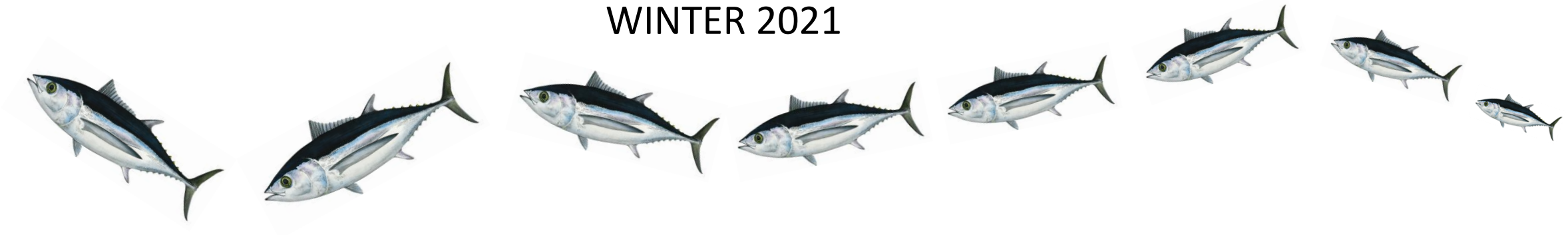
SOUTH PACIFIC ALBACORE STOCK ASSESSMENT

WCPFC-SC17-2021 / SA-WP-02

WINTER 2021



Claudio Castillo-Jordán(a), John Hampton(a), Nicholas Ducharme-Barth(a), Haikun Xu(b), Tiffany Vidal(a), Peter Williams(a), Finlay Scott(a), Graham Pilling(a) and Paul Hamer(a)

(a) Oceanic Fisheries Program, Pacific Community (SPC),
(b) Inter-American Tropical Tuna Commission (IATTC/CIAT)

2021 SOUTH PACIFIC ALBACORE - HIGHLIGHT

2021 stock assessment is a collaboration with the IATTC/CIAT

- Main collaborator at the IATTC **Dr. Haikun Xu**
- Support from Dr. Cleridy Lennert-Cody and IATTC team

Main new changes

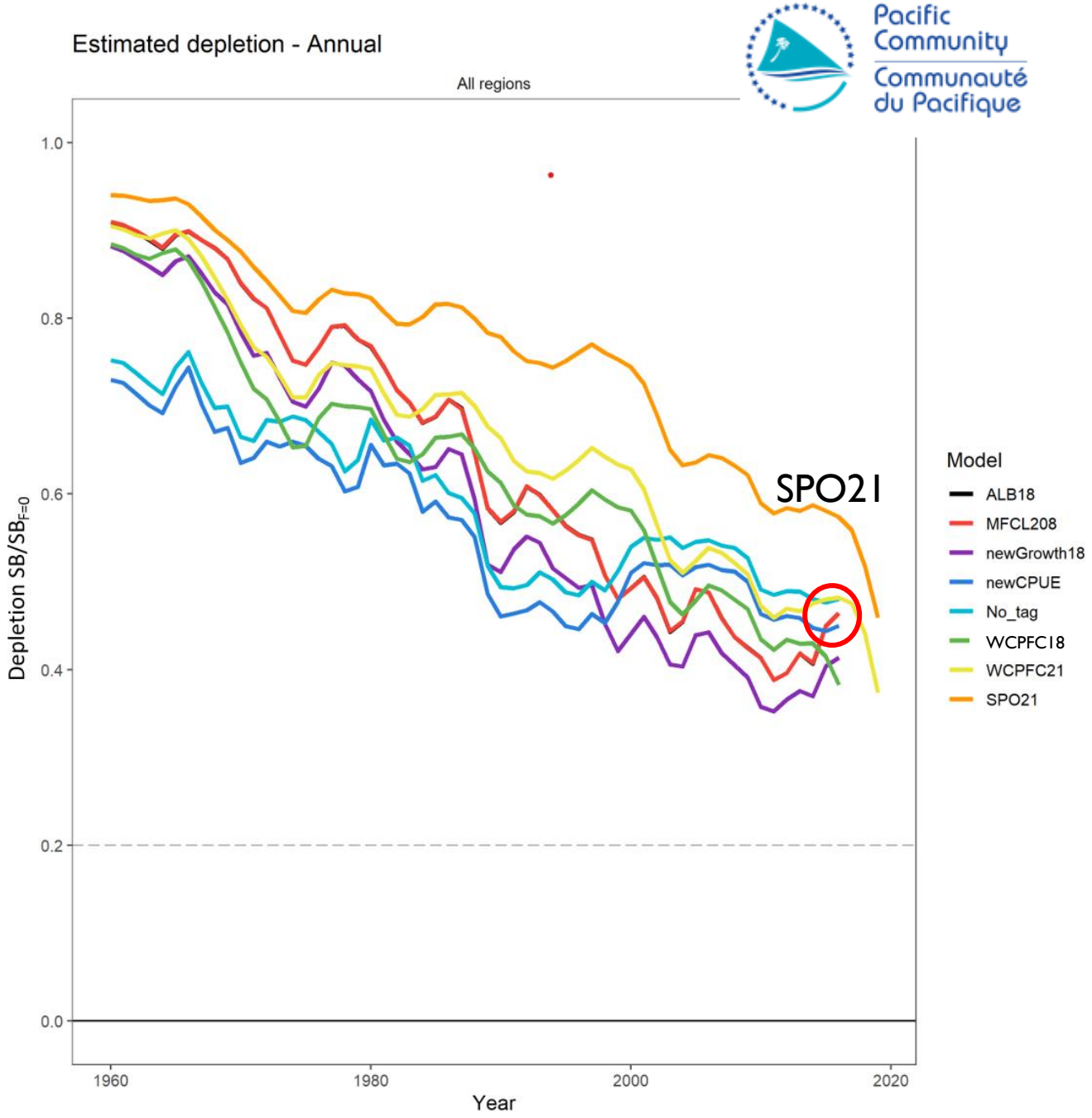
- New regions definition (South Pacific-wide)
- New growth parameters
- Growth and Natural mortality approach
- New MFCL 2.08 version

SUMMARY

- Previous assessment was in 2018, WCPFC-CA only (Tremblay-Boyer et al. 2018).
- Model spatial and fishery structures for ‘south Pacific wide’ albacore assessment 2021 (IATTC)
- Fisheries and data inputs, including length composition until 2019 (IATTC region 4)
- CPUE index fisheries 1960-2019 (IATTC consultation)
- New growth parameters (Farley et al 2021)
- Biological assumptions similar to 2018 assessment (single sex model)
- Stepwise diagnostic model development from 2018 to 2021 model
- Uncertainty grid include: steepness (3 options), movement (2 options), data weighting (3 options), recruitment (2 options) and growth-natural mortality (2 options) (72 models in total)
- Sensitivities tag or no-tag

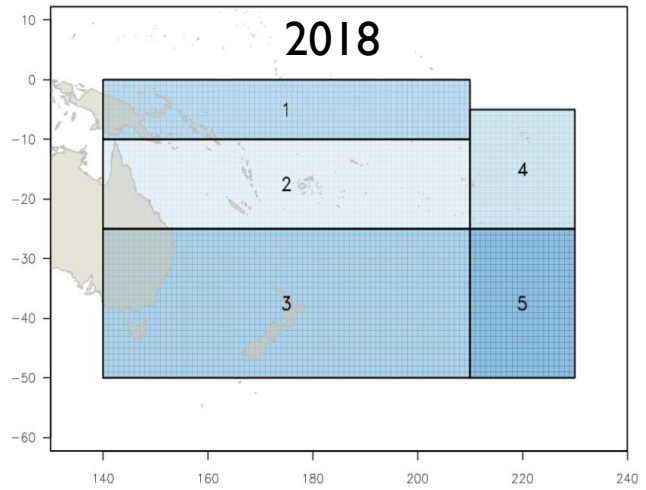
MODEL DEVELOPMENT

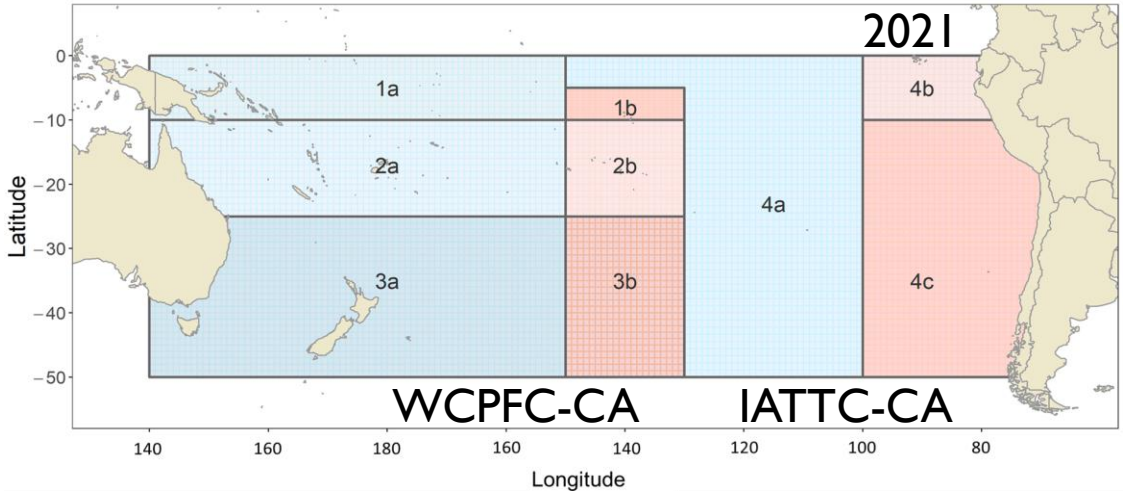
- ALB18 identical to MFCL208
- New growth decreased depletion
- New CPUE different early period
- No tag does not affect the results
- New data WCPFC18
- WCPFC21
- SPO21 (IATTC data)



2021 ASSESSMENT

- MFCL (V2.08.02), single sex, spatial structured
- “Simplified” spatial structure compared with 2018 (5 to 4 regions) South Pacific ocean (3 x WCPFC, 1 x IATTC)
- 25 fisheries (17 LL, 2 DN, 2 TR, 4 Index fisheries (1 per region)
- Similar approach to 2018, CPUE standardisation (spatio-temp delta GLMM, VAST, Thorson et al. 2015)
- New otolith based growth parameter estimations (L_{max}=107.23 cm; k= 0.268/yr; L_{min}= 41.07 cm), and an alternative growth LF estimation fixing just L_{max} (L_{max}=107.23 cm; k= 0.210/yr, L_{min}= 46.06 cm)
- **Movement hypotheses: MFCL (internal estimated)** and **SEAPODYM** movement (fix param., external).





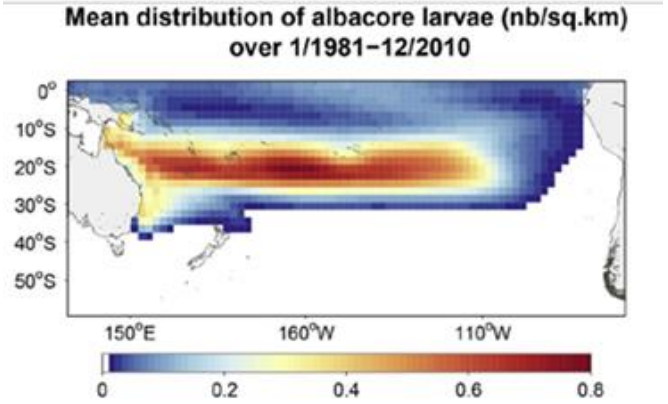
Other sources of information to inform movement rates: Spatial Ecosystem And Population Dynamics Model; SEAPODYM (Senina et al. 2020)

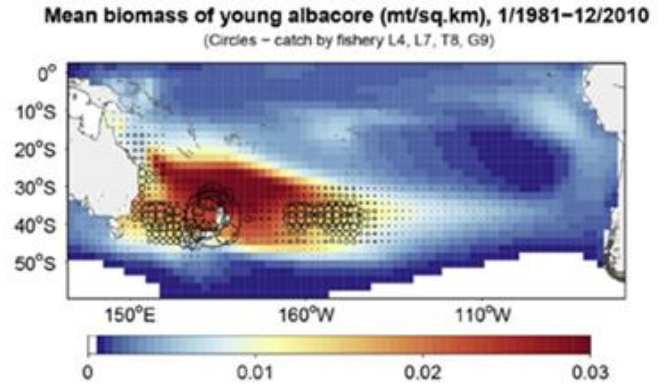
- SEAPODYM provides predictions on spatio-temporal exchange of biomass by age class (in numbers and months), forced by environmental/habitat variables
- Convert this to an "average" matrix of probabilities for movement between regions by 'quarter' and age
- Apply this matrix of quarterly/age movement probabilities to MFCL (fixed)

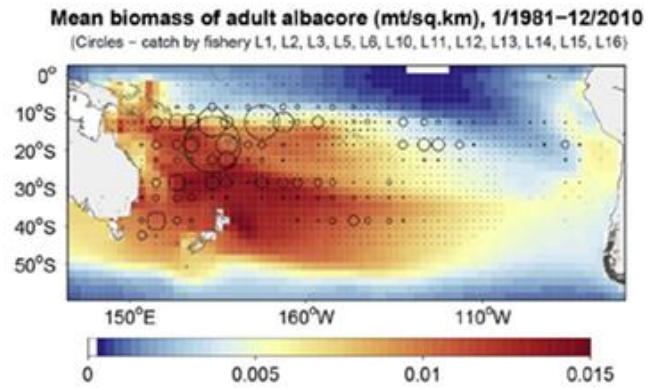
Quantitative modelling of the spatial dynamics of South Pacific and Atlantic albacore tuna populations

Inna N. Senina [a,*], Patrick Lehodey [a], John Hampton [b], John Sibert [c]

Deep–Sea Research II 175 (2020) 104667





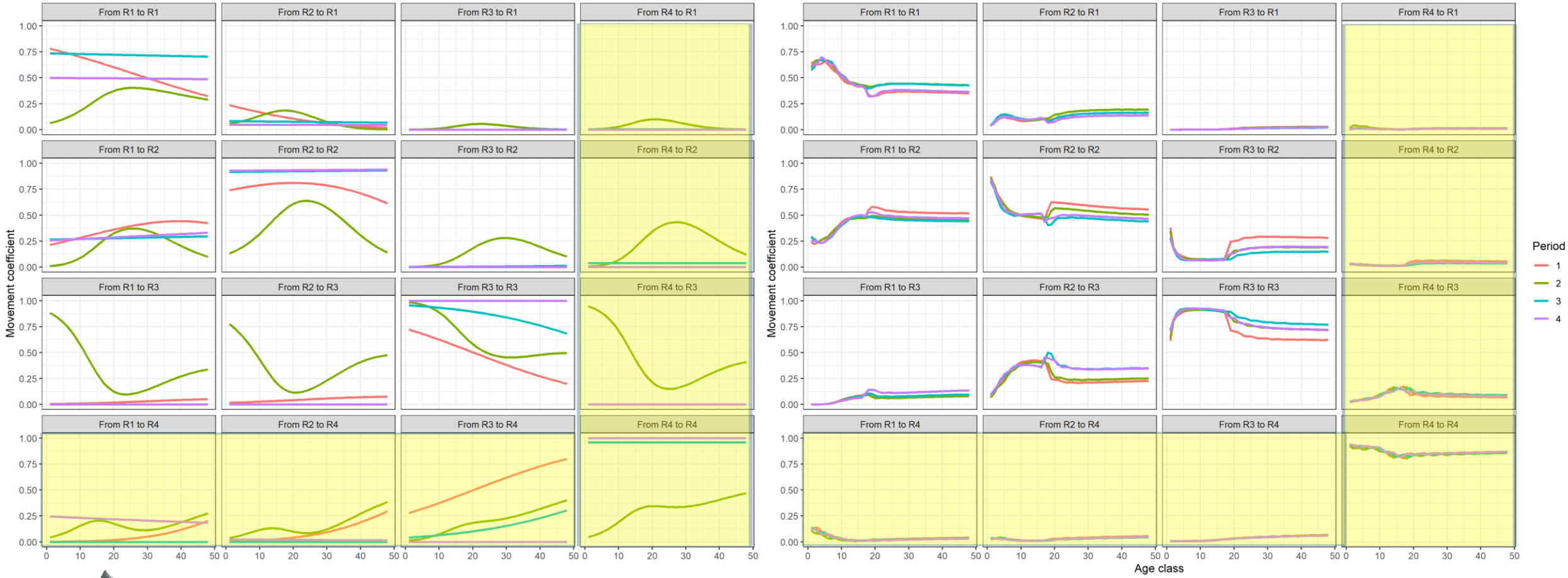


MOVEMENT

Pacific Community
Communauté du Pacifique

MFCL estimated internally (M1)

SEAPODYM (M2)



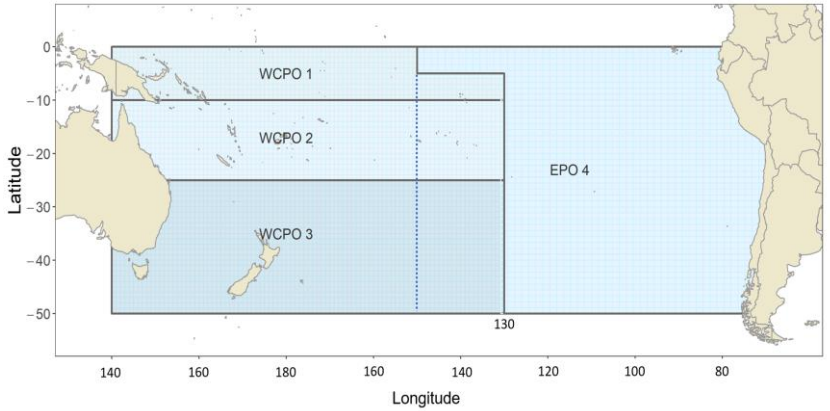
Interaction Region1,2,3 / Region 4

Bilyana Stoyanovska | Dreamstime.com

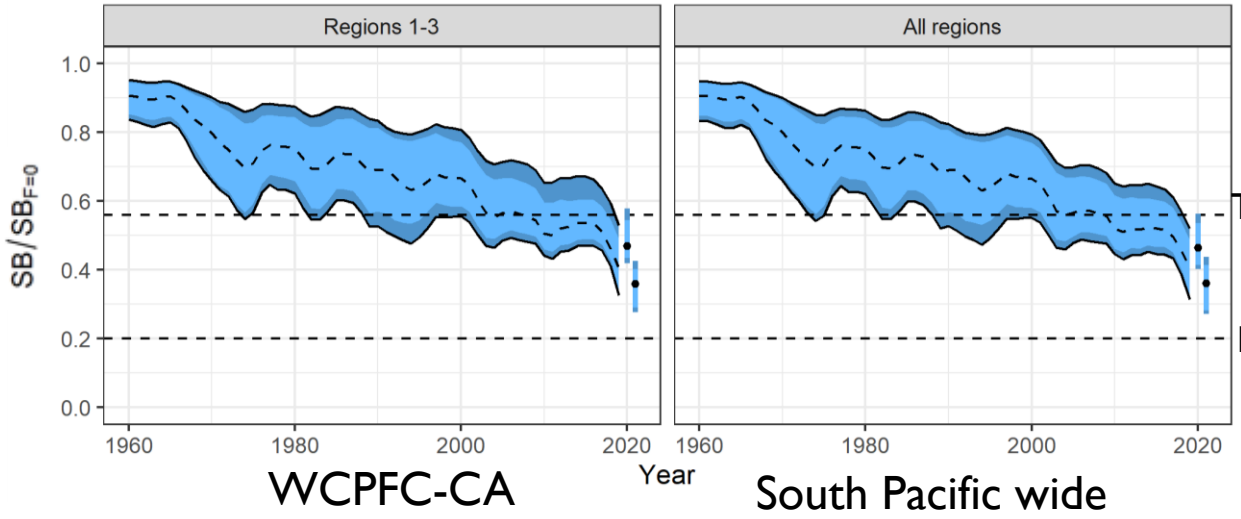
STRUCTURAL UNCERTAINTY GRID

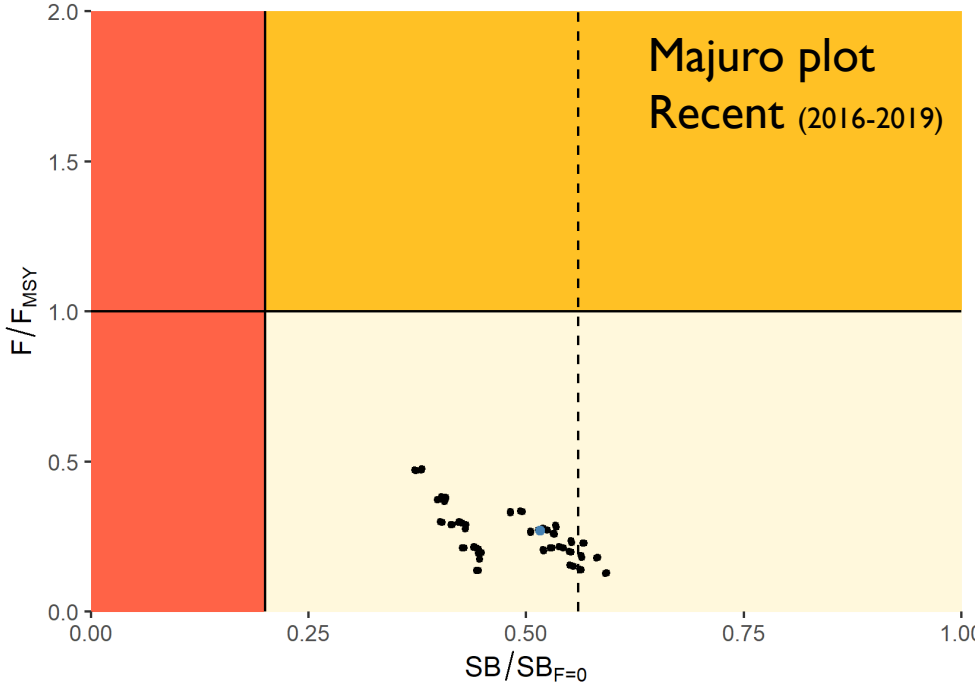
Axis	Value
Steepness	0.65 **0.80** 0.95
Movement	**Model estimated**, SEAPODYM
Data weighting	50 (low) **25 (medium)** 10 (high)
Recruitment distribution	**SEAPODYM**, Regions 3 - 4
Growth/M-at-age	**Otolith growth/associated M-at-age**, LF/associated M-at-age

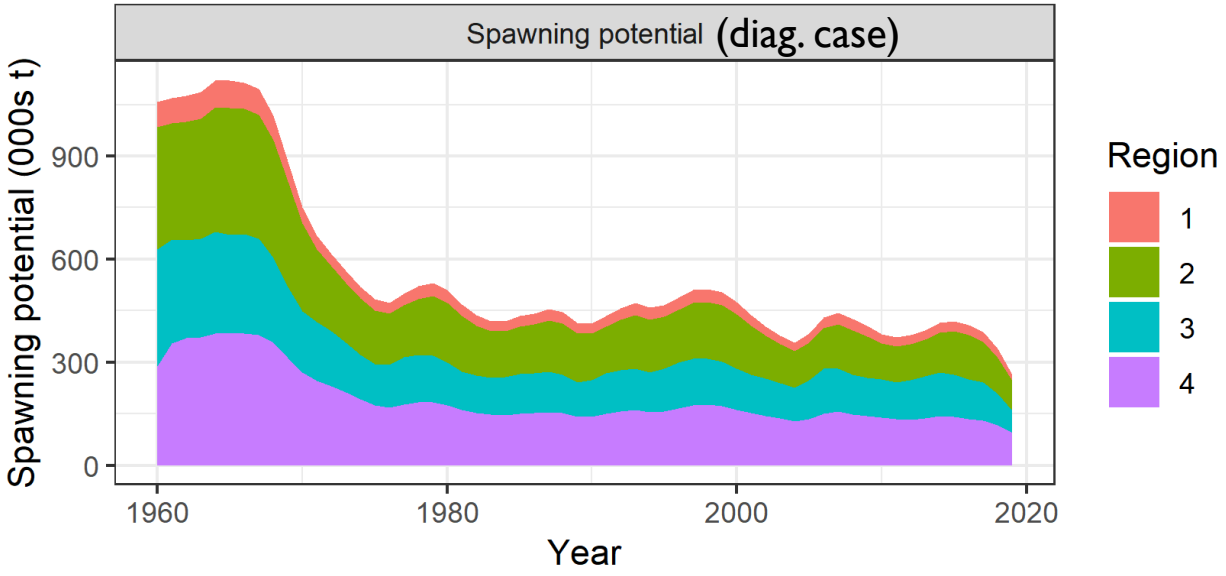
OUTCOMES 2021



Dynamic depletion







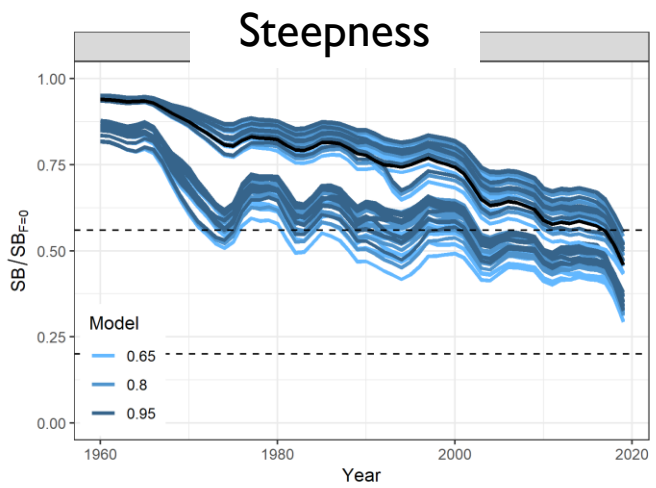
KEY UNCERTAINTIES

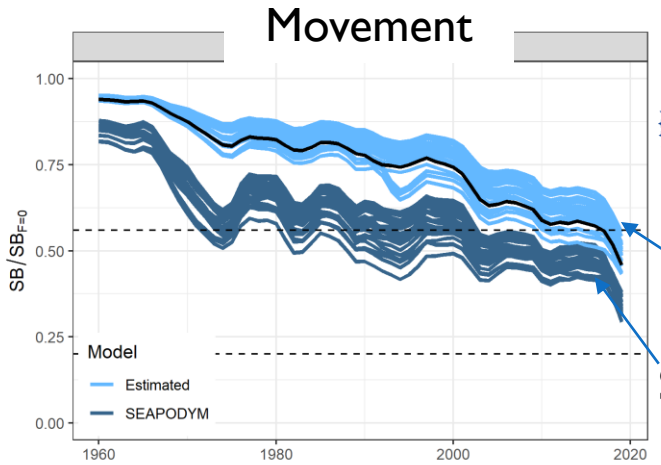
All regions
South Pacific wide

Overlap for some analysis

Main uncertainties:

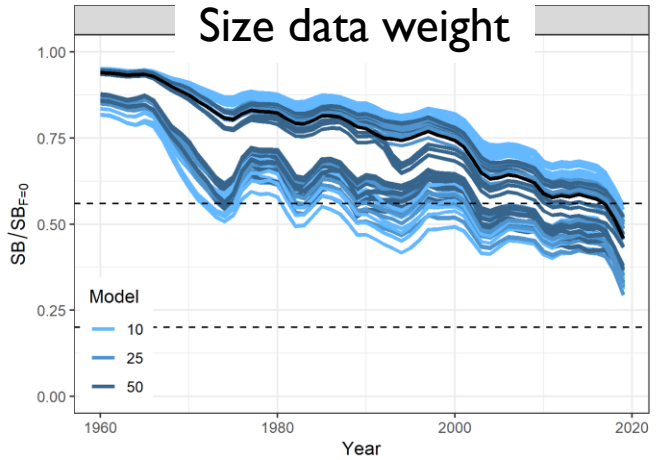
- Movement
- Size data weighting

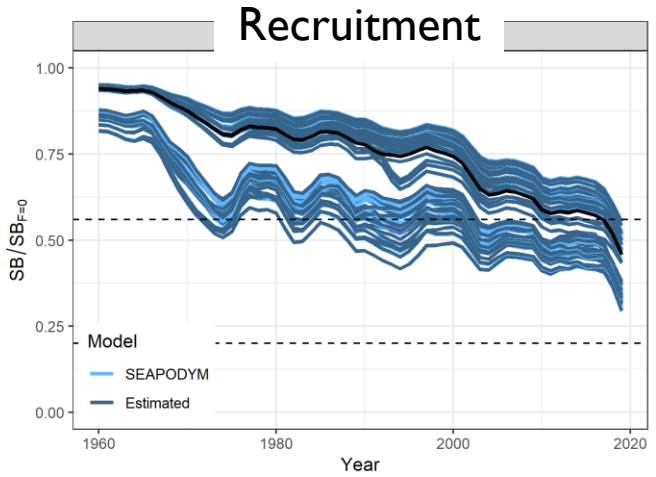


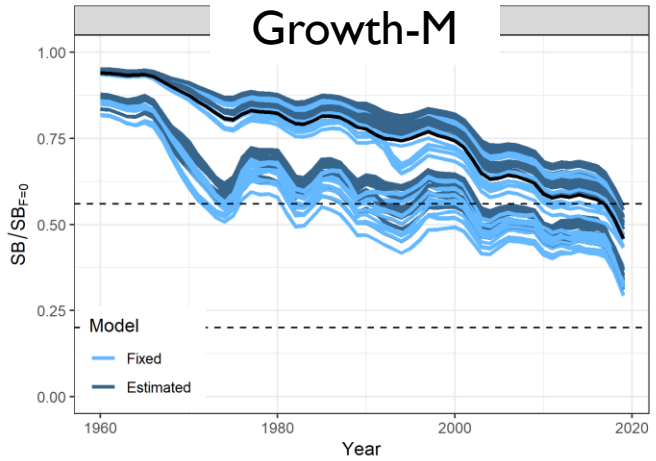


Internal estimation

SEAPODYM

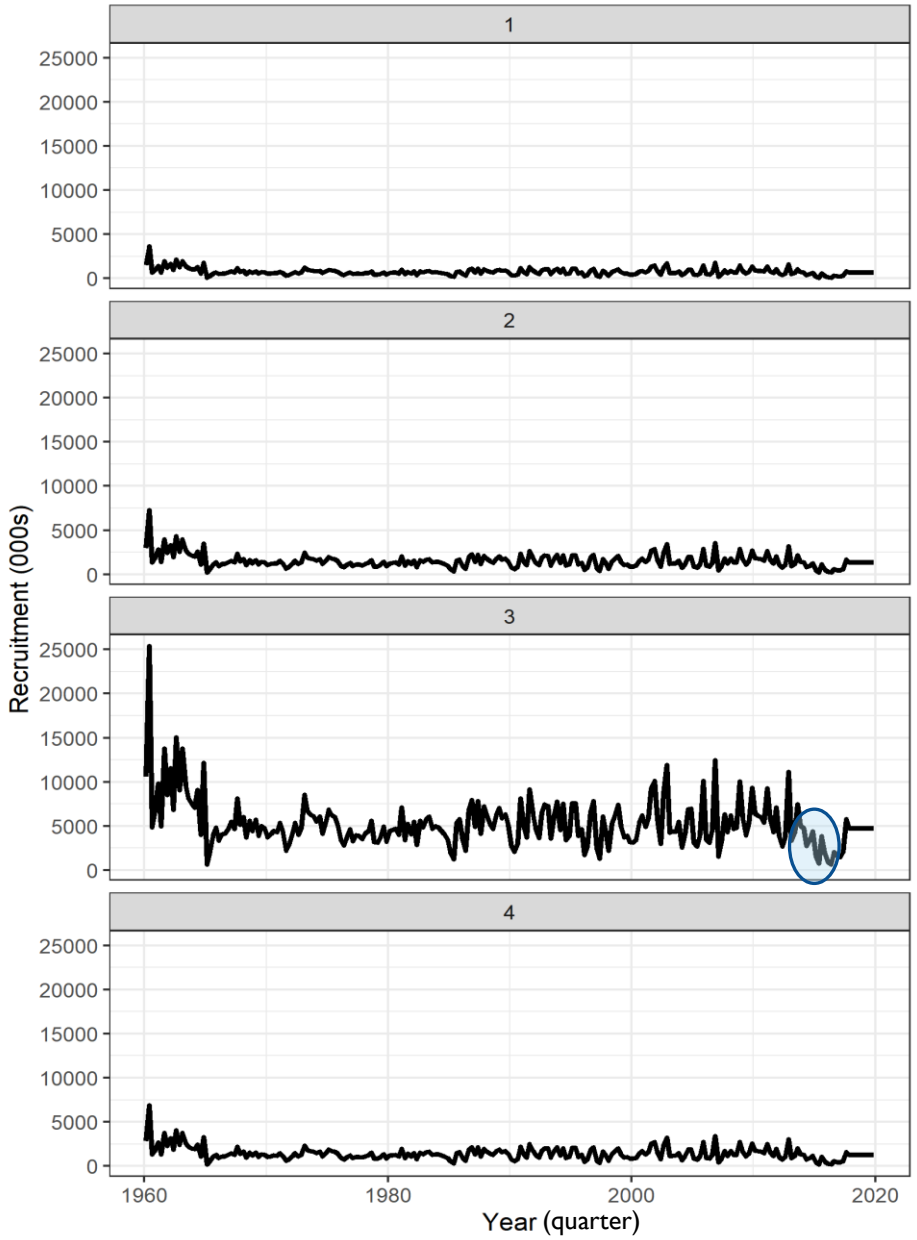






Depletion ($SB/SB_{F=0}$)

RECRUITMENT

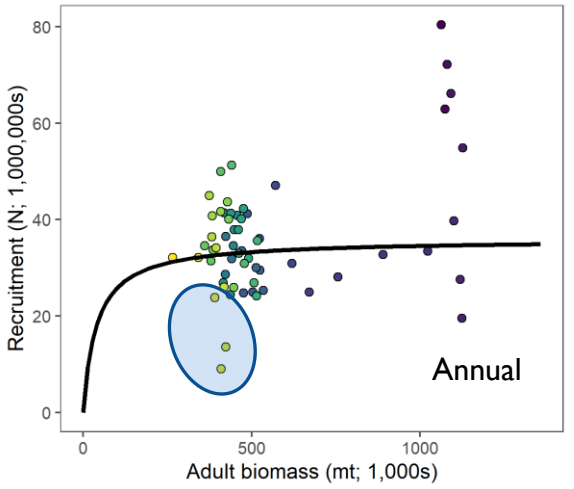


- Last 9 quarters = average recruitment

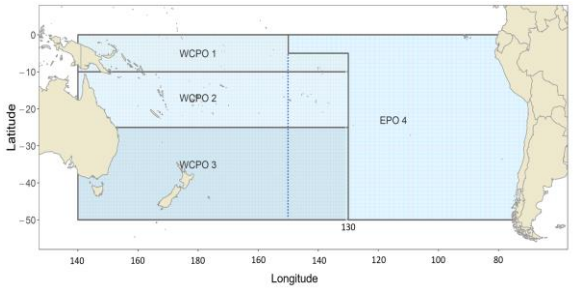
- Low recruitment estimated for years 2015-2017

- Investigation of influences on low recruitment estimates:
  - not related to region 4
  - mostly related to region 3 data
  - not influenced by the alternative movements
  - not driven by the recent CPUE in region 3
  - exploration of LF data suggests related to multiple data set (LLs, Index fisheries, and more so NZ troll)

- Low recruitment could be related to El Niño 2015-16



OFP-SPC, SC17-EB-IP-09



MAIN CONCLUSIONS

- Spawning potential has generally declined across the model period, with that decline increasing in the most recent years. Consistent general trends by regions
- SPO “latest” (2019) and “recent” (2016-2019) (Table 5)

	Mean	Median	Min	10%	90%	Max
$SB_{latest}/SB_{F=0}$	0.35	0.36	0.25	0.27	0.44	0.46
$SB_{recent}/SB_{F=0}$	0.48	0.47	0.37	0.40	0.56	0.59

- Uncertainty in movement and the size frequency data weighting are the major contributors to the overall assessment uncertainty.
- CPUE indices lacked contrast to inform population scale, which was more influenced by the size composition data.
- Poor recruitment estimated in 2015-2017 period

BY RFMO

WCPFC-CA

	Mean	Median	Min	10%	90%	Max
C_{latest}	78946	78434	75673	76740	79163	118706
$SB_{F=0}$	457559	452323	415746	432039	483703	501602
$SB_{latest}/SB_{F=0}$	0.35	0.36	0.26	0.28	0.43	0.44
$SB_{recent}/SB_{F=0}$	0.49	0.47	0.39	0.42	0.58	0.61

IATTC-CA

	Mean	Median	Min	10%	90%	Max
C_{latest}	8351	8166	7845	7903	8773	12229
$SB_{F=0}$	187230	157583	92190	95879	336838	379718
$SB_{latest}/SB_{F=0}$	0.35	0.36	0.22	0.24	0.46	0.48
$SB_{recent}/SB_{F=0}$	0.43	0.43	0.28	0.31	0.56	0.57

interim Target Reference Point (iTRP) for WCPFC convention area

- The iTRP of $SB/SB_{F=0}$ = 0.56, is based on the objective of achieving a 'longline vulnerable biomass' equivalent to that estimated for 2013 + 8%,

- Which equated to a depletion level of 0.56 under the relevant assessment at that time.

- Based on the current assessment the 'longline vulnerable' biomass for the WCPFC convention area is:

  Recent (2016-2019) period: median 78% of 2013+ 8%

  Latest (2019) period: median 60% of 2013+ 8%

KEY CHALLENGES AND RESEARCH SUGGESTIONS

- **Movement:** Biological research to improve understanding of population structure and movement, genetics, otolith chemistry, spatial growth etc. – multimethod approaches
- **Recruitment dynamics:** Environmental/oceanography influences on South Pacific albacore recruitment
- **Implications poorly specified spatial models:** MSE or simulation-estimation approaches to investigate implications of spatial/movement uncertainties
- **Early life growth, growth variation**: Spatio-temporal analysis of growth (i.e. last major otolith sampling/ageing were in 2009-2010), daily age of even smaller fish, alt. growth models
- **General model complexity:** parameter reductions (1000s effort deviates – move to catch conditioned), spatial complexity.
- **Independent estimates of population scale** (lack of CPUE contrast): Close-kin mark-recapture - CKMR (point estimates to scale future assessments, Bravington et al. 2021 (SC17-SA-IP-14)

UPDATED GRID AND REFERENCE POINT CALCULATIONS

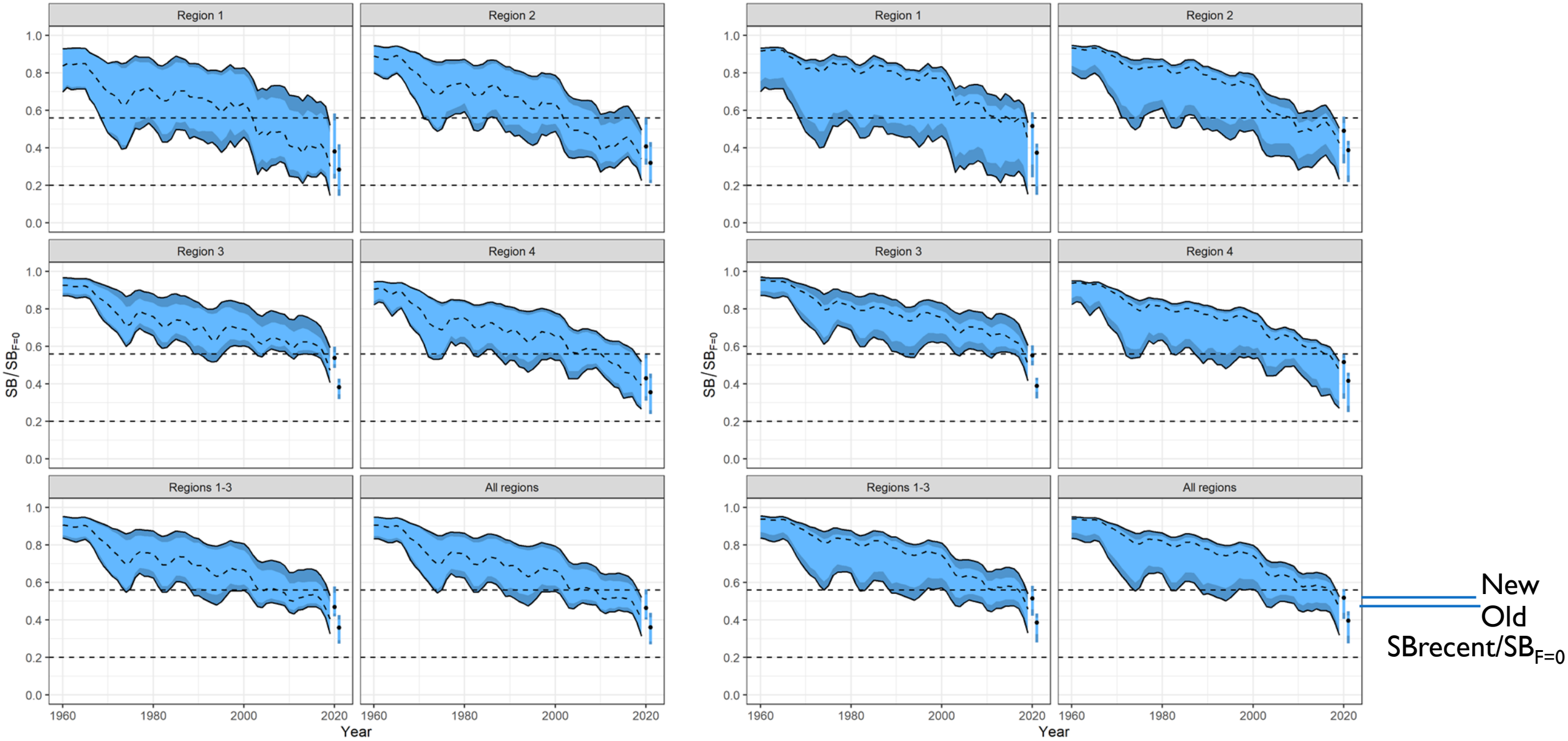
- SC directed the Science Service Provider to down-weight the SEAPODYM models (M2) in the movement axis of the structural uncertainty grid by 50%

- The new grid still include the 72 models, but with 36 models (M2) down-weighted by 50% for calculating the median value

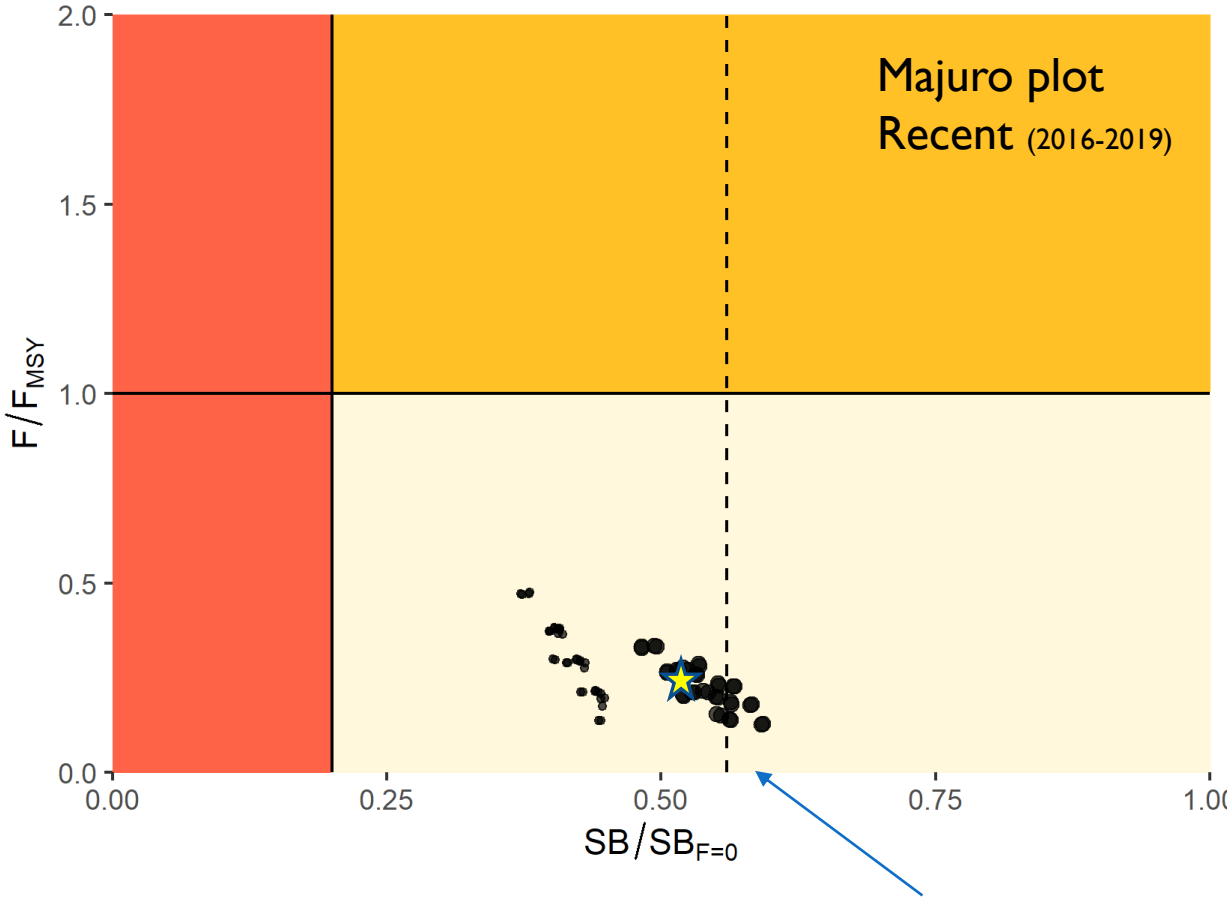
OLD GRID EQUALLY WEIGHTED ALL MODELS

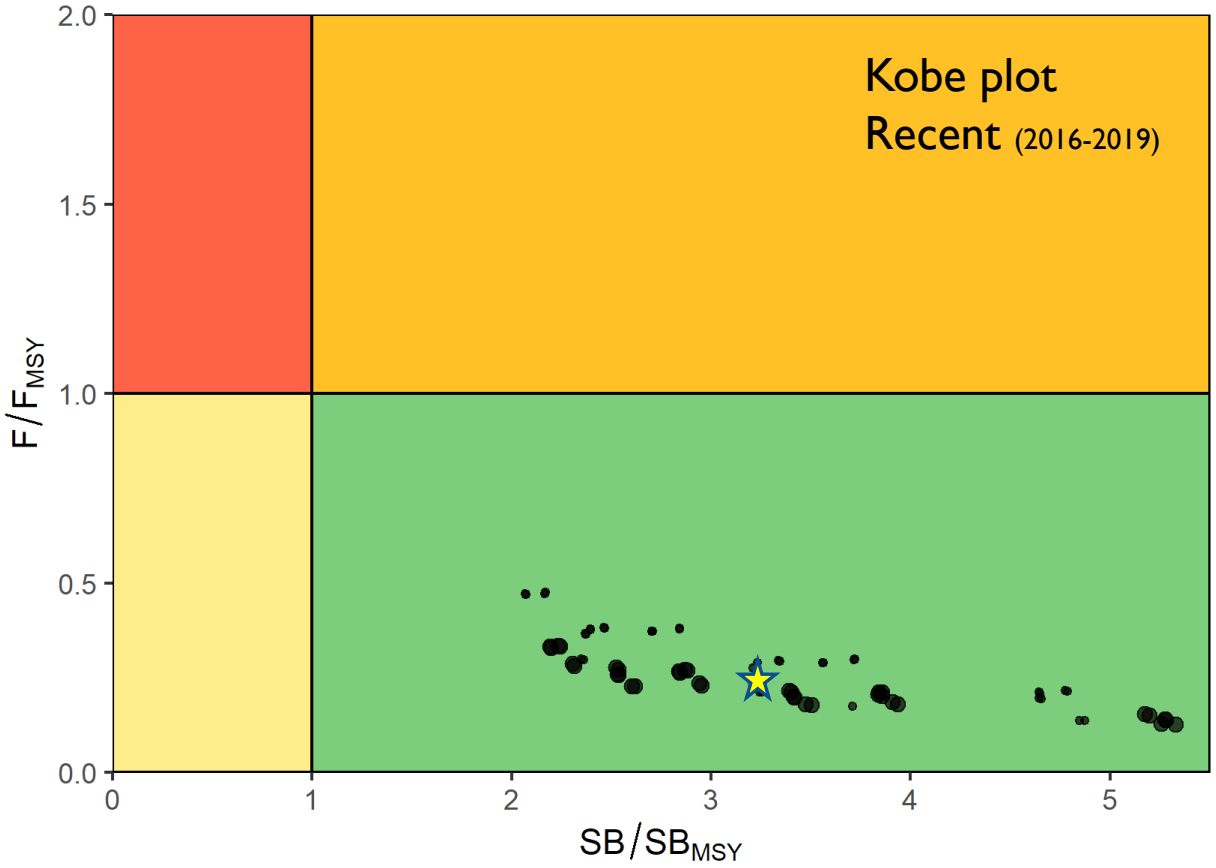
NEW GRID OUTCOMES WITH DOWN-WEIGHTED M2 MODELS FOR MANAGEMENT ADVICE

Pacific Community
Communauté du Pacifique



NEW PLOTS DOWN-WEIGHTED SEAPDYM (M2) MODELS





- Yellow star represents the median
- M1 models (larger black dots), M2 models (SEAPODYM) (small black dots)

NEW TABLE OF REFERENCE POINT VALUES WITH DOWN-WEIGHTED SEAPODYM (M2) MODELS

ALL REGIONS

	Mean	Median	Min	10%	90%	Max
C_{latest}	87184	86827	83519	85092	87633	130936
F_{MSY}	0.06	0.06	0.05	0.05	0.07	0.08
$fmult$	4.37	4.25	2.11	2.69	6.62	7.84
F_{recent}/F_{MSY}	0.25	0.24	0.13	0.15	0.37	0.47
MSY	115661	120020	68200	75584	158600	166240
SB_0	623542	660200	361800	392590	845100	929300
$SB_{F=0}$	675861	678345	524886	537740	824855	873278
SB_{latest}/SB_0	0.41	0.41	0.34	0.37	0.46	0.48
$SB_{latest}/SB_{F=0}$	0.37	0.40	0.25	0.27	0.45	0.46
SB_{latest}/SB_{MSY}	2.50	2.33	1.45	1.69	3.921	4.28
SB_{MSY}	109710	104100	48040	61497	157500	190000
SB_{MSY}/SB_0	0.18	0.18	0.11	0.11	0.22	0.23
$SB_{MSY}/SB_{F=0}$	0.16	0.16	0.09	0.11	0.22	0.23
$SB_{recent}/SB_{F=0}$	0.50	0.52	0.37	0.41	0.57	0.59
SB_{recent}/SB_{MSY}	3.34	3.22	2.07	2.24	5.18	5.33
$YF_{current}$	81998	85020	58440	63656	94720	101400

NEW TABLE OF REFERENCE POINT VALUES WITH DOWN-WEIGHTED SEAPODYM (M2) MODELS

Pacific Community
Communauté du Pacifique

WCPFC-CA

	Mean	Median	Min	10%	90%	Max
C_{latest}	78788	78455	75673	76959	79126	118706
$SB_{F=0}$	459648	463424	415746	431617	491092	501602
$SB_{latest}/SB_{F=0}$	0.37	0.39	0.26	0.28	0.43	0.45
$SB_{recent}/SB_{F=0}$	0.51	0.52	0.39	0.42	0.58	0.61

IATTC-CA

	Mean	Median	Min	10%	90%	Max
C_{latest}	8396	8242	7845	8074	8760	12229
$SB_{F=0}$	216213	233755	92190	98063	356491	379718
$SB_{latest}/SB_{F=0}$	0.38	0.42	0.22	0.25	0.46	0.48
$SB_{recent}/SB_{F=0}$	0.47	0.52	0.28	0.32	0.56	0.57

interim Target Reference Point (iTRP) for WCPFC convention area
Updated for the down-weighted SEAPODYM (M2) models

- Based on the current assessment the 'longline vulnerable' biomass for the WCPFC convention area is:

  Recent (2016-2019) period: median 76% of 2013+ 8%

  Latest (2019) period: median 56% of 2013+ 8%

TO BE CONTINUE...

https://ofp-sam.shinyapps.io/SALSA/

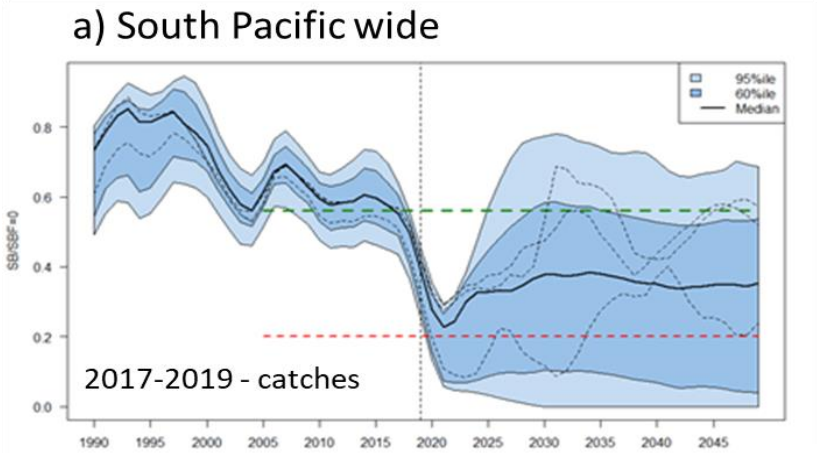
South Pacific ALbacore Stock Assessment

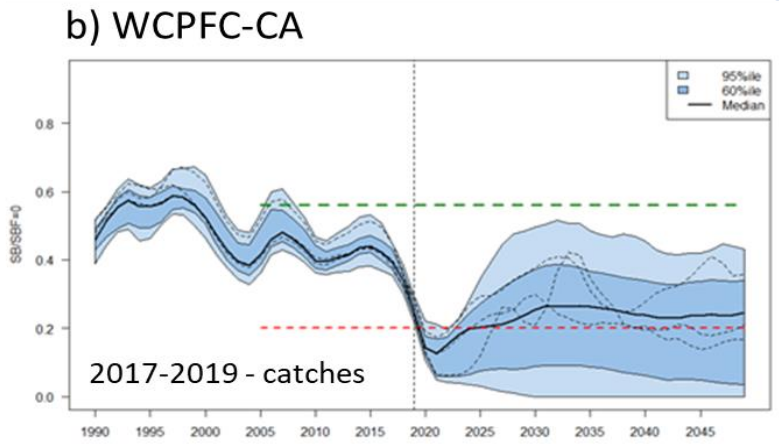
Version 0.0.1 The Filthy Fraco

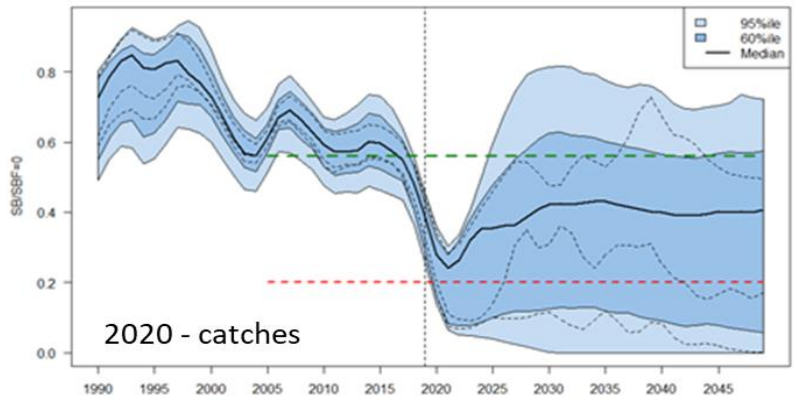
EXTRA SLIDES

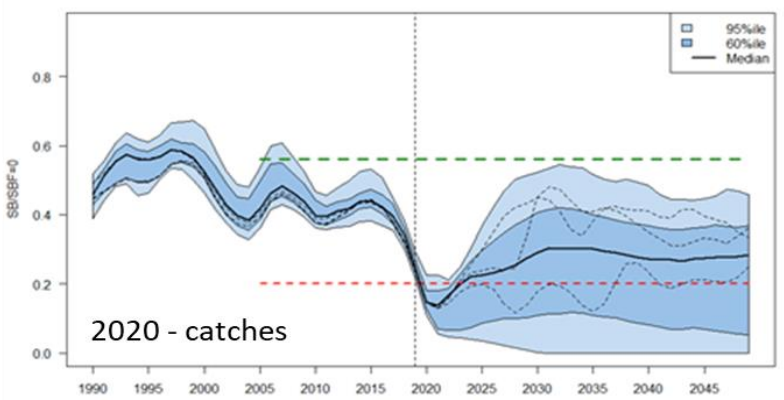
PROJECTIONS

Catch based









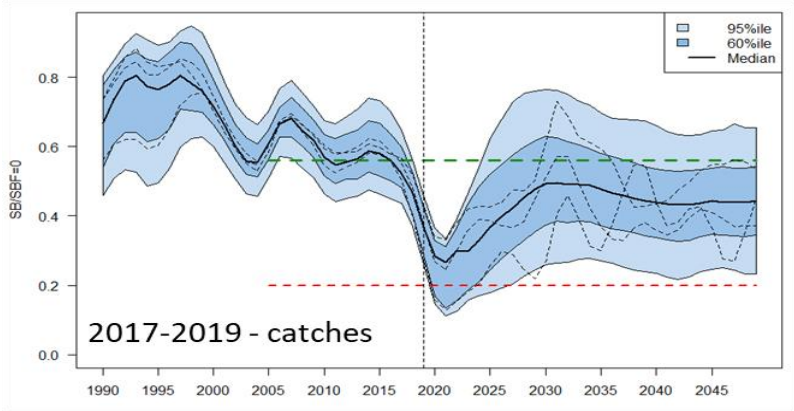
Fishing level	$SB_{2025}/SB_{F=0}$	$SB_{2035}/SB_{F=0}$	$SB_{2049}/SB_{F=0}$	Risk $SB_{2049}/SB_{F=0}$ < LRP	F/F_{MSY}	Risk $F>F_{MSY}$
2017-2019 average	0.33	0.38	0.35	30%	0.43	27%
2020	0.36	0.43	0.41	26%	0.37	26%

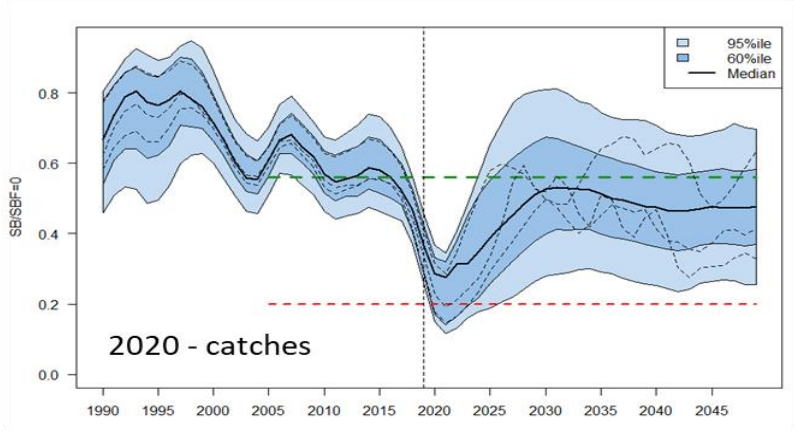
Fishing level	$SB_{2025}/SB_{F=0}$	$SB_{2035}/SB_{F=0}$	$SB_{2049}/SB_{F=0}$	Risk $SB_{2049}/SB_{F=0}$ < LRP
2017-2019 average	0.20	0.26	0.24	36%
2020	0.22	0.30	0.28	30%

Pacific Community
Communauté du Pacifique

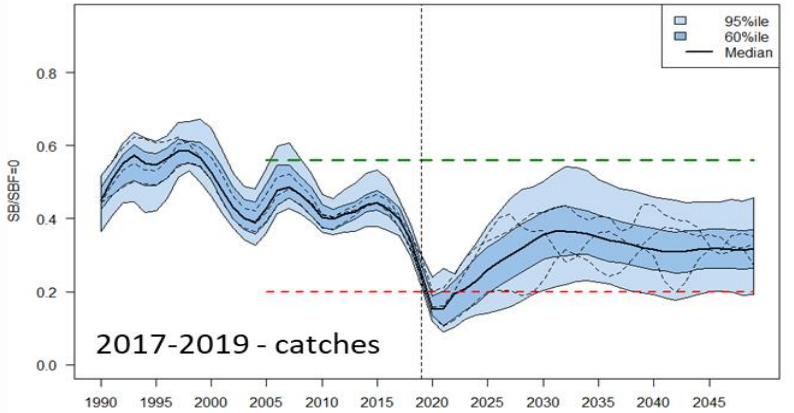
Effort based

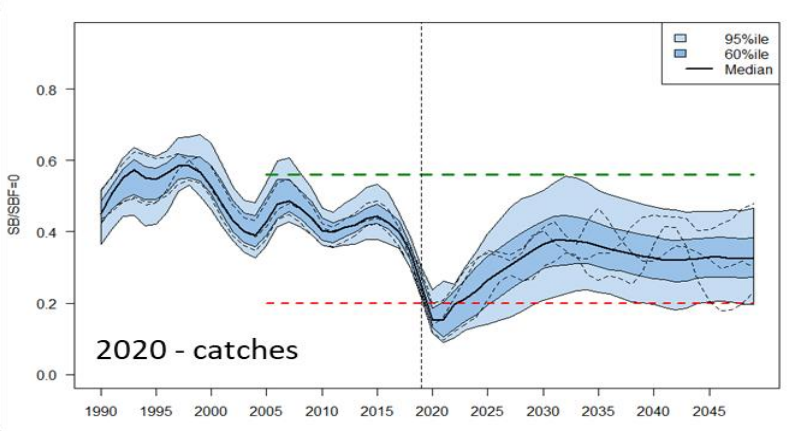
a) South Pacific wide





b) WCPFC-CA

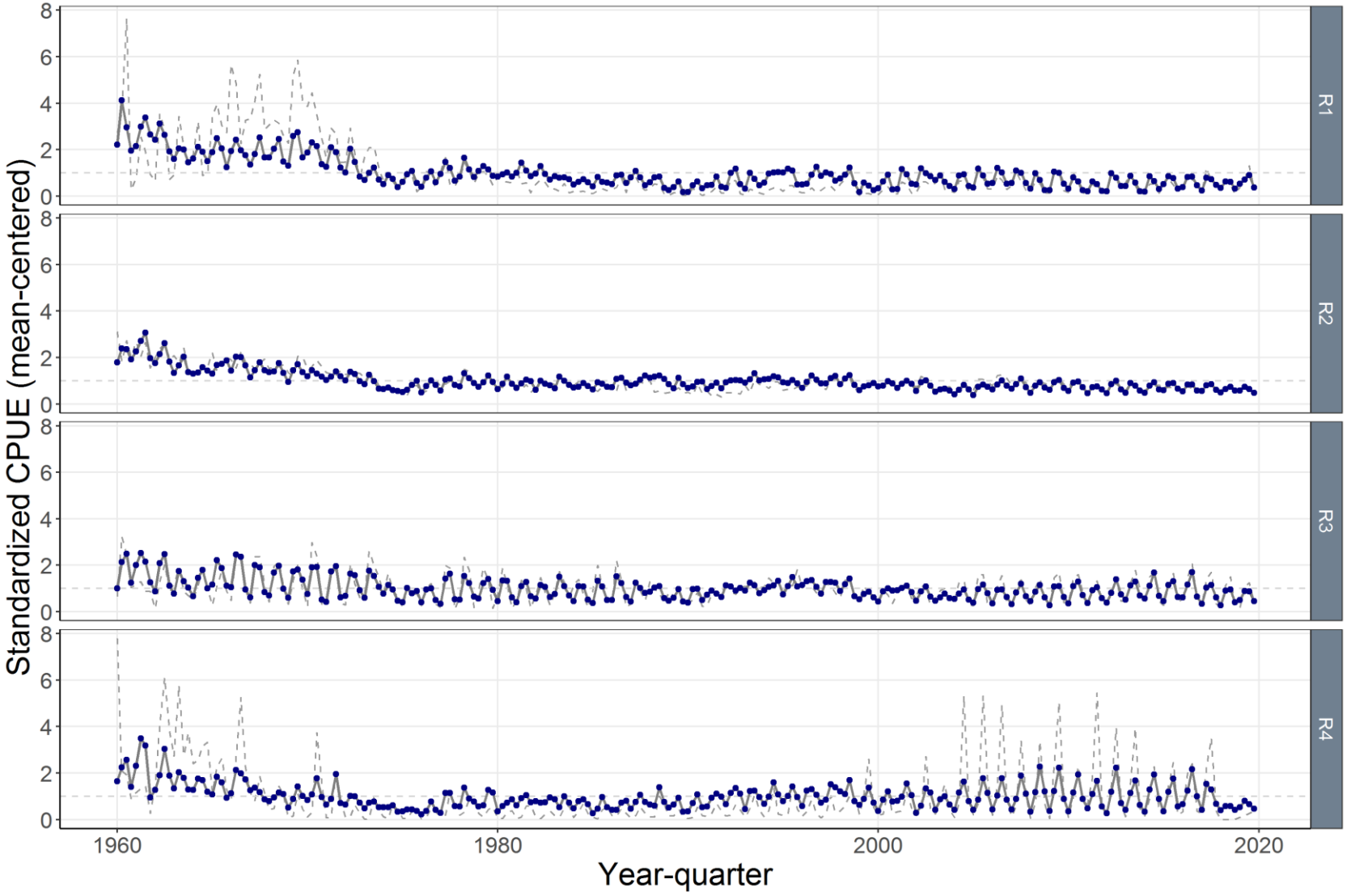




Fishing (effort) level	$SB_{2025}/SB_{F=0}$	$SB_{2035}/SB_{F=0}$	$SB_{2049}/SB_{F=0}$	Risk $SB_{2049}/SB_{F=0}$ < LRP	F/F_{MSY}	Risk $F>F_{MSY}$
2017-2019 average	0.37	0.48	0.44	1%	0.26	0%
2020	0.39	0.51	0.48	0%	0.24	0%

Fishing (effort) level	$SB_{2025}/SB_{F=0}$	$SB_{2035}/SB_{F=0}$	$SB_{2049}/SB_{F=0}$	Risk $SB_{2049}/SB_{F=0}$ < LRP
2017-2019 average	0.26	0.35	0.32	4%
2020	0.26	0.36	0.32	3%

CPUE


Standardized CPUE (mean-centered)
0
2
4
6
8
R1
R2
R3
R4
1960
1980
2000
2020
Year-quarter

Proposed fishery definitions

Fishery Number	Gear	Model Code-Fleets	Flags	Model region	Fleet area
1	LL	1-LL-DWFN	ALL	1	a
2	LL	2-LL-PICT	ALL	1	a
3	LL	3-LL-DWFN	ALL	2	a
4	LL	4-LL-PICT	ALL	2	a
5	LL	5-LL-AZ	AU/NZ	2	a
6	LL	6-LL-DWFN	ALL	3	a
7	LL	7-LL-PICT	ALL	3	a
8	LL	8-LL-AZ	AU/NZ	3	a
9	LL	9-LL-DWFN	All	1	b
10	LL	10-LL-PICT	All	1	b
11	LL	11-LL-DWFN	ALL	2	b
12	LL	12-LL-PICT	ALL	2	b
13	LL	13-LL-DWFN	ALL	3	b
14	LL	14-LL-PICT	ALL	3	b
15	TR	15-3a-All-TR	ALL	3	a
16	DN	16-3a-All-DN	ALL	3	a
17	DN	17-3b-All-DN	ALL	3	b
18	LL	18-LL-EPO1	ALL	4	a
19	LL	19-LL-EPO2	ALL	4	b
20	LL	20-LL-EPO3	ALL	4	c
21	TR	21-TR-EPO	ALL	4	a, b, c
22	LL	1-L-INDEX	INDEX	1	-
23	LL	2-L-INDEX	INDEX	2	-
24	LL	3-L-INDEX	INDEX	3	-
25	LL	4-L-INDEX	INDEX	4a	a*

- Including separate fisheries for the 'overlap area' of each WCPO region
  = 21 extraction fisheries

- 4 index fisheries for CPUE analysis (one per model region)

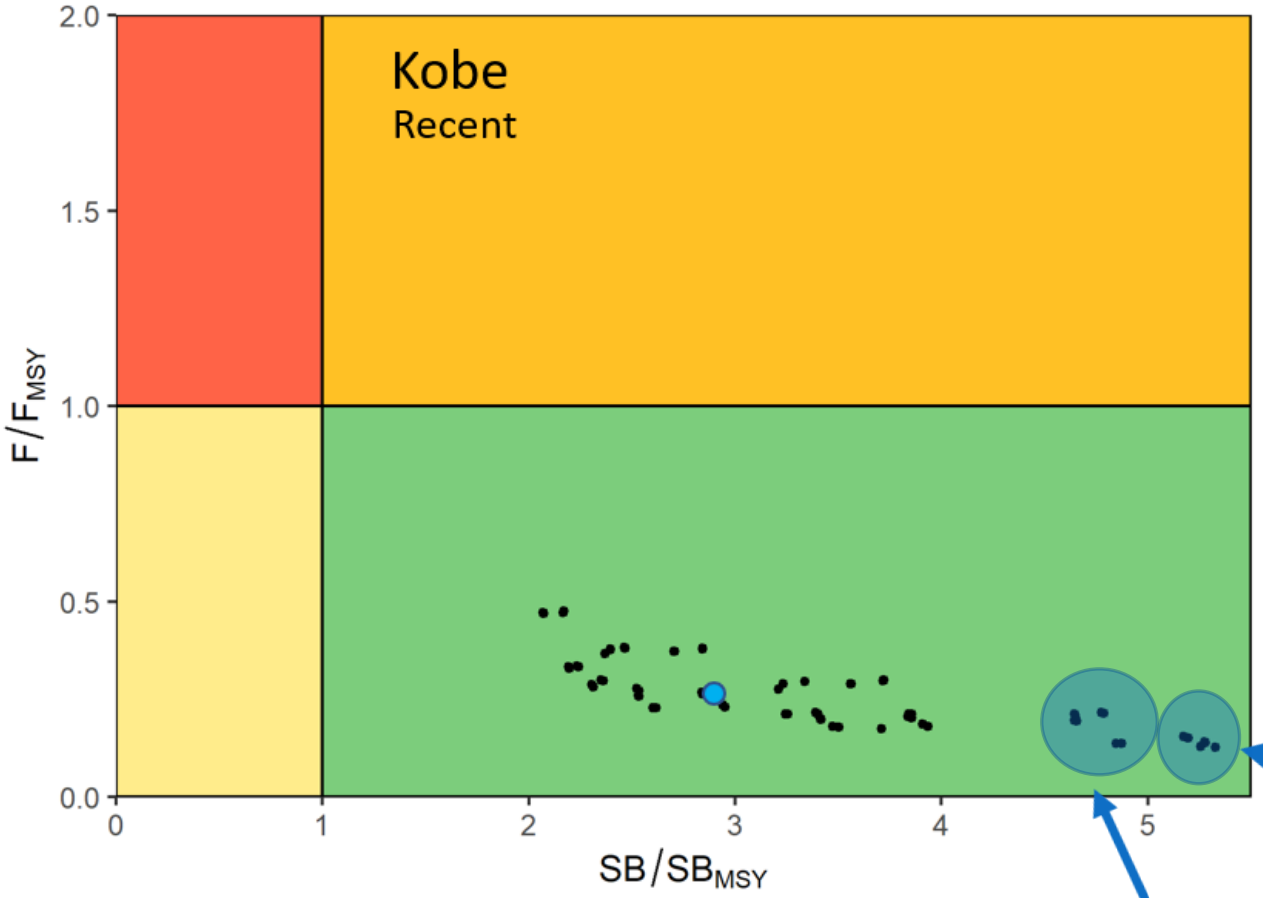
- * considering a second index fishery for area 4 b, c,- indexing a different (smaller) size/age component

- Splitting the CPUE time series would further increase index fleets

STRUCTURAL UNCERTAINTY GRID

Axis	Value
Steepness	0.65 **0.80** 0.95
Movement	**Model estimated**, SEAPODYM
Data weighting	50 (low) **25 (medium)** 10 (high)
Recruitment distribution	**SEAPODYM**, Regions 3 - 4
Growth/M-at-age	**Otolith growth/associated M-at-age**, LF/associated M-at-age

Question regarding grid models with high SB/SB_{MSY}



High productive models
Steepness 0.95 (S3)
LF growth, higher juvenile M (G2)

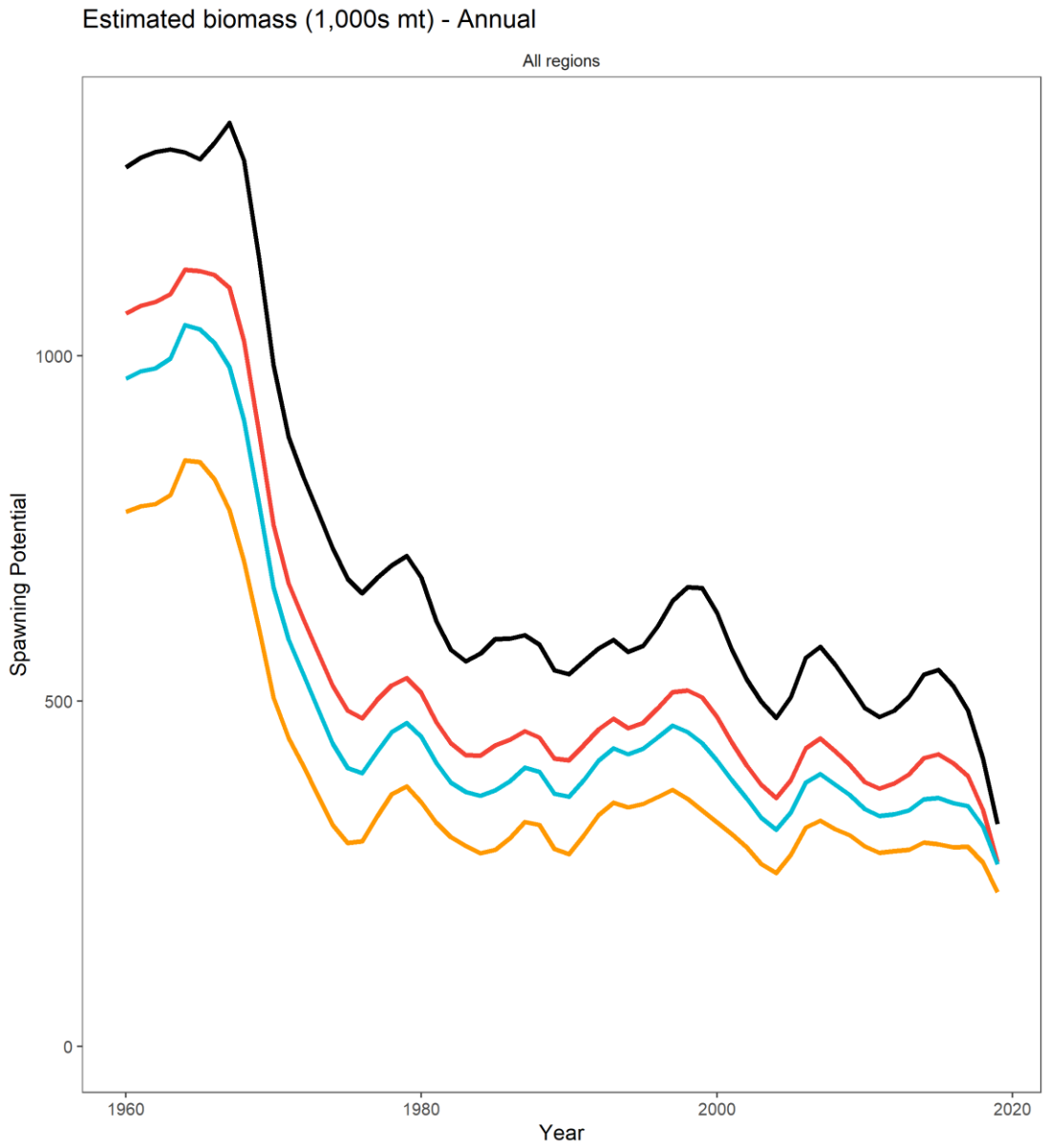
SB/SBmsy > 5
N=6

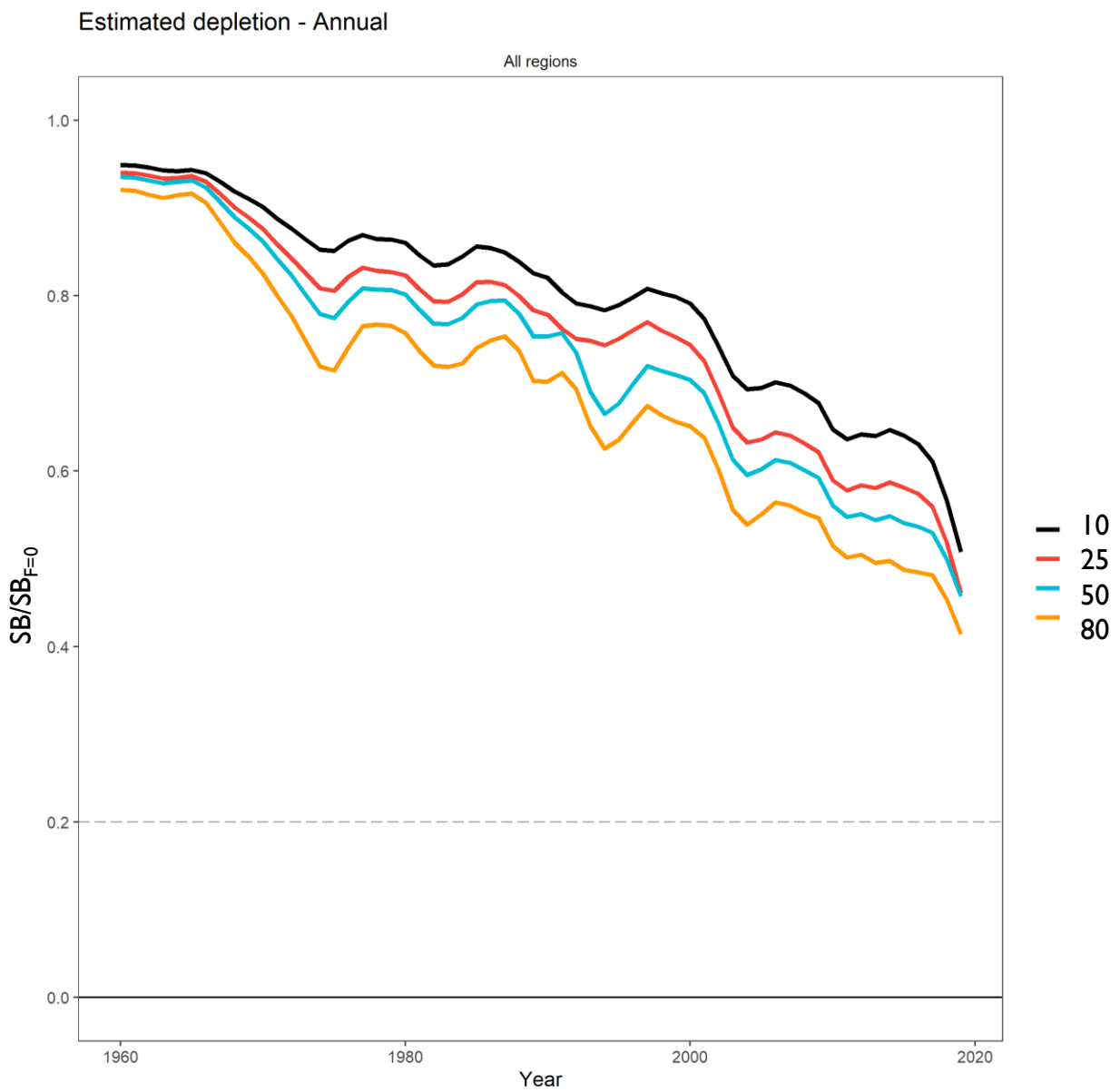
SB/SBmsy > 4
N=9

model	sbrecent_sbmsy
24 S1M2D3R2G2	4.776892
50 S3M1D1R1G2	5.256445
52 S3M1D1R2G2	5.328957
54 S3M1D2R1G2	5.195295
56 S3M1D2R2G2	5.175051
58 S3M1D3R1G2	5.278910
60 S3M1D3R2G2	5.275835
62 S3M2D1R1G2	4.789506
64 S3M2D1R2G2	4.776892
66 S3M2D2R1G2	4.645942
68 S3M2D2R2G2	4.647846
69 S3M2D3R1G1	4.849349
70 S3M2D3R1G2	4.655514
71 S3M2D3R2G1	4.874076
72 S3M2D3R2G2	4.643346

QUESTION REGARDING SIZE DATA WEIGHTING DIFFERENCE BETWEEN 2018 AND 2021 GRIDS – BELOW SHOWS DIAGNOSTIC MODEL WITH WEIGHTING DIVISOR OF 80 INCLUDED

Pacific Community
Communauté du Pacifique

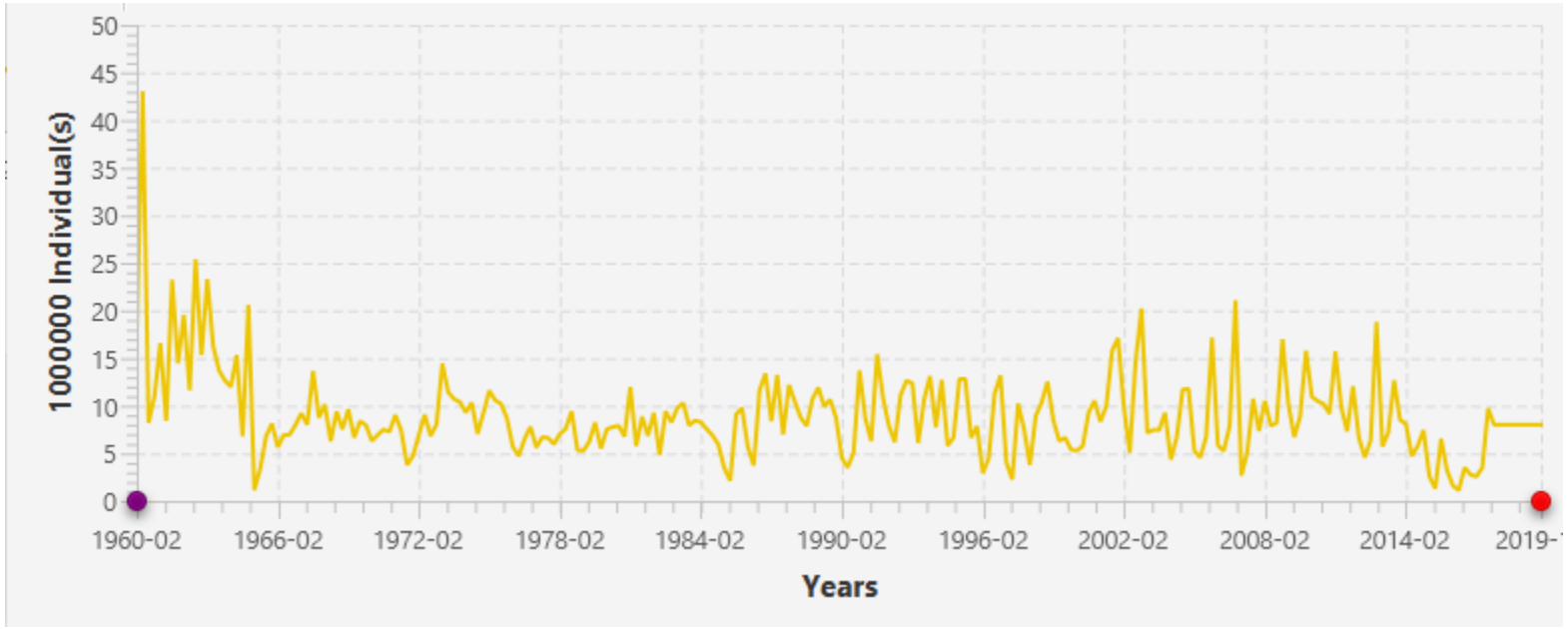


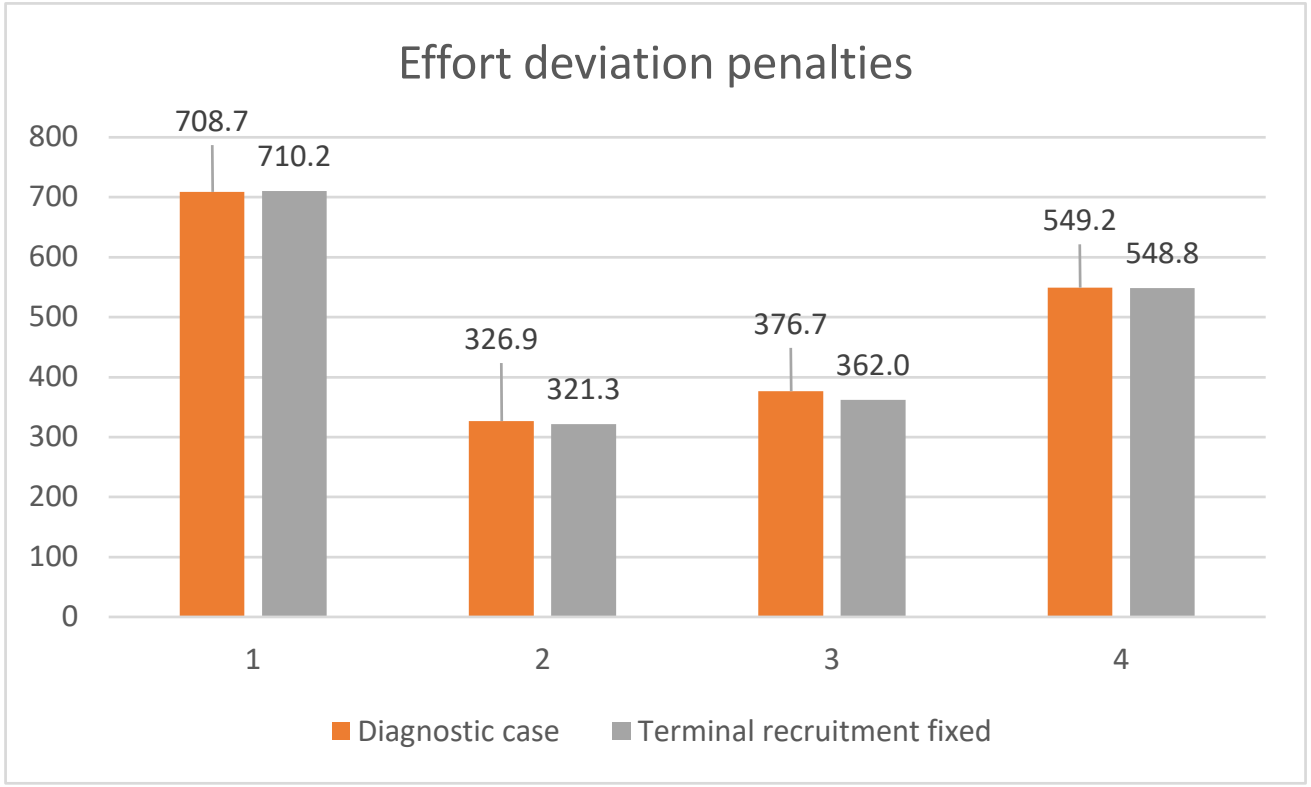


DIAGNOSING THE CAUSE OF RECENT LOW RECRUITMENT

ADDITIONAL SLIDES EXPLORING THE INFLUENCE OF REMOVING RECENT SIZE COMPOSITION DATA FROM NZ TROLL AND REGION 3 LONGLINE ON THE ESTIMATION OF RECENT RECRUITMENTS

DIAGNOSTIC CASE MODEL

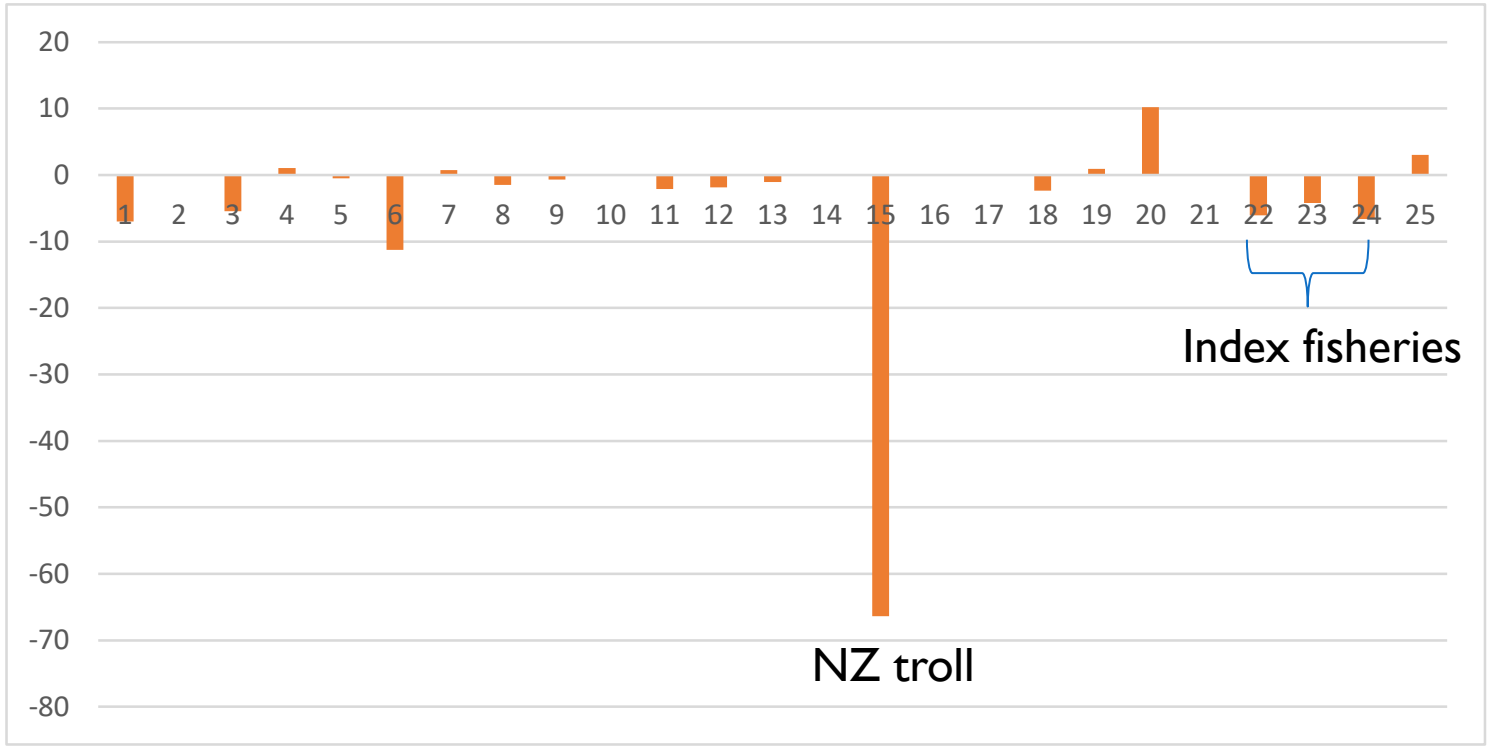




- Little impact of fixing last 24 terminal recruitments to mean (cf last 9)
- Overall, effort dev penalties actually reduced in the longer fixed terminal recruitment case
- Indicates that CPUE data are unlikely to be driving the recent low recruitment

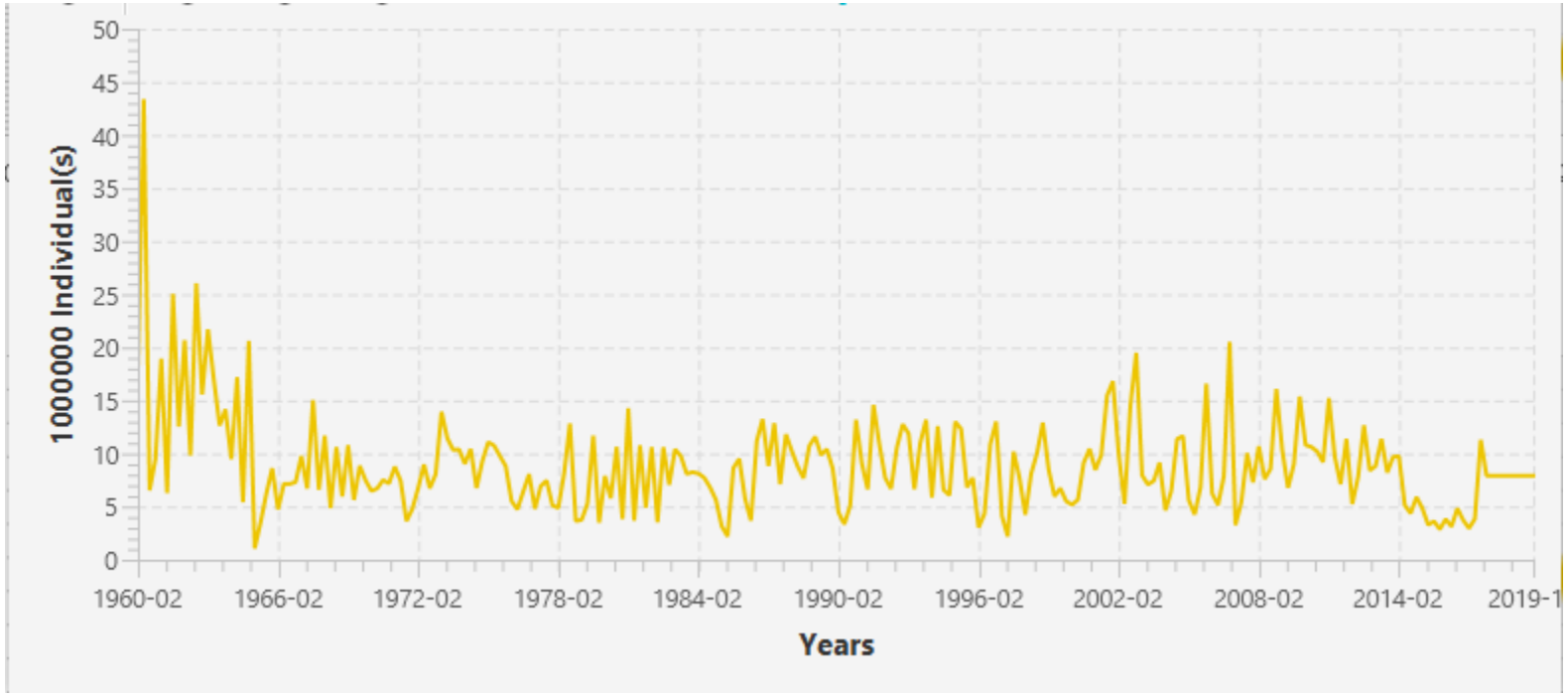
CHANGE IN LF DATA LIKELIHOOD

DIFFERENCE BETWEEN DIAGNOSTIC CASE (9 TERM. RECRUITMENTS FIXED, AND 24 TERM. RECRUITMENTS FIXED – NEGATIVE VALUES INDICATE POORER FIT OF THE LATTER)



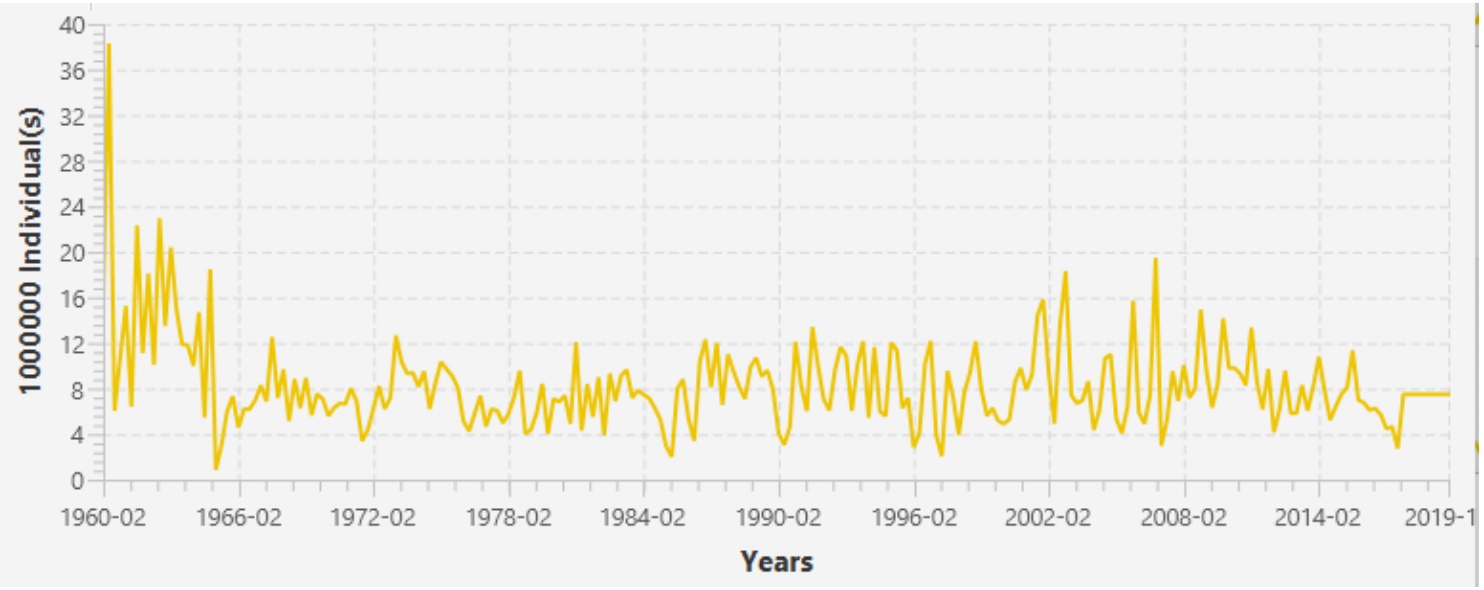
- Indicates that F15 (NZ troll) LF data is the main data source resulting in the low recent recruitment
- But some longline fisheries have some minor influence

NO NZ TR LF 2014-2019



- Removing the last 6 years of NZ TR LF data moderates the estimated recruitment decline, but does not completely remove it

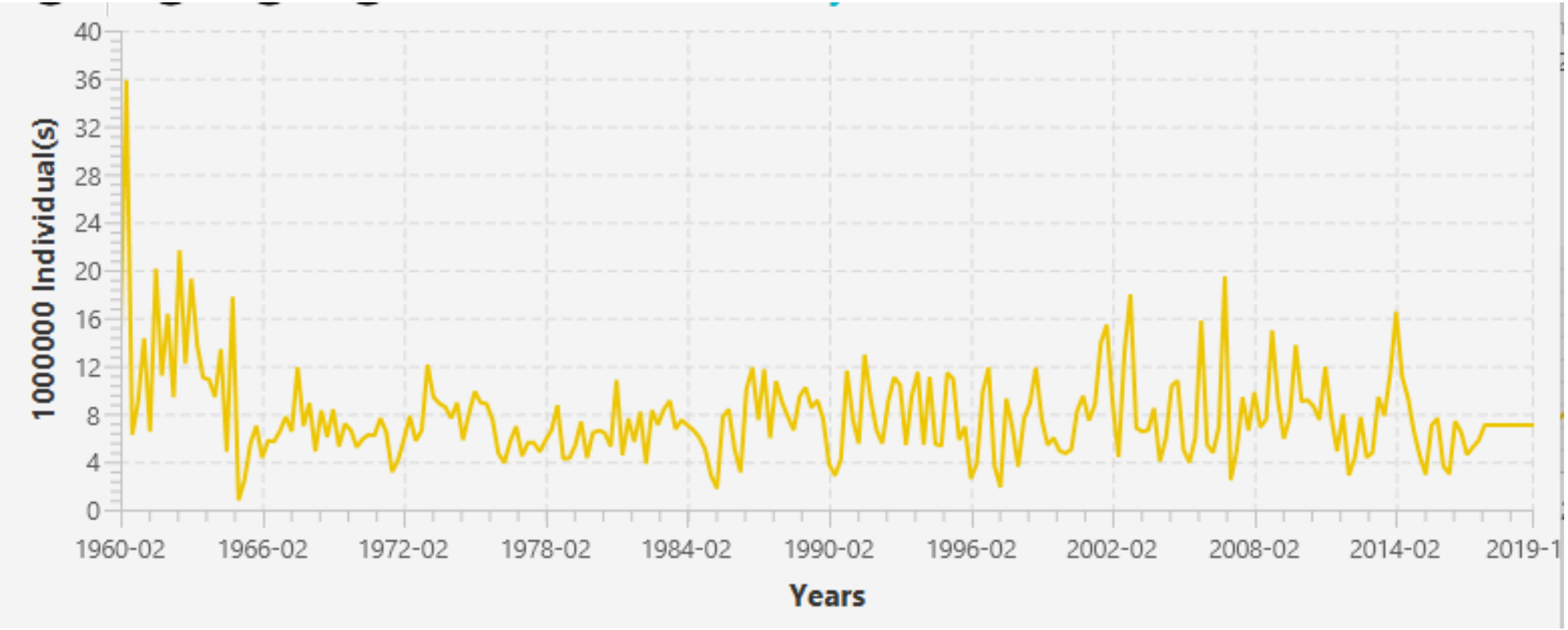
ADDITIONAL REMOVAL OF ALL 2018-2019 LL LF DATA (IN ADDITION TO NZ TR DATA 2014-2019)



Recent recruitment decline further moderated but not completely removed

Conclusion: Recent low recruitment is driven mainly by recent LF data, particularly NZ troll. Index fishery CPUE data likely not implicated.

ADDITIONAL REMOVAL OF ALL 2017-2019 LL LF DATA (IN ADDITION TO NZ TR DATA 2014-2019)



STRUCTURAL UNCERTAINTY GRID

Axis	Value
Steepness	0.65 **0.80** 0.95
Movement	**Model estimated**, SEAPODYM
Data weighting	50 (low) **25 (medium)** 10 (high)
Recruitment distribution	**SEAPODYM**, Regions 3 - 4
Growth/M-at-age	**Otolith growth/associated M-at-age**, LF/associated M-at-age