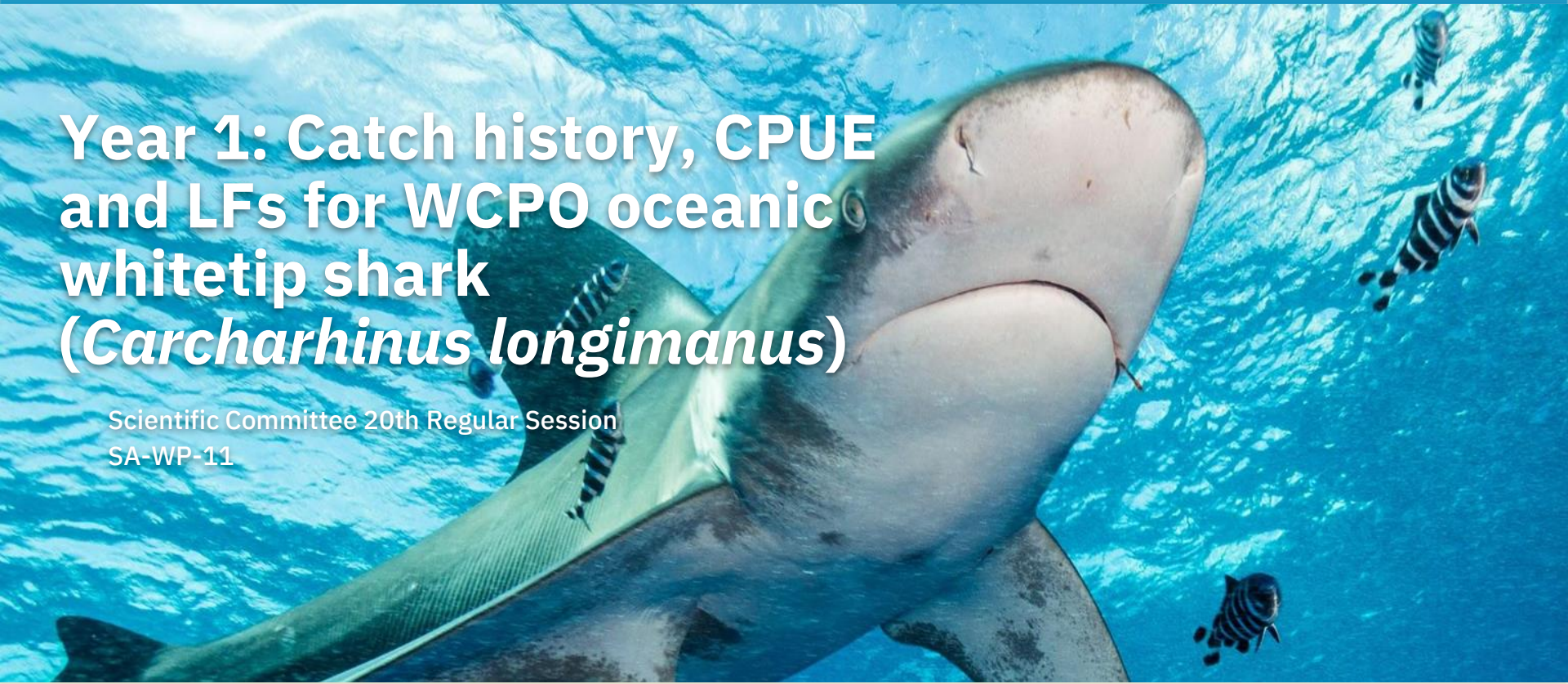
Year 1: Catch history, CPUE and LFs for WCPO oceanic whitetip shark (*Carcharhinus longimanus*)



Scientific Committee 20th Regular Session
SA-WP-11

Prepared by:
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Philipp Neubauer
Steve Brouwer
Kath Large

Date:
August 2024

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Overview:

- Background

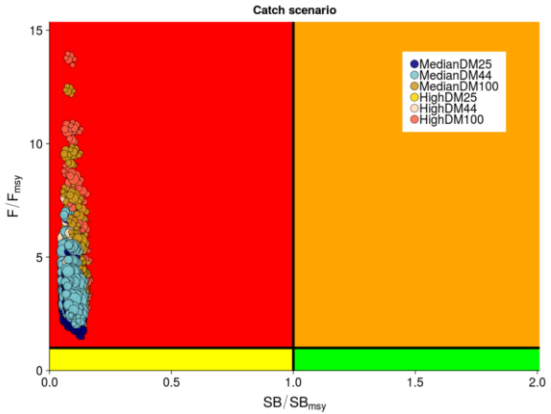
- Methods for
  - **catch reconstruction (CR)**,
  - **CPUE,** and
  - **length compositions** for potential use in assessment

- Largely based on developments made in the context of other shark assessment

Background

2. SC15 conclusions:

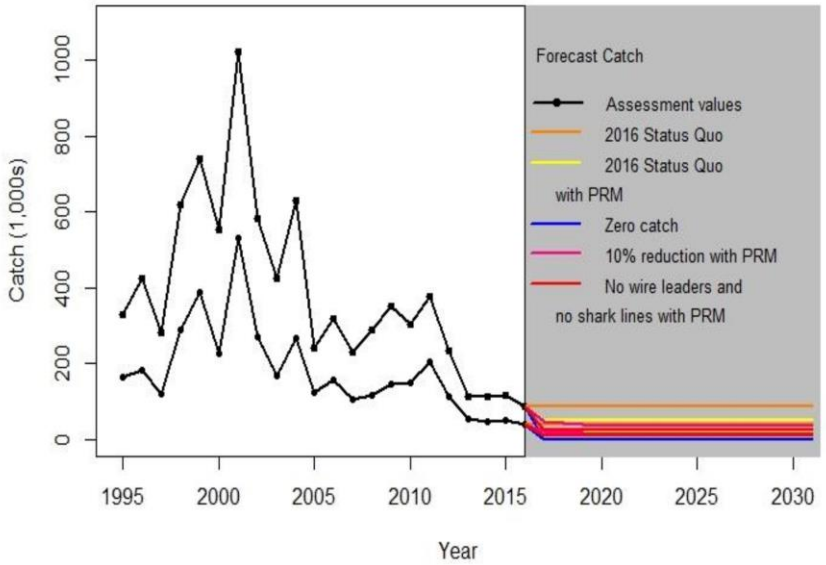
- Stock status: overfished and undergoing overfishing based on depletion and MSY-based reference points
- Very slight recovery in stock biomass in the most recent years (2013-2016)
- Few, if any, target fisheries
    - greatest impact from longline bycatch
    - lesser impact from purse seine



Future stock projections – Bigelow *et al.* (2022)

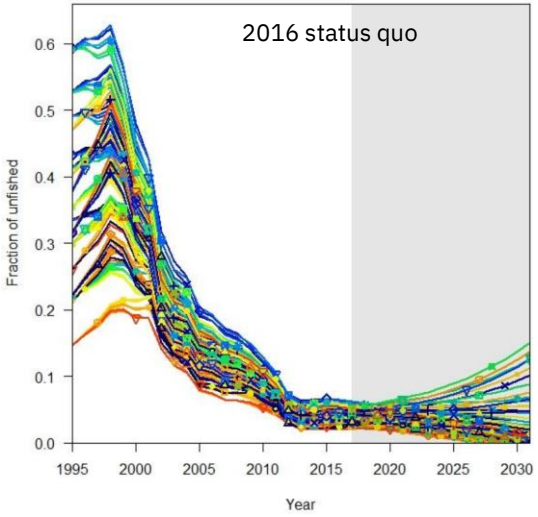
Considered five future catch scenarios forecasted within a 15 year window

- 2019 assessment values projected, with:
  - assumption 43.75% mortality (status quo)
  - status quo with updated estimates of handling & PRM (LL-retrieval M 19.2%, PRM (8%))
  - 10% catch reduction (2017-2020) and updated estimates (LL-retrieval 19.2%, PRM 8%)
  - assumption of reduced mortality from gear-ban (41.2%) and updated estimates (LL-retrieval 19.2%, PRM (3%))
  - zero future catch

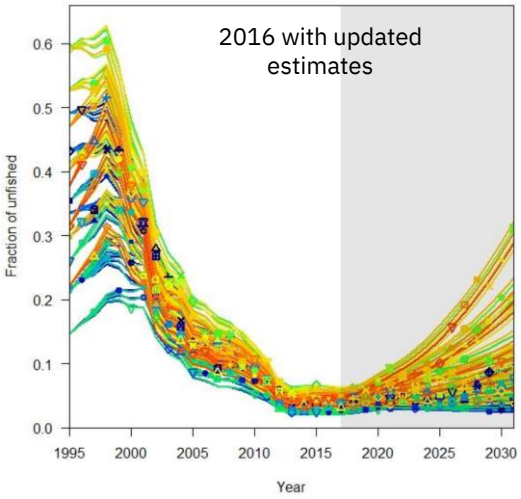


Future stock projections – Bigelow *et al.* (2022)

- Population was projected to increase over the projection period under new mortality scenarios: higher projected SB in 2031 relative to 2016
- Will need to consider appropriate catch scenarios for updated assessments;
- New assessment may be able to provide insights into which scenarios are most likely.



mean $SB_{2031}/SB_{F=0}$ = 0.015



mean $SB_{2031}/SB_{F=0}$ = 0.070

Stock, biology & length structure

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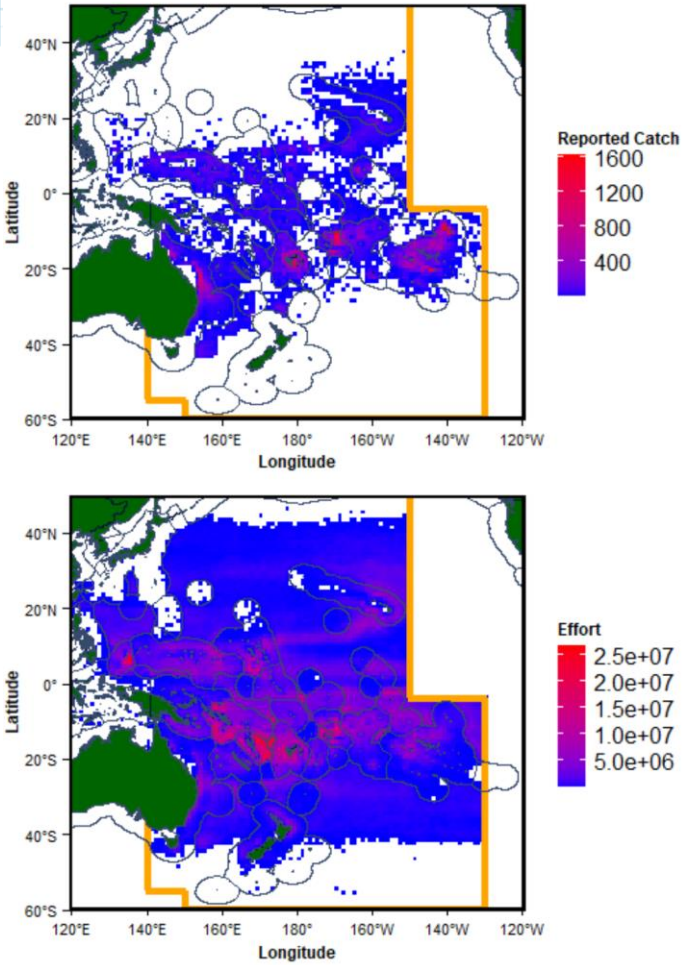
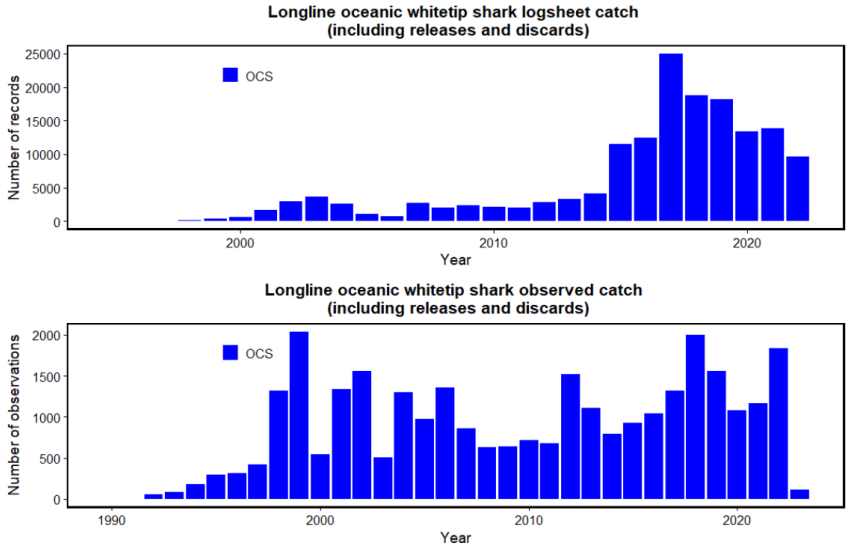
Fishery

- Most reported LL catch is south of the equator to 25° South



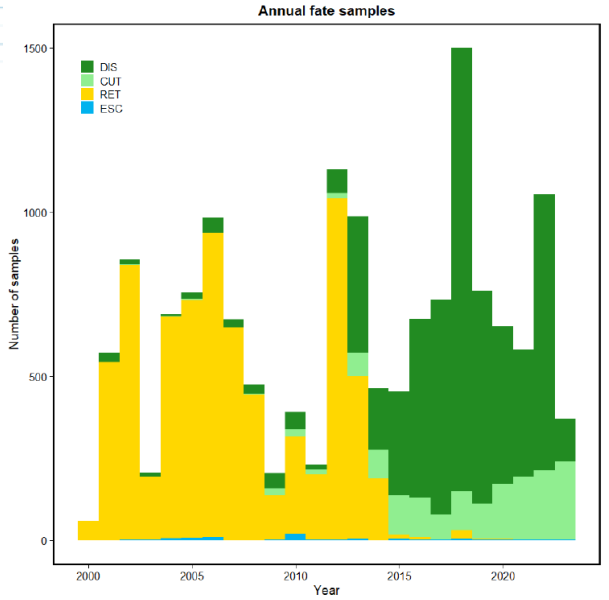
Fishery

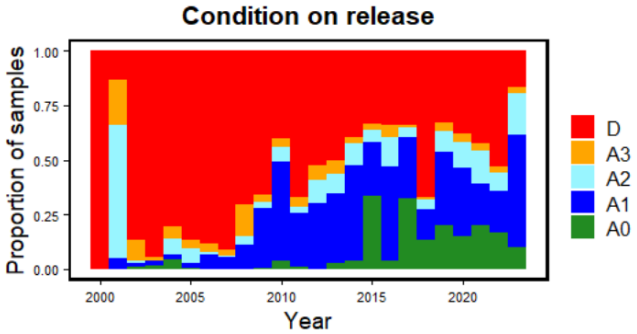
- Most reported LL catch is south of the equator to 25° South
- Probably not well reported in the past



Fishery

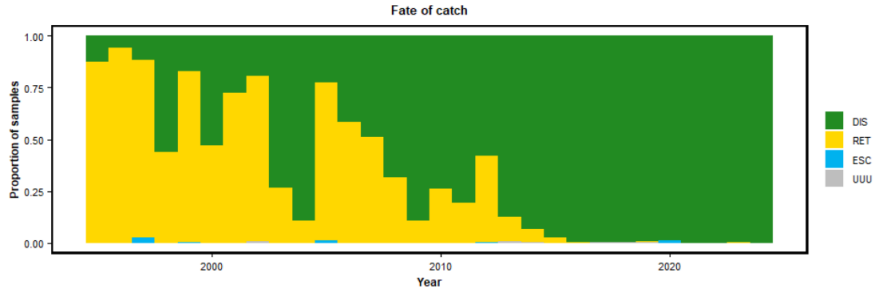
- Most reported LL catch is south of the equator to 25° South
- Probably not well reported in the past
- Increasingly cut free, near 100% non-retention in recent years
- Still reasonably high handling mortality

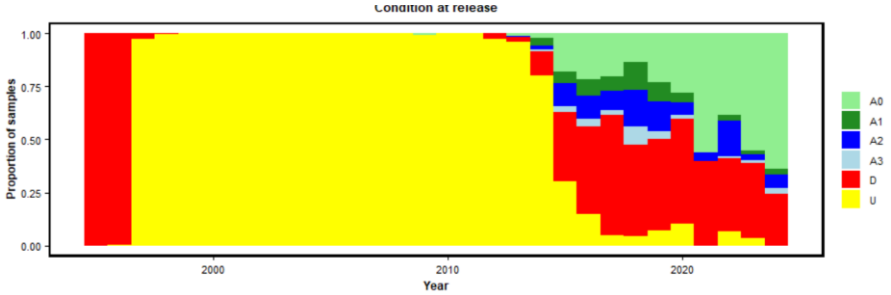




Fishery

- Most reported LL catch is south of the equator to 25° South
- Probably not well reported in the past
- Increasingly cut free, near 100% non-retention in recent years
- Still reasonably high handling mortality
- Little PS catch; increasingly discarded in good condition.





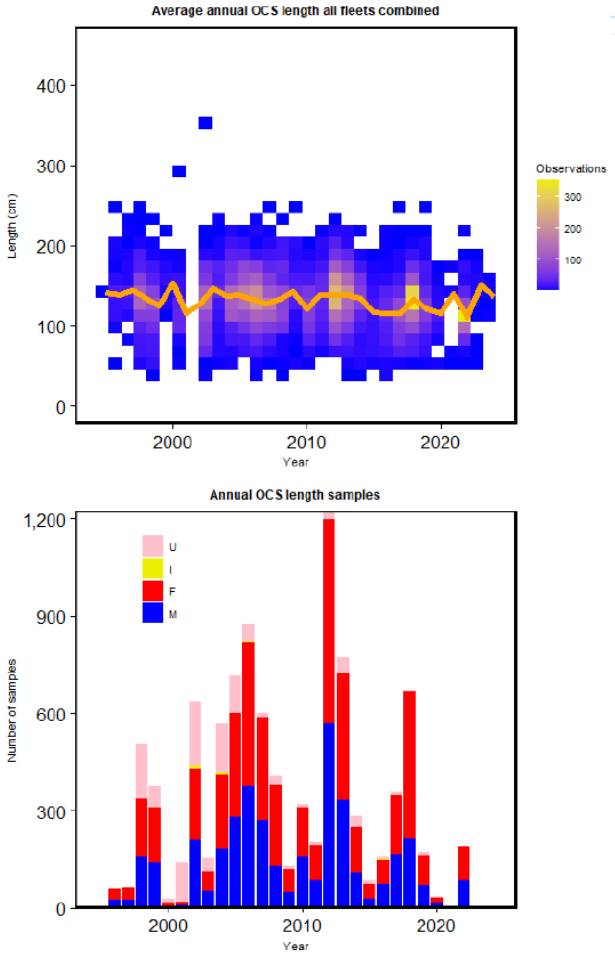
Recent research on biology:

Growth (VB)	k = 0:103cm, L_0 = 82:9cm, Linf = 341:7cm k = 0:.085cm, L_0 = 64, Linf = 309.4 k = 0:045, L_0 = 99cm, Linf = 342:5cm	Seki et al. (1998) Joung et al. (2016) D'Alberto et al. (2017)
Litter size	1–14 (mean: 6.2, n = 97) 10–11 (n = 2)	Seki et al. (1998) Joung et al. (2016)
Birth size	55–77 cm (TL) 64cm Unobserved (99 cm TL modelled)	Seki et al. (1998) Joung et al. (2016) D'Alberto et al. (2017)
Maturity (TL)	Males: 167–195 cm; females: 175–189 cm Males: 194.4 cm; females: 193.4 cm Males: 193 cm; females: 224 cm	Seki et al. (1998) Joung et al. (2016) D'Alberto et al. (2017)
PRM	Bigelow K, Carvalho F. (2021a) – LL-mortality, Bigelow & Carvalho (2021b) – (Project 101), Hutchinson et al. (2022) – PRM sharks in LL-fisheries	

Any suggestion on biology research for us to follow up?

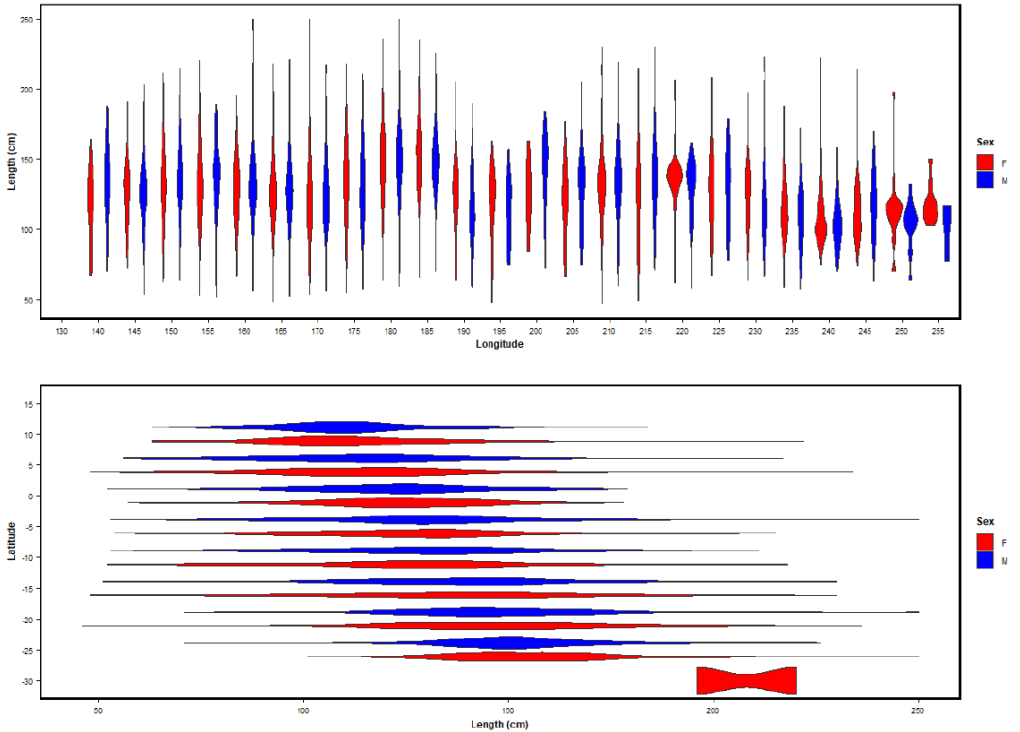
Stock structure

- Reasonable amounts of length data from longline observers



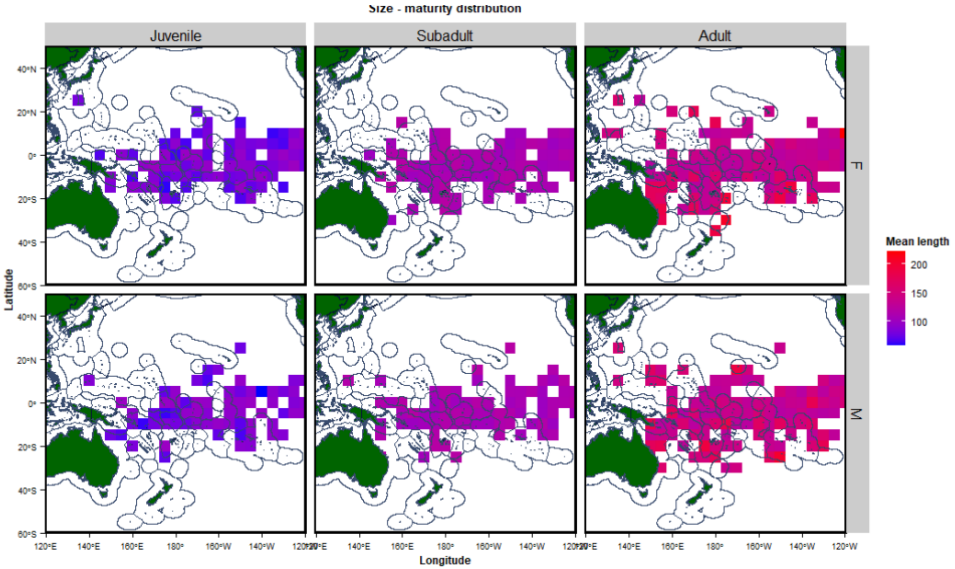
Stock structure

- Reasonable amounts of length data from longline observers
- Larger individuals south of equator



Stock structure

- Reasonable amounts of length data from longline observers
- Larger individuals south of equator
- Unclear about underlying cause - no discernable patterns in maturity in space



Standardised length compositions

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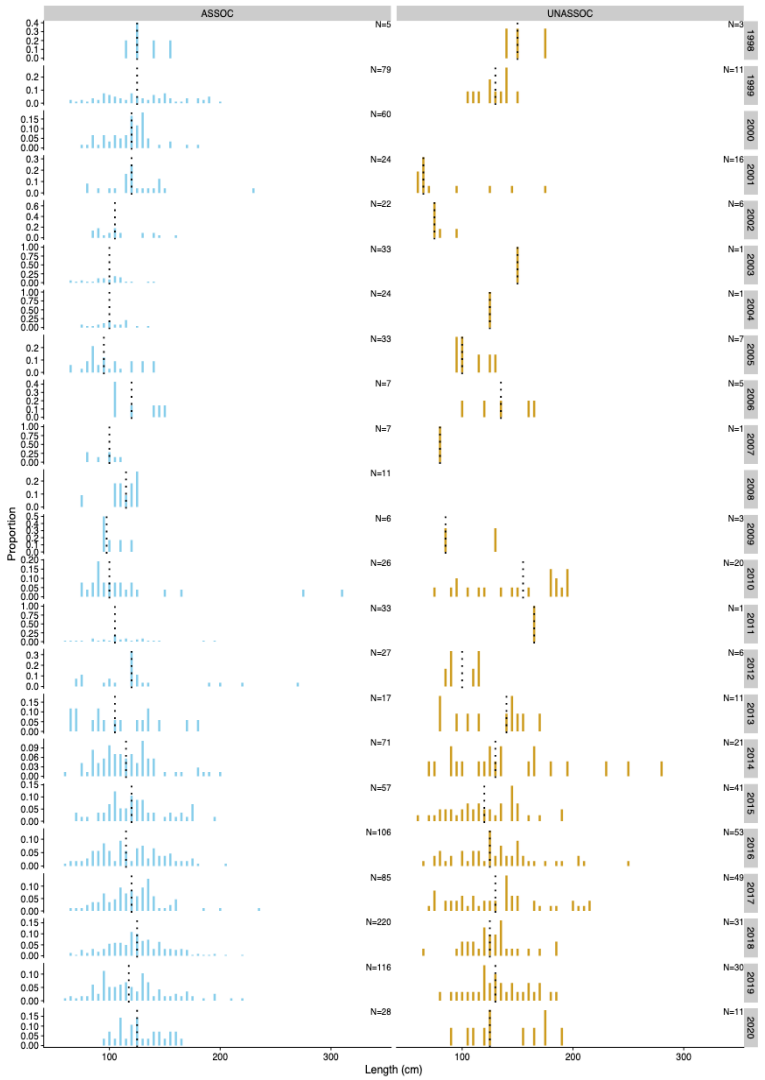
Length compositions

- Only for longline. Low number of PS length samples, insufficient for models.



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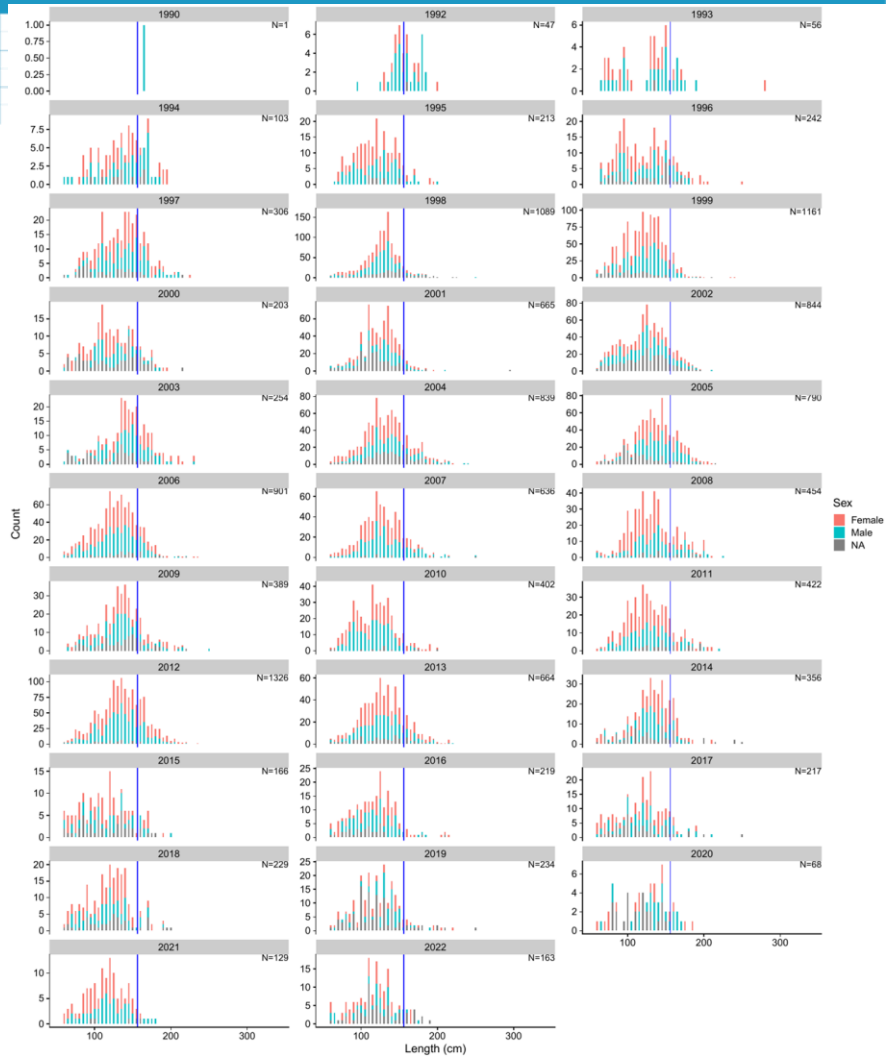

Length compositions

- Only for longline. Low number of PS length samples, insufficient for models.
- Model-based scaling of LFs for capture fisheries and indices
  - Scaling (prediction to total catch) for capture fisheries
  - Scaling by CPUE, using year effects only for index fisheries
- Little/no year effect in both models: not needed to fit the data

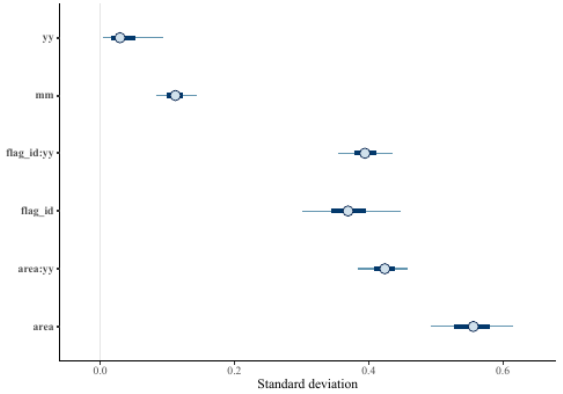

Figure 27: Length-composition standardisation model estimates (posterior median and 95% confidence interval) for standard deviation parameters associated with standardising effects.

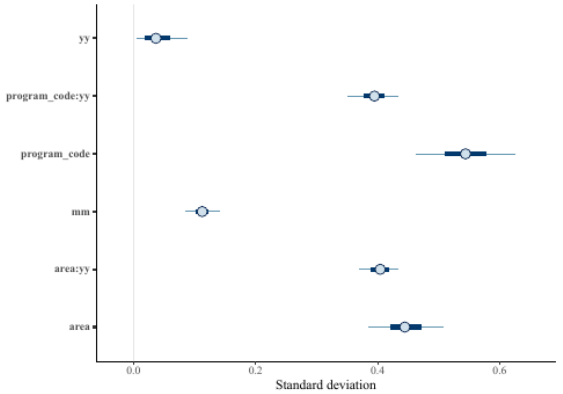

Figure 28: Length-composition standardisation model estimates using CPUE data (posterior median and 95% confidence interval) for standard deviation parameters associated with standardising effects.

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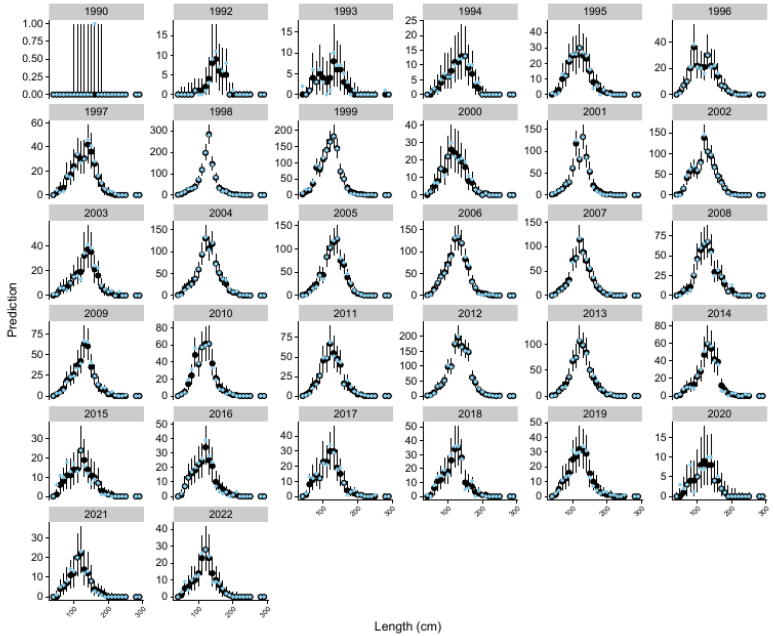
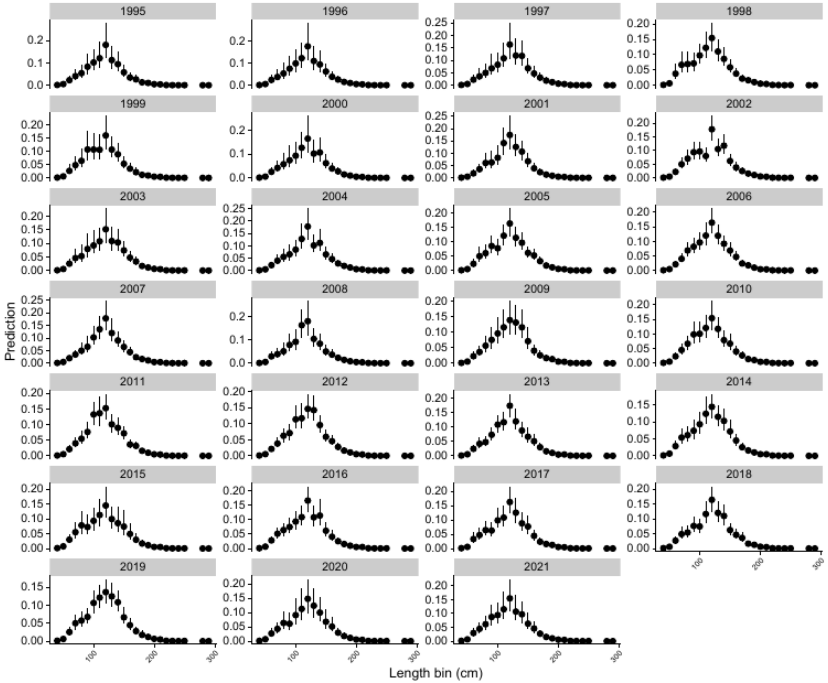


Scaled LFs

- Little detectable change in length compositions over time across the WCPO
- Contrasts with strong reductions in observed longline catch rates in late 1990s and early 2000s
- Lack of detectable trends possibly due to low observer coverage



Catch reconstruction

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Approach

Series of GLMM models used for catch-reconstruction for PS and LL catches based on observed catch-rates

Multi-model predictions using model-based stacking

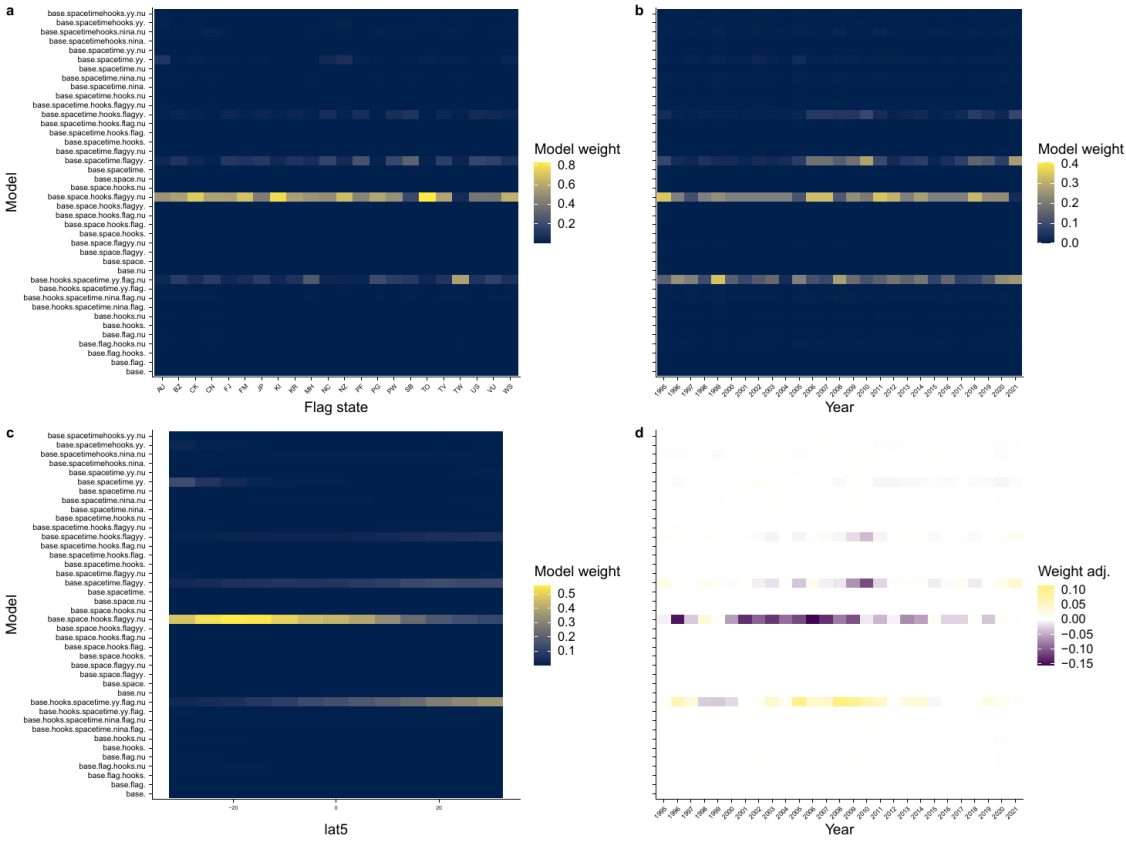
Estimates model weights based on leave-one-out prediction ability across strata

Model	Model terms
base	(1|yy) + (1|mm) + s(SST) + s(chla) + s(swo-n) + s(dist2coast)
base.flag	base + (1|flag-id)
base.hooks	base + s(log(hooks))
base.flag.hooks	base + s(log(hooks)) + (1|flag-id)
base.space	base + t2(lon5,lat5)
base.space.hooks	base + t2(lon5,lat5) + s(log(hooks))
base.space.hooks.flag	base + t2(lon5,lat5) + s(log(hooks)) + (1|flag-id)
base.space.flagyy	base + t2(lon5,lat5) + (1|flag-id) + (1|flag-id:yy)
base.space.hooks.flagyy	base + t2(lon5,lat5) + s(log(hooks)) + (1|flag-id) + (1|flag-id:yy)
base.spacetime	base + t2(lon5,lat5,mm)
base.spacetime.hooks	base + t2(lon5,lat5,mm) + s(log(hooks))
base.spacetime.hooks.flag	base + t2(lon5,lat5,mm) + s(log(hooks)) + (1|flag-id)
base.spacetime.flagyy	base + t2(lon5,lat5,mm) + (1|flag-id) + (1|flag-id:yy)
base.spacetime.hooks.flagyy	base + t2(lon5,lat5,mm) + s(log(hooks)) + (1|flag-id) + (1|flag-id:yy)
base.spacetime.yy	base + t2(lon5,lat5,yy)
base.spacetimehooks.yy	base + t2(lon5,lat5,yy) + s(log(hooks))
base.hooks.spacetime.yy.flag	base + t2(lon5,lat5,yy) + s(log(hooks)) + (1|flag-id)
base.spacetime.nina	base + t2(NINA4,lon5,lat5)
base.spacetimehooks.nina	base + t2(NINA4,lon5,lat5) + s(log(hooks))
base.hooks.spacetime.nina.flag	base + t2(NINA4,lon5,lat5) + s(log(hooks)) + (1|flag-id)

Model weighting

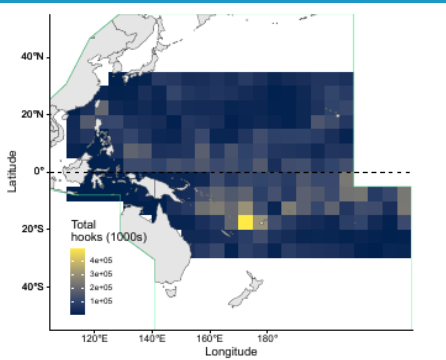
For longline:

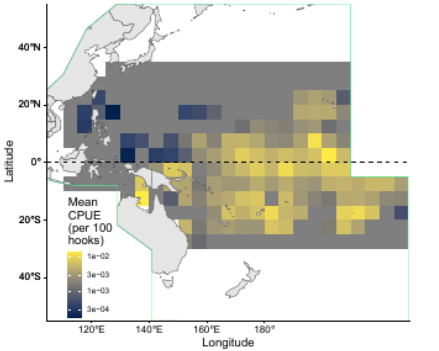
- model with flag-year interactions consistently best,
- spatio-temporal model also having high weight.

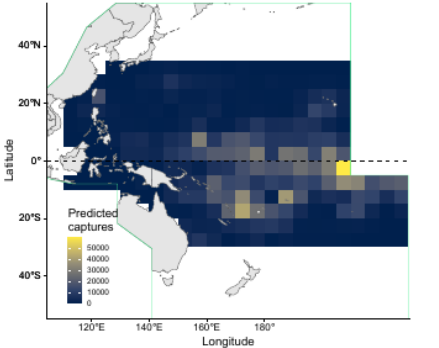


Longline

- Effort and estimated interactions mostly in south-eastern equatorial Pacific.
- CPUE relatively high throughout most of the Pacific (except for some north-western areas).
- Unclear if low CPUE and estimated catch in north-western Pacific is due to local depletion or species distribution.

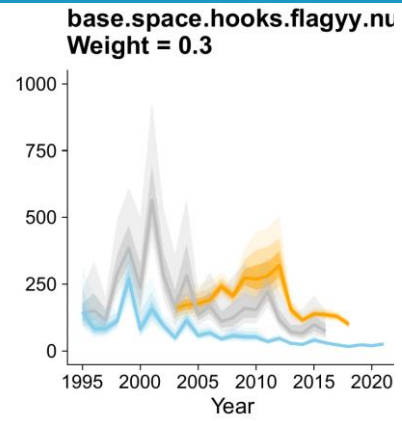


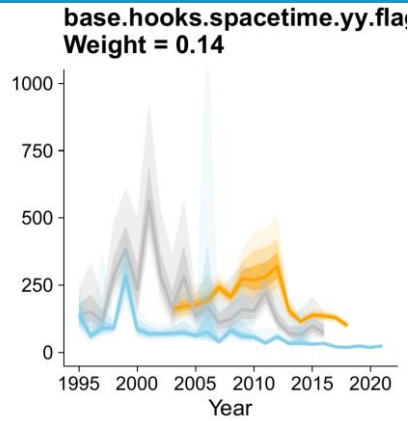


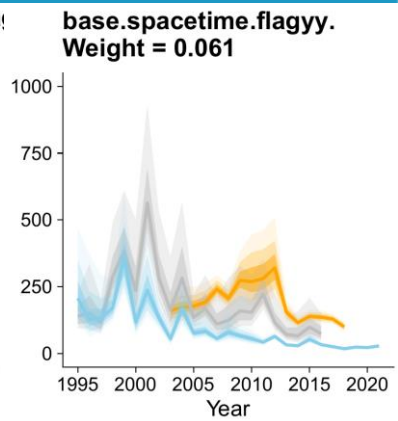


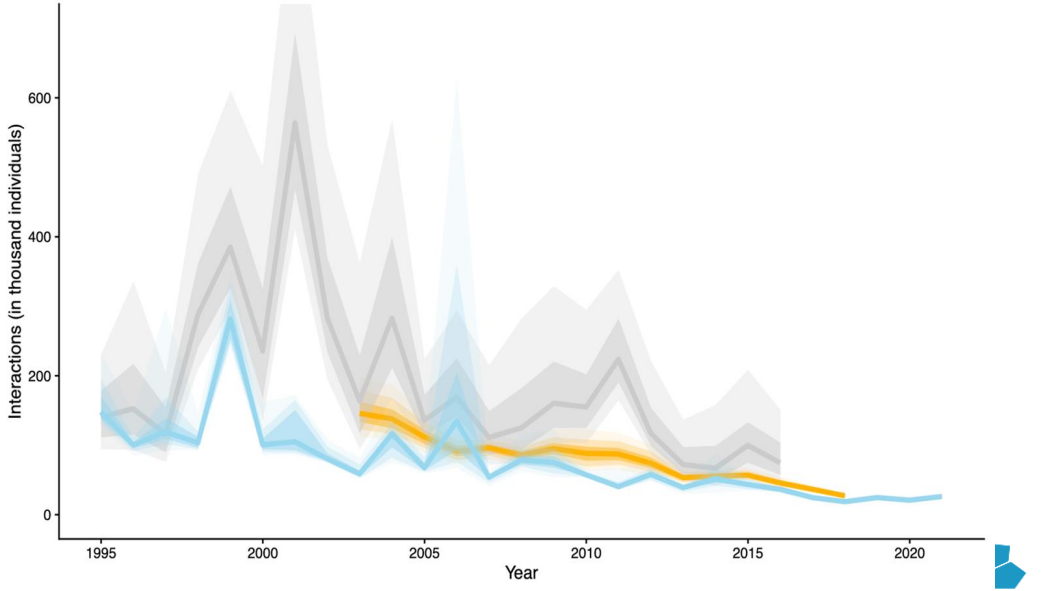
Longline

- Estimated interactions declined since 1999 from ~200k to ~50k.
- Comparable to predicted values from Peatman et al. (2018), but lower than those predicted by Tremblay-Boyer et al. (2019)
- Trends associated with DW-fleets









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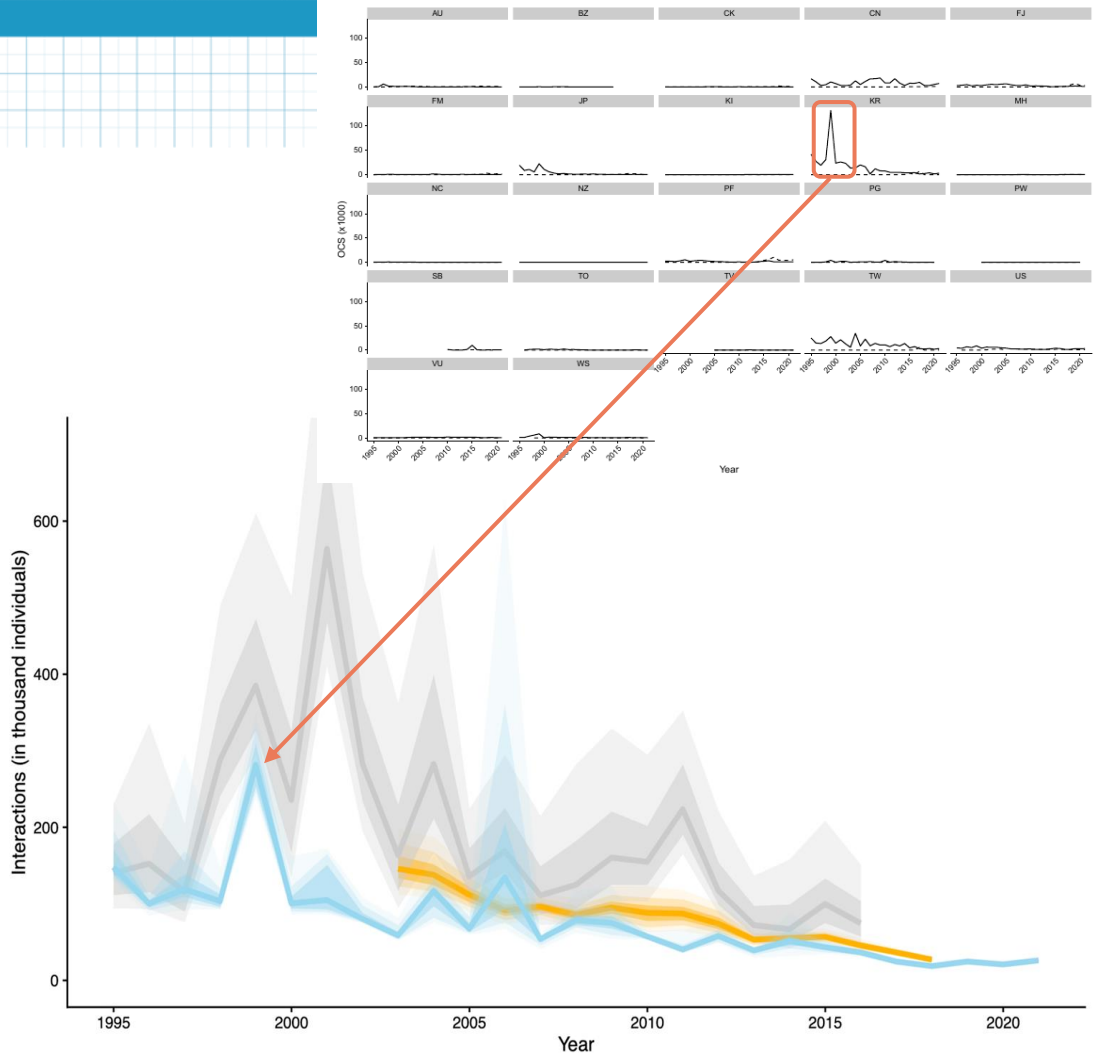
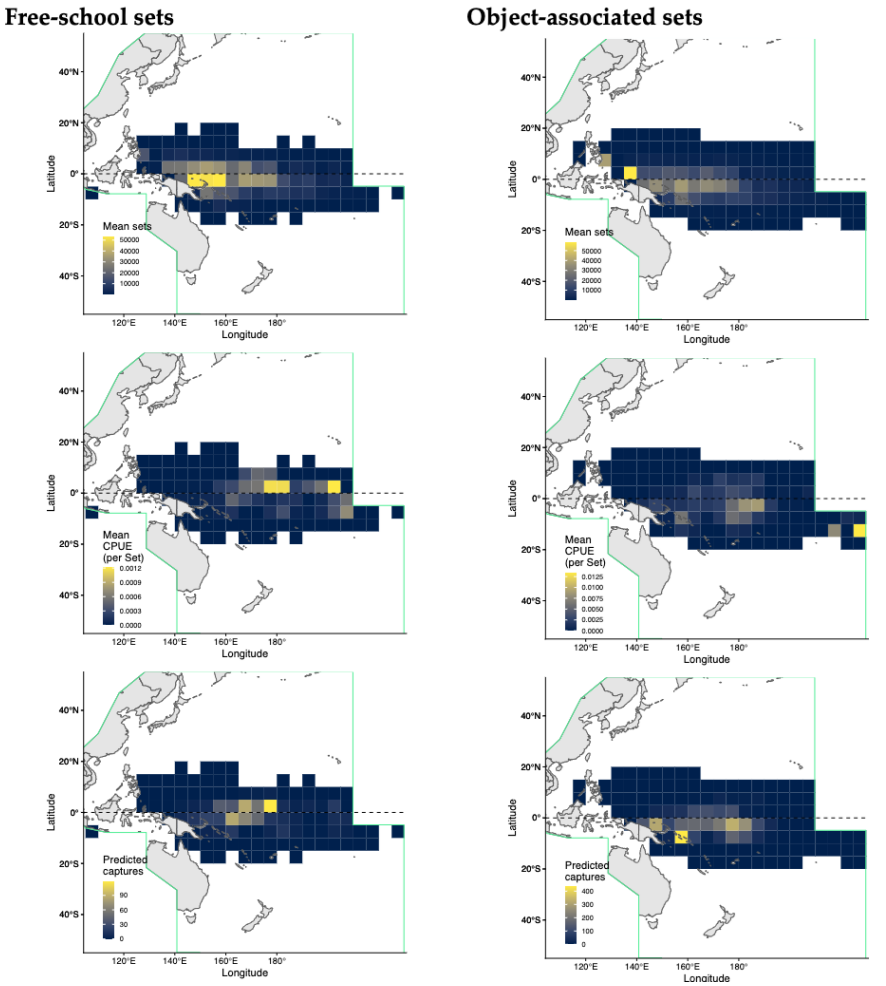


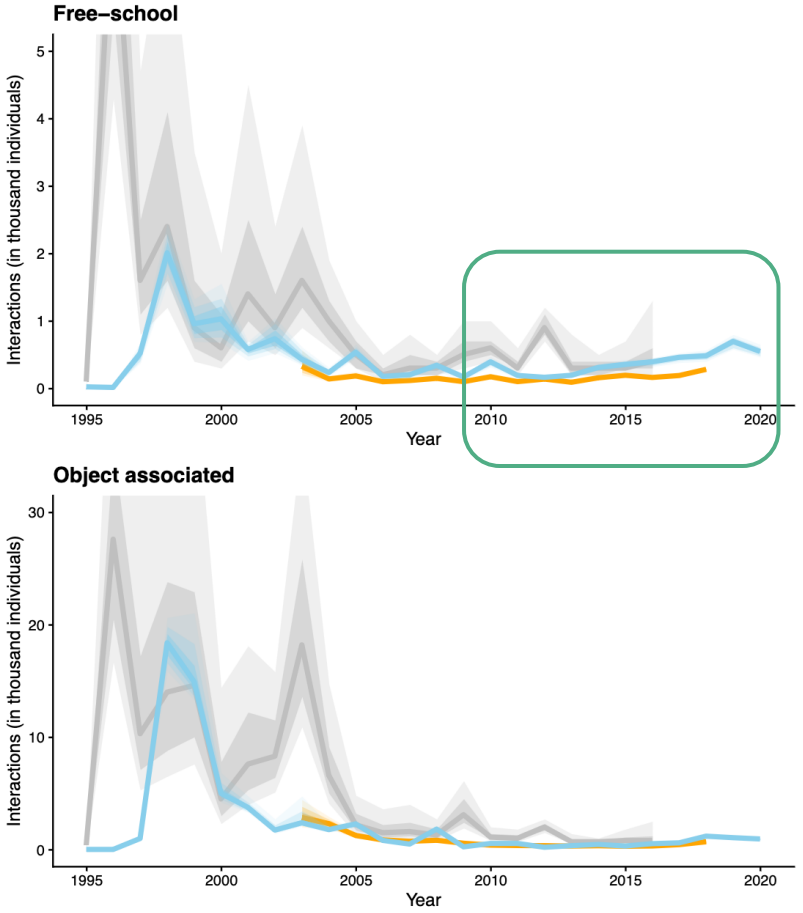
Purse-seine CR

- Effort concentrated in the western equatorial Pacific for both set-types,
- CPUE generally higher towards the central and eastern equatorial WCPO
- Given effort distribution, most interactions are further east than areas of high CPUE



Purse-seine CR

- For both set-types, estimated interactions declined since late 1990s and remain low.
- Free-school, post-2010 predicted increase until recent times.



CPUE

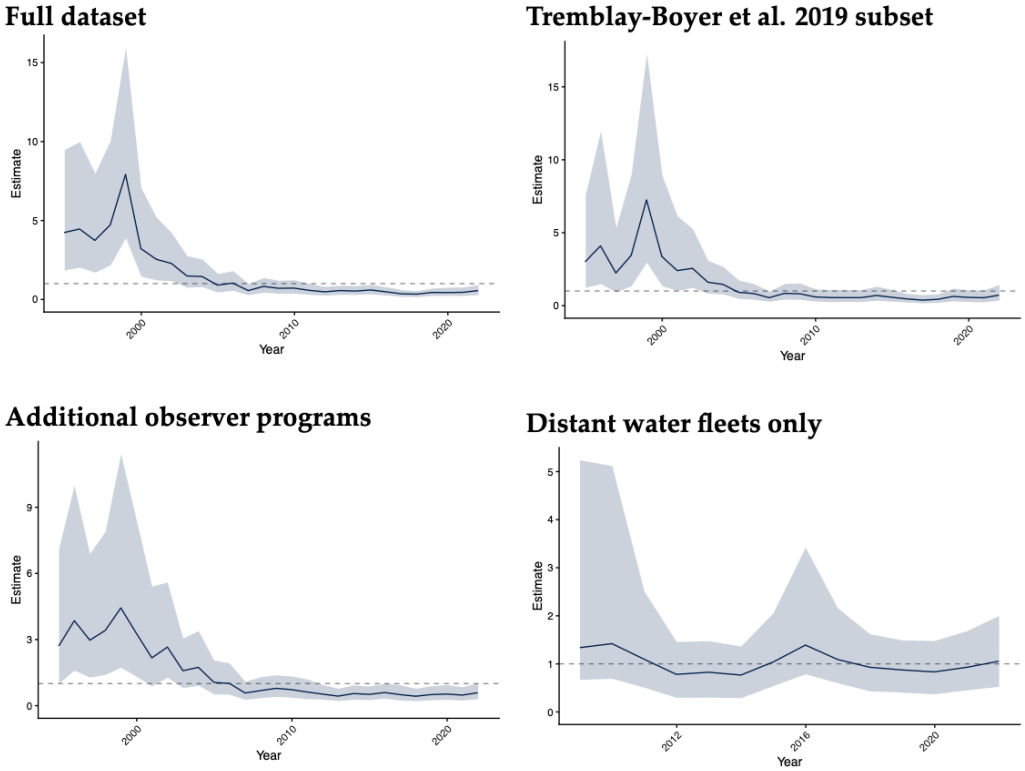
Longline CPUE

- Variables sequentially added to CPUE model
- Most complex model standardised for ENSO variables
- Models run across four sets of observer programs

Model	Model terms
CPUE.yy	(1|yy)
CPUE.yy.progyy	(1|yy) + (1|program-code) + (1|program-code:yy)
CPUE.yy.progyy.hooks.HBF	CPUE.yy.progyy + s(log(hooks)) + s(HBF)
CPUE.yy.progyy.hooks.HBF.ves	CPUE.yy.progyy + s(log(hooks)) + s(HBF) + (1|vessel-id)
CPUE.yy.progyy.hooks.HBF.ves.mm	CPUE.yy.progyy + s(log(hooks)) + s(HBF) + (1|vessel-id) + (1|mm)
CPUE.yy.progyy.hooks.HBF.ves.mm.sst	CPUE.yy.progyy + s(log(hooks)) + s(HBF) + (1|vessel-id) + (1|mm) + s(SST)
CPUE.yy.progyy.hooks.HBF.ves.mm.sst.nina	CPUE.yy.progyy + s(log(hooks)) + s(HBF) + (1|vessel-id) + (1|mm) + s(SST) + NINA4-MA4
CPUE.yy.progyy.hooks.HBF.ves.mm.sst.nina.progint	(1|yy) + (1|program-code:yy) + s(log(hooks)) + s(HBF) + (1|vessel-id) + (1|mm) + s(SST) + NINA4-MA4 + (1+NINA4-MA4|program-code)
CPUE.yy.progyy.hooks.HBF.ves.mm.sst.nina.progint.latlong	(1|yy) + (1|program-code:yy) + s(log(hooks)) + s(HBF) + (1|vessel-id) + (1|mm) + s(SST) + NINA4-MA4 + (1+NINA4-MA4|program-code) + t2(lon5,lat5, bs=c("cr","cr"), k=c(5,5))

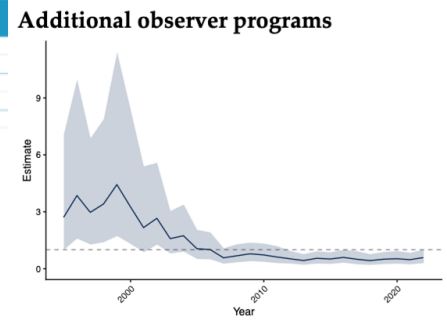
Longline CPUE

- Similar trends for most indices, but different degrees of decline
- Highly variable at the start, declined post-1999, flattens around 2008
- High initial CPUE for full set and Tremblay-Boyer et al. 2019; lower index for additional-observer set

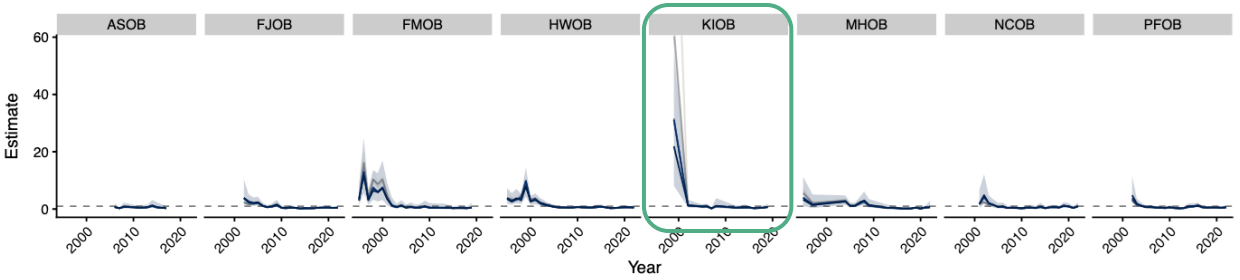


Longline

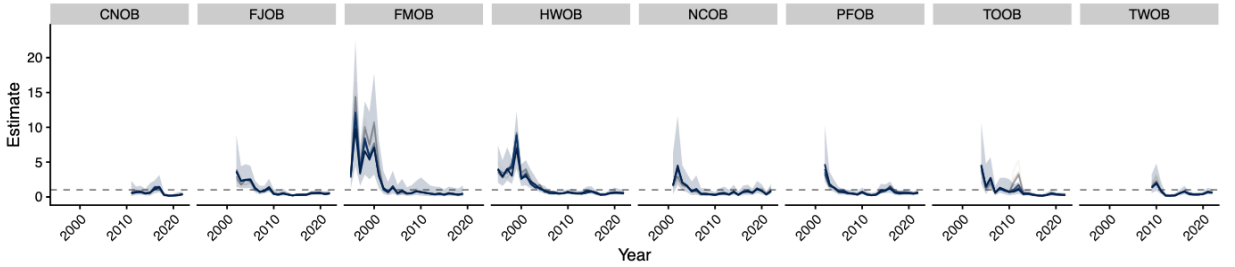
- Plotting by observer programme suggests single datapoint drives very high early peak catch rate; likely not correct
- Alternative set of observer-programs appears more consistent.



Tremblay-Boyer et al. 2019



Additional observer programs



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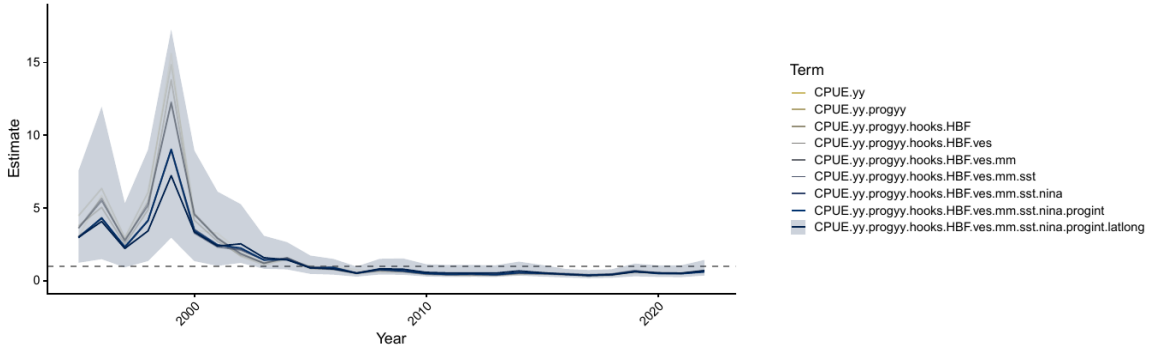
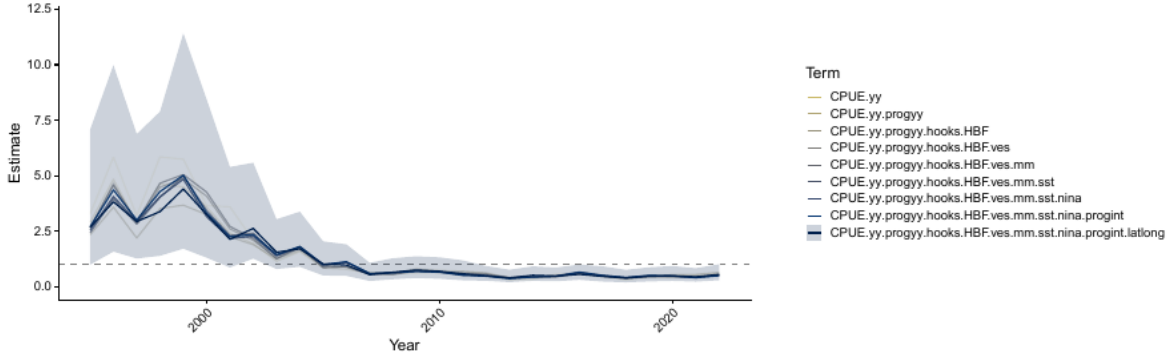
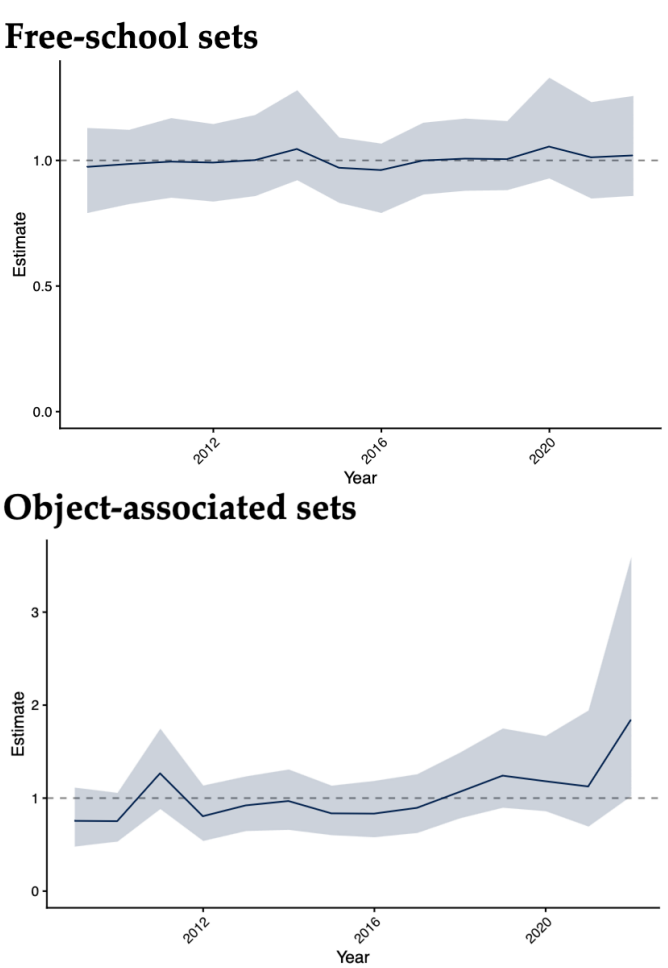


Additional observer programs



Purse-seine CPUE

- Shorter time series, 2009 start-date - too few captures pre 2009
- Different results by set-types: Relatively flat indices for free-school, standardisation effect by NINA4 covariate
- Increasing index for associated sets, standardisation effect by observer program and less by NINA4 covariate



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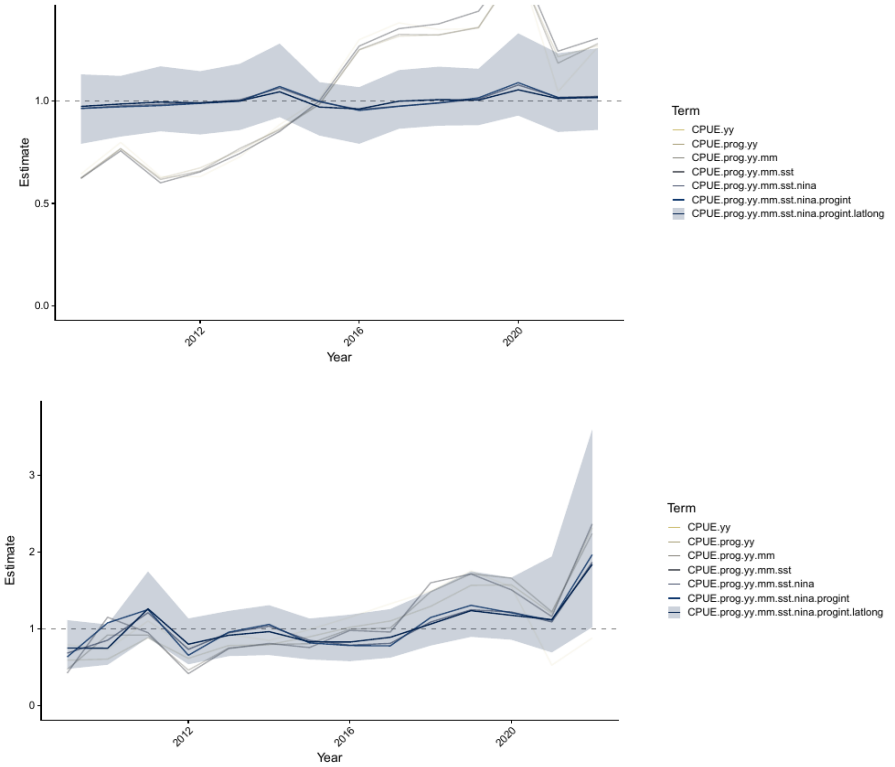
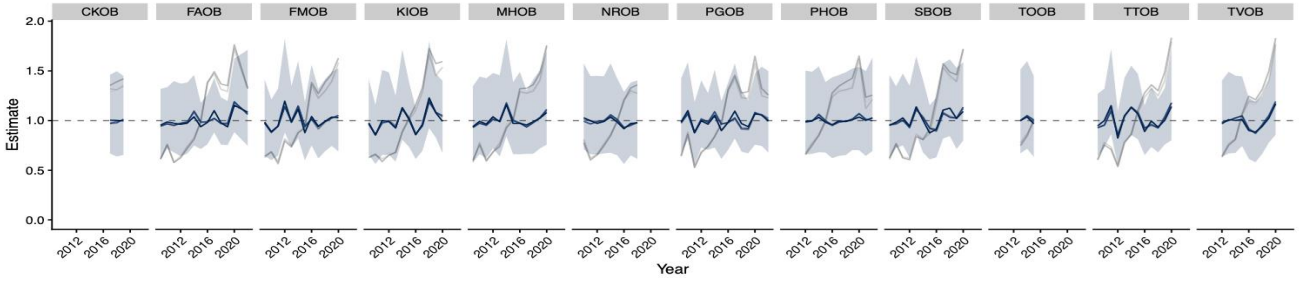
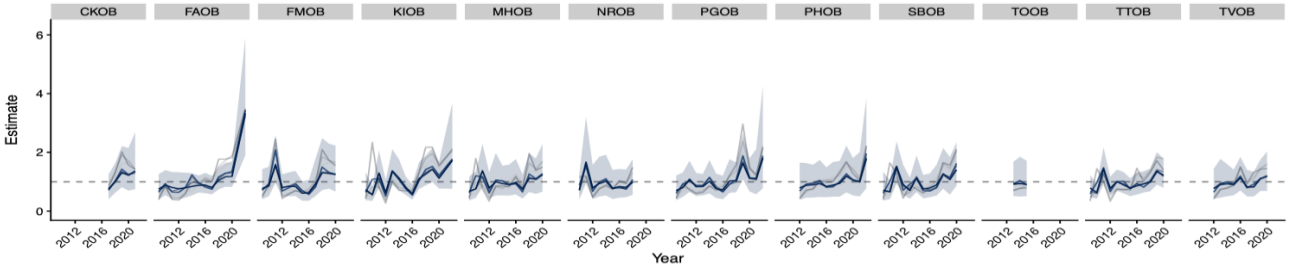


Purse-seine

Free-school sets



Object-associated sets



Preliminary findings

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Data Science

Recommendations

- There are likely to be sufficient data and a sufficiently consistent signal in the different datasets, especially from longline, to conduct a stock assessment: We suggest that a fully integrated assessment could be attempted.
- Alternative assessment methods (for example surplus production assessments) should be run in parallel with an integrated assessment.
- Length-based or hybrid length-based spatial assessments provide an alternative approach that is independent of recent longline data, and allows for multi-model inference that can strengthen conclusions and potential management advice from an integrated approach.

Ngā mihi rā.
Thank you for your input!

DRAGONFLY
Data Science

Good with data