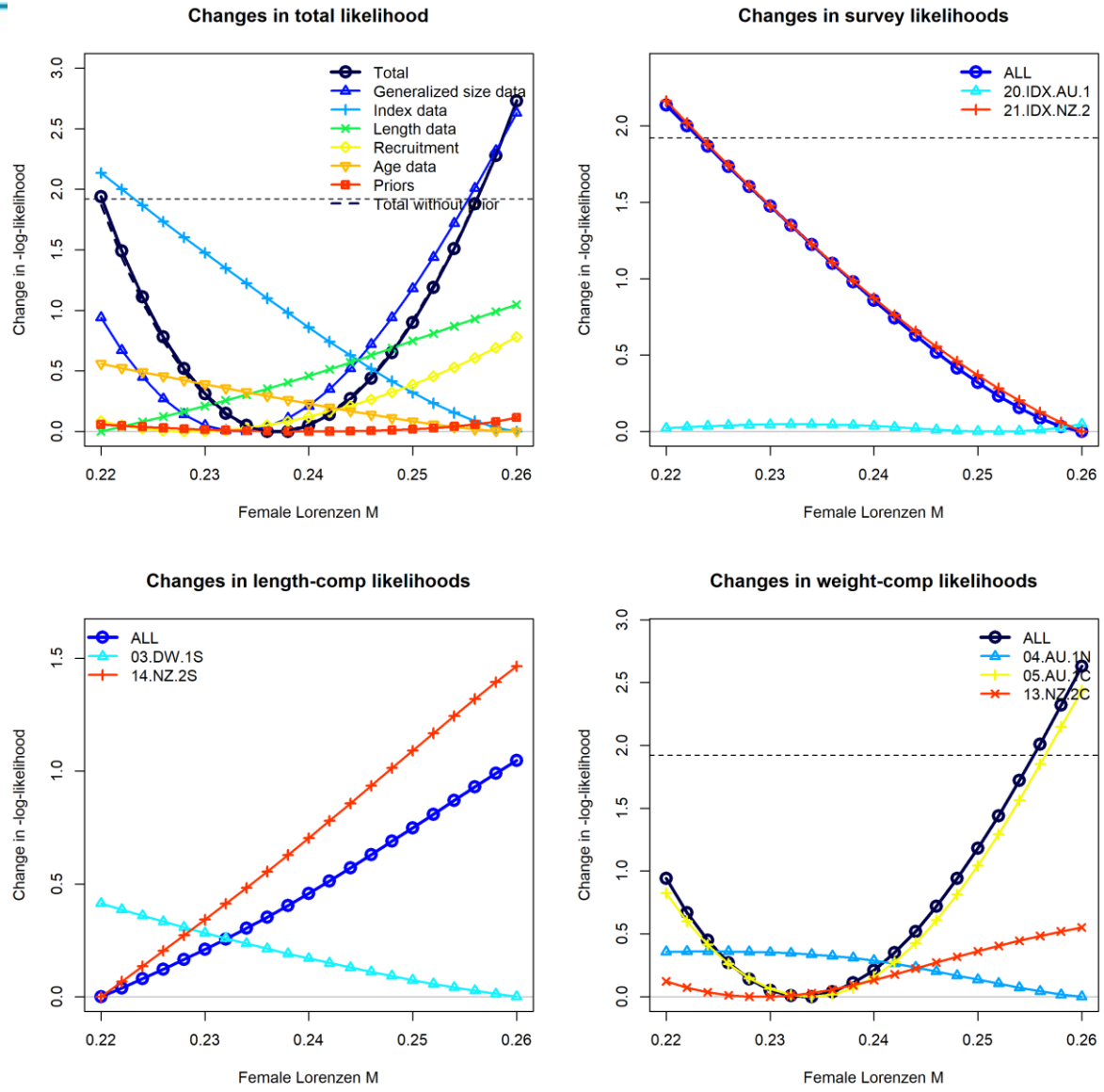




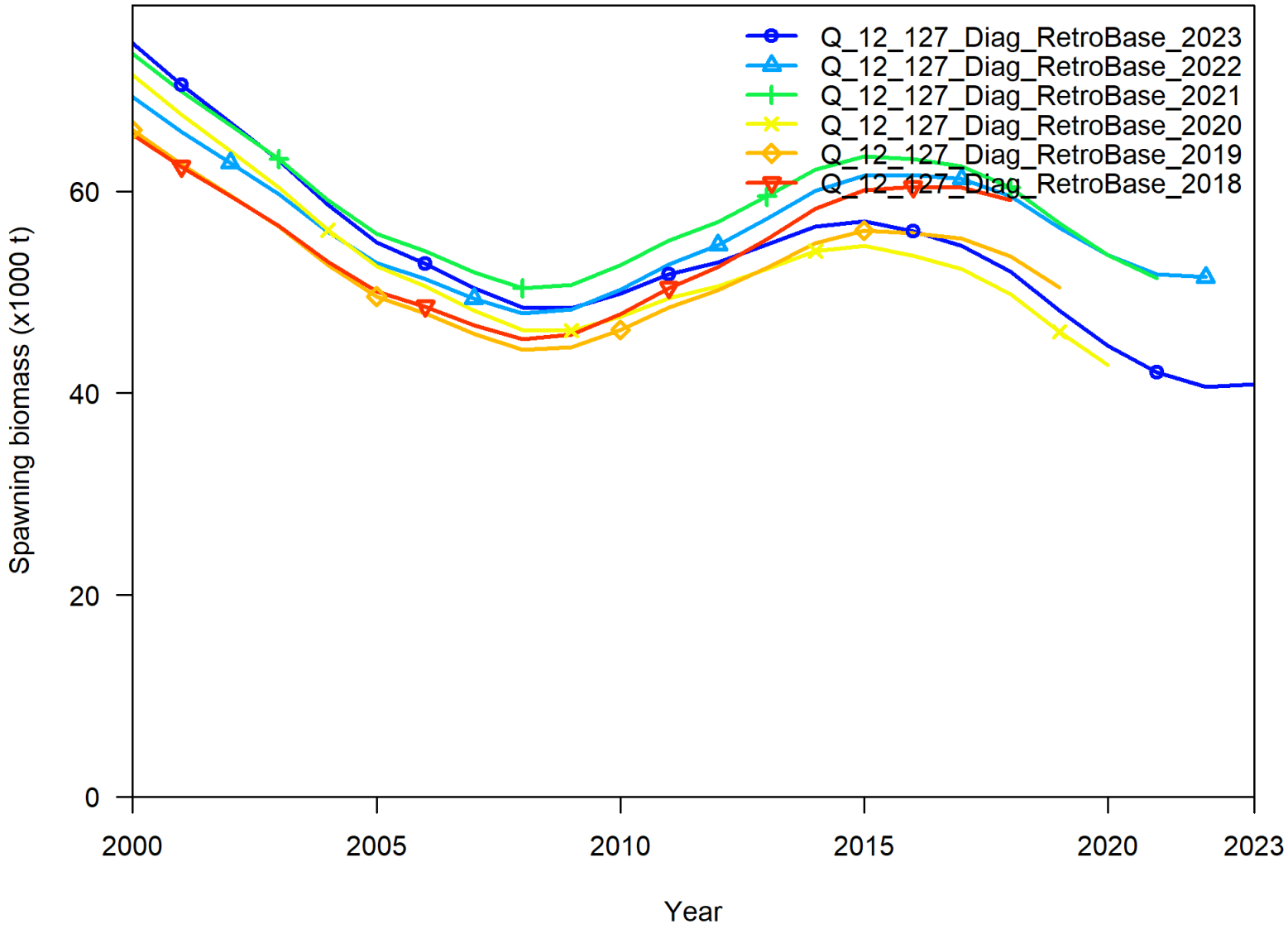




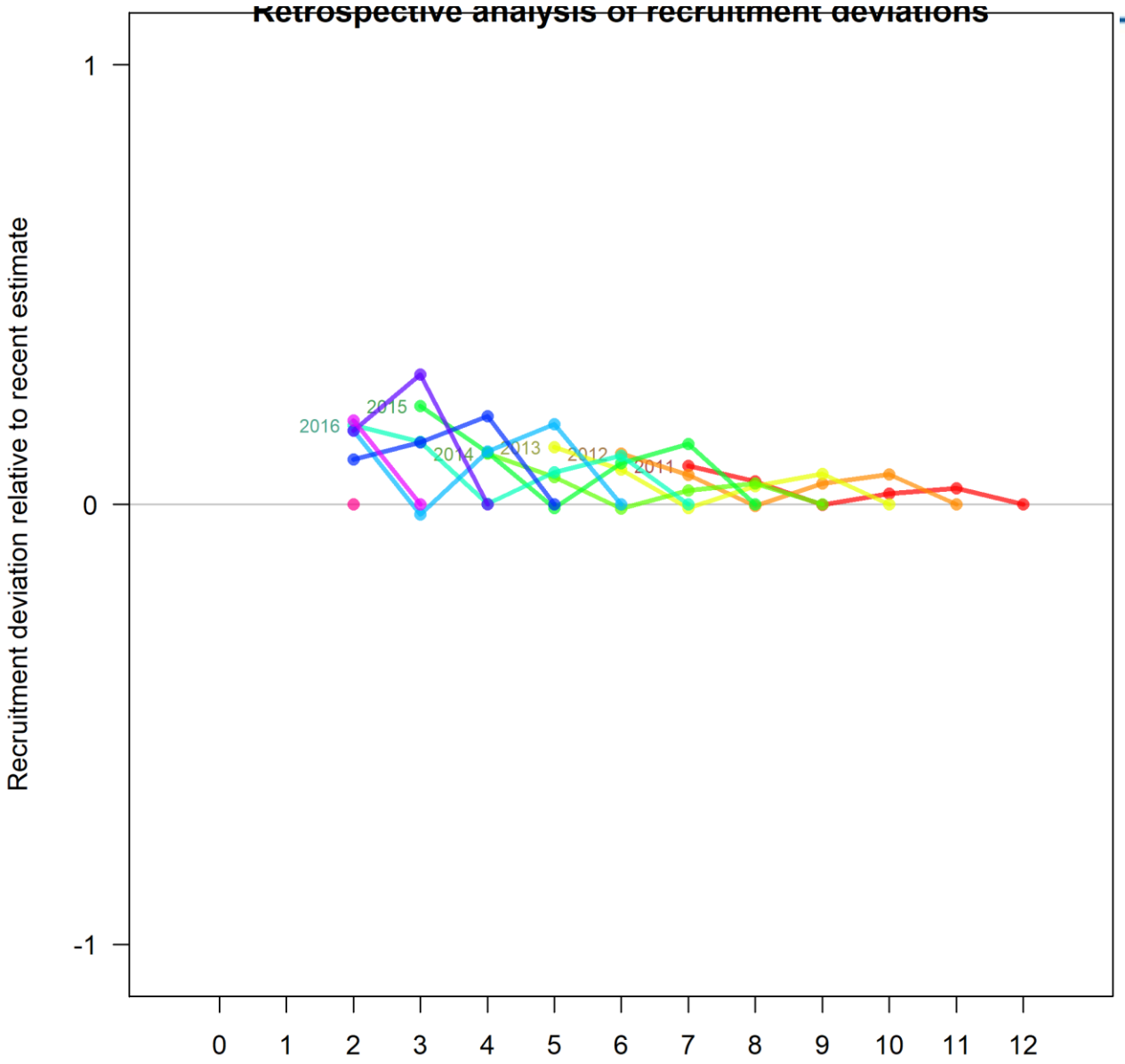
Likelihood profile: Natural mortality



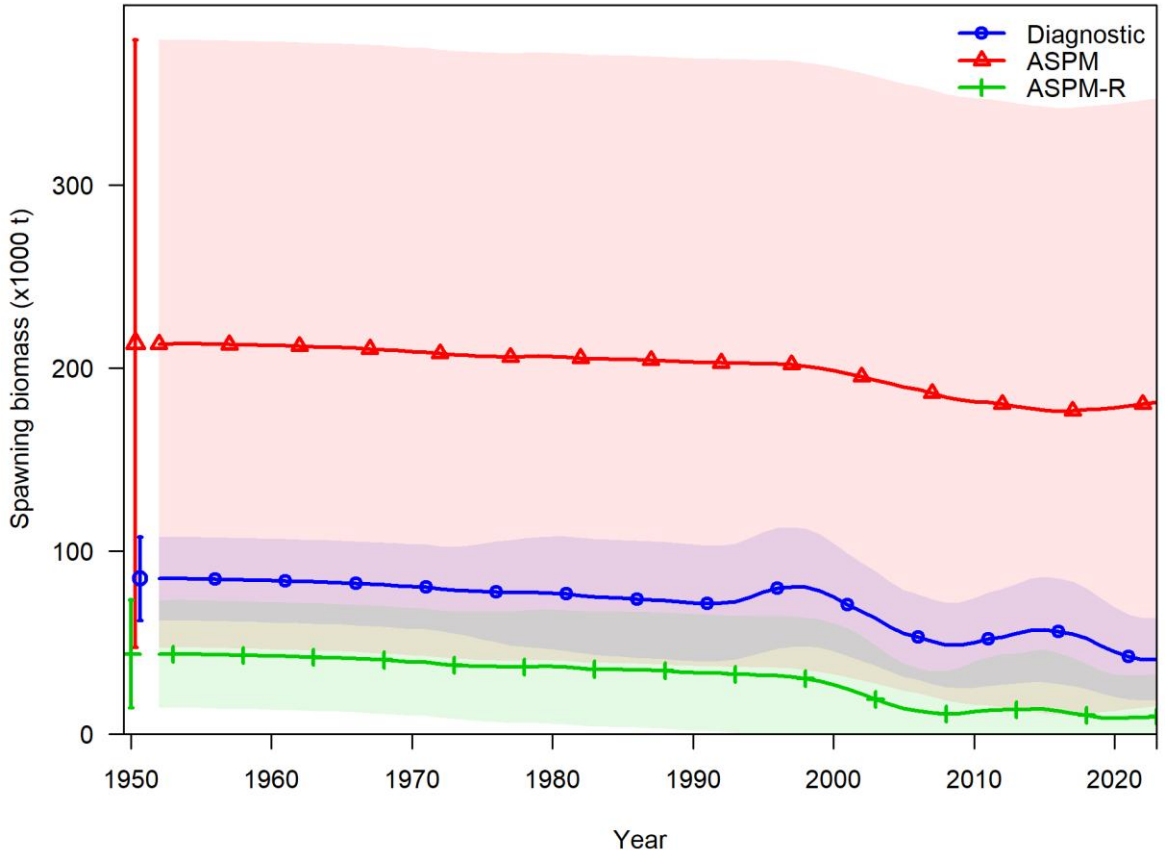
Retrospectives: Female spawning biomass



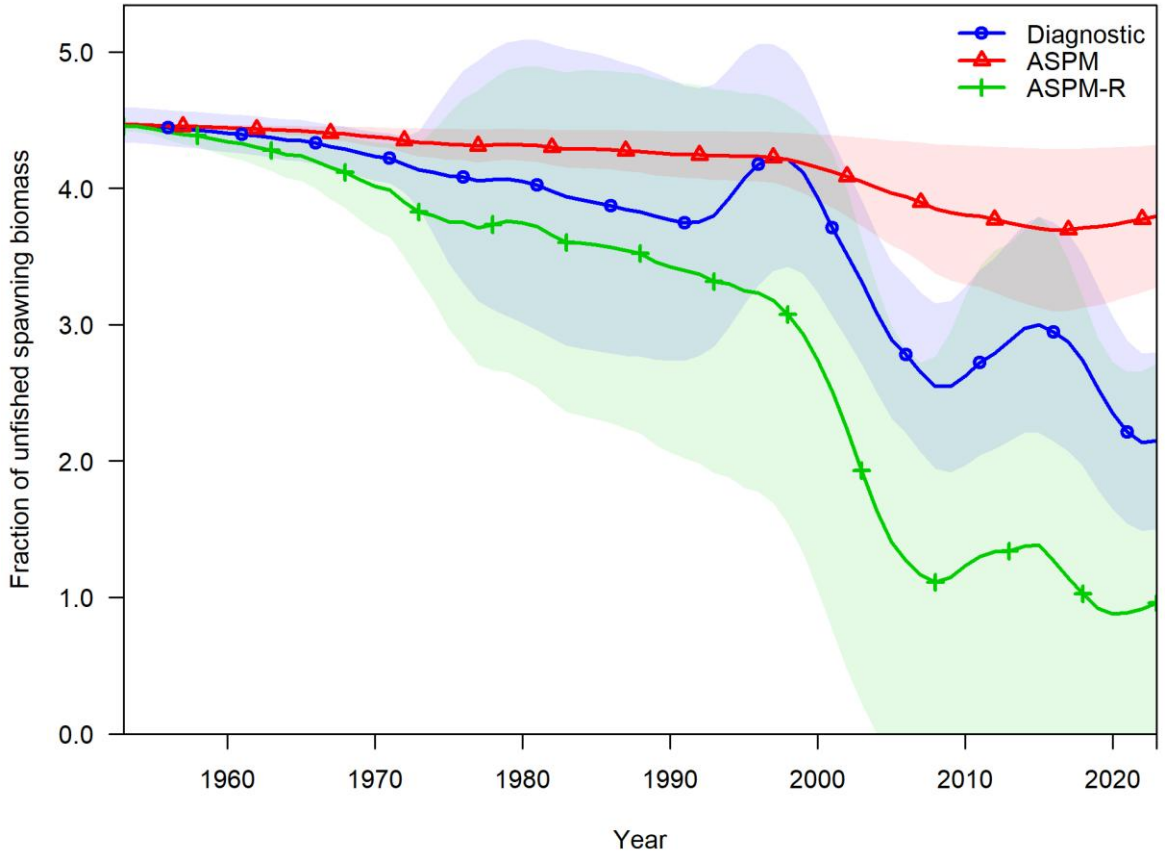
Retrospectives: Recruitment (squid plot)



ASPM: Female spawning biomass



ASPM: Relative spawning biomass (~depletion)



Structural uncertainty grid

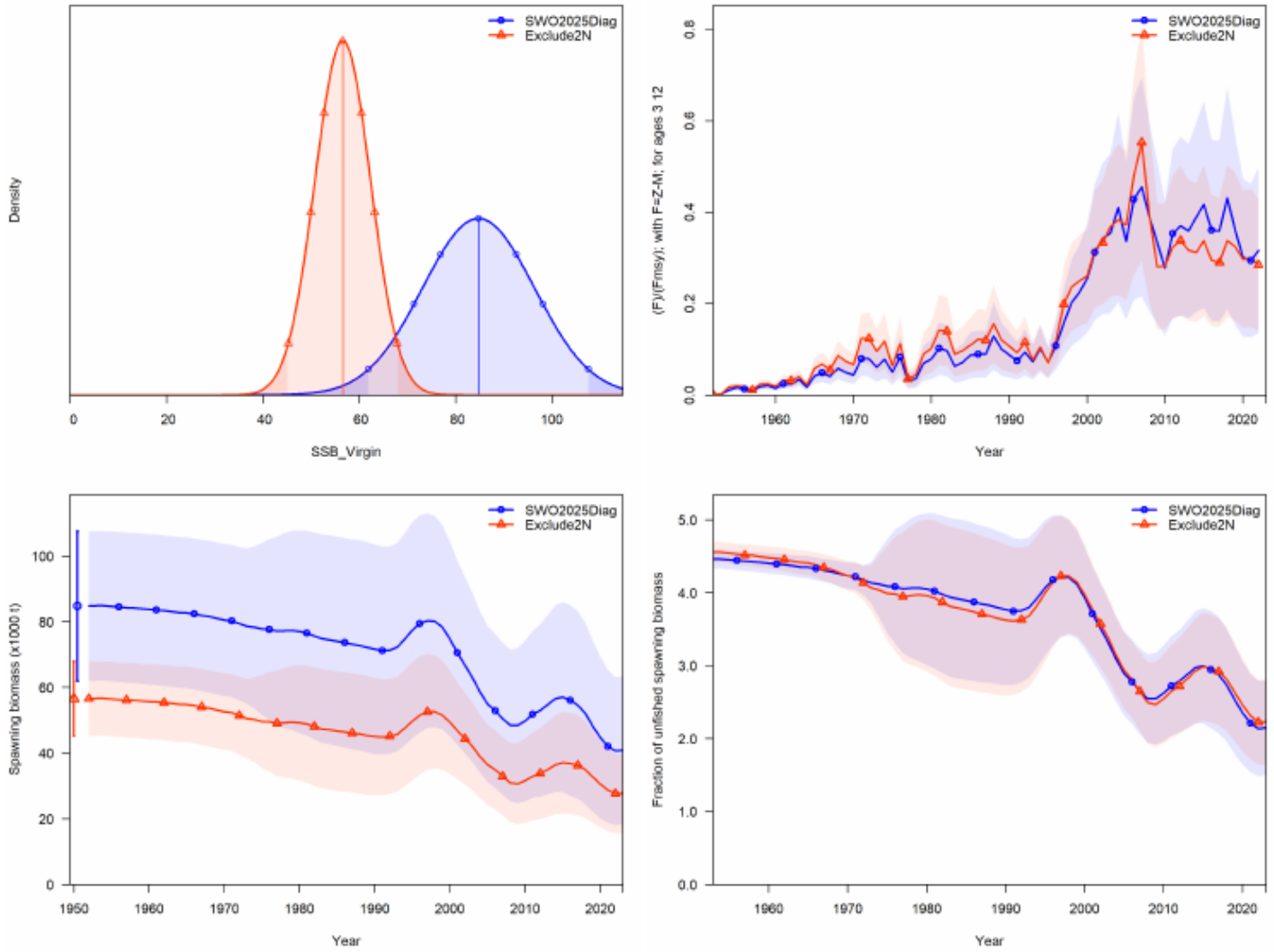
360 models: Most influential were steepness, mortality and data weighting (weight)
Compared to 2021: movement and mortality

Axis	Option 1	Option 2	Option 3	Option 4	Option 5
CPUE	**AU & NZ**	AU & PICT	AU & EU		
Steepness	0.7	**0.8**	0.9		
Prop recruit	**1:3**	1:4			
Movement	**diagnostic**	½ 1 -> 2	½ 2 -> 1		
Data weight	**Francis**	½ weight	2 x weight	½ length	2 x length
Mortality	estimated	fixed			

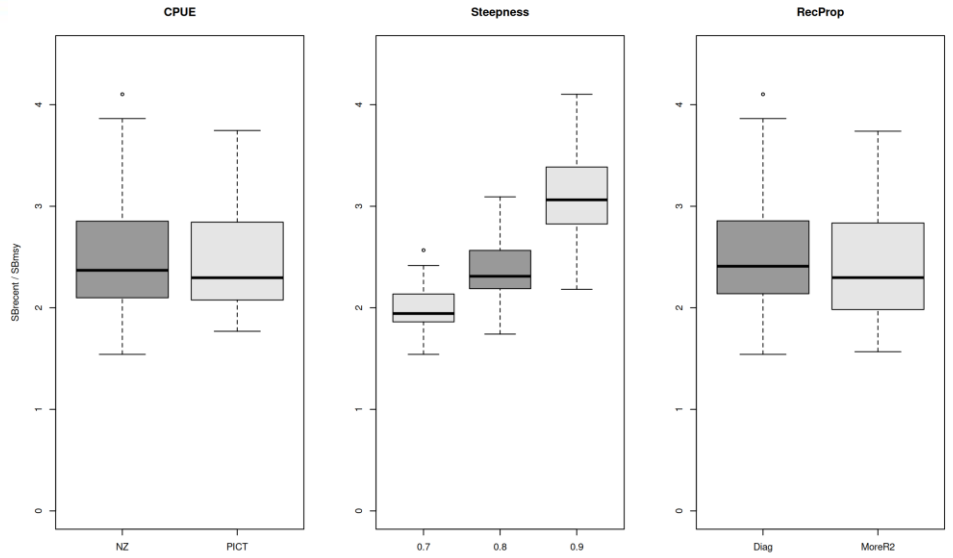
Additional sensitivities:

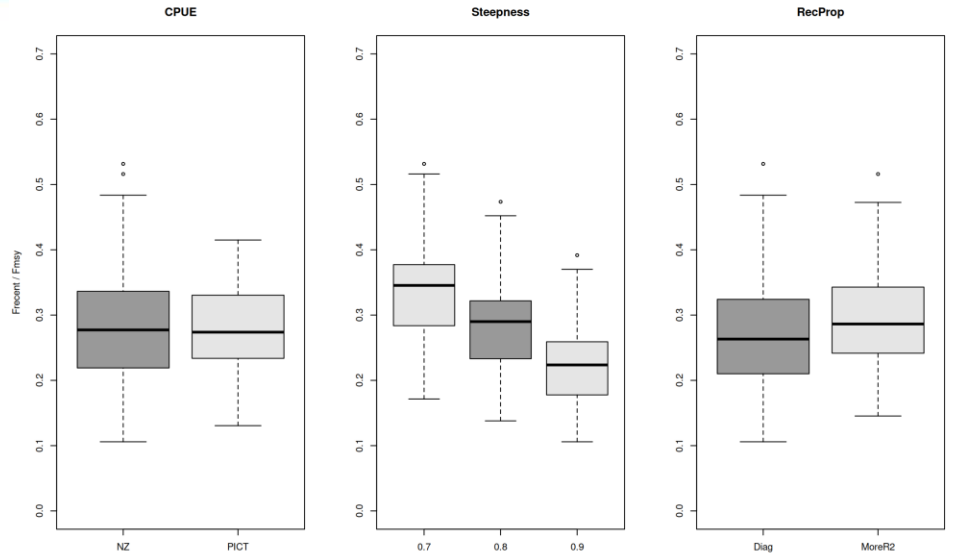
- EU index in region 2 (Fig 64. – very similar to diagnostic)
- Fixed (externally estimated) growth (Fig. 70 – implausible biomass estimates)
- Remove subregion 2N (Fig. 71 – deserves more attention!)

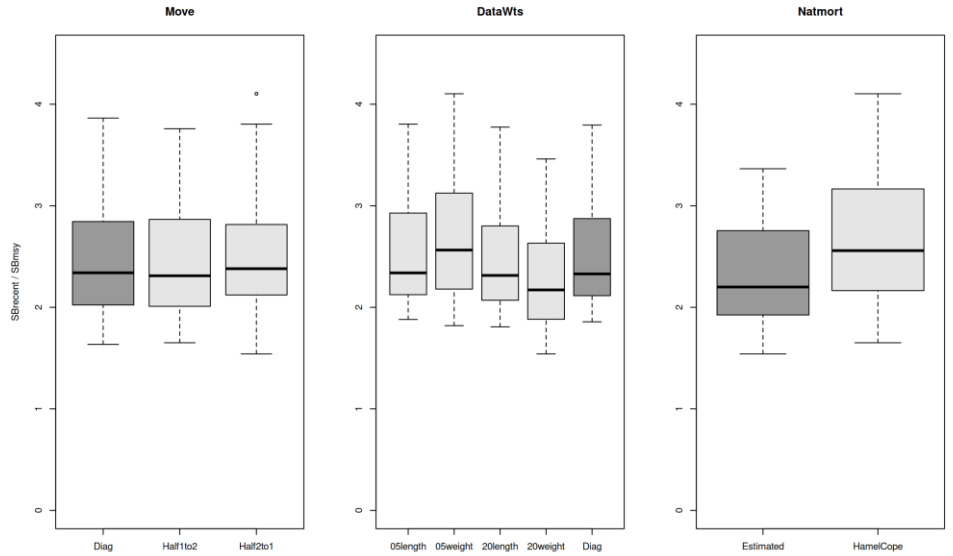
Sensitivity: Exclude subregion 2N

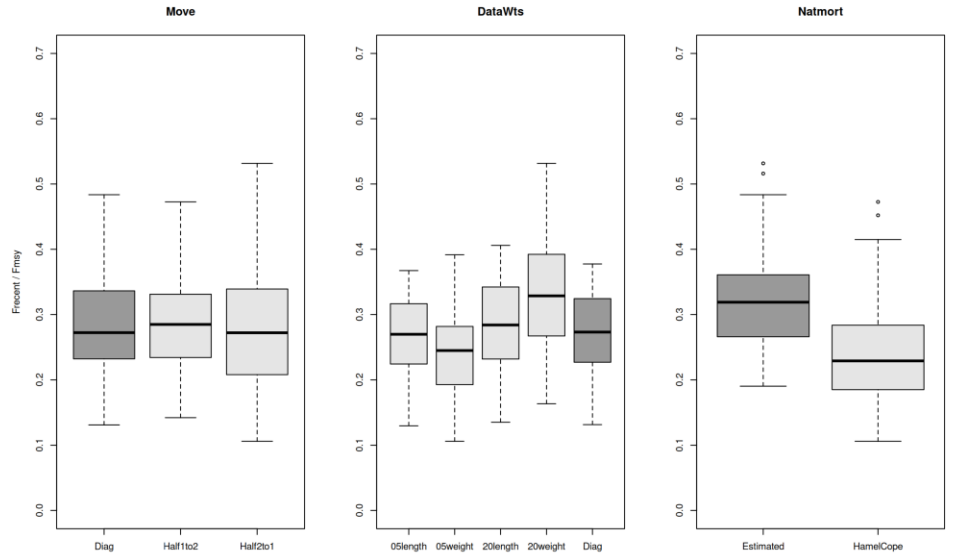


Structural uncertainty grid: Results by grid axis

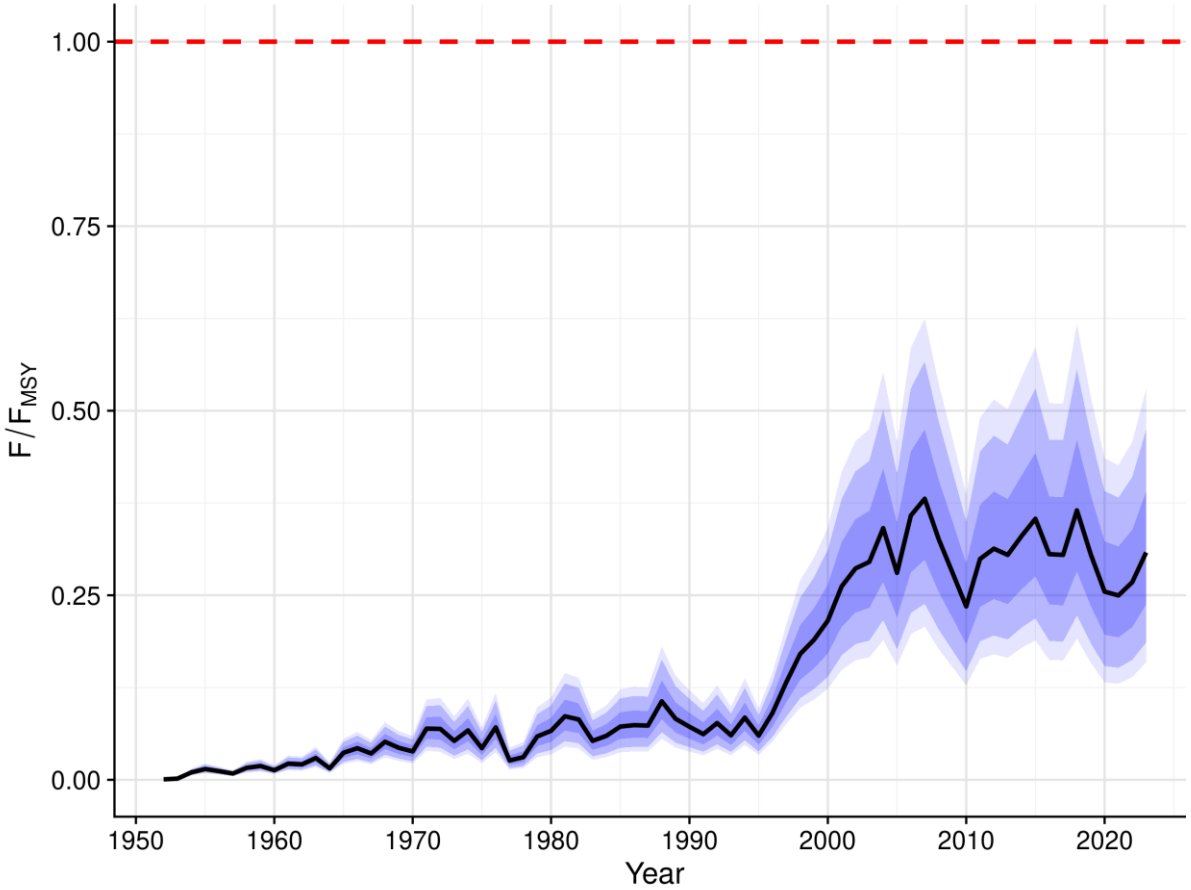


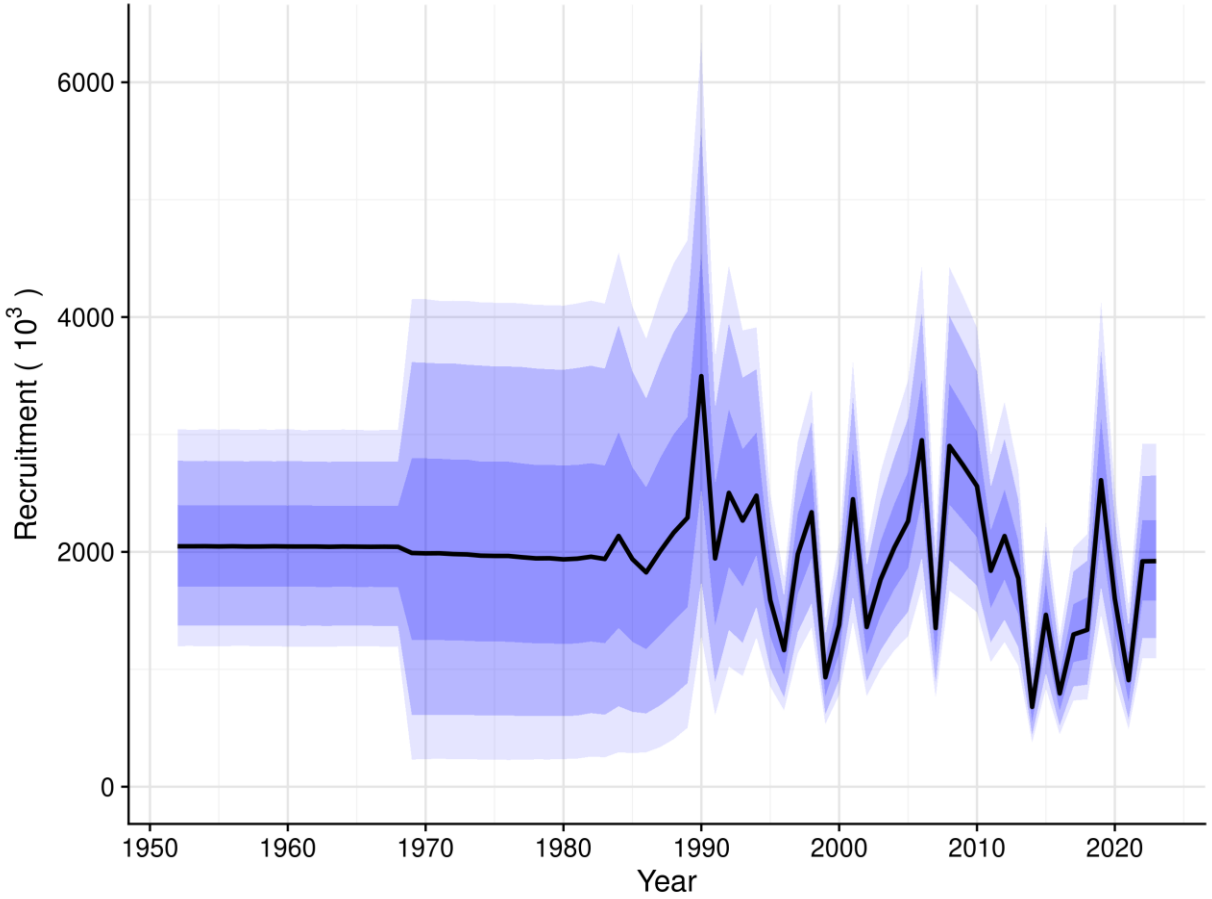






Structural uncertainty grid: with estimation error





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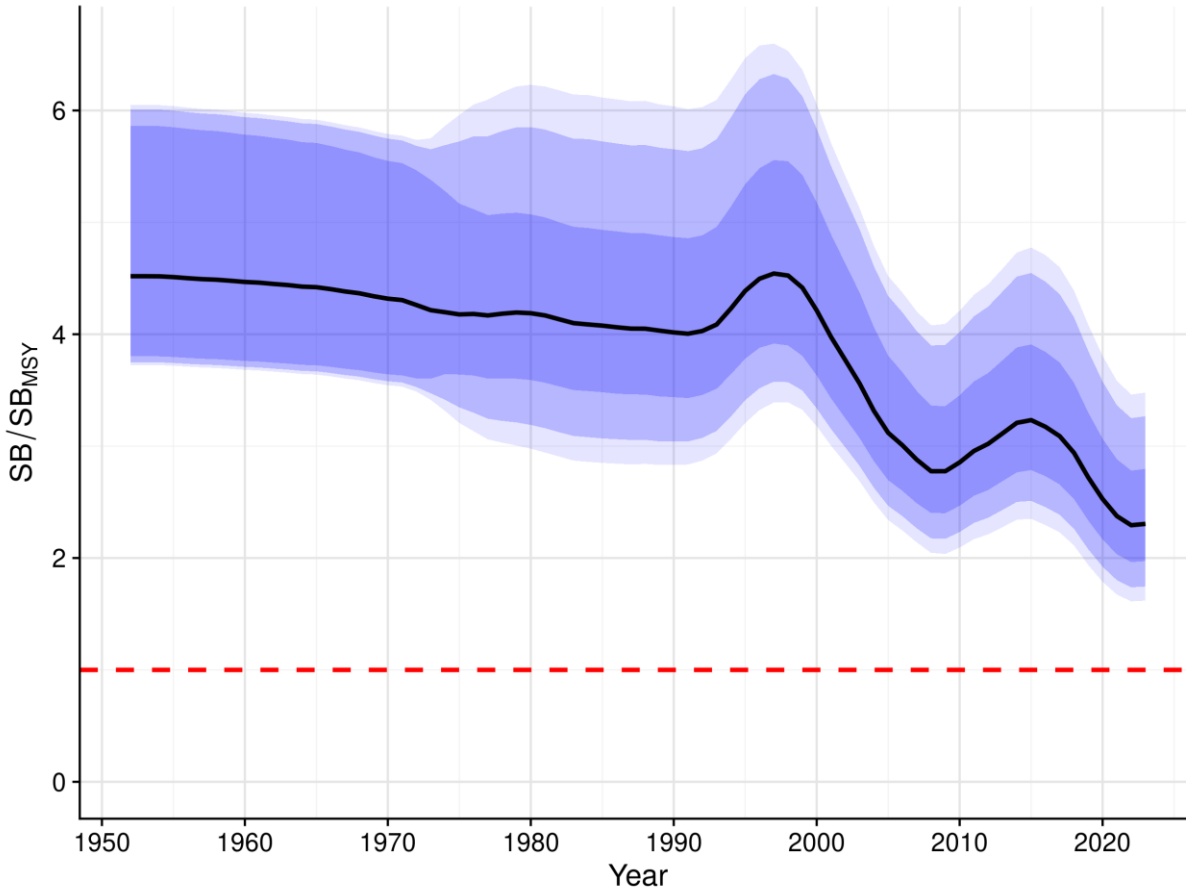
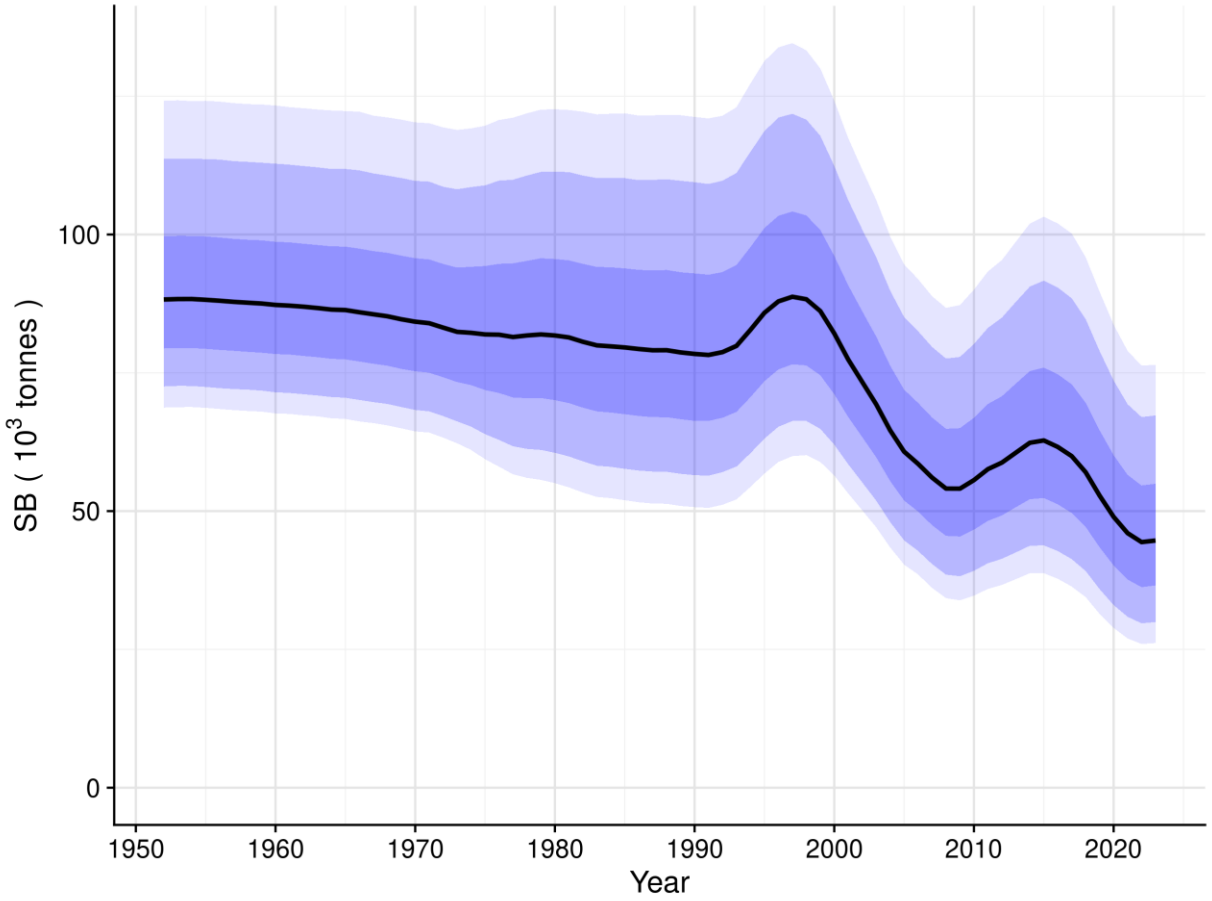
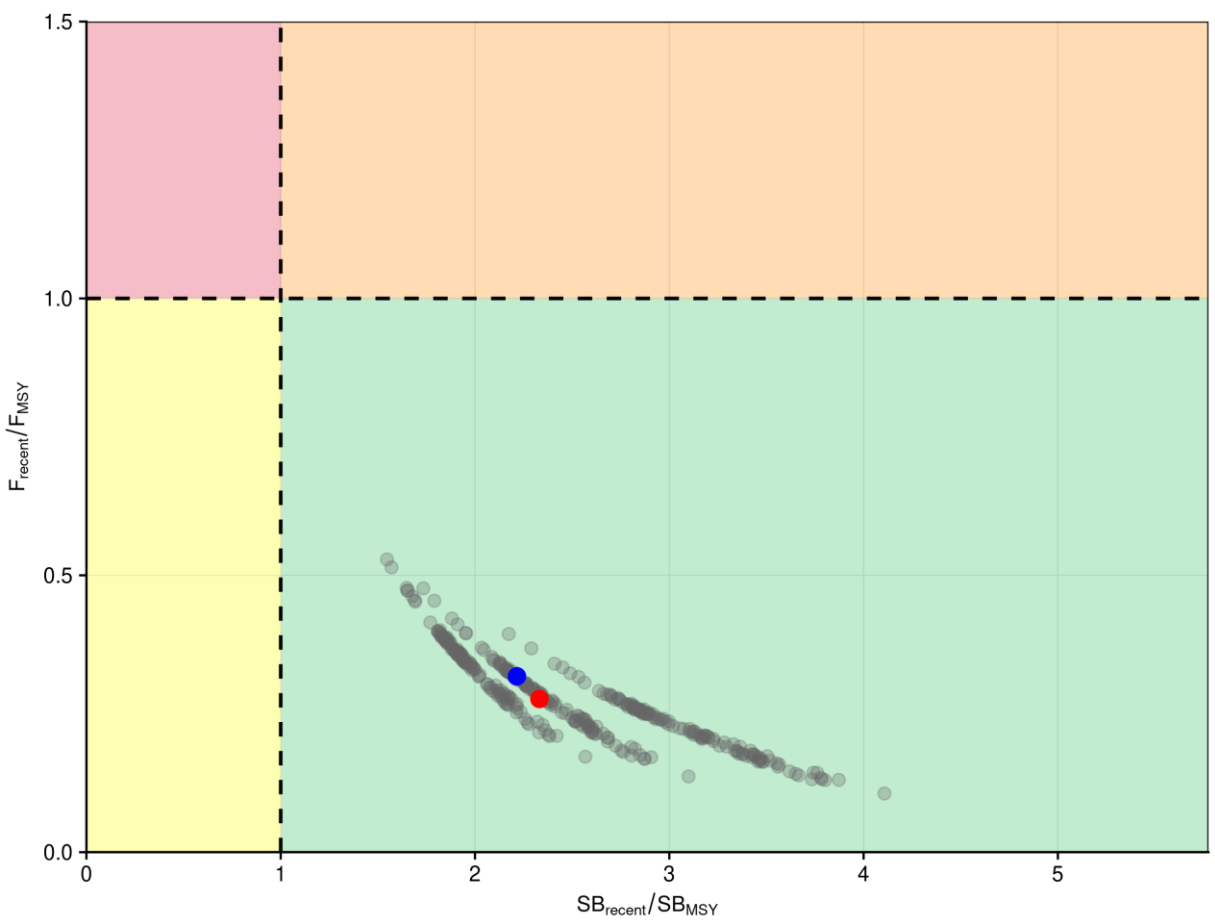
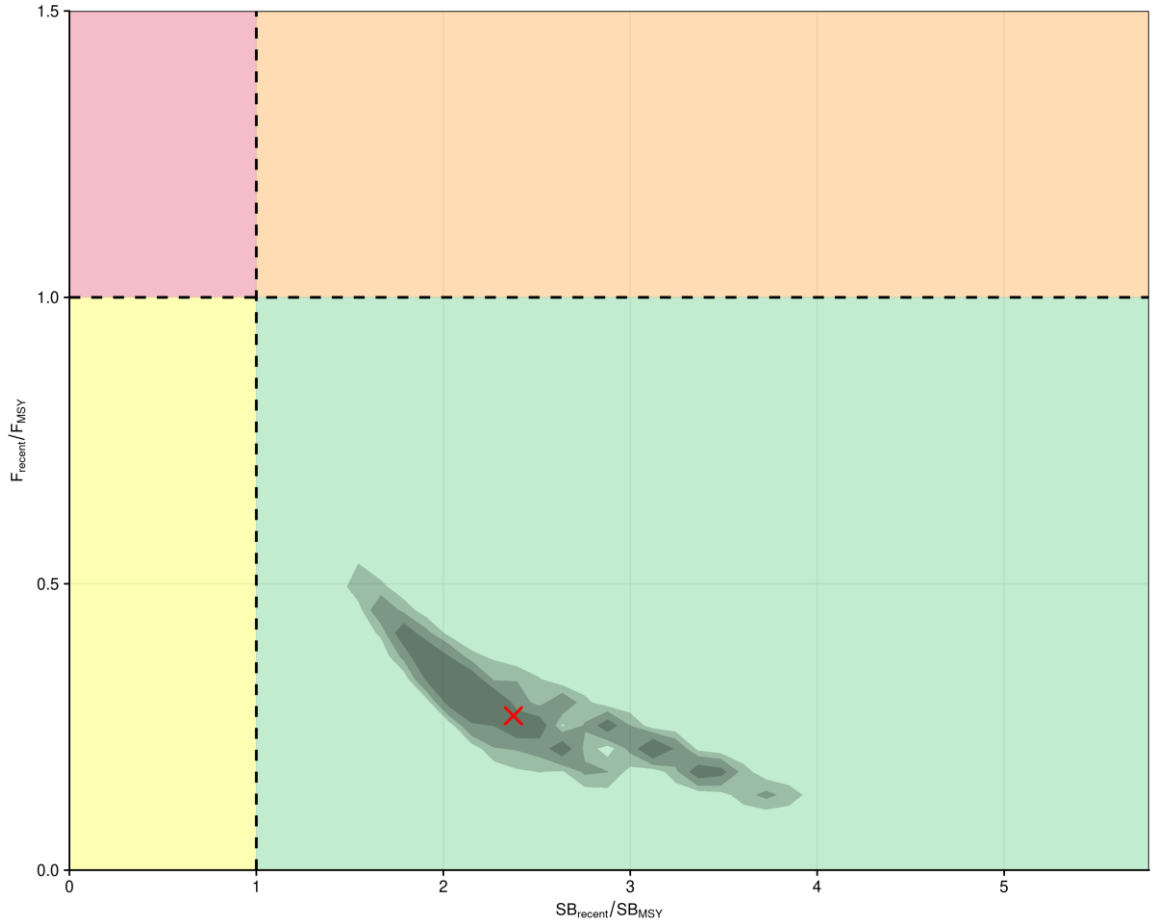


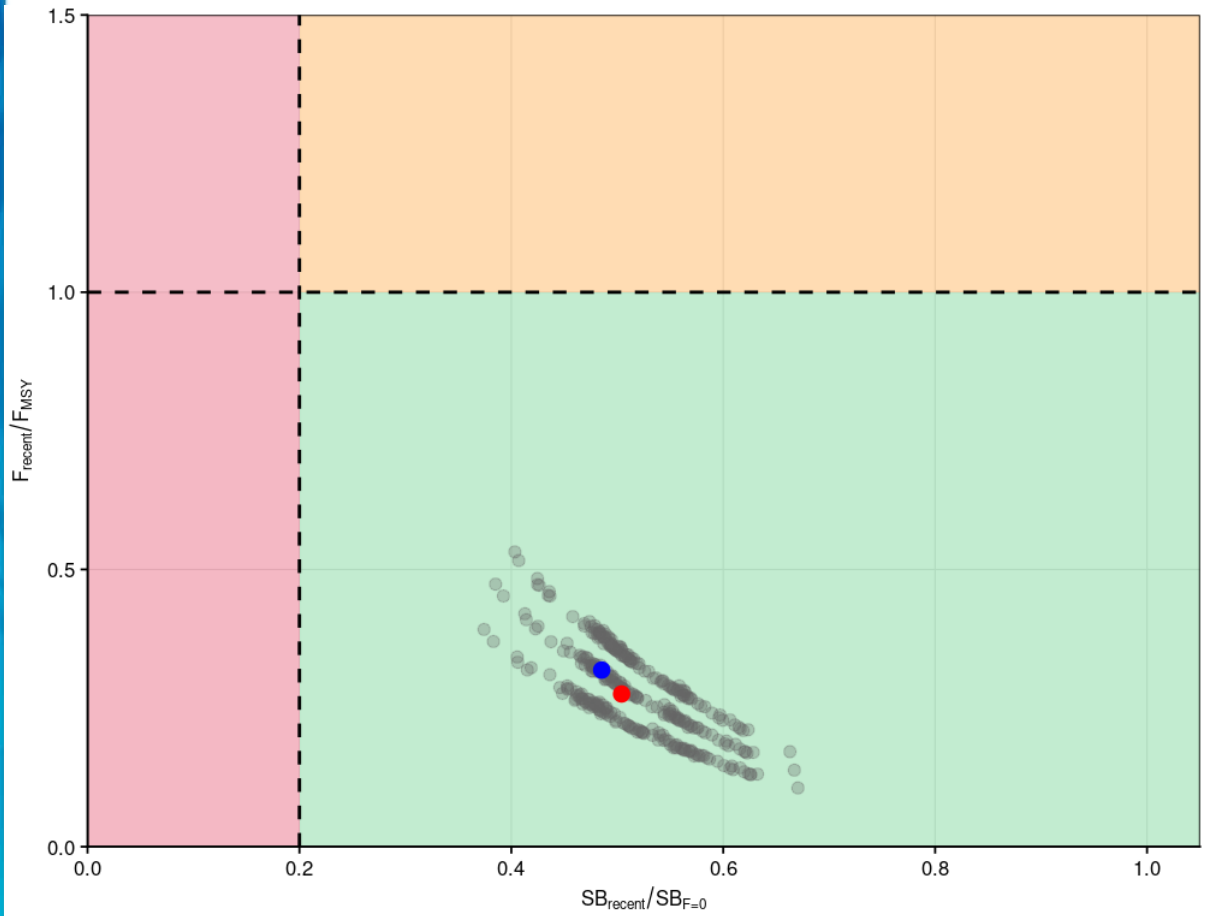


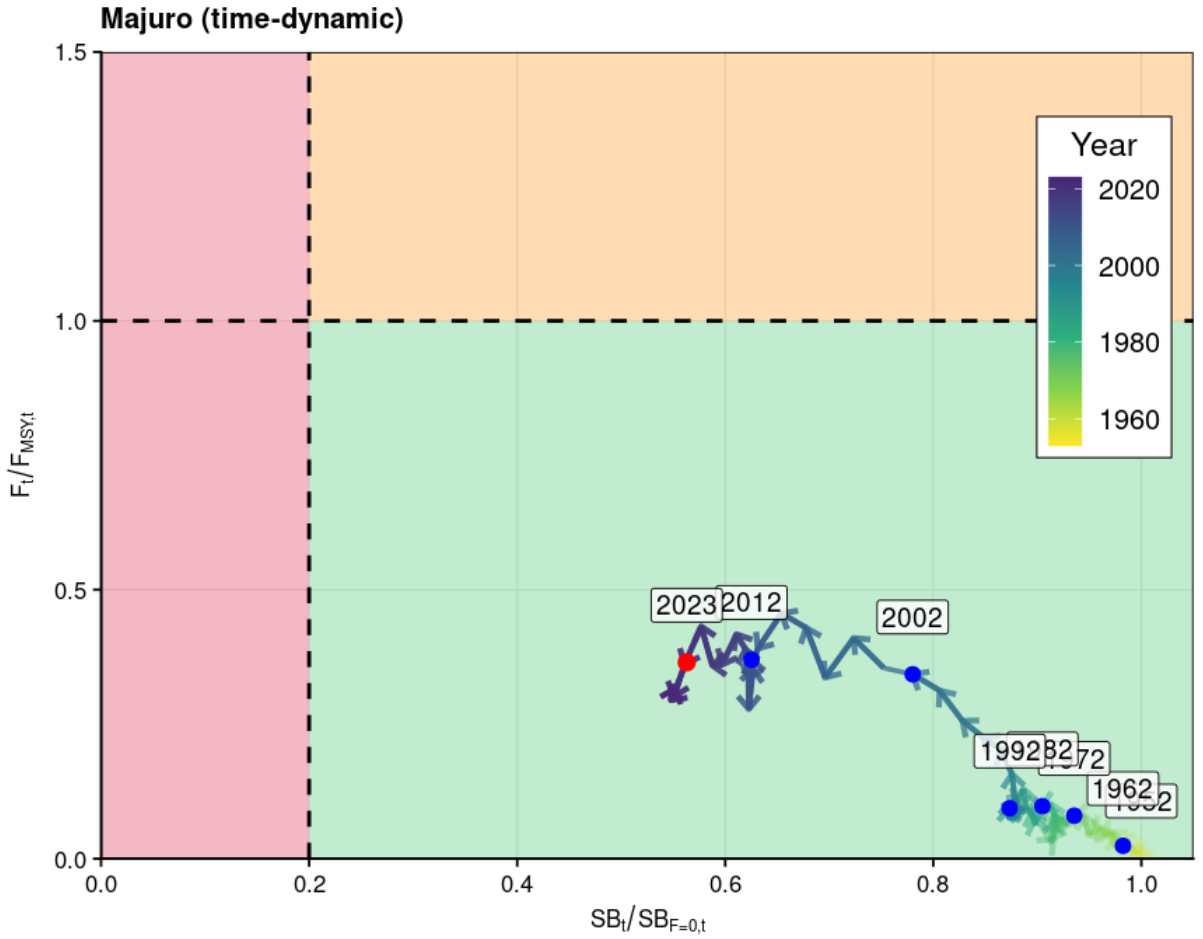
Structural uncertainty grid: Kobe plots



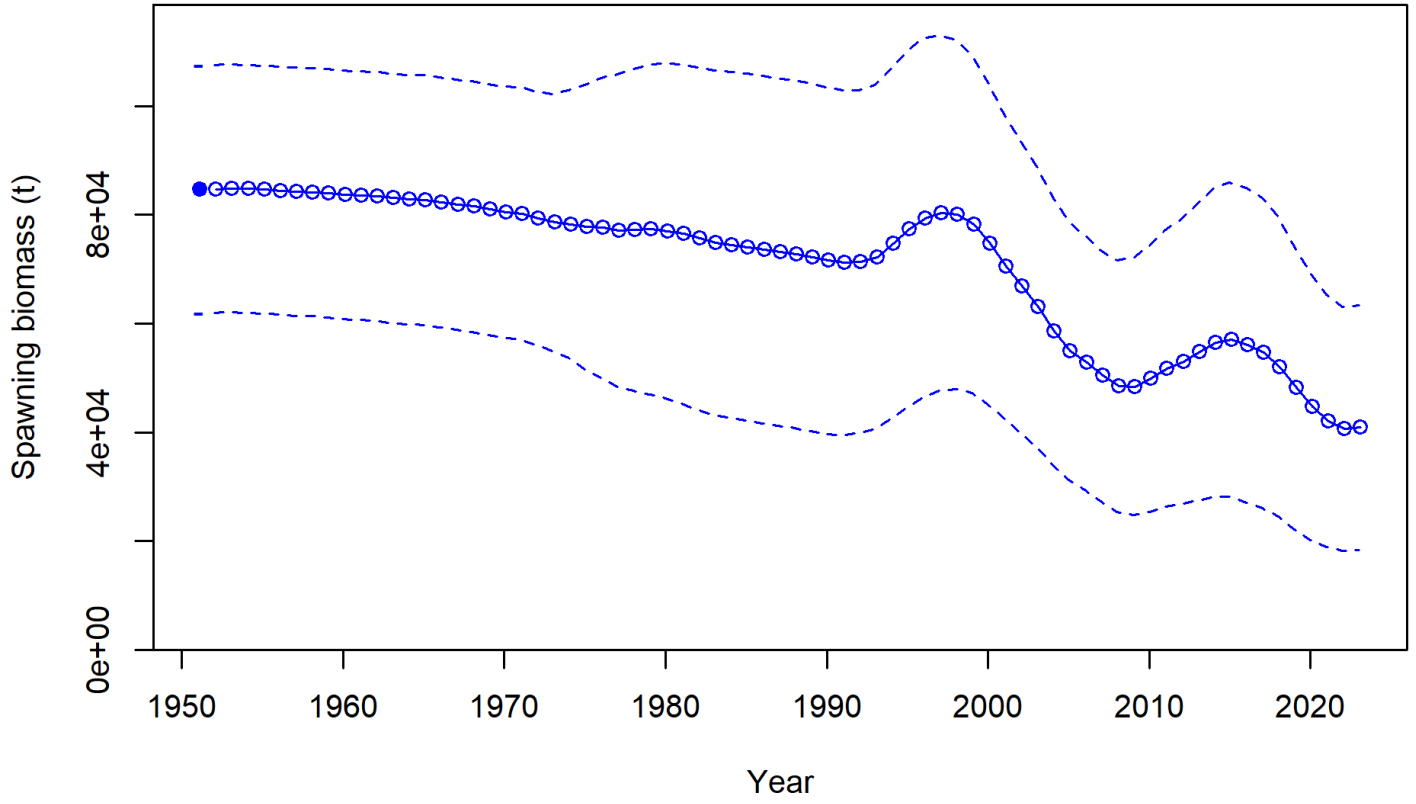


Structural uncertainty grid: Majuro plots

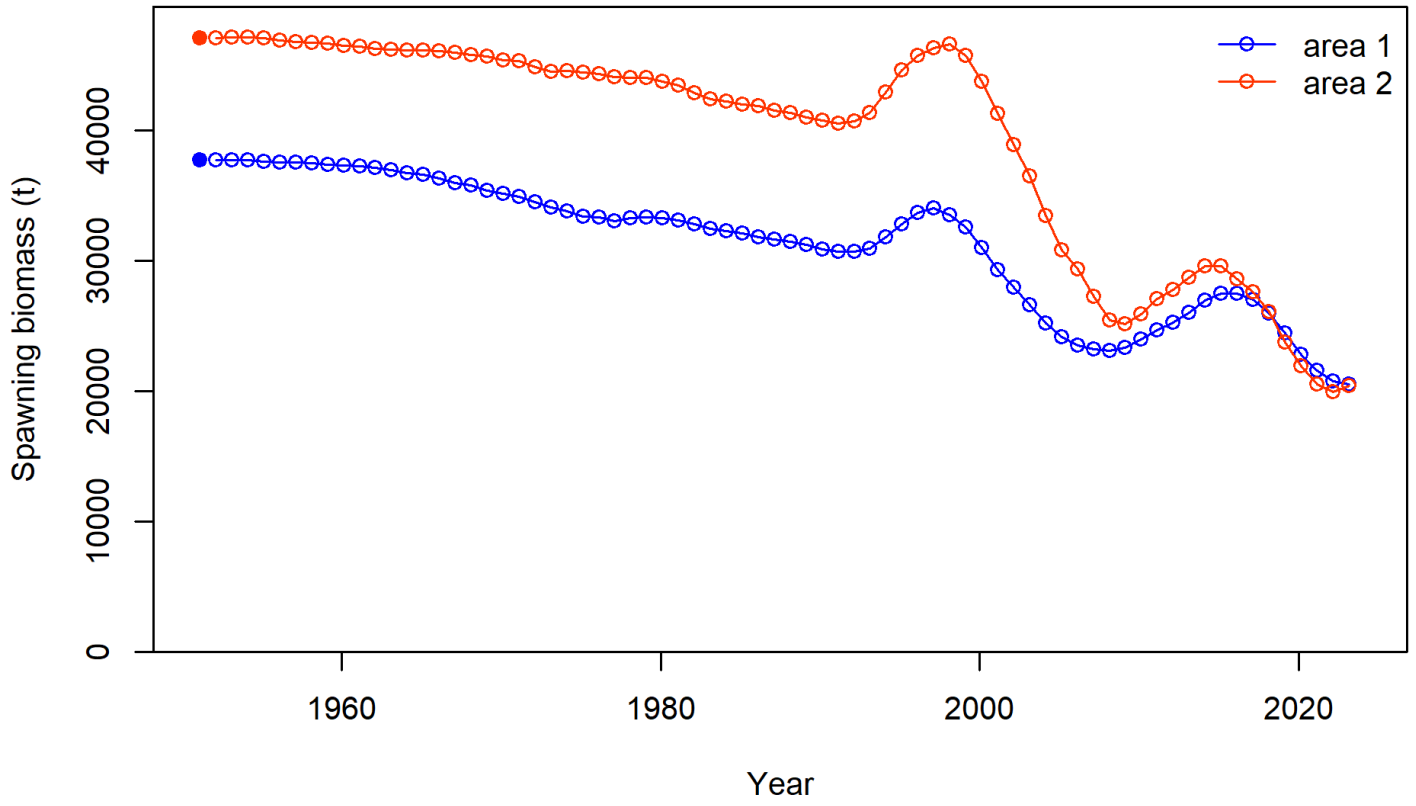




Spawning biomass: Diagnostic with uncertainty



Spawning biomass: Diagnostic by region



SWO2025 in a nutshell

	Median	10th %ile	90th %ile
F_{recent}/F_{MSY}	**0.27**	**0.16**	**0.41**
SB_{recent}/SB_{MSY}	**2.37**	**1.80**	**3.37**
$SB_{recent}/SB_{F=0}$	0.50	0.46	0.58

- 0% risk of overfishing
- 0.01% risk overfished

- Are we really that certain? Have we missed some uncertainty?
- Results broadly consistent with previous assessments
- Needed conflict in data to get plausible biomass

Summary:

- For future review?
  - stock structure
  - regional boundaries
  - stock assessment boundaries
- CPUE shows a weak signal on population scale (AU vs NZ)
- Important composition data:
  - AU and NZ weight data – especially from 05.AU.1C – noting recent drop (and discarding)
  - Length data from 14.NZ.2S (collection discontinued)
- Model sensitive to recent data (retrospectives)

Recommendations for further work

- More age data (better bang for buck than CKMR?)
- Standardise length composition data to account for variability in sampling (e.g. flag changes, spatial variation in fishing/sampling)
- Standardise collection methods and sampling protocols
- Improve conversion factors
- Review optimal data (types and measurement standards) to be collected for future assessments
- Review biology and stock structure
- Explore CPUE issues (especially with EU fishery, but also DWFN?)

Elders: past, present and commenting

In your esteemed expert opinion, and with a couple of decades of new data, are you able to say anything about whether the stock is in better or worse condition relative to 2006?

There's still very little information in all that data - who knew?

Phew! This was a really difficult one, but you have presented a very well-considered set of advice taking account of the main uncertainties

Elders: past, present and MSY

MSY reference points? Really? When you don't know anything about *h*?

Extract from 2006 stock assessment report:

4. The data are not sufficient to estimate a stock recruitment relationship reliably, and most or all models explored suggest some form of non-stationary (or at least highly variable) recruitment dynamics. This seriously undermines the usefulness of the MSY-related reference points. However, in so far as these

- Extract from 2025 email:
  "… and you come out an MSY Manchurian candidate …"

GitHub repository

A publicly accessible GitHub repository has been created, for the 2025 swordfish diagnostic model:

https://github.com/PacificCommunity/ofp-sam-swo-2025-diagnostic

https://www.youtube.com/watch?v=6NXnxTNIWkc

4 Non Blondes: What's Up

25 years and my life is still

Tryin' to get up that great big hill of hope

For a destination

And so I cry sometimes when I'm lying in bed

Just to get it all out what's in my head

And I, I am feeling a little peculiar

And so I wake in the morning and I step outside

And I take a deep breath and I get real high

And I scream from the top of my lungs

"What's going on?"

4 Non Blondes: Revolution

And I try

Oh my God, do I try

I try all the time

In this institution

And I pray

Oh my God, do I pray

I pray every single day

For revolution

Chant of the Assessment Revolution:

Oh hear now, ye who bear the burden of models,
and witness the tale of uncertain days.

Though the veil of uncertainty grew more dense,
Though the ensemble gave way to the ancient grid,
Lo, a minor revolution did stir the depths,
A tremor beneath the surface of our knowing.

For the signs were poor in the sacred indices,
And length data, though plentiful, lacked grace.
No age did speak from the records of the sea,
And conversions faltered at the altar of form.

Catches came in weight and number,
Measures muddled across the years,
And lo, the heads of fishes were severed,
Their wholeness lost to time and scale.

Thus must the faithful restore their bodies,
Or summon righteous factors of conversion,
That length may rise anew as LJFL.

As in all revolutions, chaos was the tide—
No calm procession from twenty and one to twenty and five,
No gentle walk from step to step,
But storming, yes, storming of the Bastille.

Yet the brethren of the model stood firm,
Their heads remained upon their shoulders.
Though late the chant of outcome came,
Still it sang of hope, not hollow artifice.

A model now stands, though once shrouded in doubt —
Strong enough, we pray, for these post-revolutionary times.

Let this labor not be lost,
Let the effort be judged as worthy.

Amen.