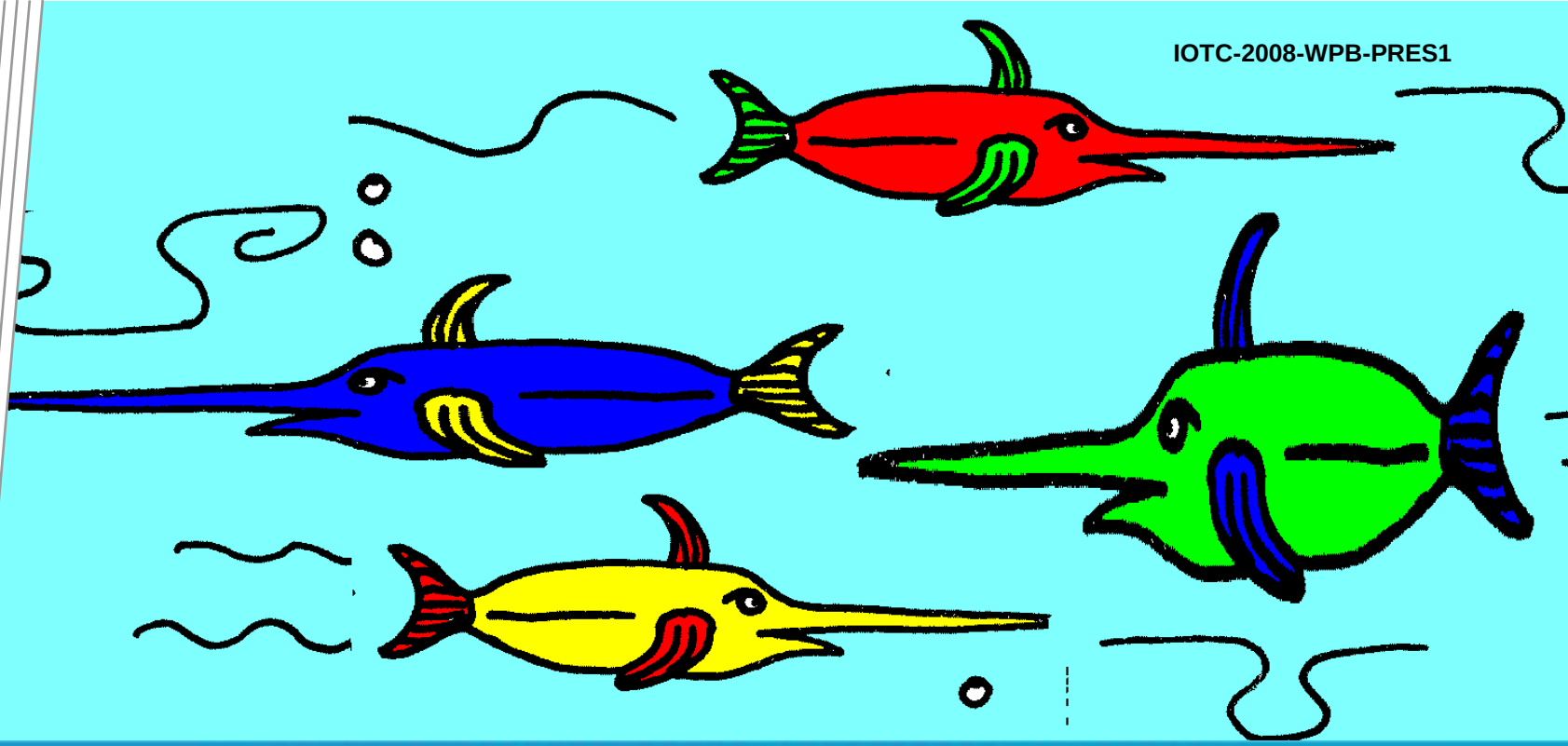


Stock Assessment of Southern WCPO Swordfish 1952-2007

Dale Kolody
Nick Davies
Robert Campbell
Richard Bian

NIWA
Taihoro Nukurangi

CSIRO

www.csiro.au

OUTLINE

- 2006 Assessment
  - CMM2006-03
  - Unresolved Issues
  - Swordfish Assessment Workshop
- 2008 Methods
  - New data
  - New Spatial Structure
  - Parallel assessments
- Results
  - CASAL Assessment (WCPFC-SC4 SA-WP-6)
  - MULTIFAN-CL (WCPFC-SC4 SA-WP-7 –Revision 1)
- Conclusions

CMM 2006 - 03

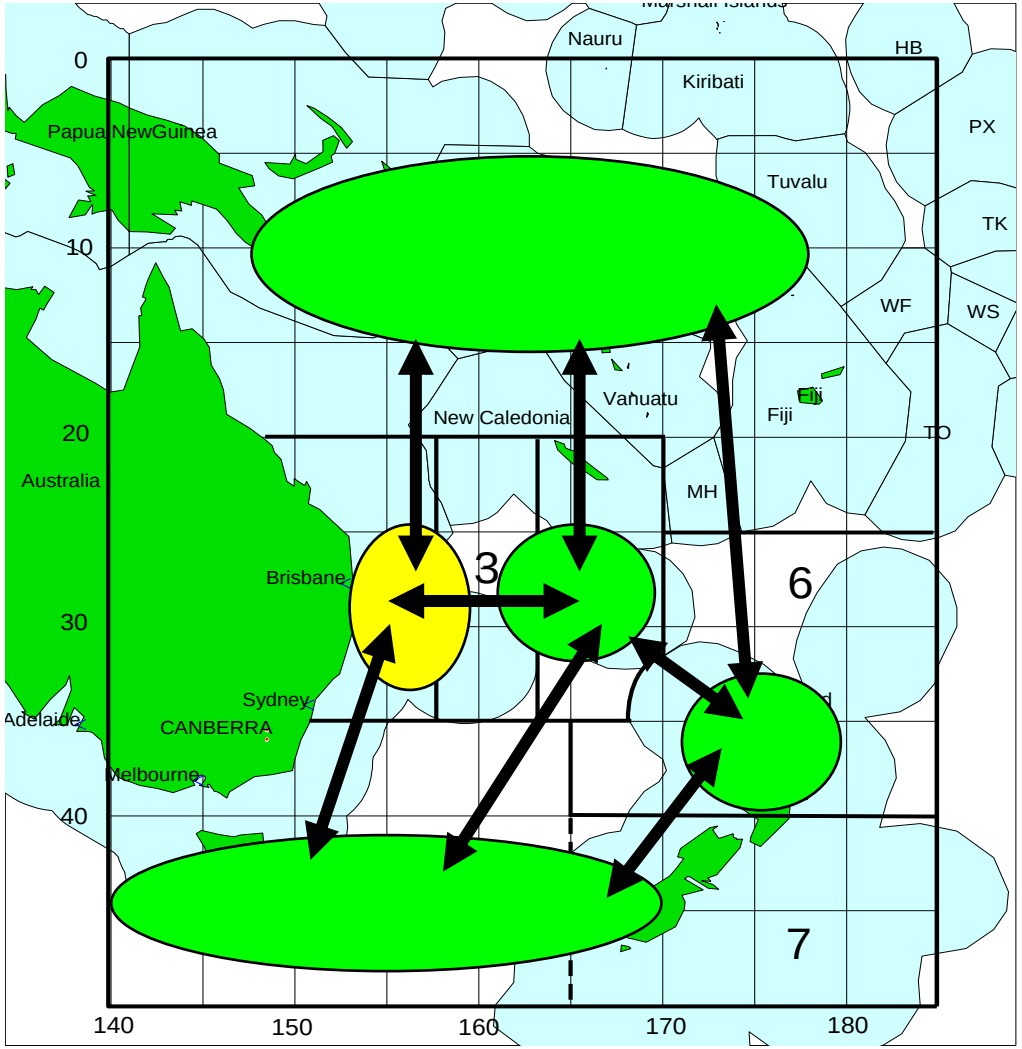
- " … recommended as a precautionary measure that there be no increases in fishing mortality on this stock until estimates of stock status are more certain."
- "… limiting the number of their fishing vessels fishing for swordfish in the Convention Area south of 20ºS..."
- "The Commission will review this measure in 2008, on the basis of advice from the scientific committee, following their consideration of an updated swordfish assessment that improves the understanding of stock structure and assesses the status of swordfish throughout its range and distribution in the South Pacific Ocean."

2006 Spatial Structure and Movement assumptions

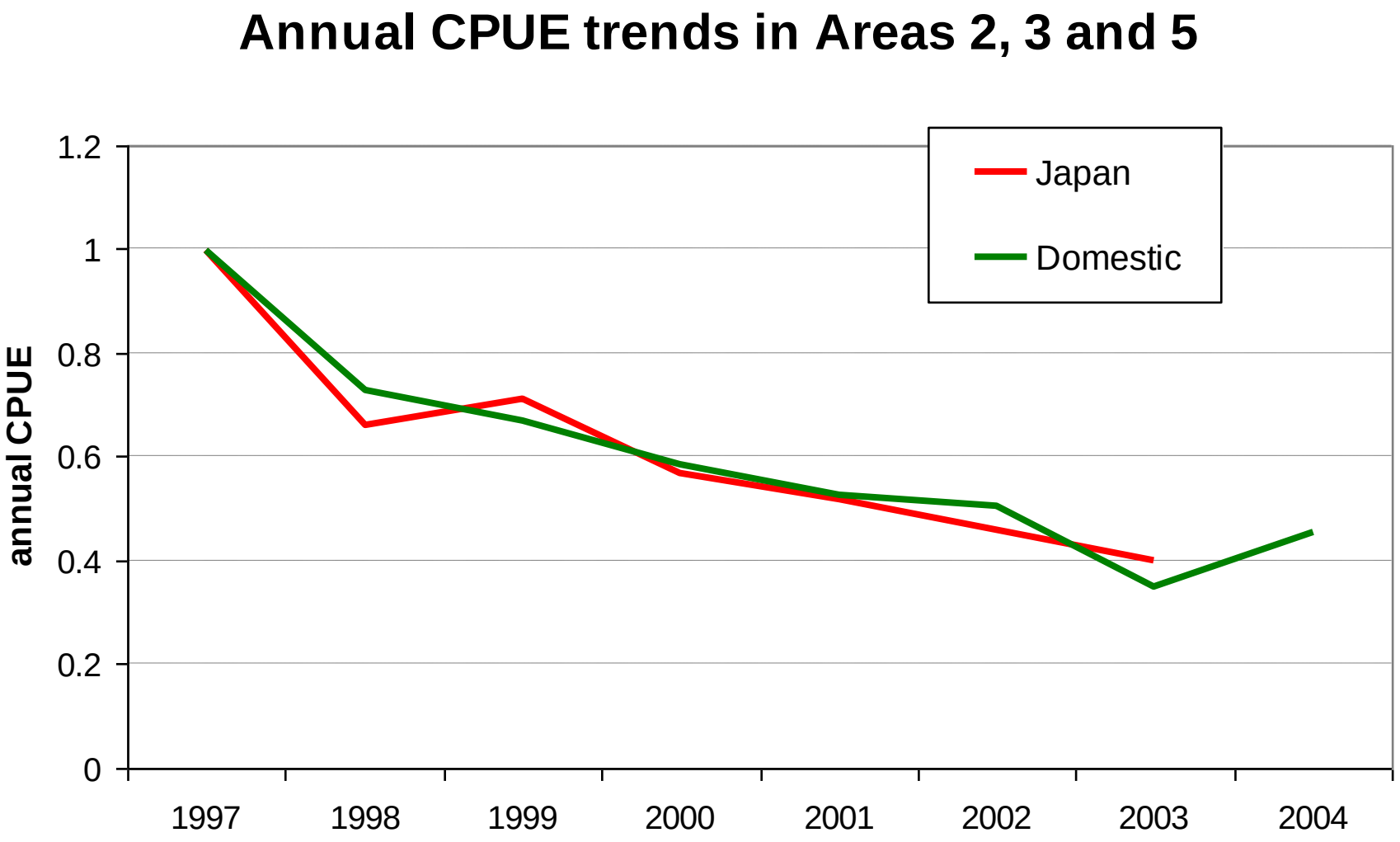
Tropical tuna
By-catch fisheries

Targeted SWO fisheries

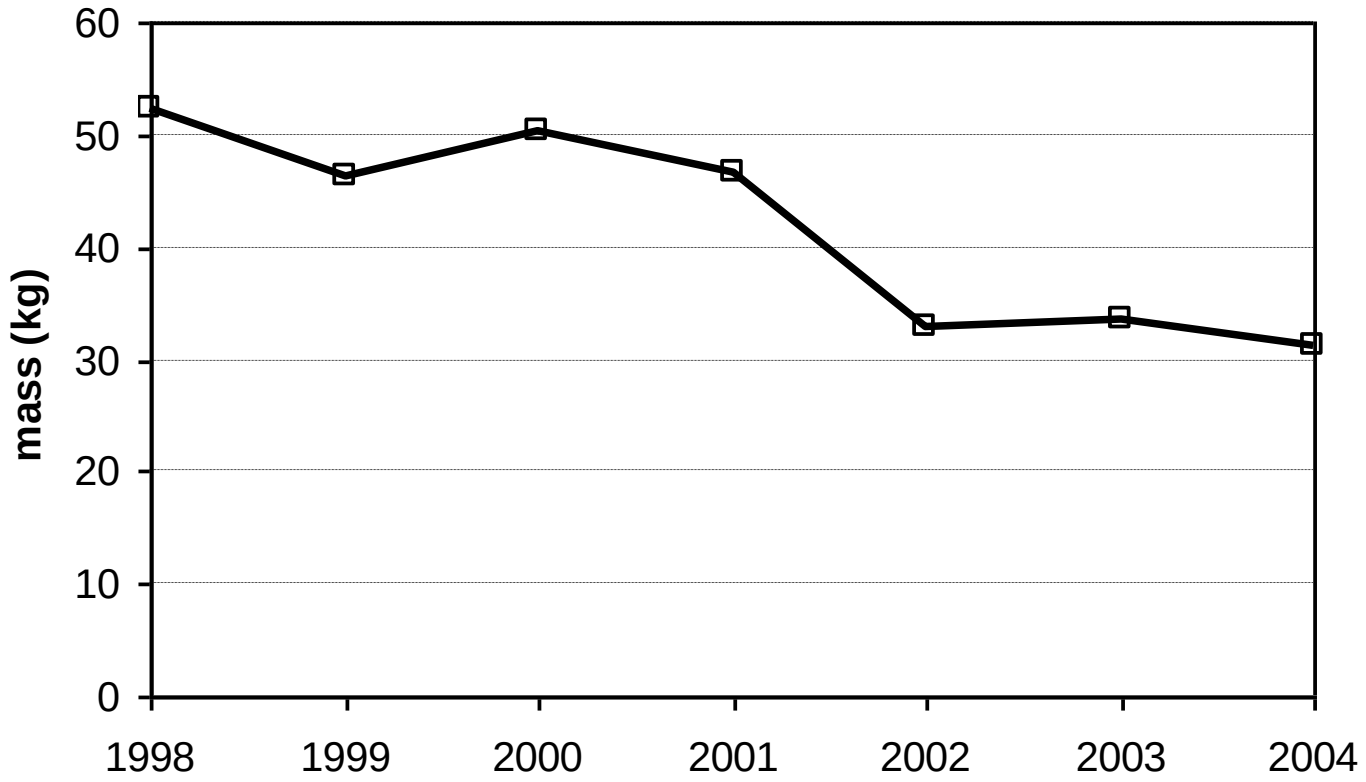
Southern Bluefin tuna
By-catch fisheries



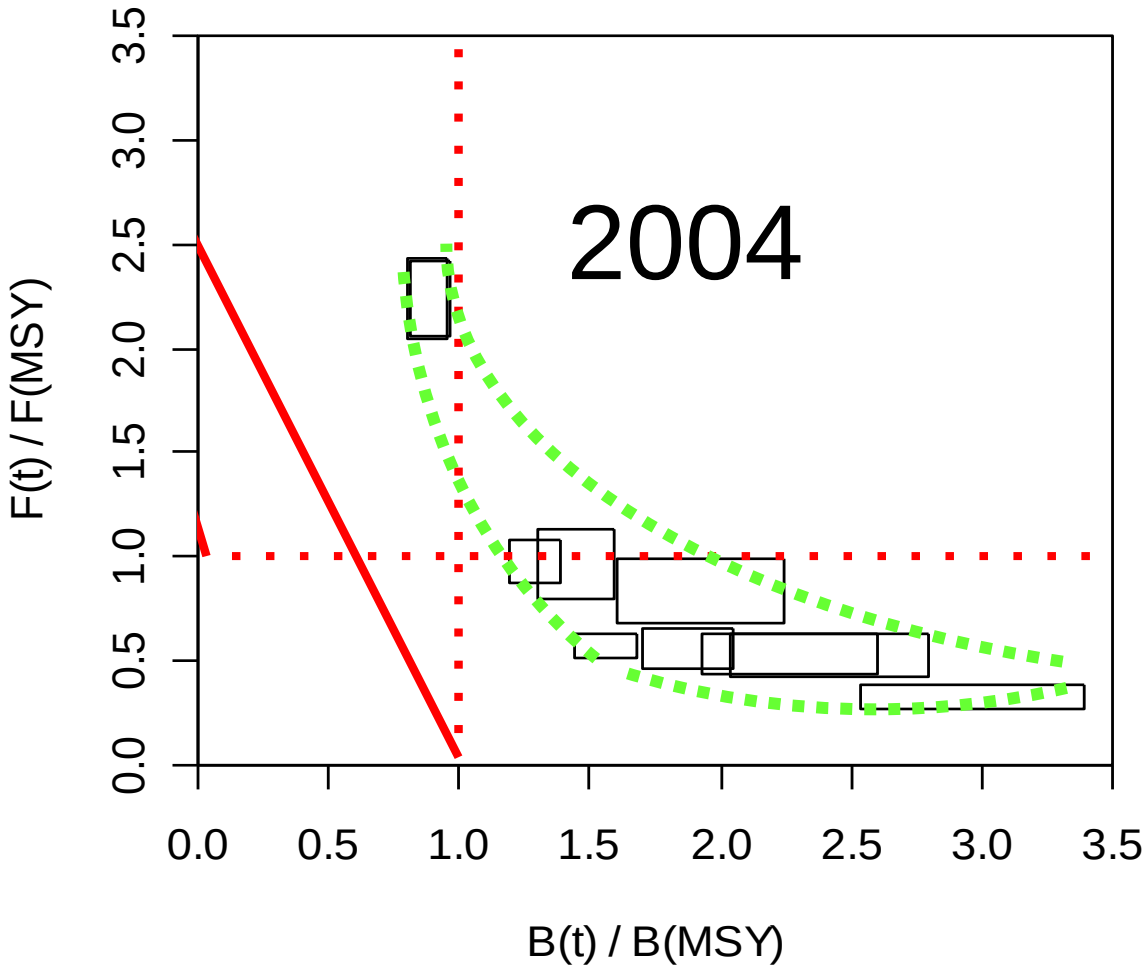
2006: Key data



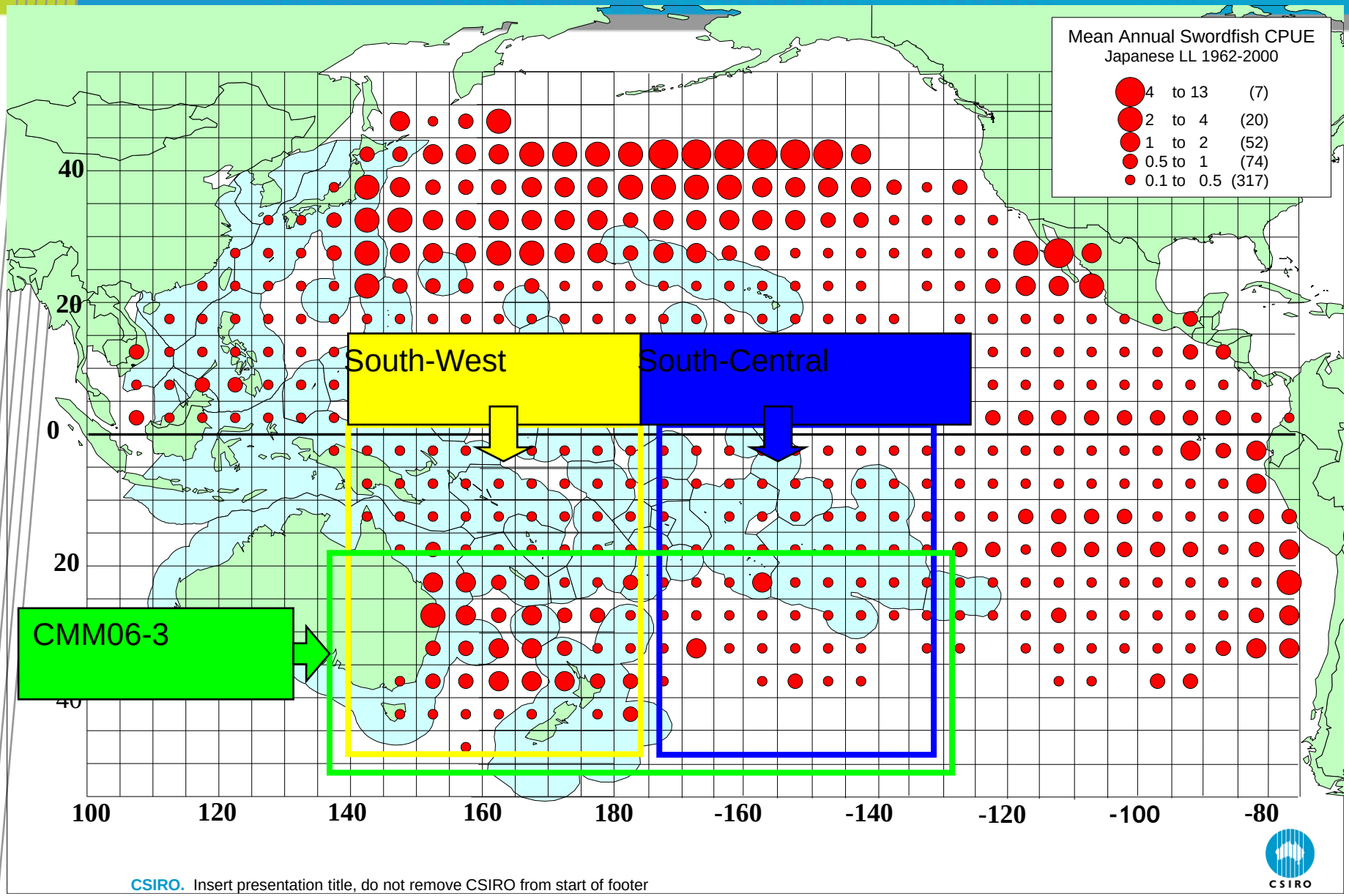
Australian fishery Declining Size Trend (trunked mass)



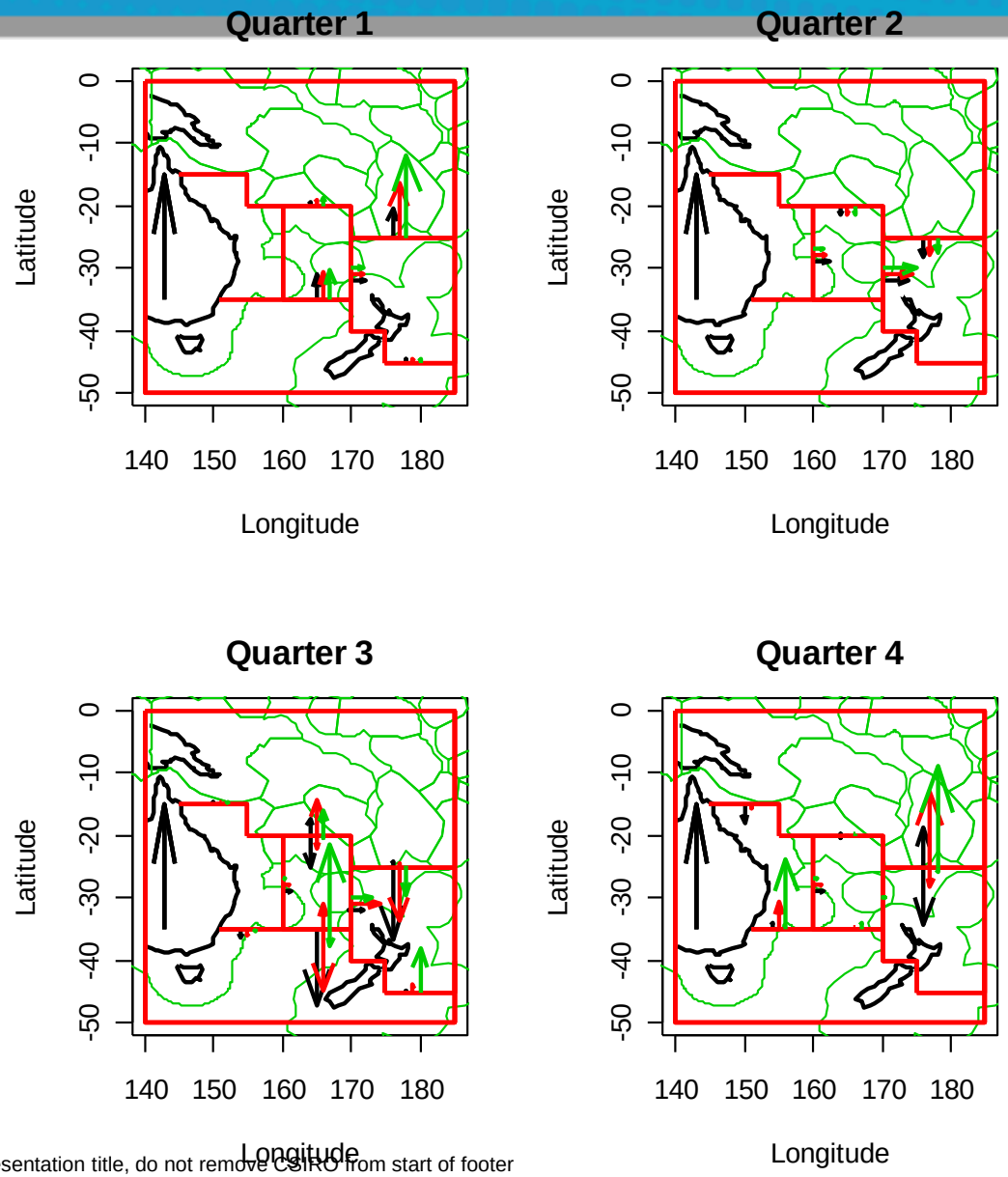
2006 Assessment: 2004 Stock Status Summary



Assessment Issues 1: Spatial domain

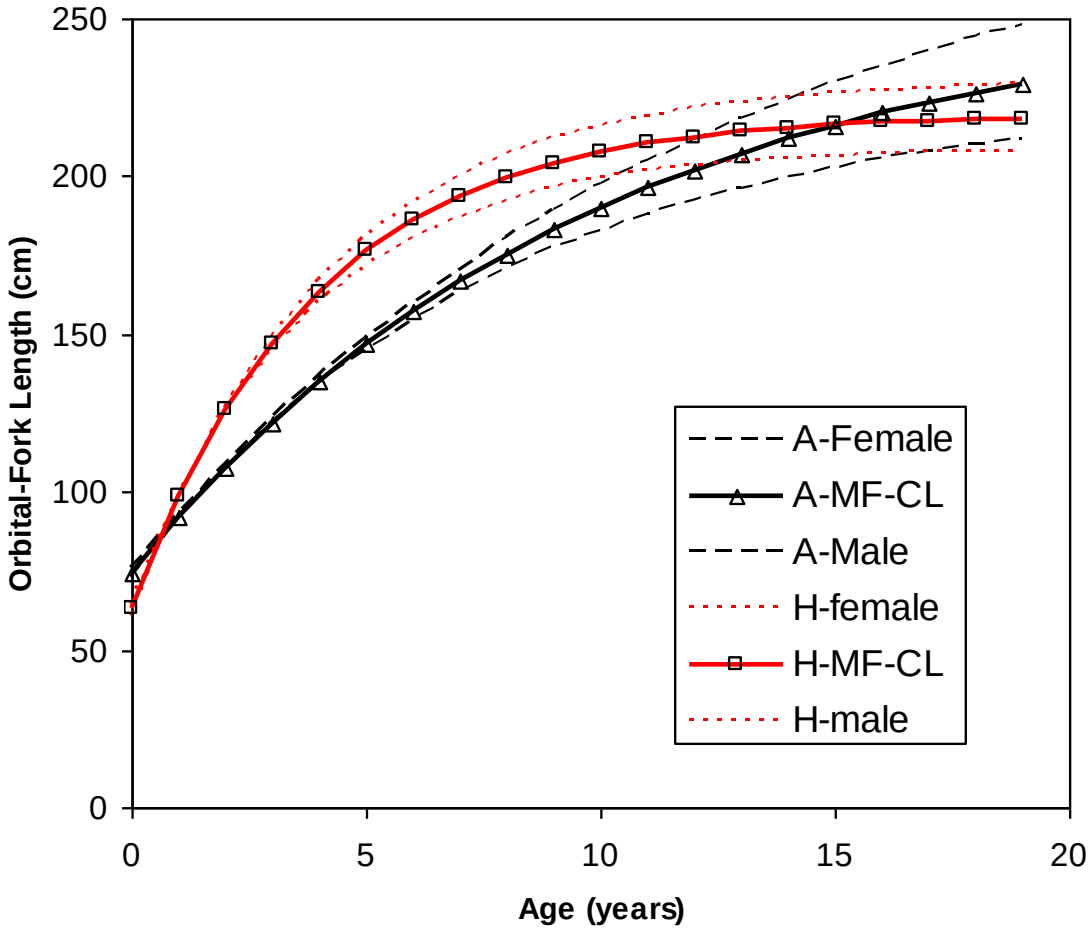


Assessment Issues 2: Indirect migration Estimates



Assessment Issues 3: Biological Uncertainty

Growth Rates



Southern WCPO Swordfish Assessment Workshop Working Paper: SA-IP–1

- 16-18 April 2008, SPC, Noumea
- Swordfish biologists and assessment scientists invited from CCMs and beyond
- Objectives:
  - provide a technical review of data, analyses and stock assessment modelling assumptions underpinning the stock assessment of broadbill swordfish during 2008.
- 12 Working Papers (many submitted to WCPFC-SC4)

List of relevant SC4 WPs and IPs

- Stock assessment papers
  - SA-WP-6 Kolody et al. A Multifan-CL Stock Assessment of Southern Western-Central Pacific Swordfish 1952-2007
  - SA-WP-7 Davies et al. CASAL Stock Assessment for South-West-Central Pacific Broadbill Swordfish 1952-2007
  - SA-IP–2 Kolody & Davies. Spatial structure in South Pacific Swordfish Stocks and Assessment Models.
  - SA-IP–3 Campbell. Data summary pertaining to the catch of swordfish by longline fleets operating in the southern WCPO.
  - SA-IP–4 Campbell et al. Swordfish CPUE trends across the southern WCPO.
  - SA-WP–5 Mejuto et al. Standardized catch rates in biomass for the south central and western Pacific swordfish (*Xiphias gladius*) from the Spanish longline fleet for the period 2004-2006.

SWO Biology Papers

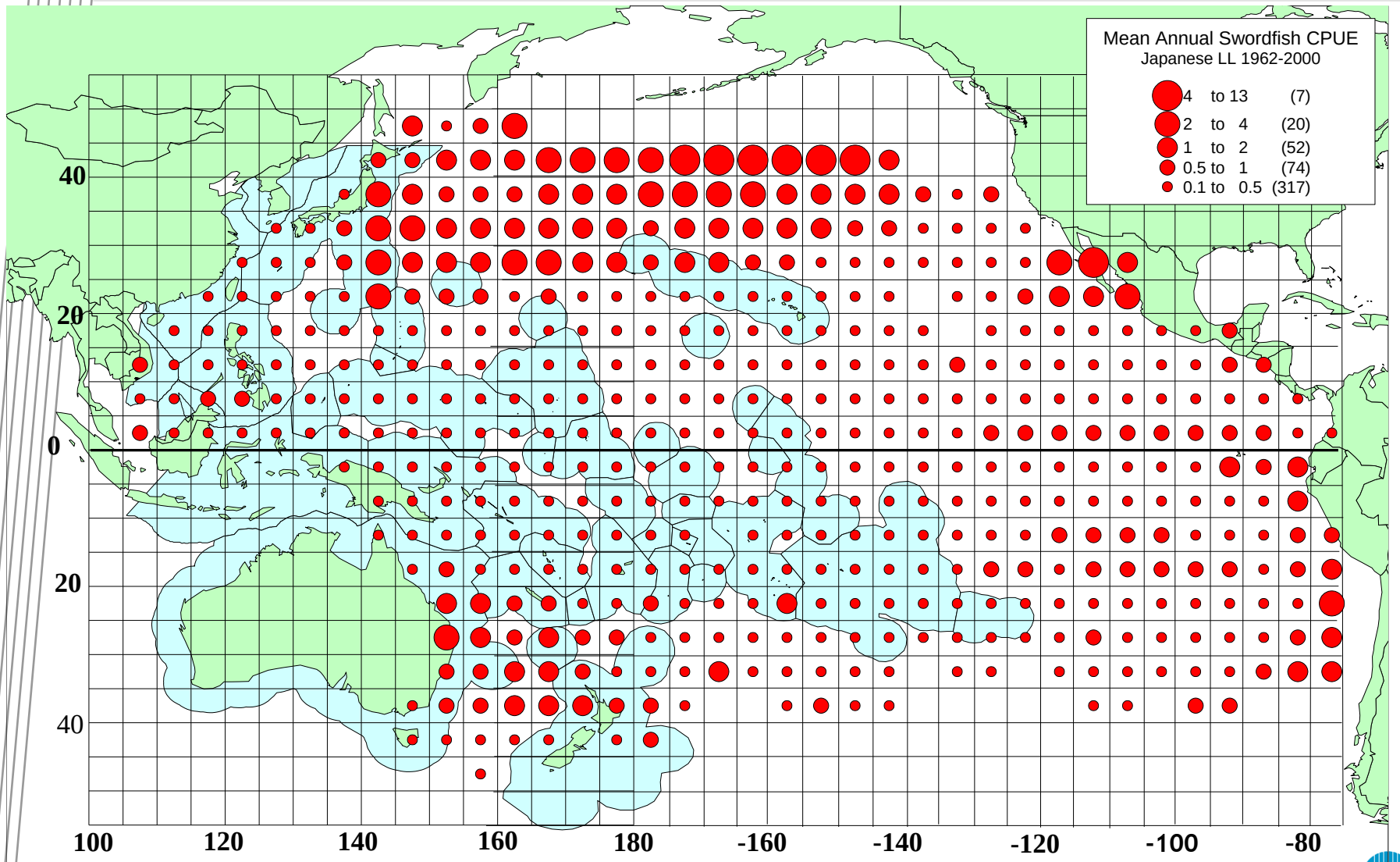
- BI-WP-1 Valeiras et al. Age and growth of swordfish (*Xiphias gladius*) in the North Pacific.
- BI-IP–2 Young et al. 2008 Comparison of maturity and ageing of swordfish from Hawai'ian and Australian waters.
- BI-WP-4 Kasapidis et al. Stock structure of swordfish (*Xiphias gladius*) in the Pacific Ocean using microsatellite DNA markers.
- BI-WP-6 Mejuto et al. Reproductive activity of swordfish (*Xiphias gladius*) in the Pacific Ocean on the basis of different macroscopic indicators.
- EB-IP–5 Mejuto et al. Preliminary overall estimations of bycatch landed by the Spanish surface longline fleet targeting swordfish (*Xiphias gladius*) in the Pacific Ocean and interaction with marine turtles and sea birds: years 1990-2005.

Spatial structure review (SA-IP–2)

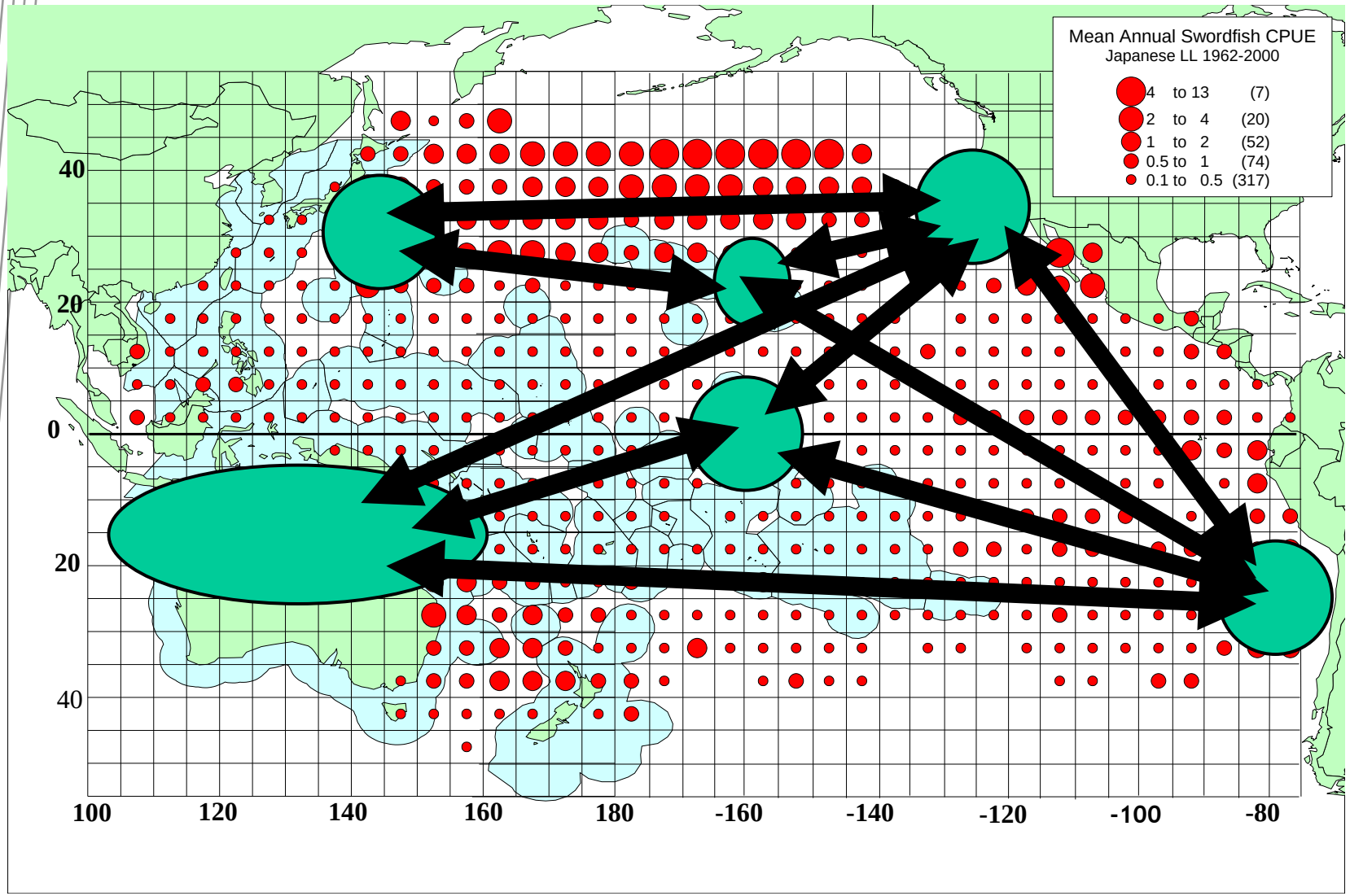
Evidence:

- Catch, size and CPUE distributions by area and season
- Genetic information
- Larval surveys and reproductive studies
- Tagging

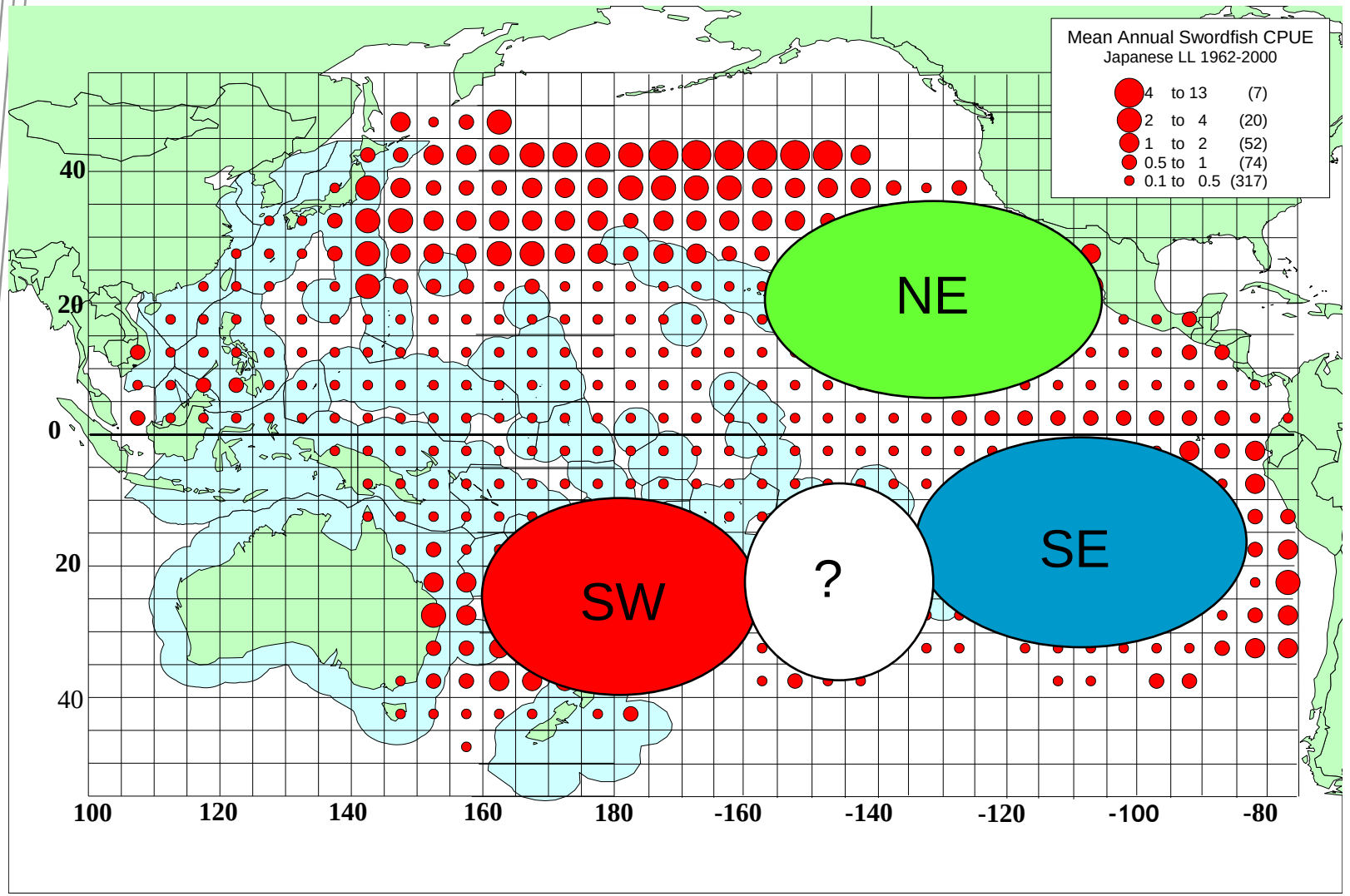
Swordfish Catch rate Distribution



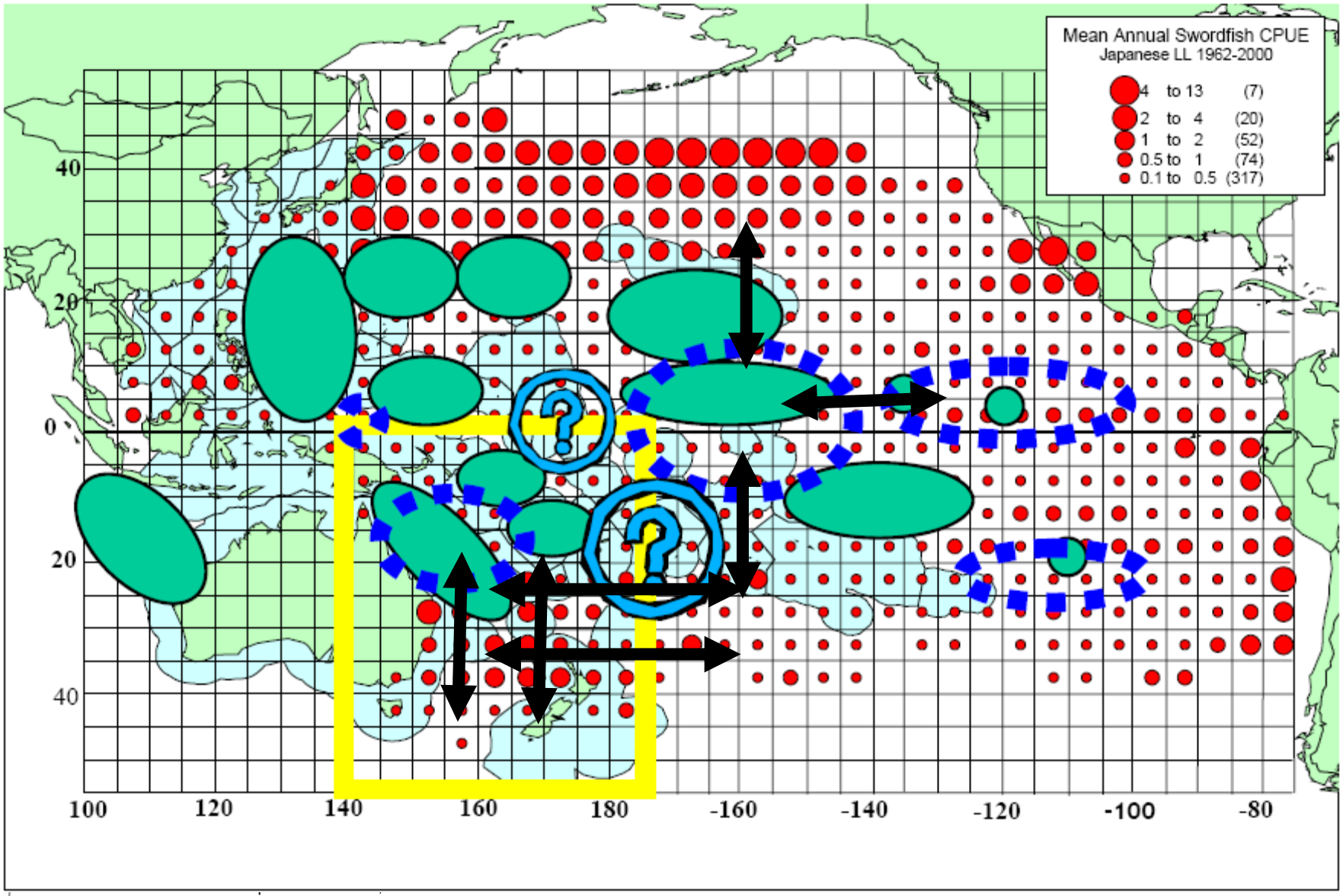
Genetic considerations: Reeb et al 2000



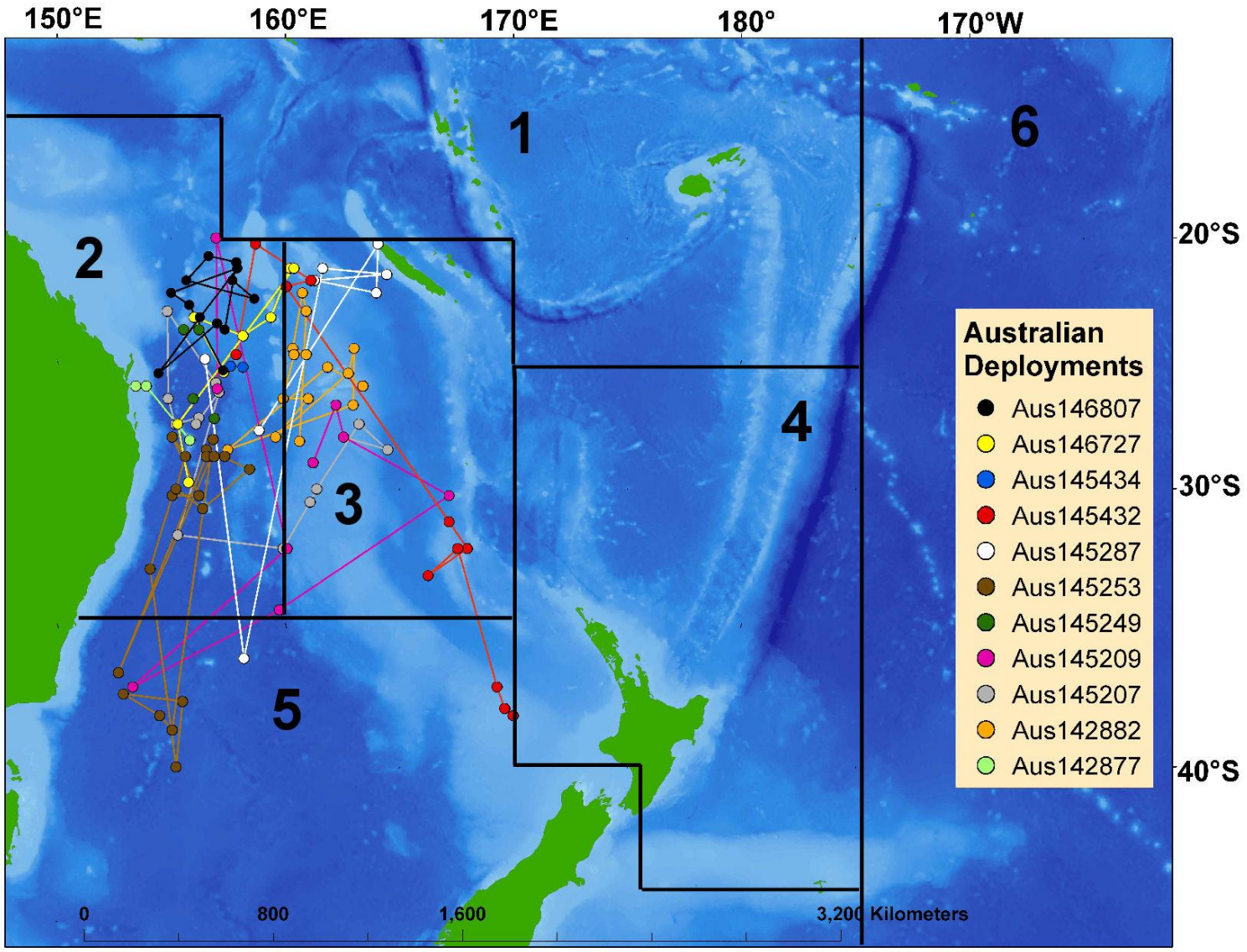
Genetic considerations: Alvaredo Bremer et al 2006



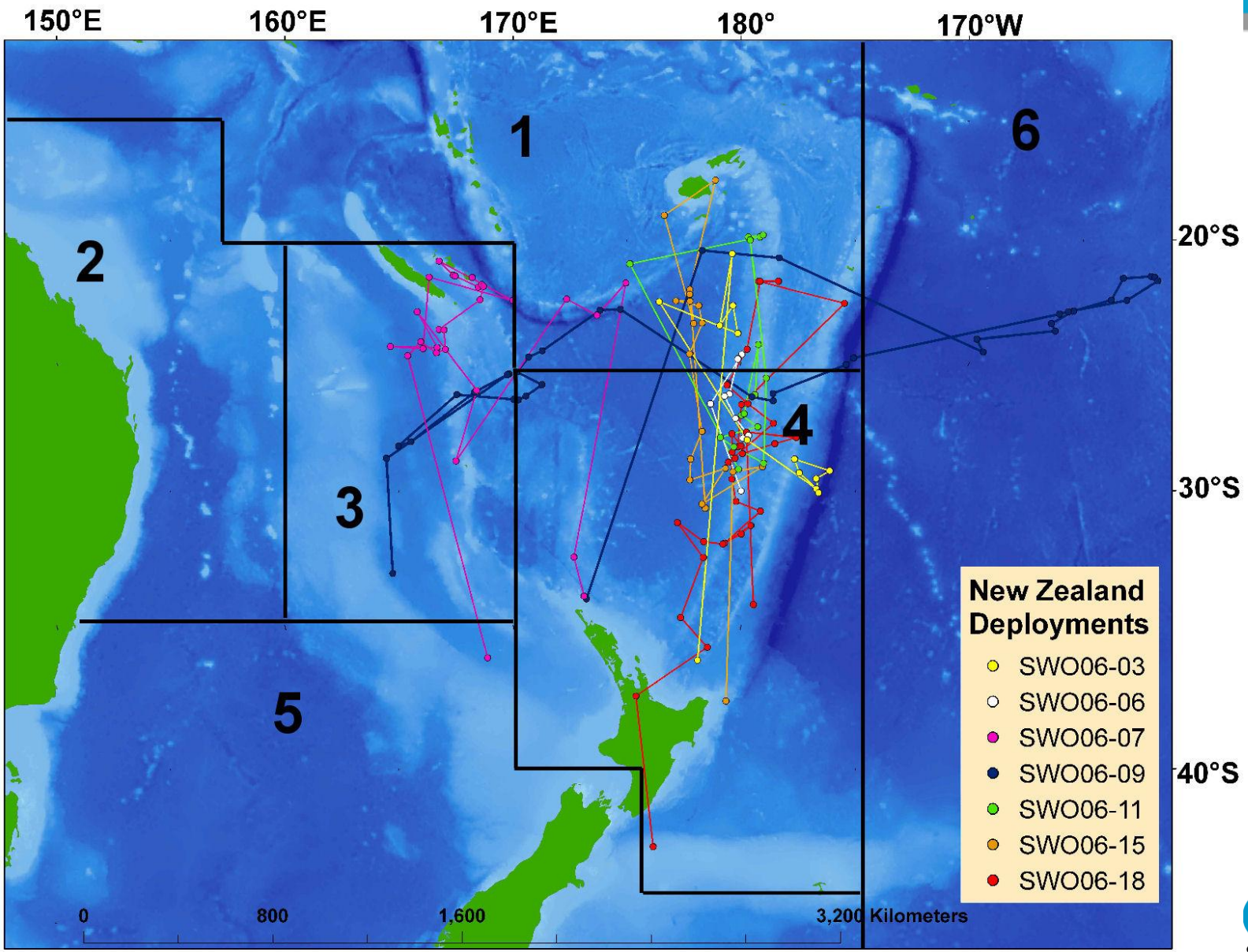
Larval Distributions and Maturity Studies
Nishikawa et al 1985, Mejuto et al. 2008, Young and Drake 2002



Australian PSAT tags
(Wilcox and Evans, unpublished data)

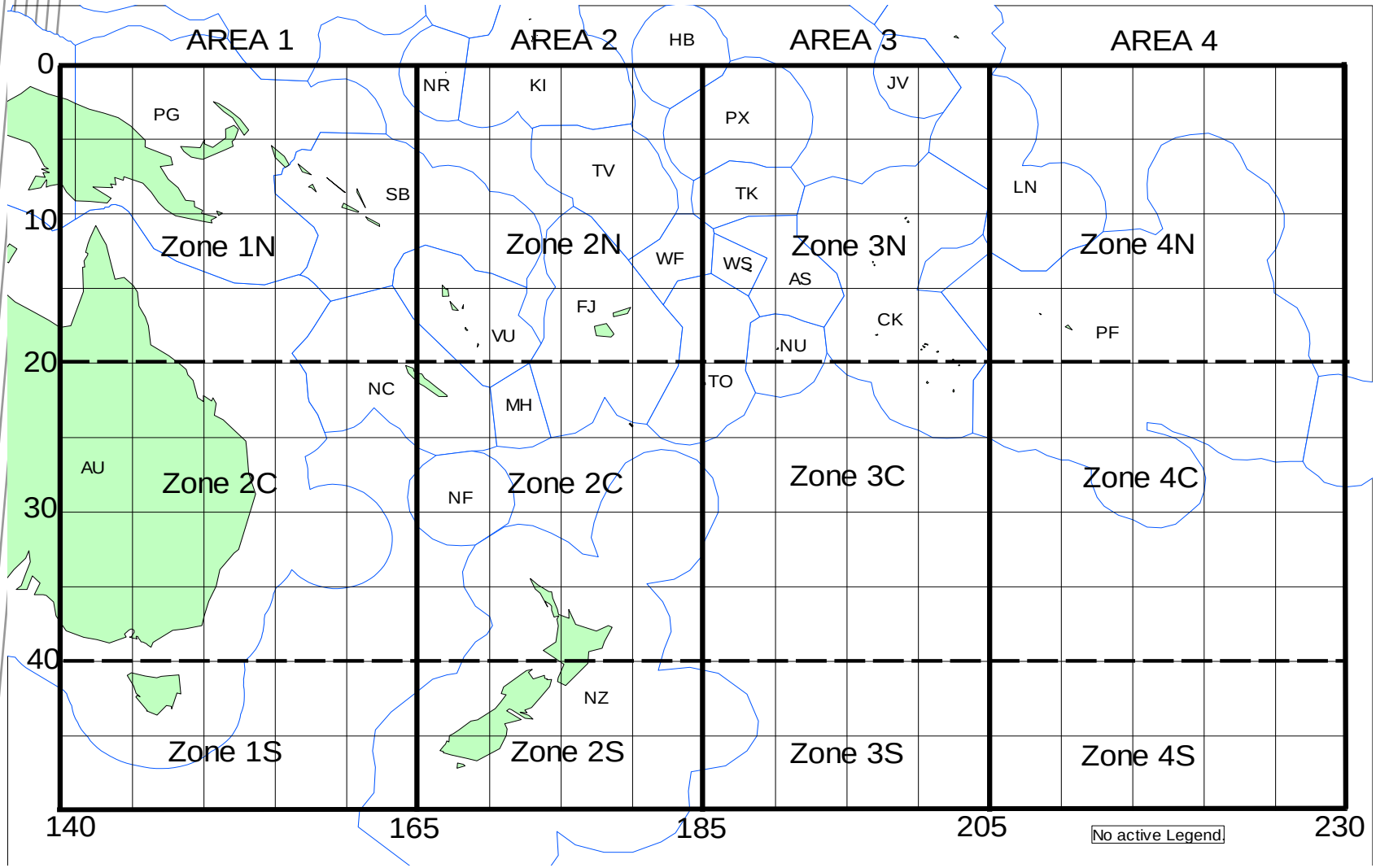


New Zealand PSAT tags (Holdsworth et al. 2007)



2008 assessment model spatial structure

South-west Pacific (SWP) **South-central Pacific (SCP)**



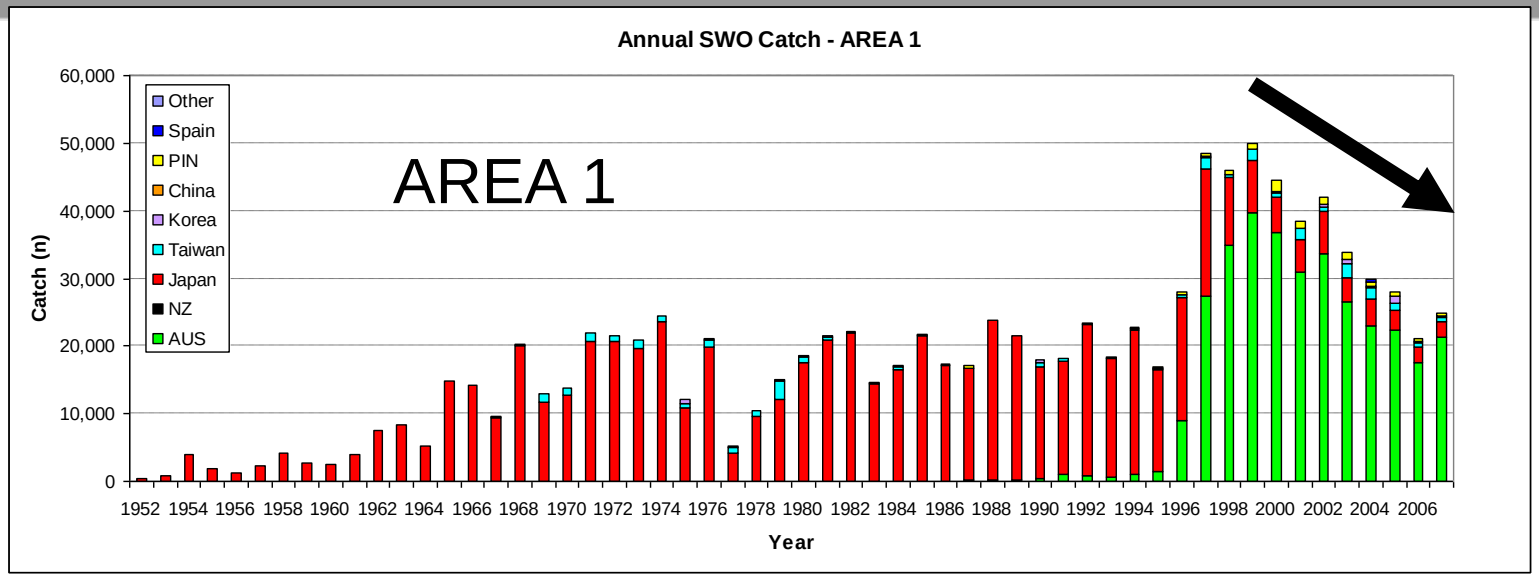
Fishery Definitions – (extended version)

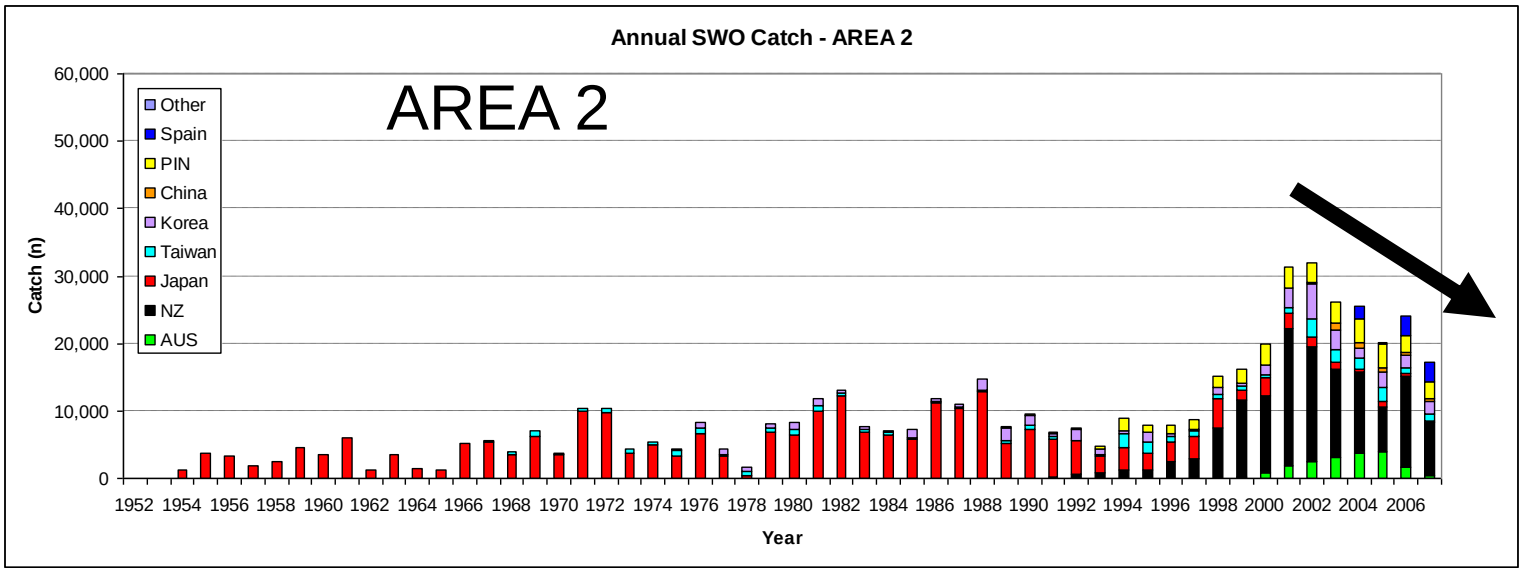
Fishery Number	Area	Sub-area (zone)	Catchability Group	Selectivity Group	Fishing Nation(s)
South-West Pacific					
1	1	N	n/a	a	Japan (plus other DWF)
2	1	C	A	a	Japan (plus other DWF)
3	1	S	n/a	b	Japan (plus other DWF)
4	1	N+C+S	B	a	Australia
5	1	N+C	n/a	a	Pacific Island Nations
6	2	N	n/a	a	Japan (plus other DWF)
7	2	C	A	a	Japan (plus other DWF)
8	2	S	n/a	c	Japan (plus other DWF)
9	2	N	n/a	a	Pacific Island Nations
10	2	C	n/a	a	Pacific Island Nations
11	2	C+S	C	d	New Zealand
South-Central Pacific					
12	3	N	A	a	Japan (plus other DWF)
13	3	C+S	n/a	a	Japan (plus other DWF)
14	3	N	n/a	a	Pacific Island Nations
15	3	C	n/a	a	Pacific Island Nations
16	4	N	A	a	Japan (plus other DWF)
17	4	C+S	n/a	a	Japan (plus other DWF)
18	4	N	n/a	a	Pacific Island Nations

New Fisheries Data used in 2008 (SA-IP-3, SA-IP-4)

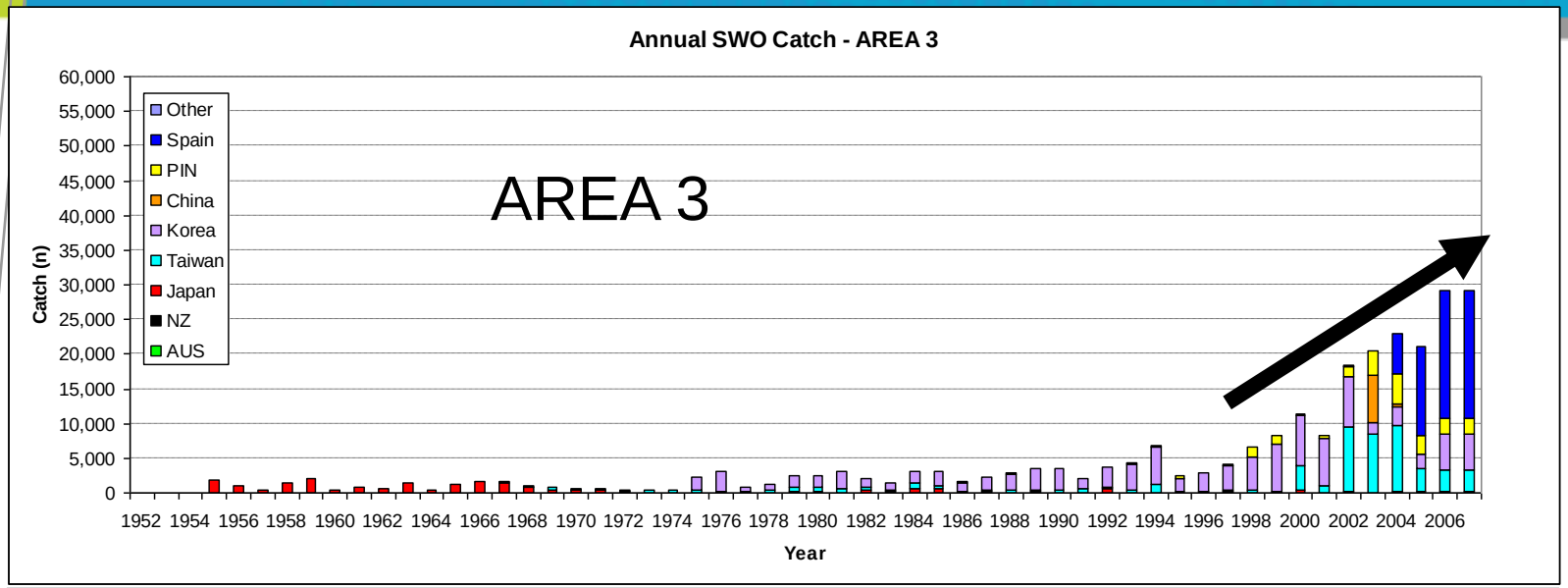
- South-West:
  - Catch, effort, size data 2005-6/7
  - Spanish size composition 2004
  - New Zealand Port sampling 2006-7
  - 2006/7 not complete
- South Central:
  - All fisheries data

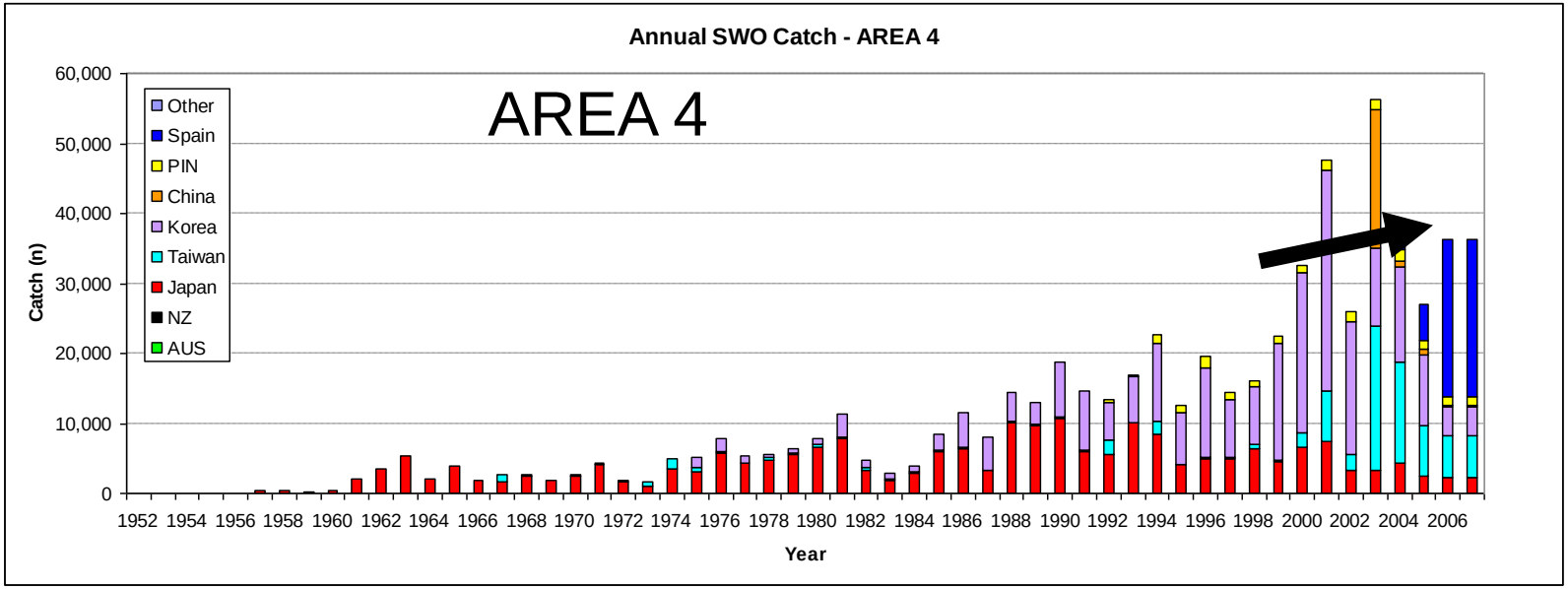
2008: Total Catches in South-West Pacific



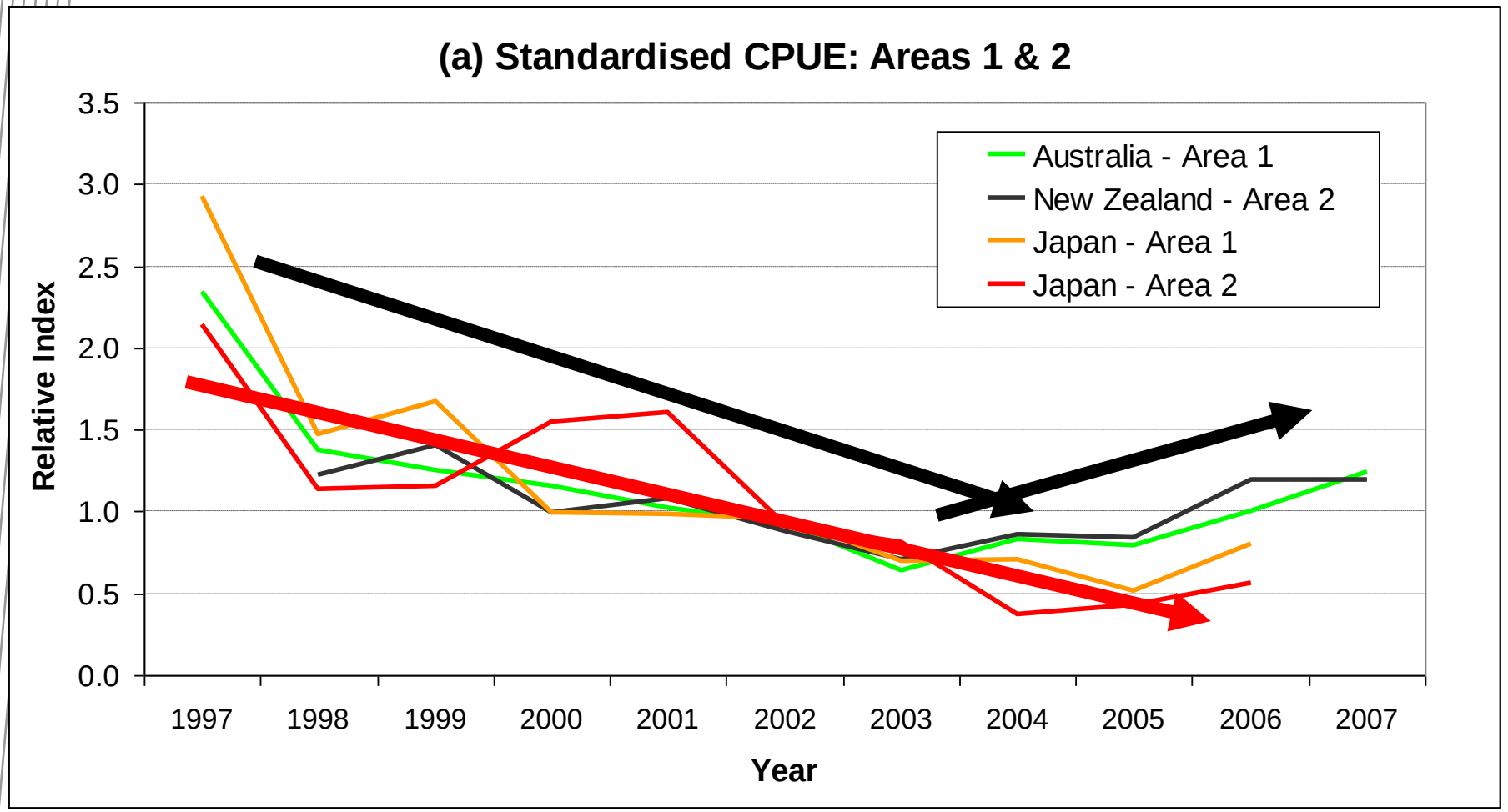


2008: Total Catches in South-Central Pacific

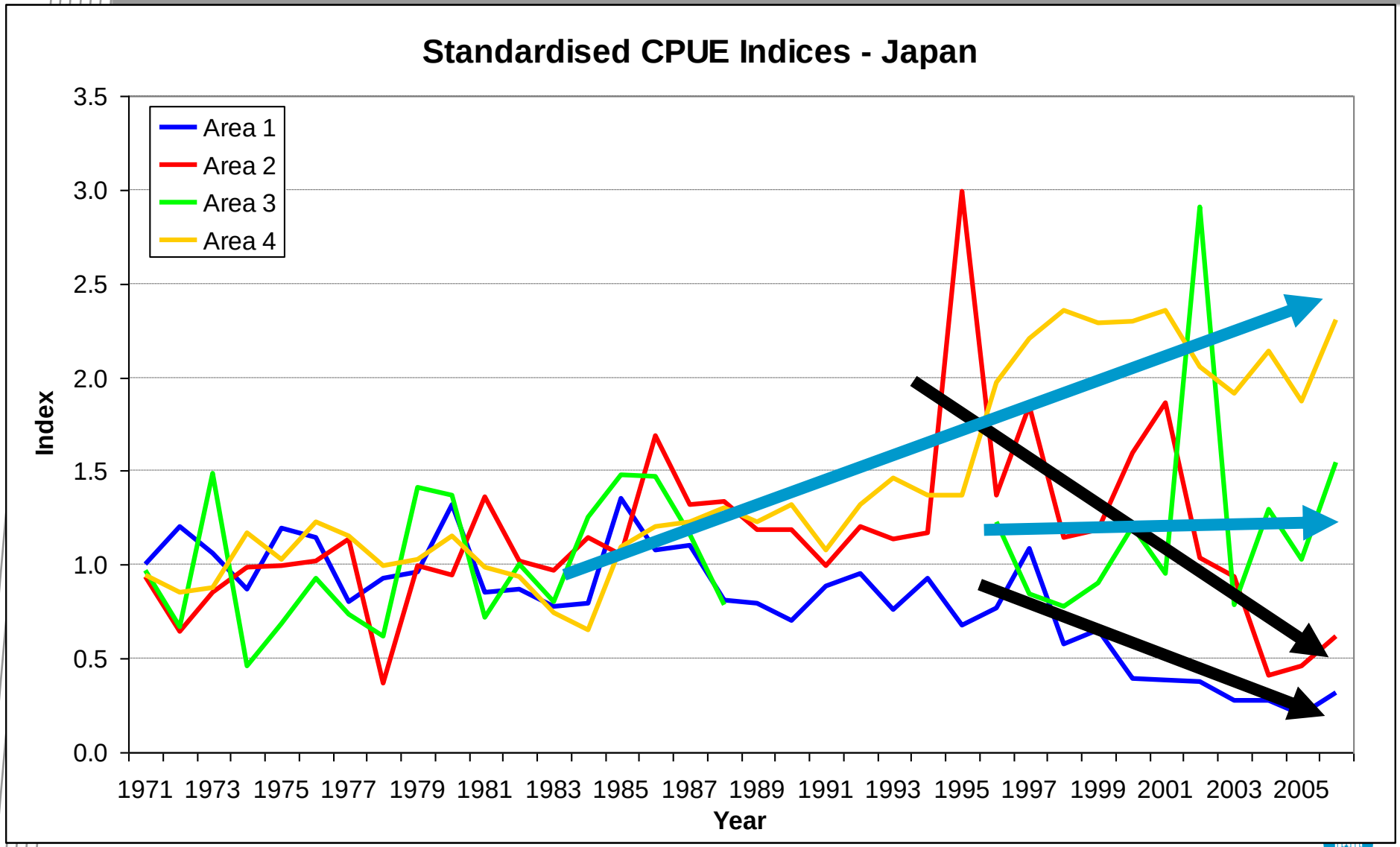




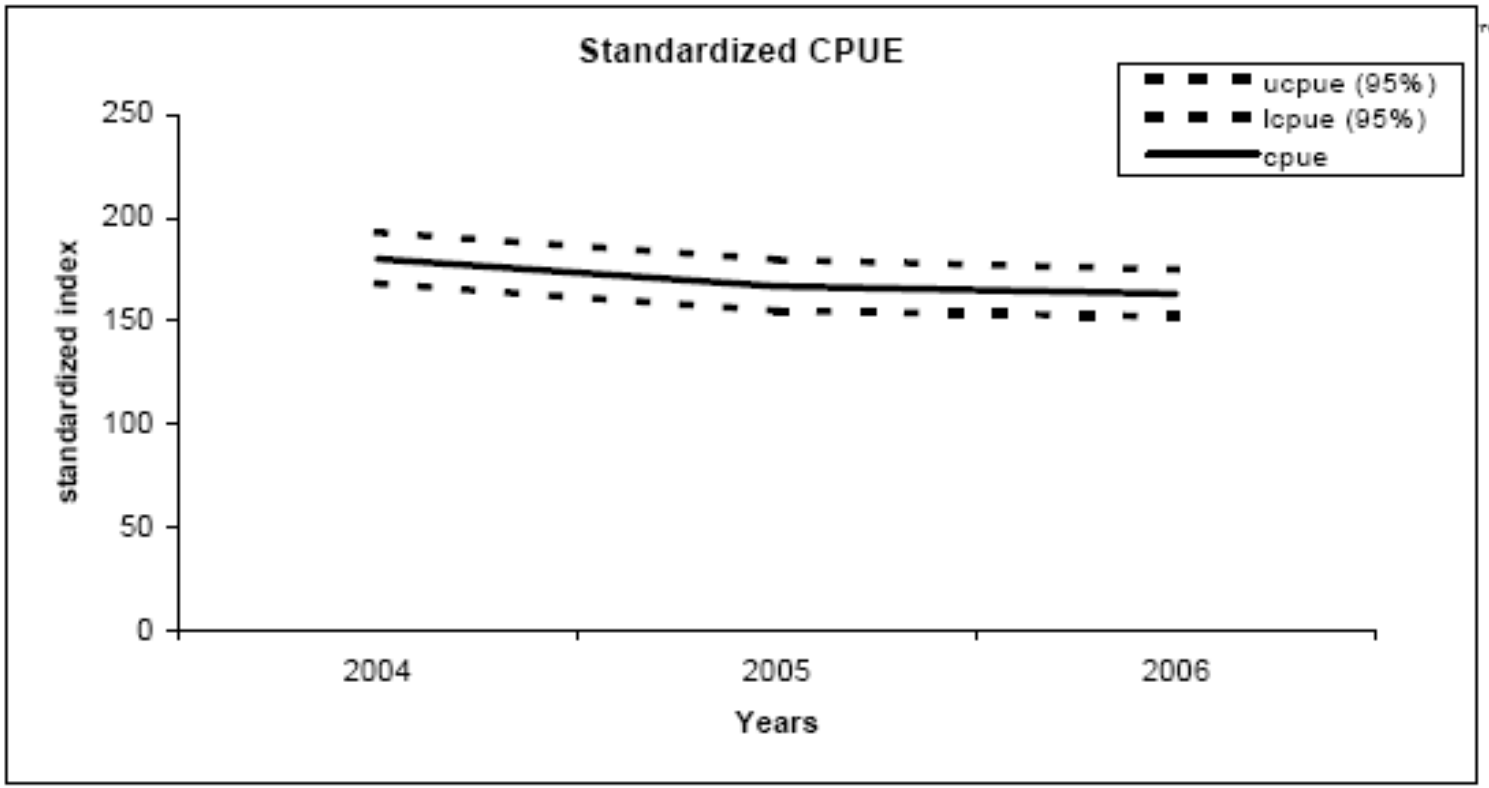
South-West Informative CPUE Series



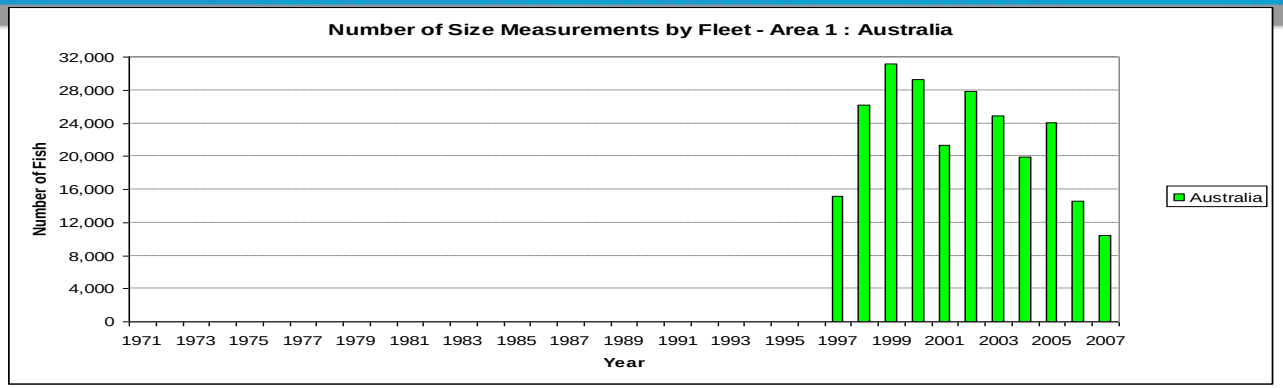
2008: South-West vs: South-Central CPUE

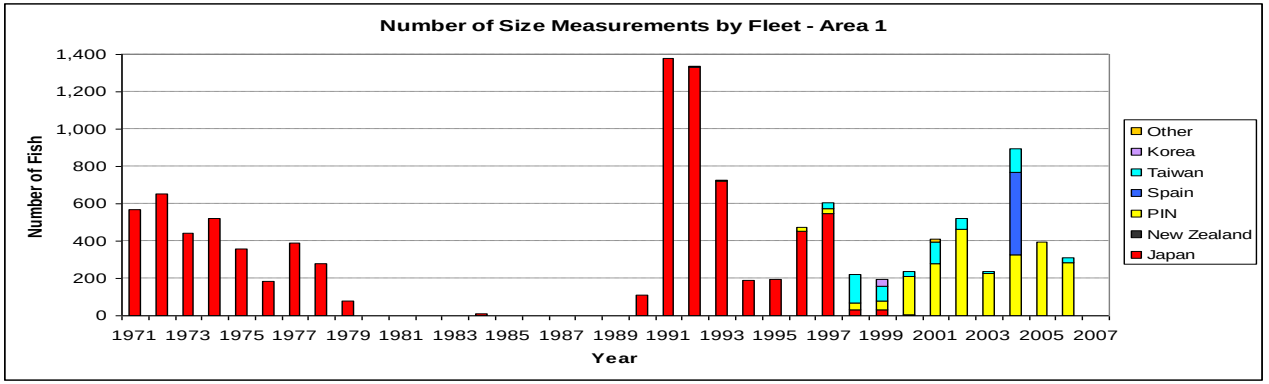


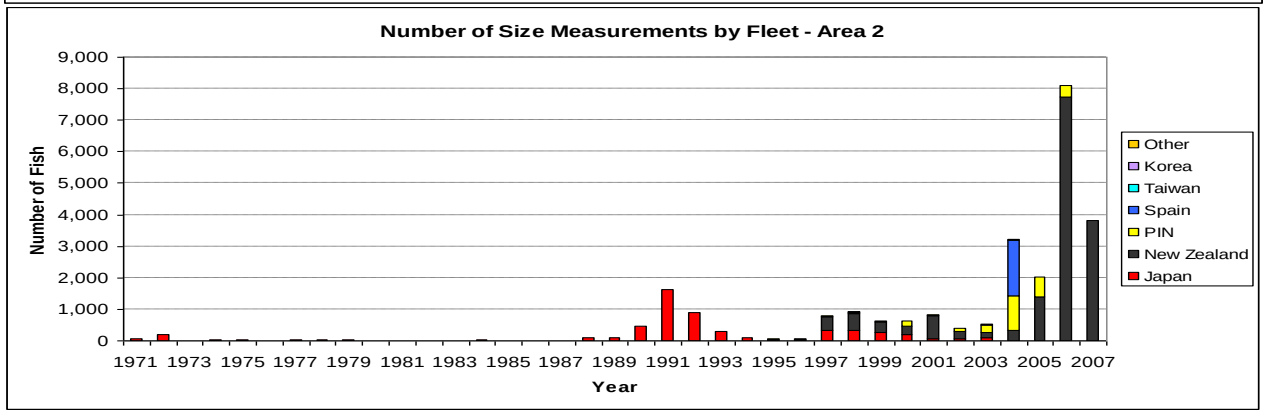
2008: South-ish Pacific Spanish CPUE SA-IP-5



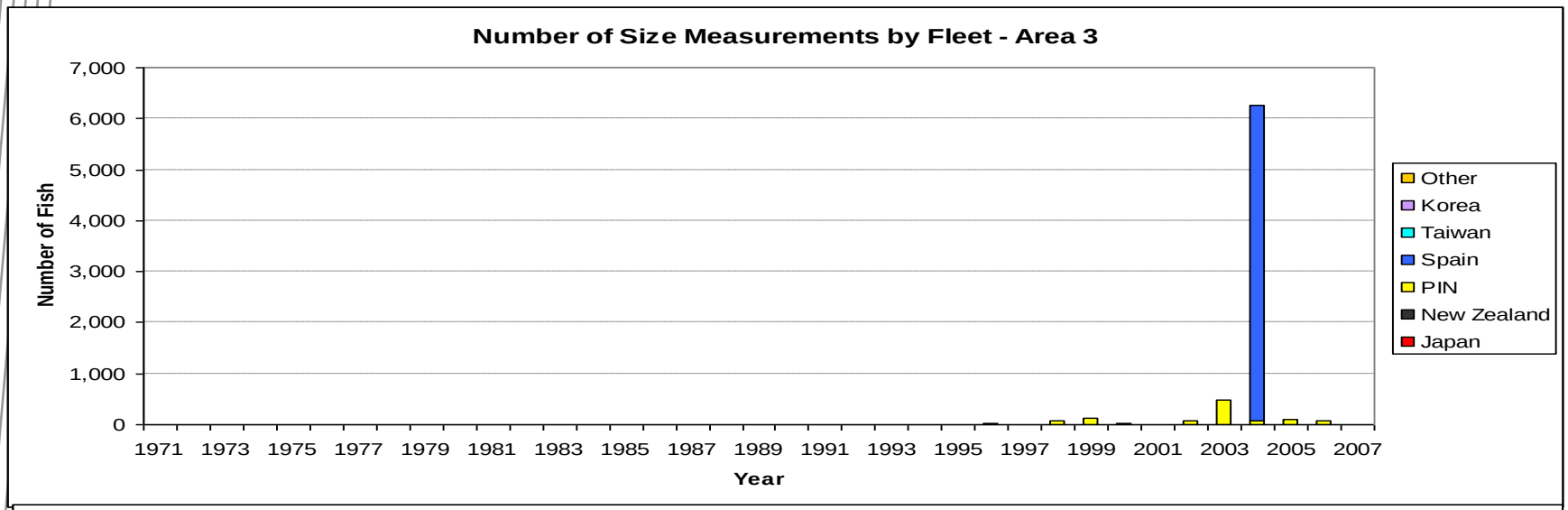
Size Sampling – South West

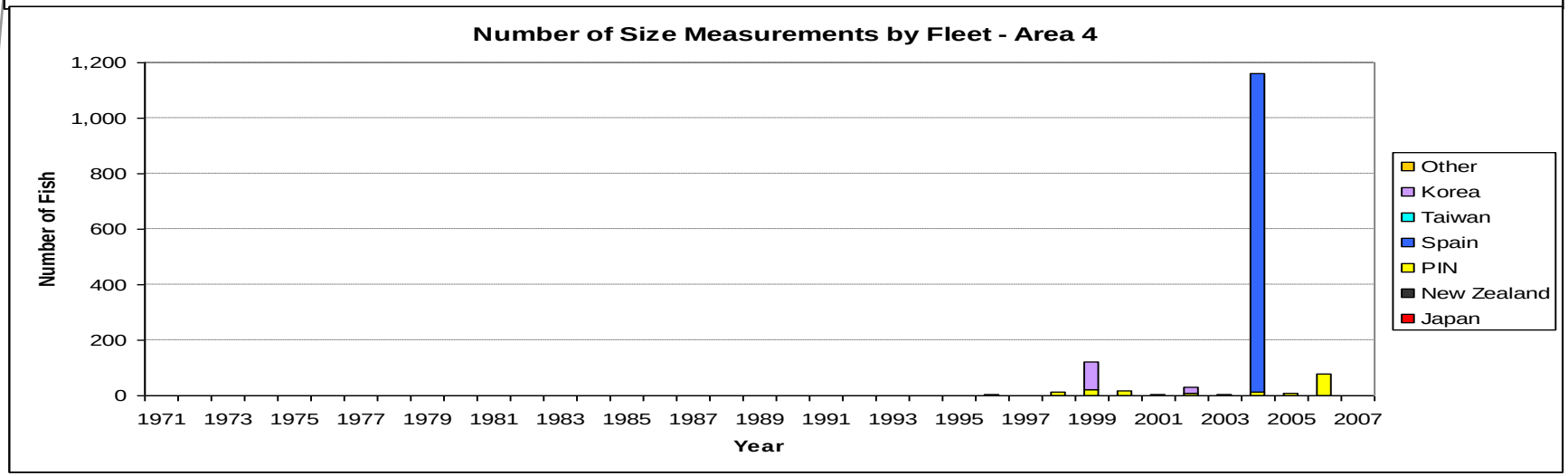






Size Sampling – South Central

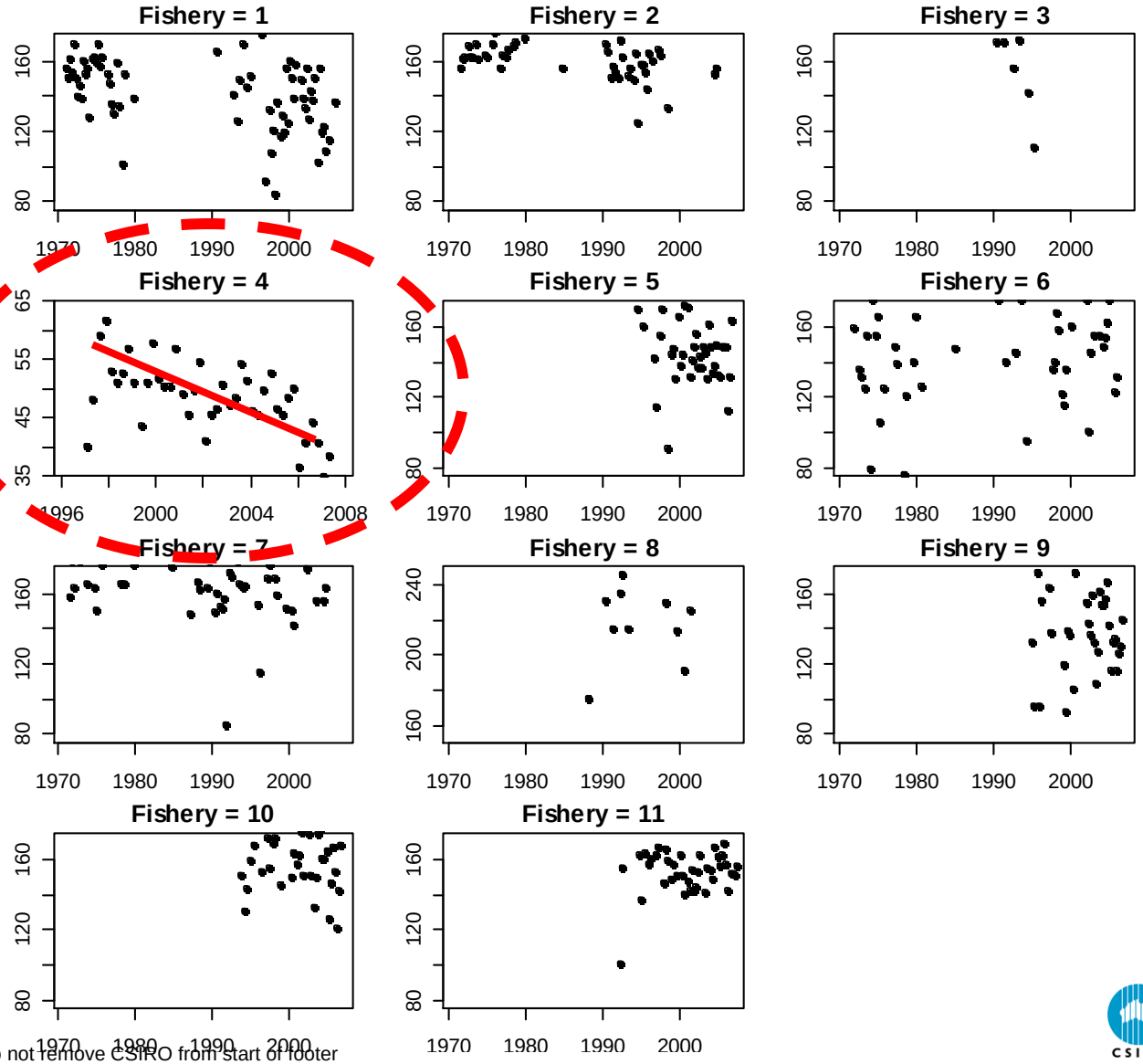




2008: SW Pacific Size Composition Data

Australia

ETBF



Parallel Assessment Modelling Approaches

- CASAL
- MULTIFAN-CL

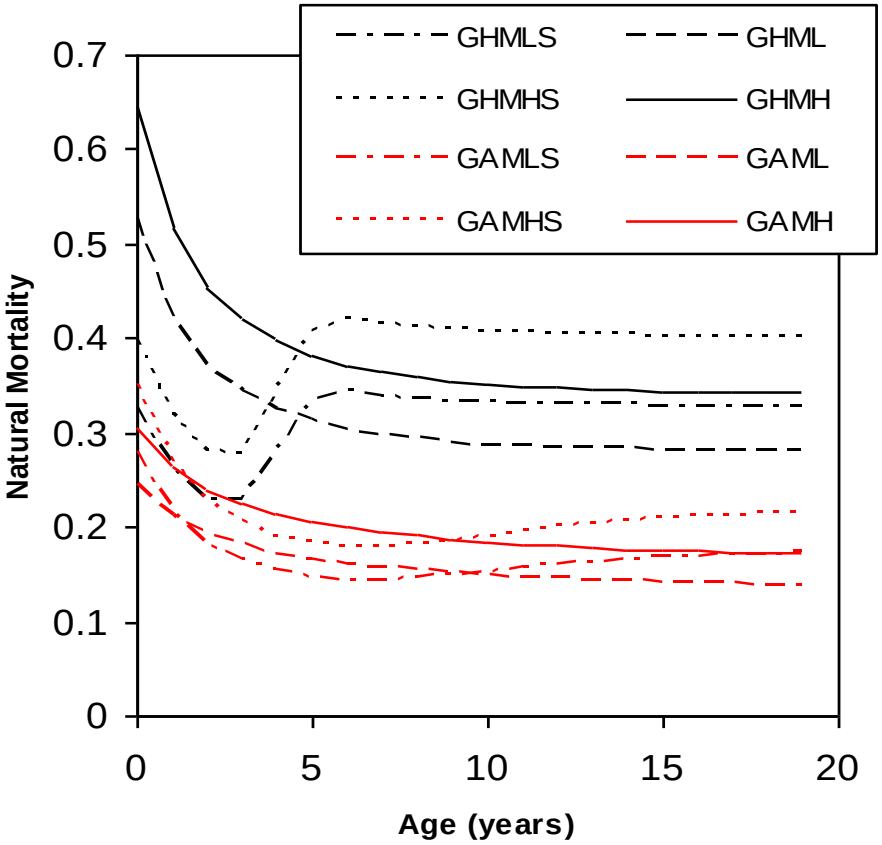
Model assumptions

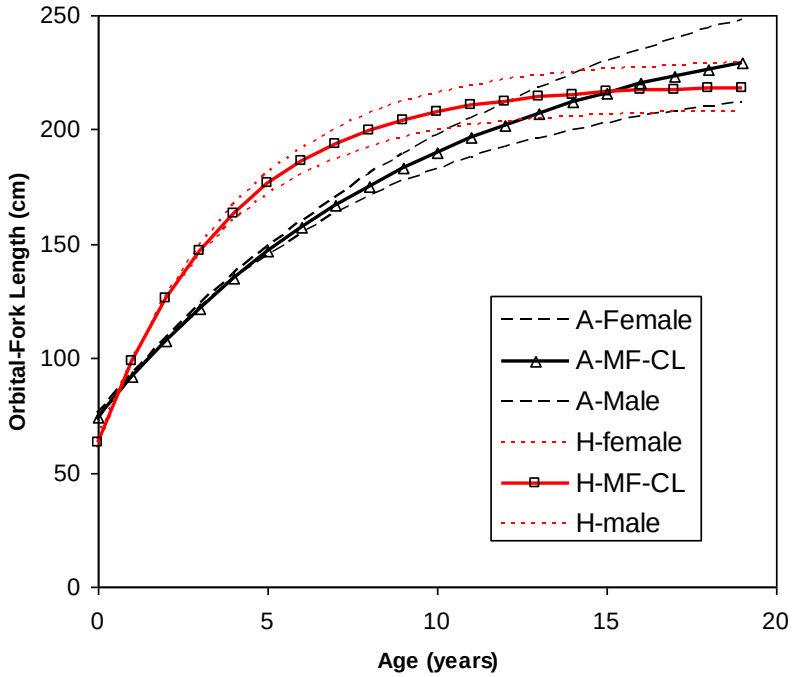
- Age-structured, annual recruitment
- Sex-aggregated
- Quarterly timestep 1952-2007
- Constant Catch (2007) projected to 2017
- Beverton-Holt SRR
- Spatially-disaggregated 2 or 4 areas
- 8-18 fisheries
- Selectivity constant over years (sometimes seasonally variable)

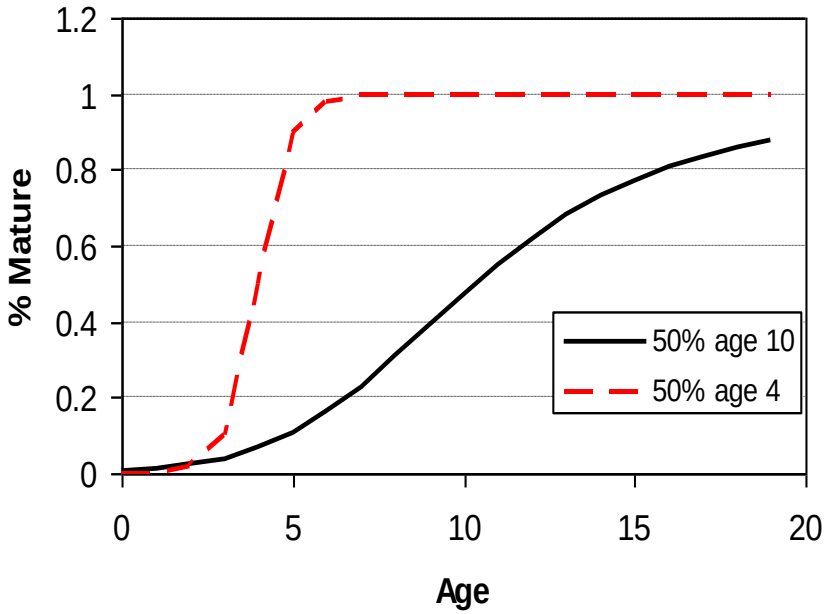
Uncertainty Grid of Model assumptions

- 2 Stock recruitment curve steepness priors (0.65, 0.9)
- 2 migration exchange rate options (based on bounds of tag analyses)
- 8 growth rate / maturity / mortality options
- 2 recruitment deviation options (ln(SD) = 0.1, 0.5)
- 2 sample size down-weighting options (for catch-at-size likelihood terms)
- 3 relative weighting options for CPUE indices
- 2 selectivity constraint options

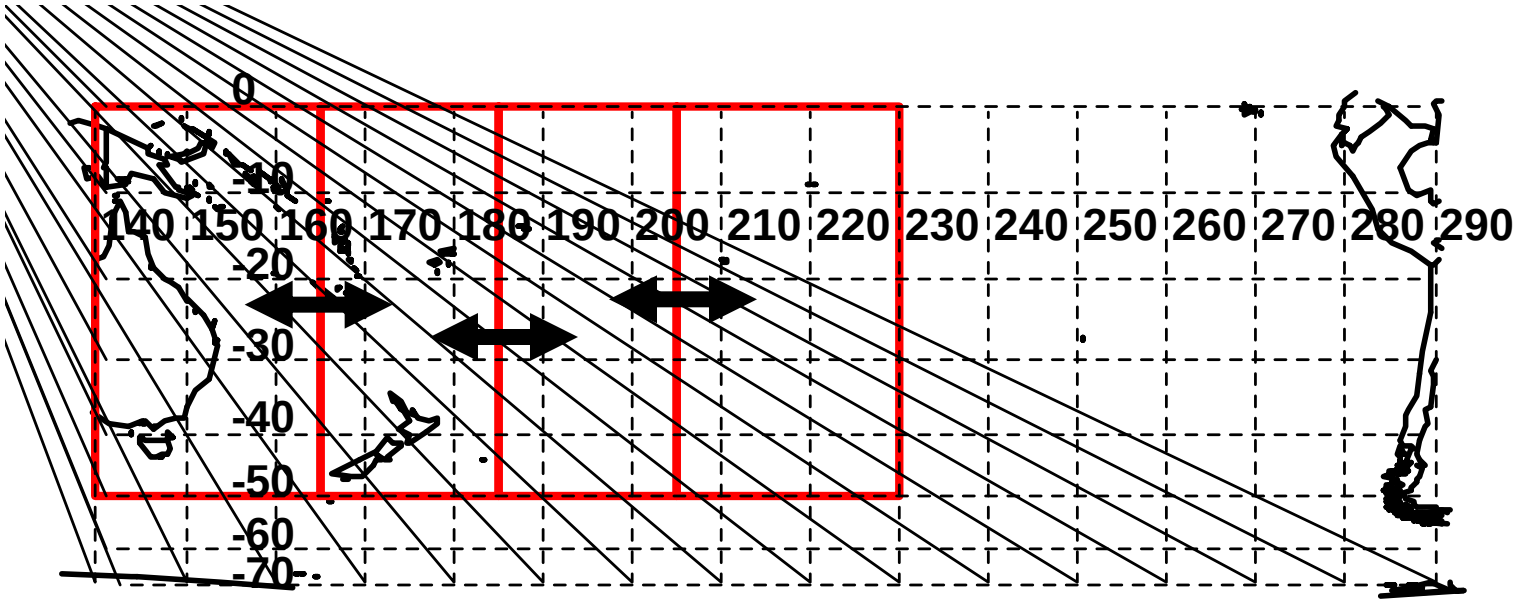
Growth, Mortality and Maturity



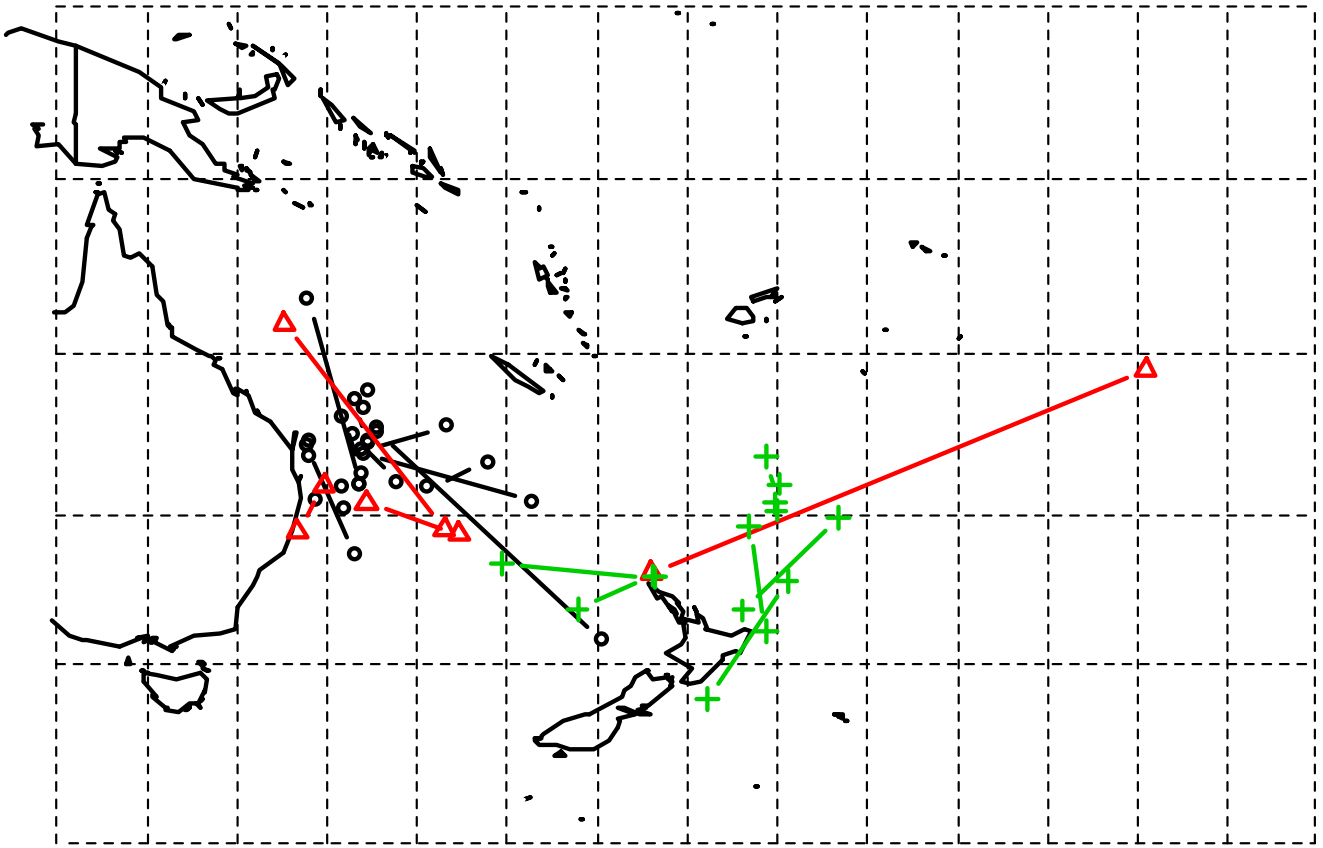




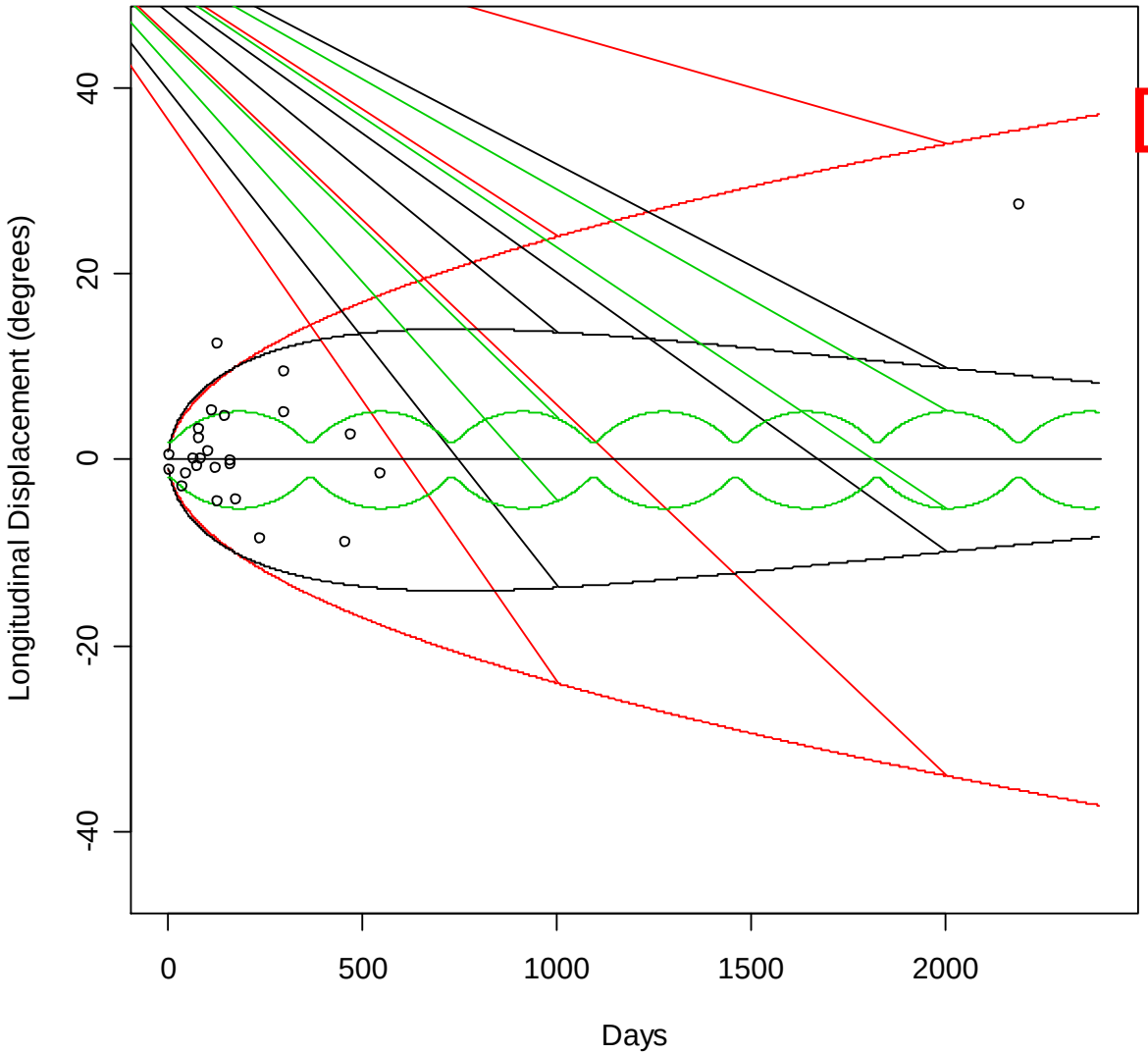
2008 Spatial Structure: Diffusion Rates (SA-IP-2)



Net PSAT and Conventional tag movements (60 days to 6 years at liberty)



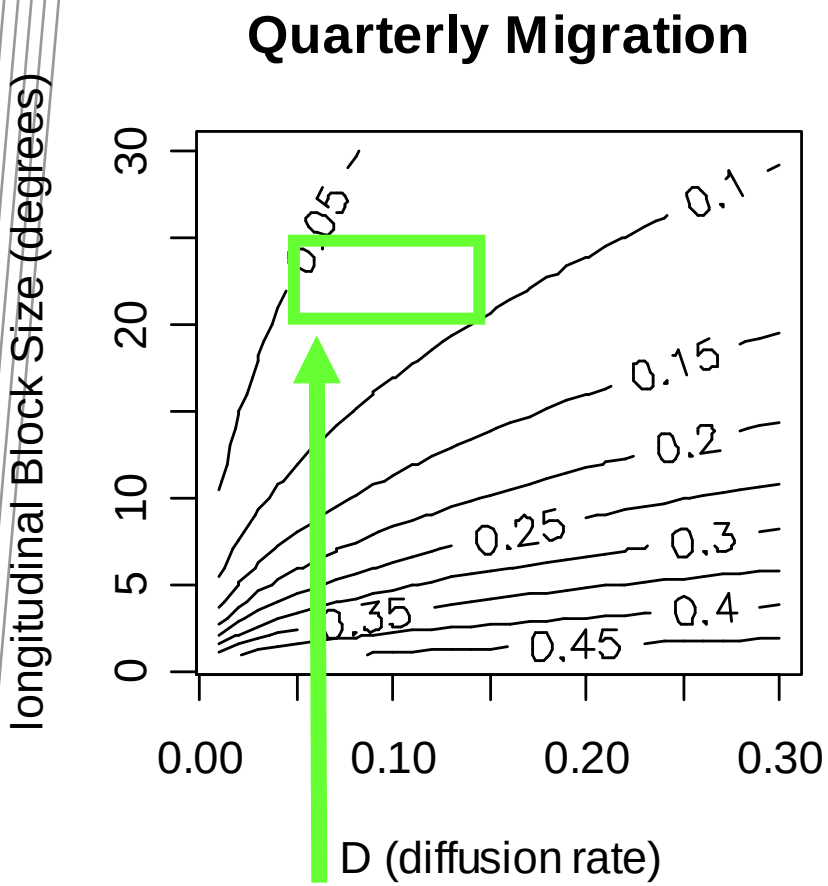
Alternative migration models

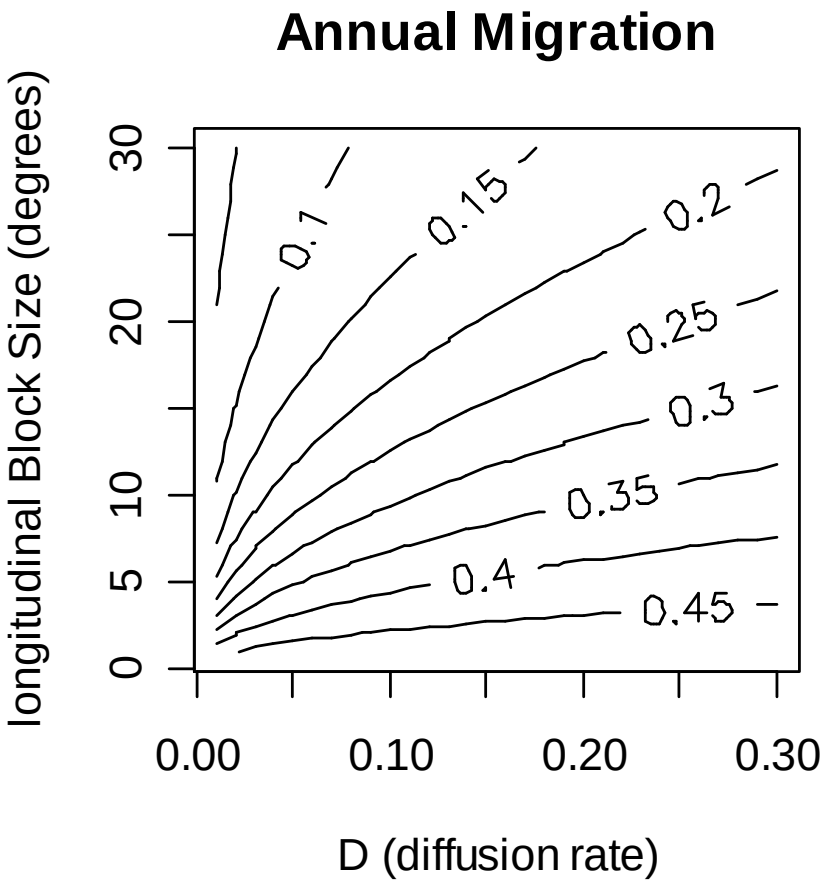


Diffusion

Site Fidelity

Diffusion -> Bulk transfer Coefficients





Revised Spatial Structure

CASAL Assessment…SA-WP-7

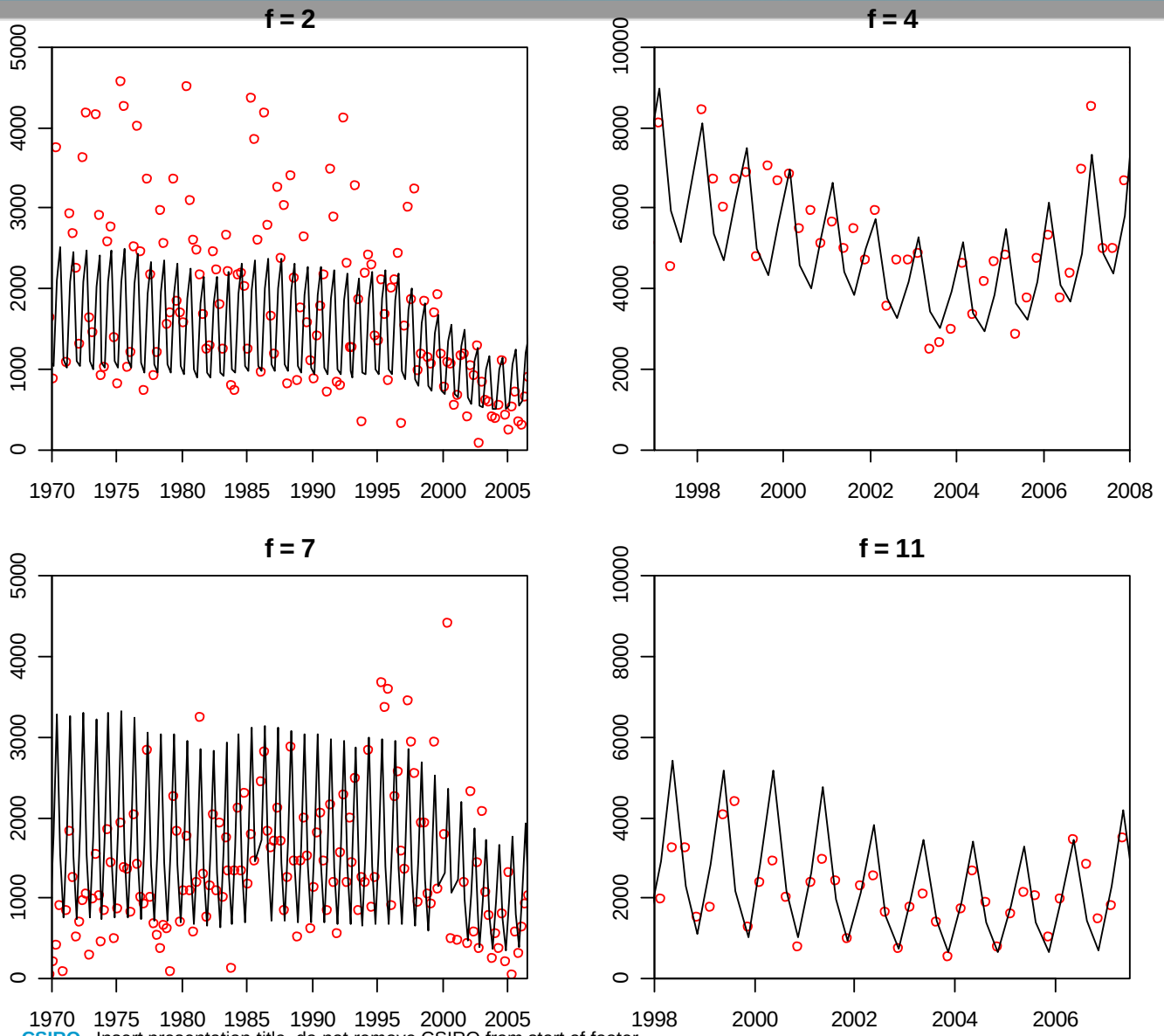
MULTIFAN-CL Assessment SA-WP-6

South-west Pacific
Uncertainty Grid of Model assumptions

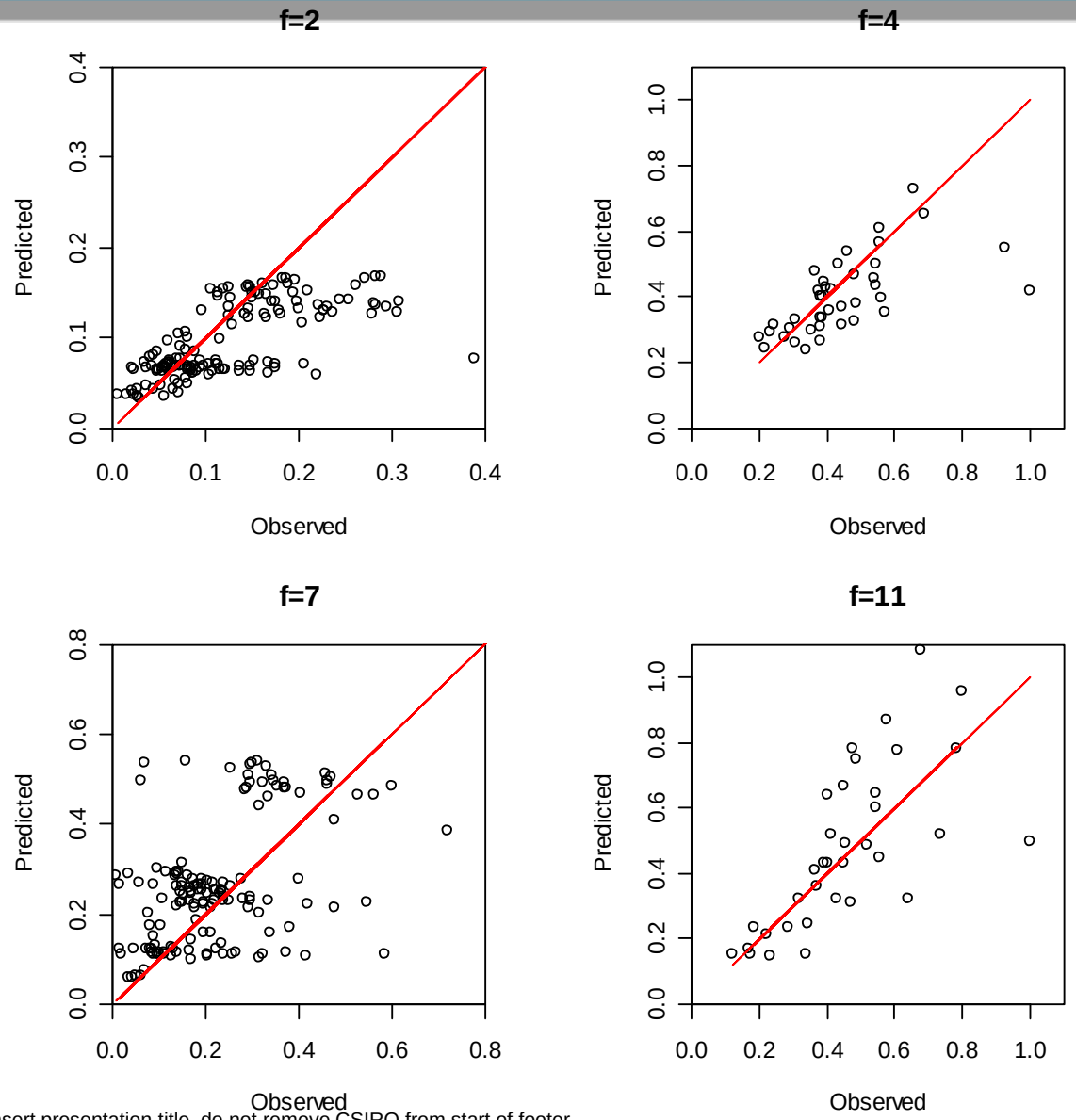
- 2 Stock recruitment curve steepness priors (0.65, 0.9)
- 2 migration exchange rate options (based on bounds of tag analyses)
- 8 growth rate / maturity / mortality options
- 2 recruitment deviation options (ln(SD) = 0.1, 0.5)
- 2 sample size down-weighting options (for catch-at-size likelihood terms) → 1
- 3 relative weighting options for CPUE indices
- 2 selectivity constraint options → 1

768 models → 192 Plausible Models

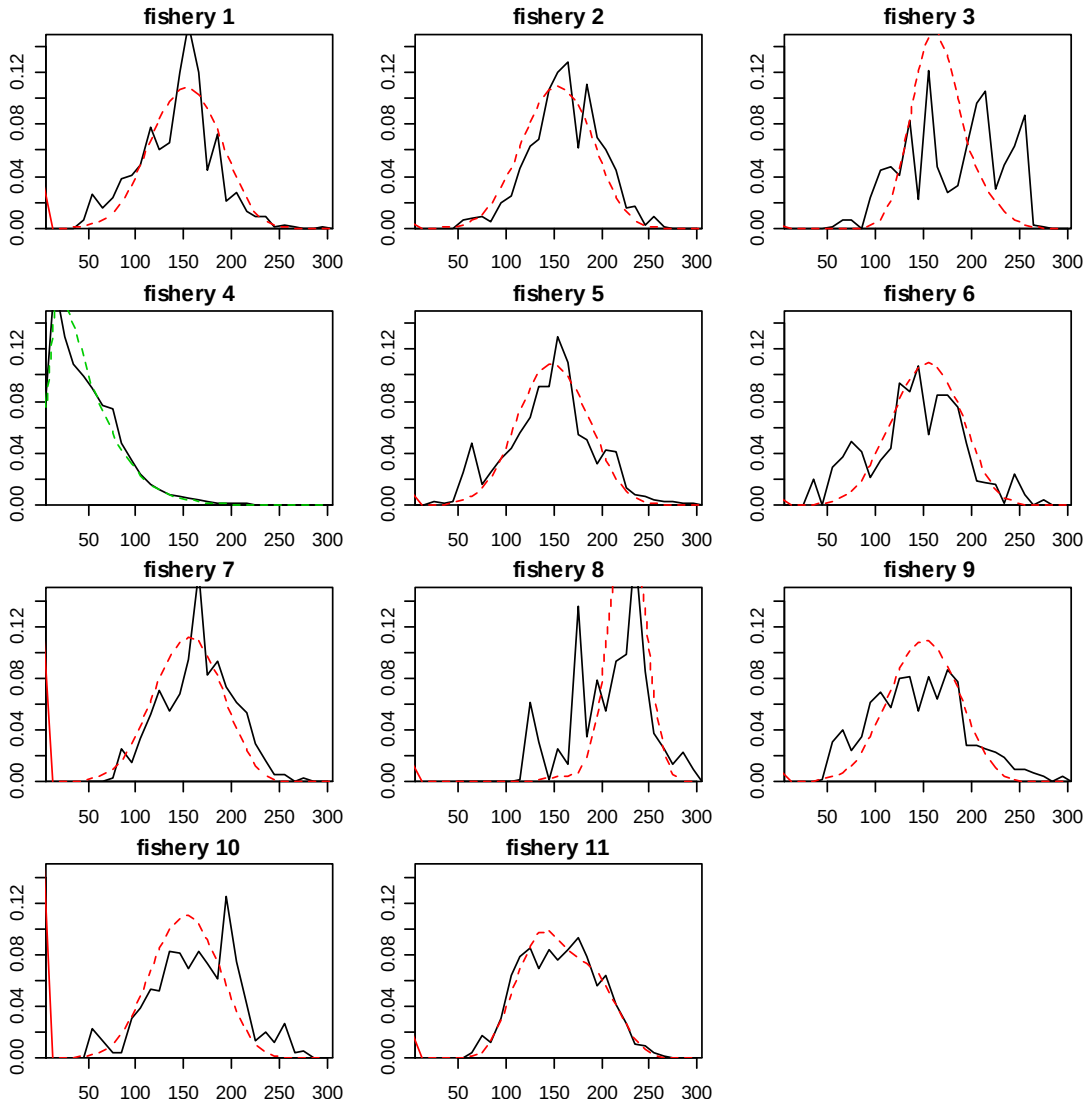
SWP Example model: CPUE fit



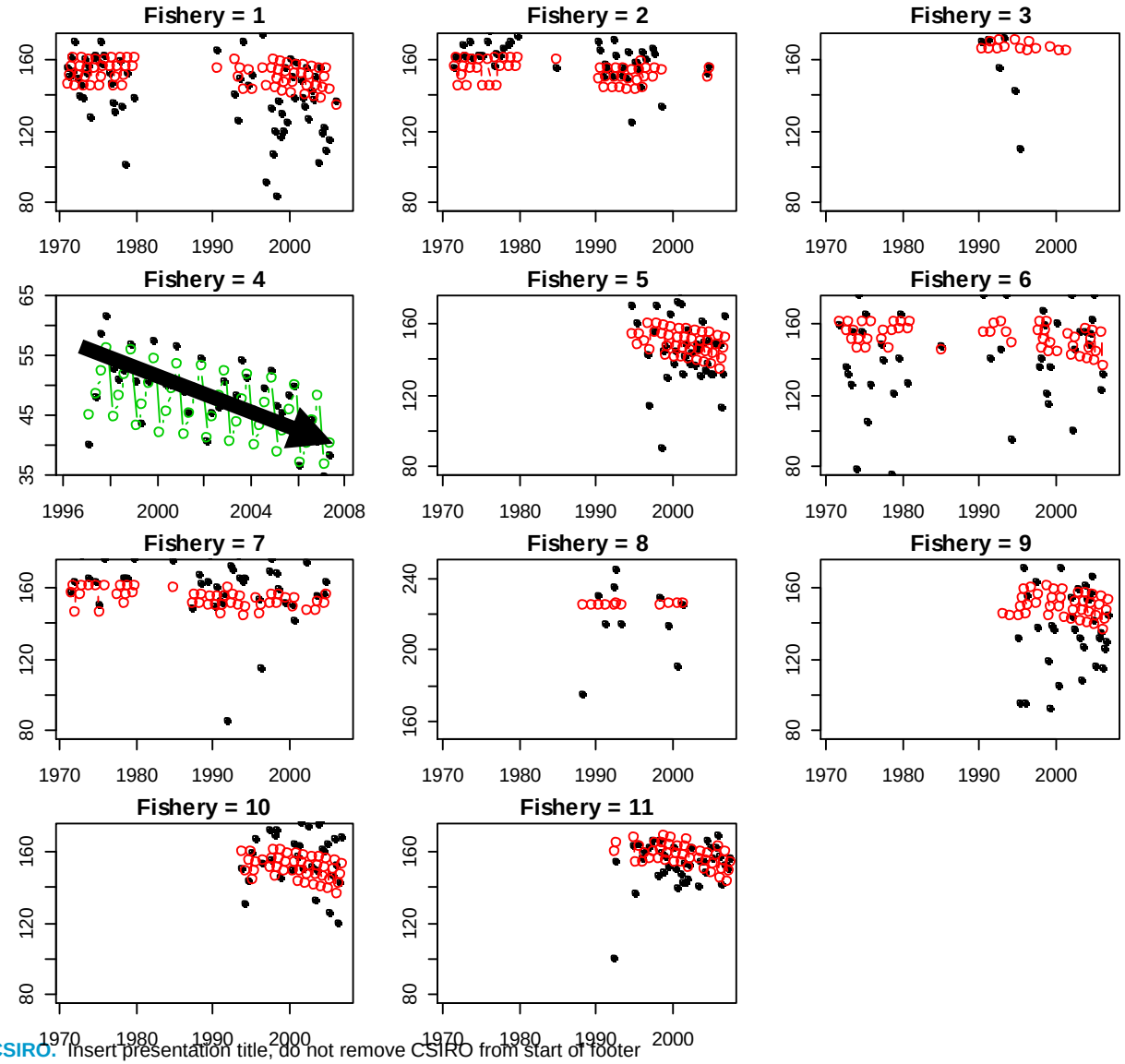
SWP Example model: CPUE fit



2008 Assessment: Example Model
typical model fit to size frequency distributions

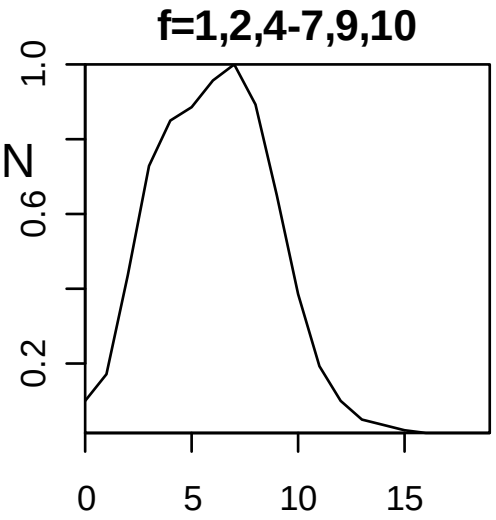


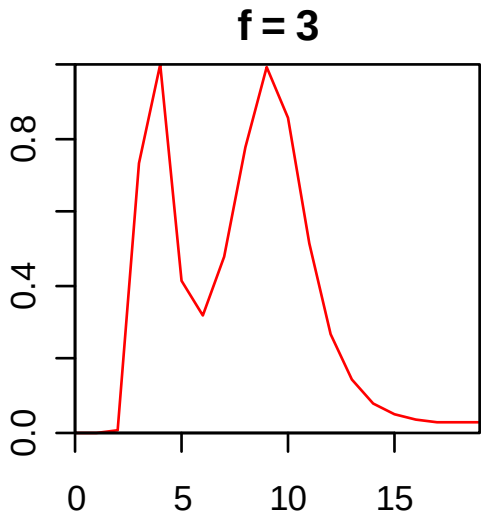
2008 Assessment: typical model fit to mean sizes



Example model fishery selectivity

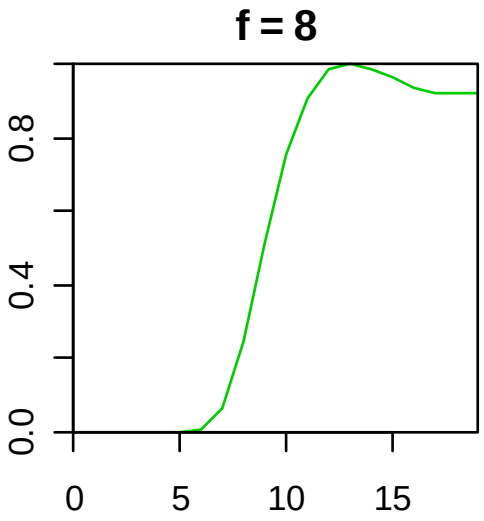
NORTHERN FLEETS

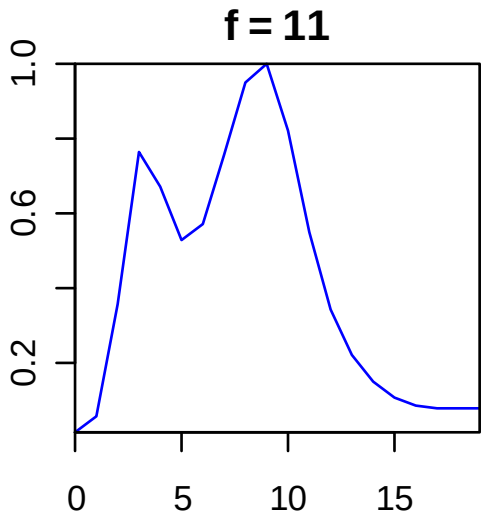




MIXED FLEET?

SBT FLEET

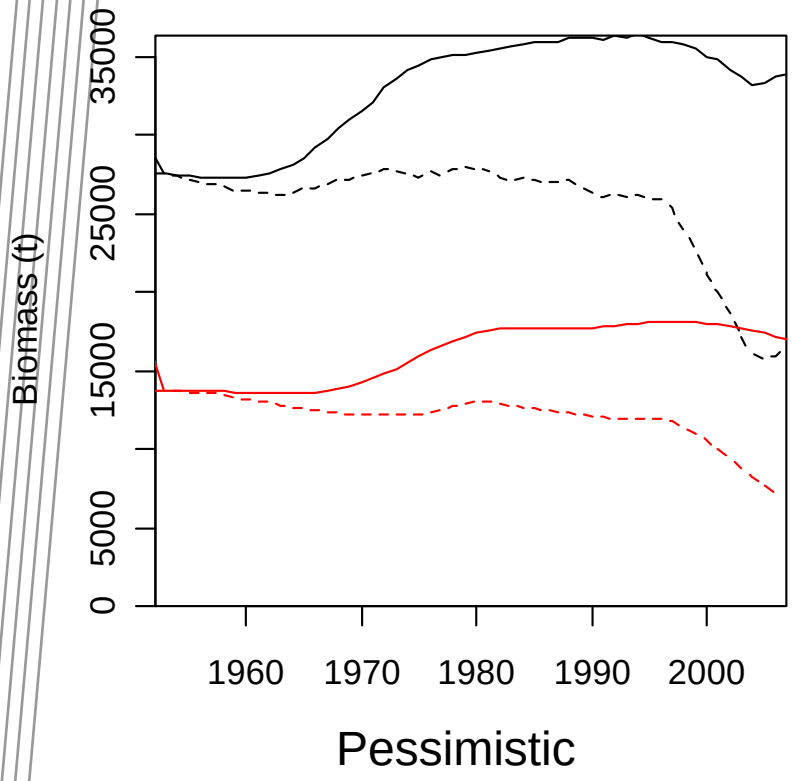




NEW ZEALAND DOMESTIC

2008 Assessment: typical biomass trends

A12F11_h65_D10_GAMLS_r5_ES05_UA1_SF



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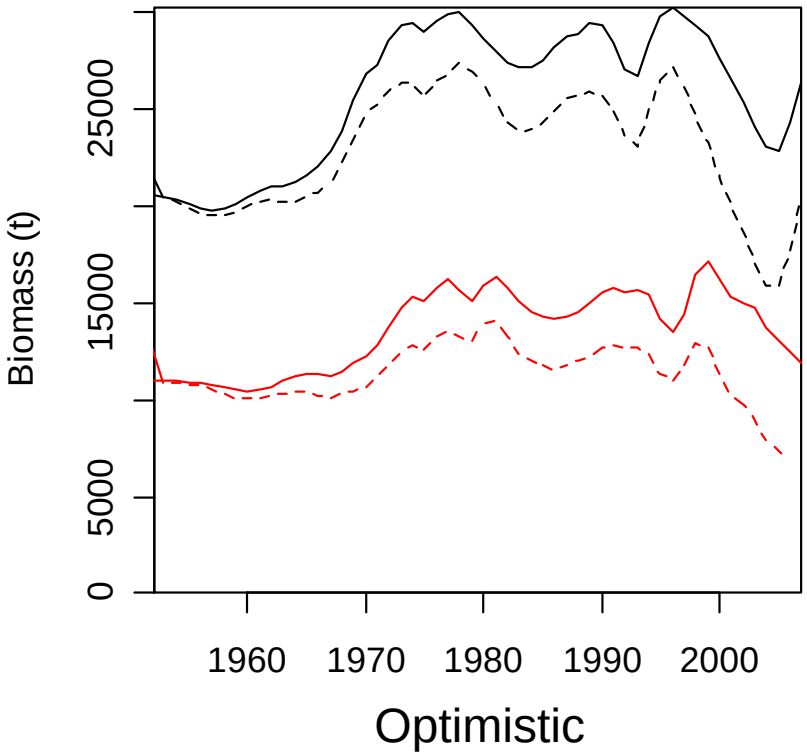
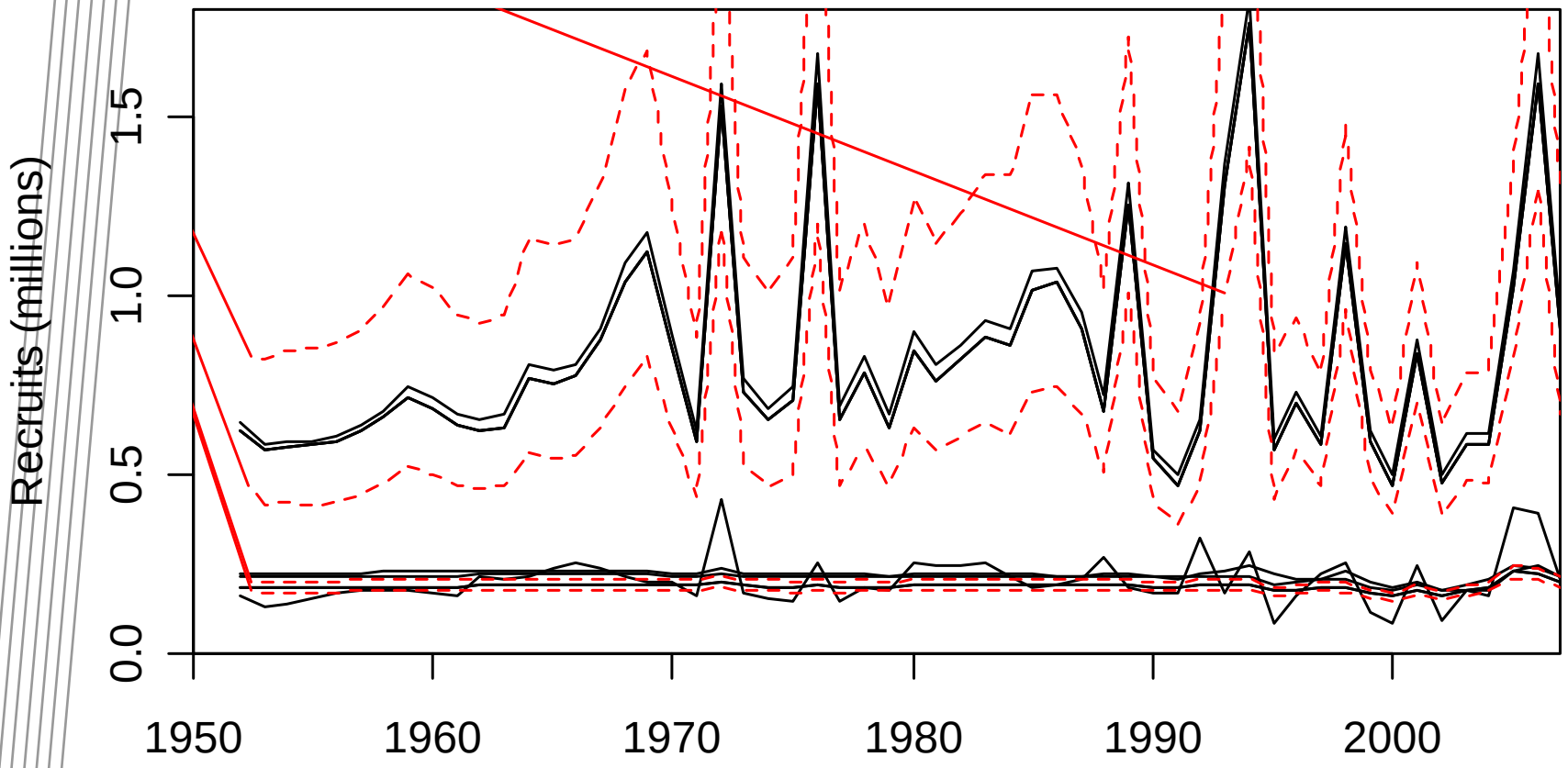


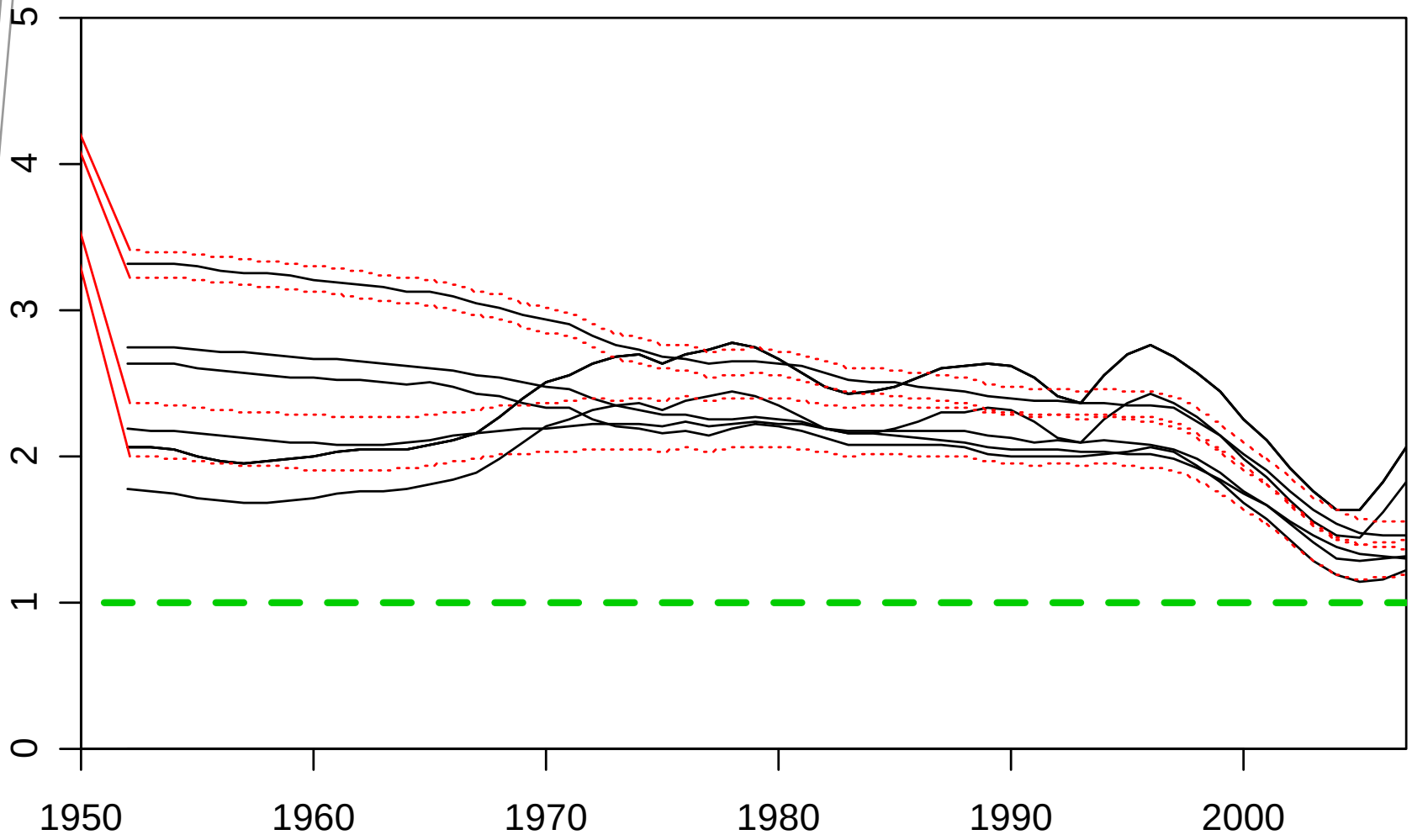
How much is 20000 tonnes of trunked swordfish?

Photo credit: David Kreutz

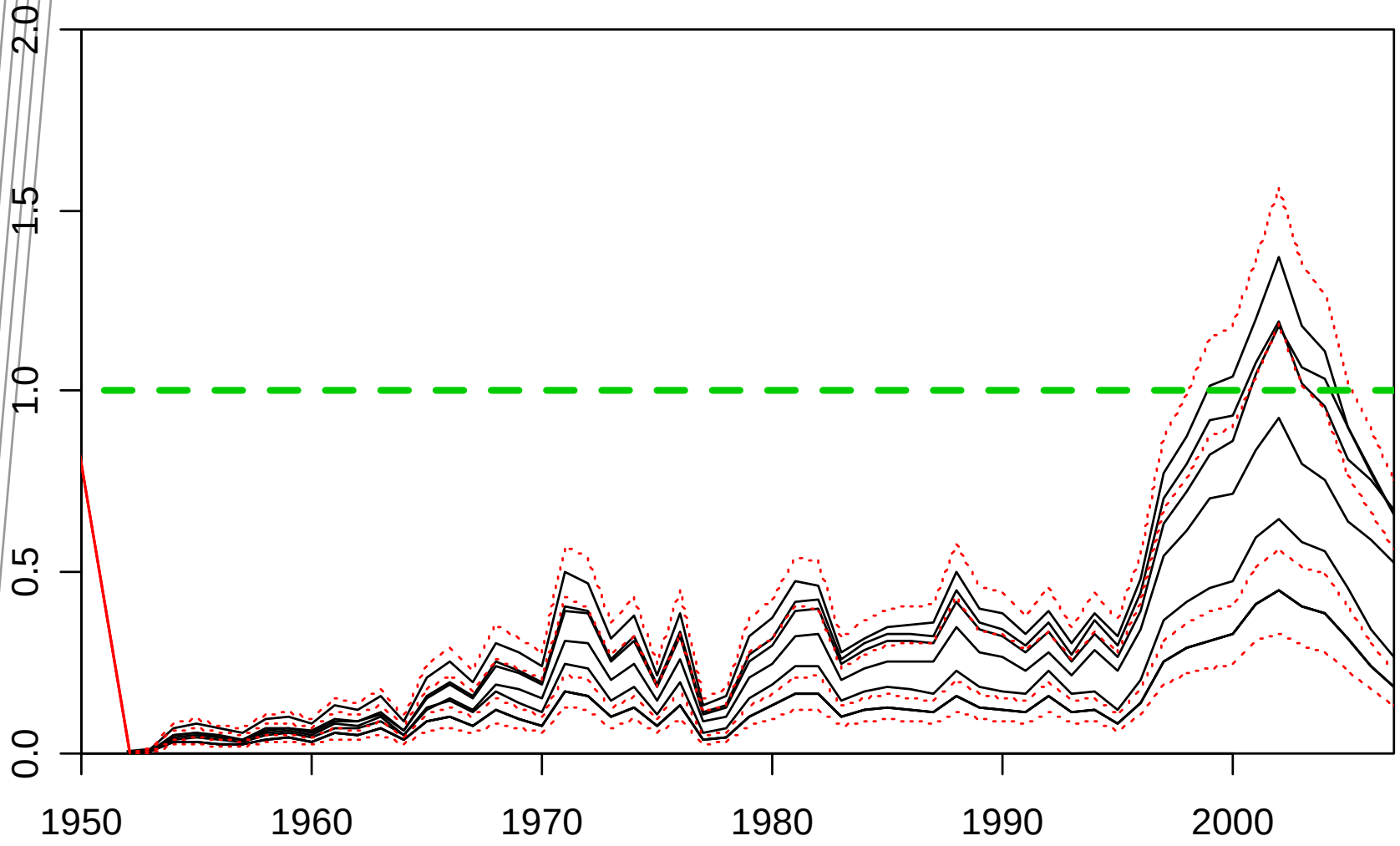
2008 Assessment: Recruitment time series



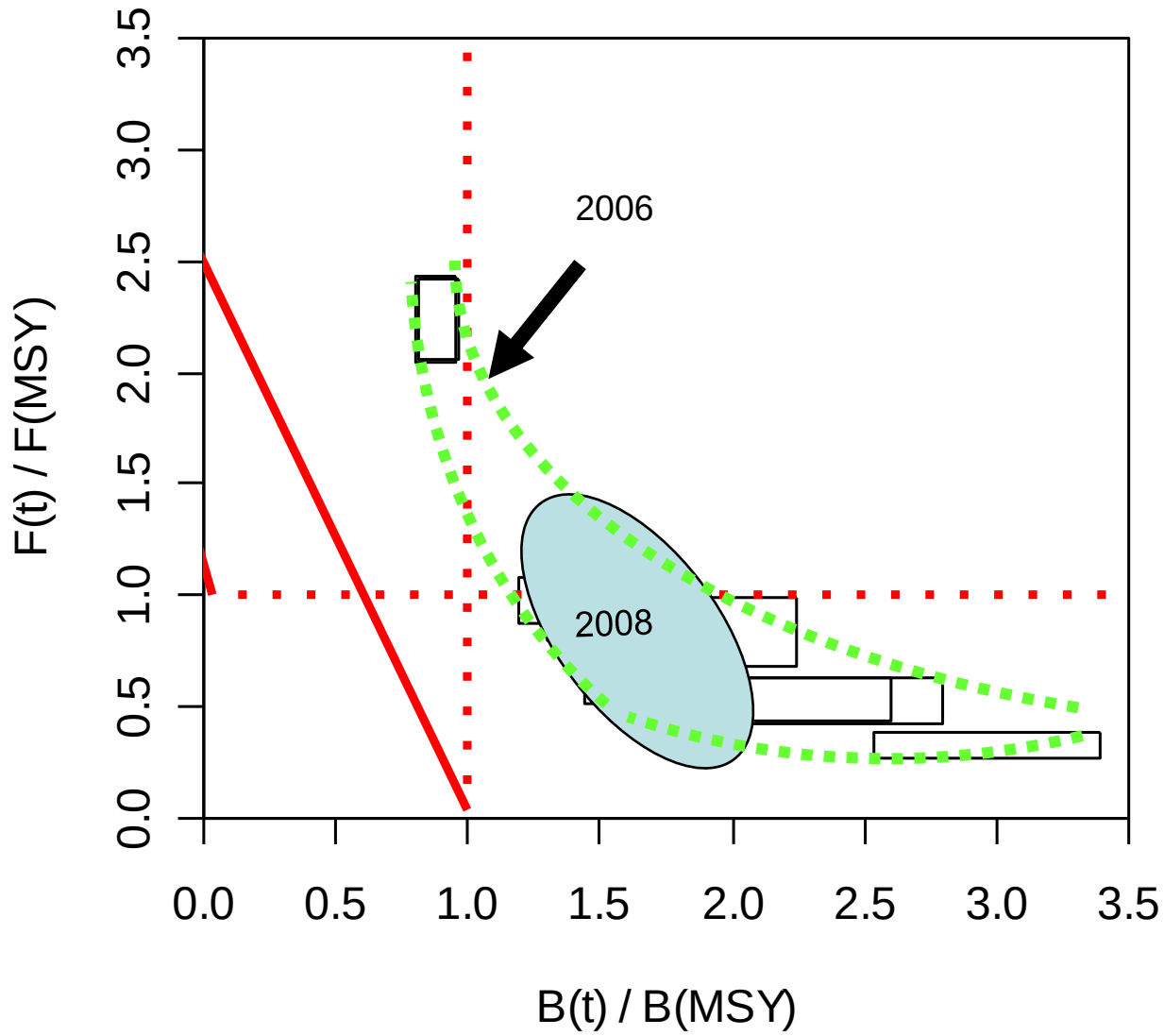
2008 Assessment: Total Biomass relative TB(MSY)



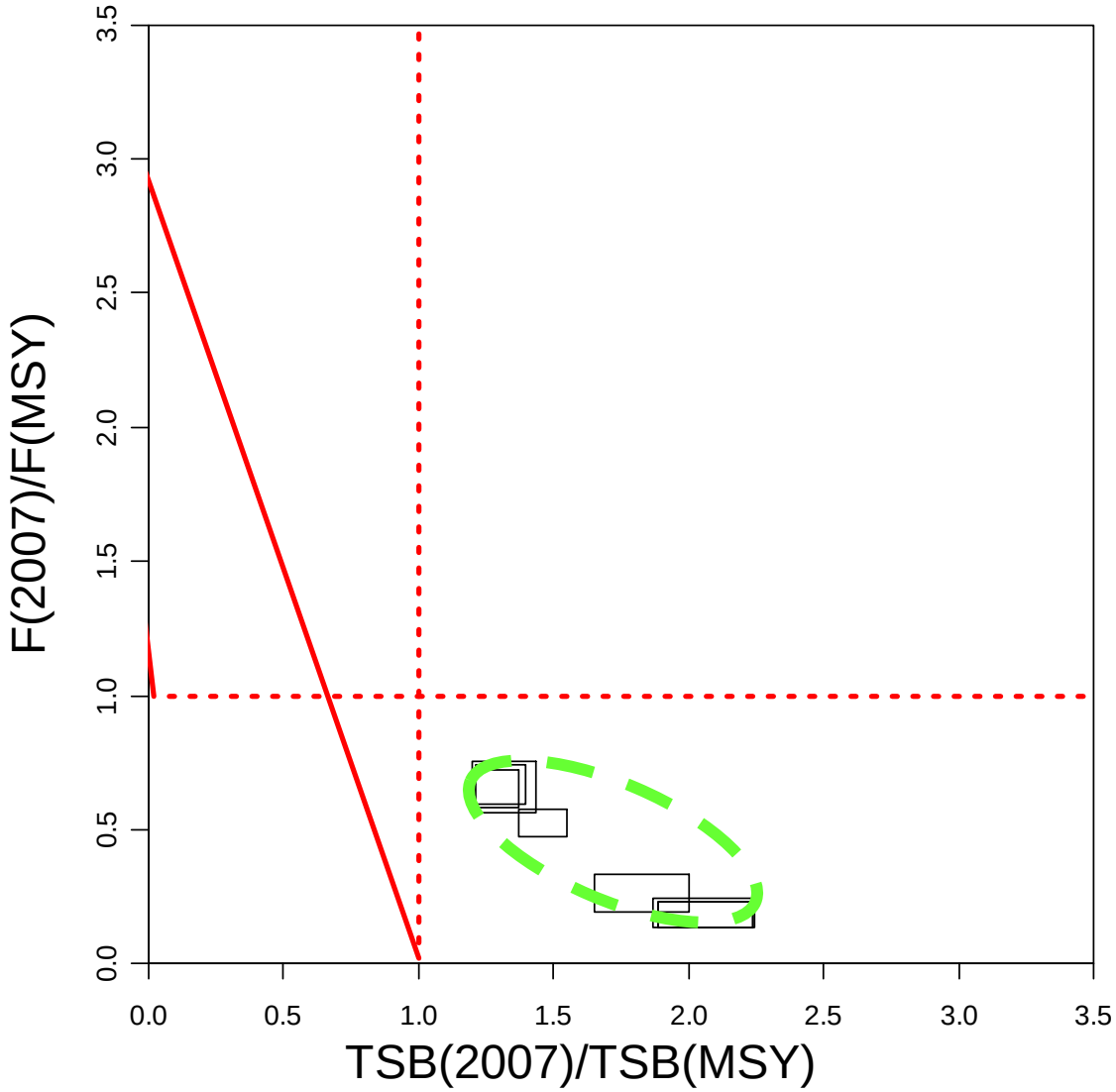
2008 Assessment: Total fishing mortality over time, relative to F(MSY)



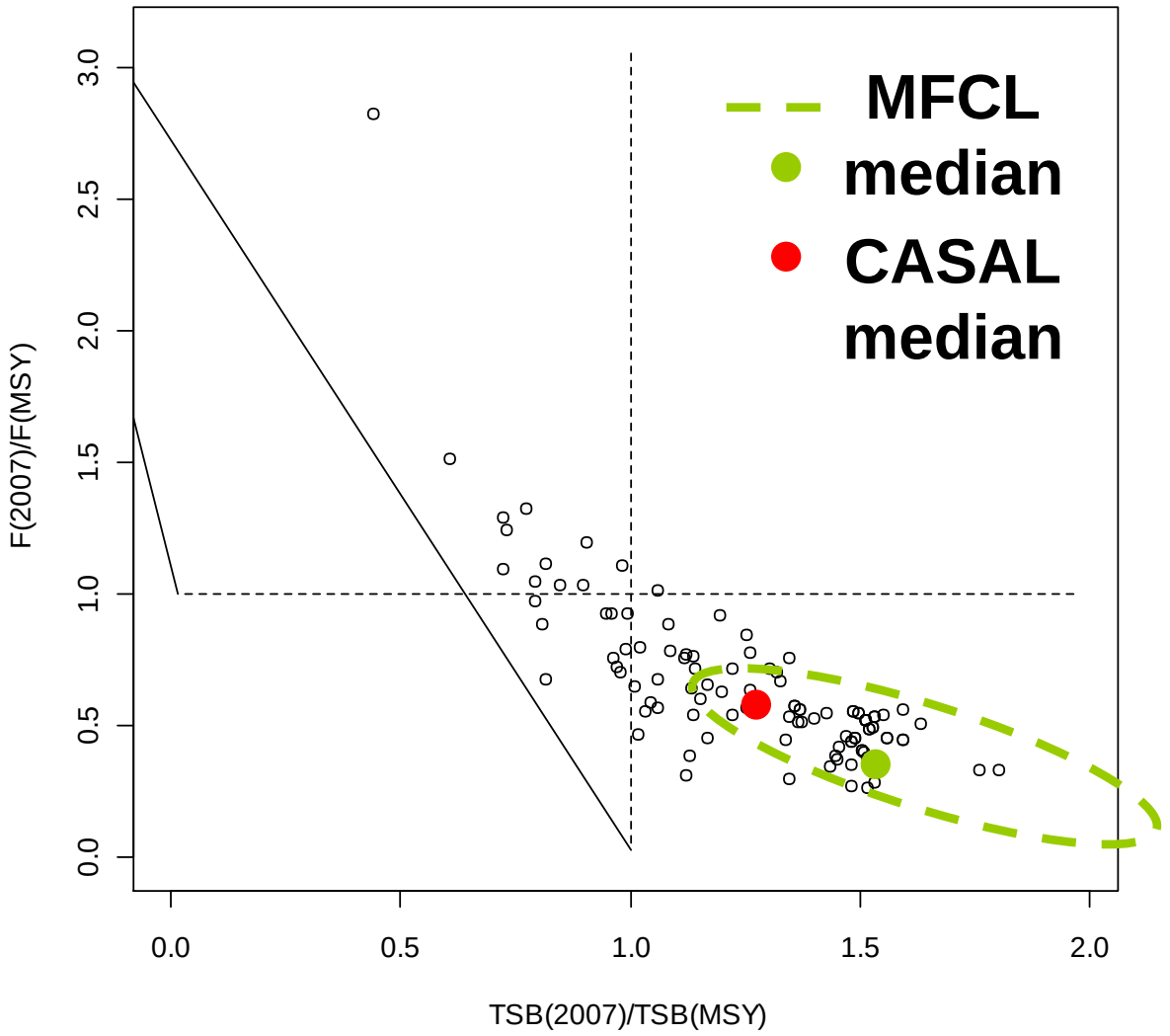
2006 vs 2008 Assessment Stock Status Summary (for the year 2004)



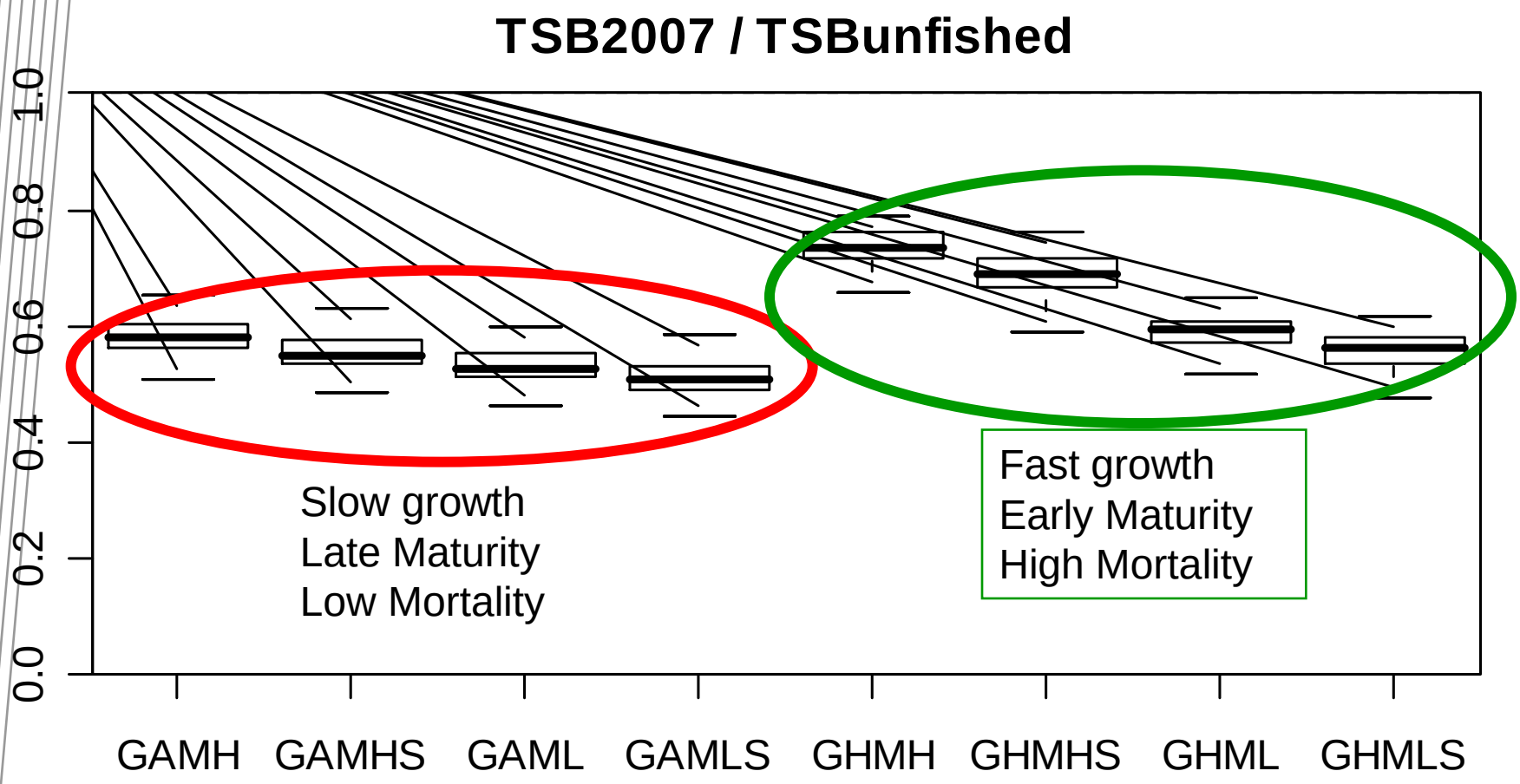
2008 Assessment: 2007 Stock Status Summary



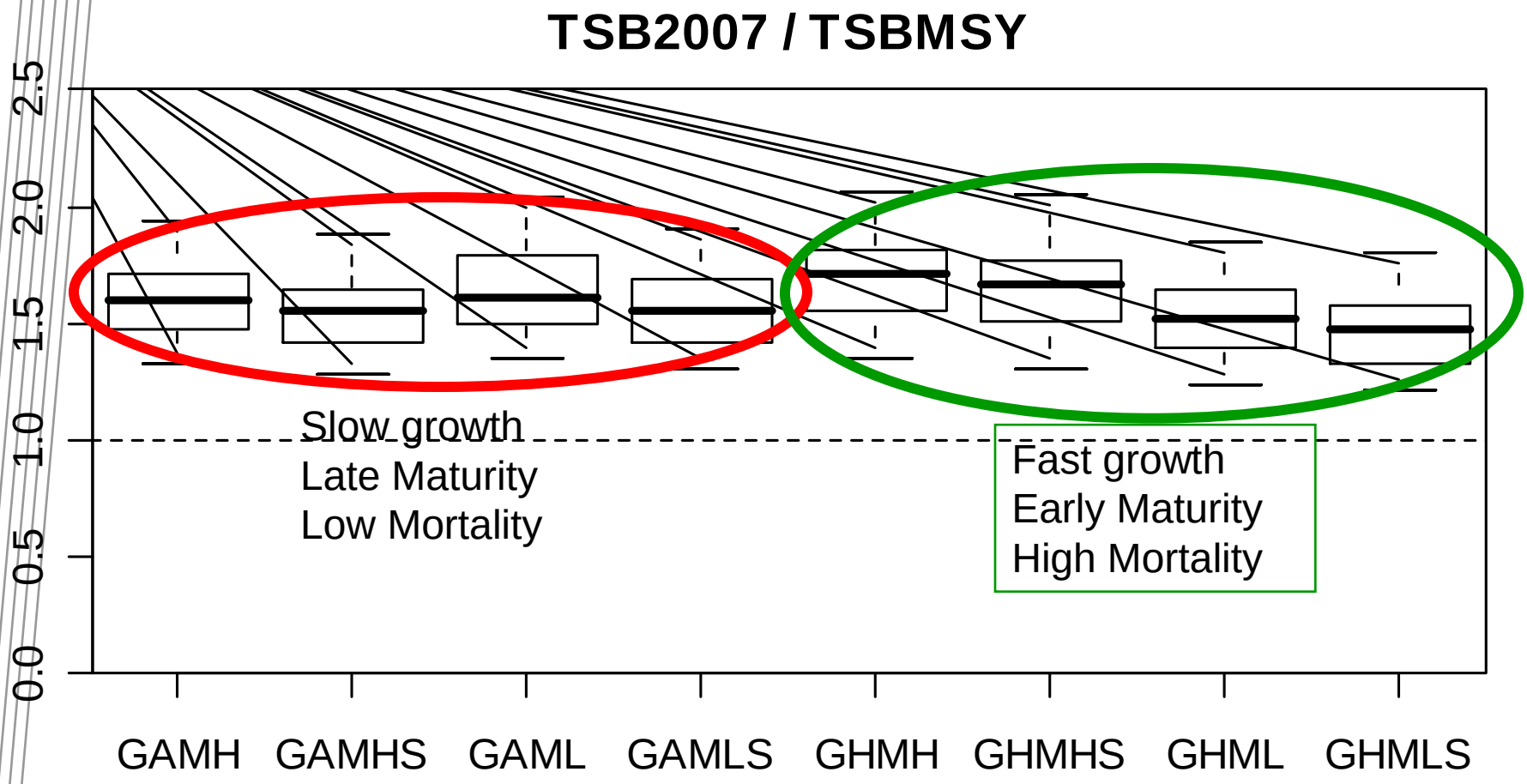
CASAL vs: MULTIFAN-CL



Model Sensitivities



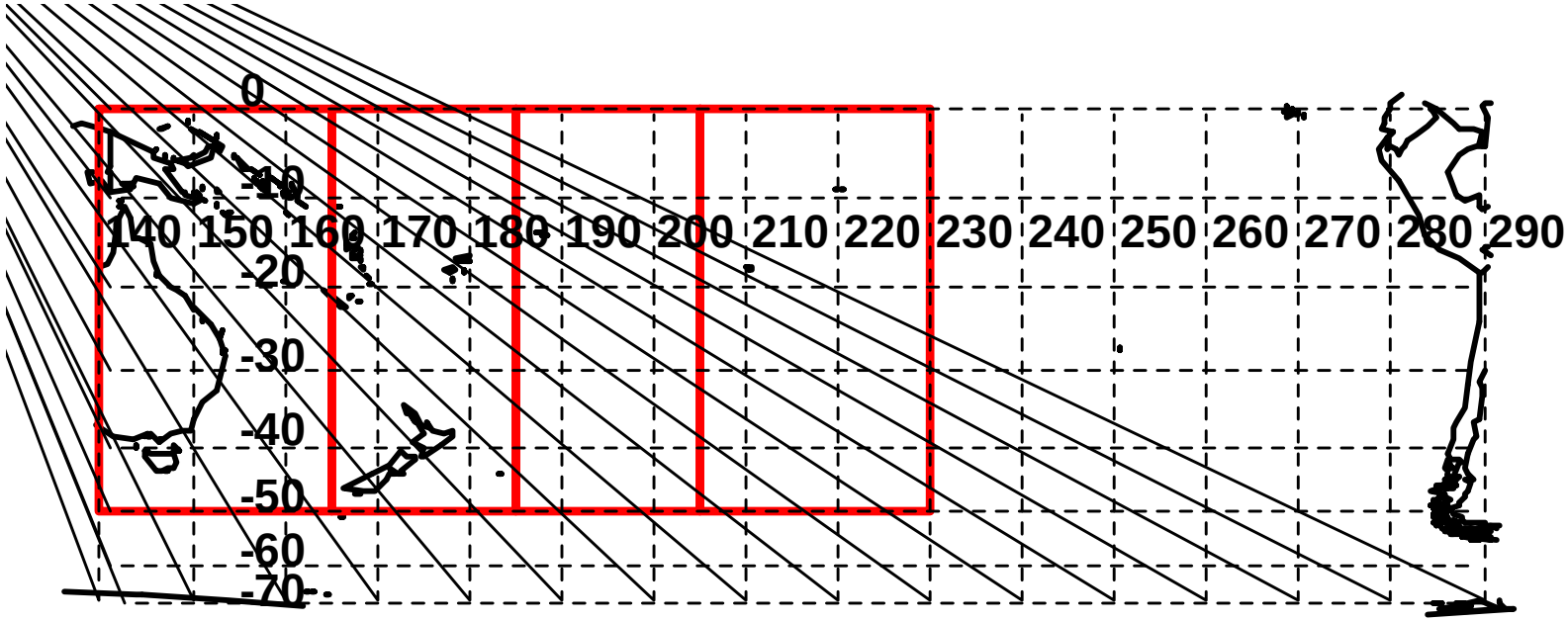
Model Sensitivities



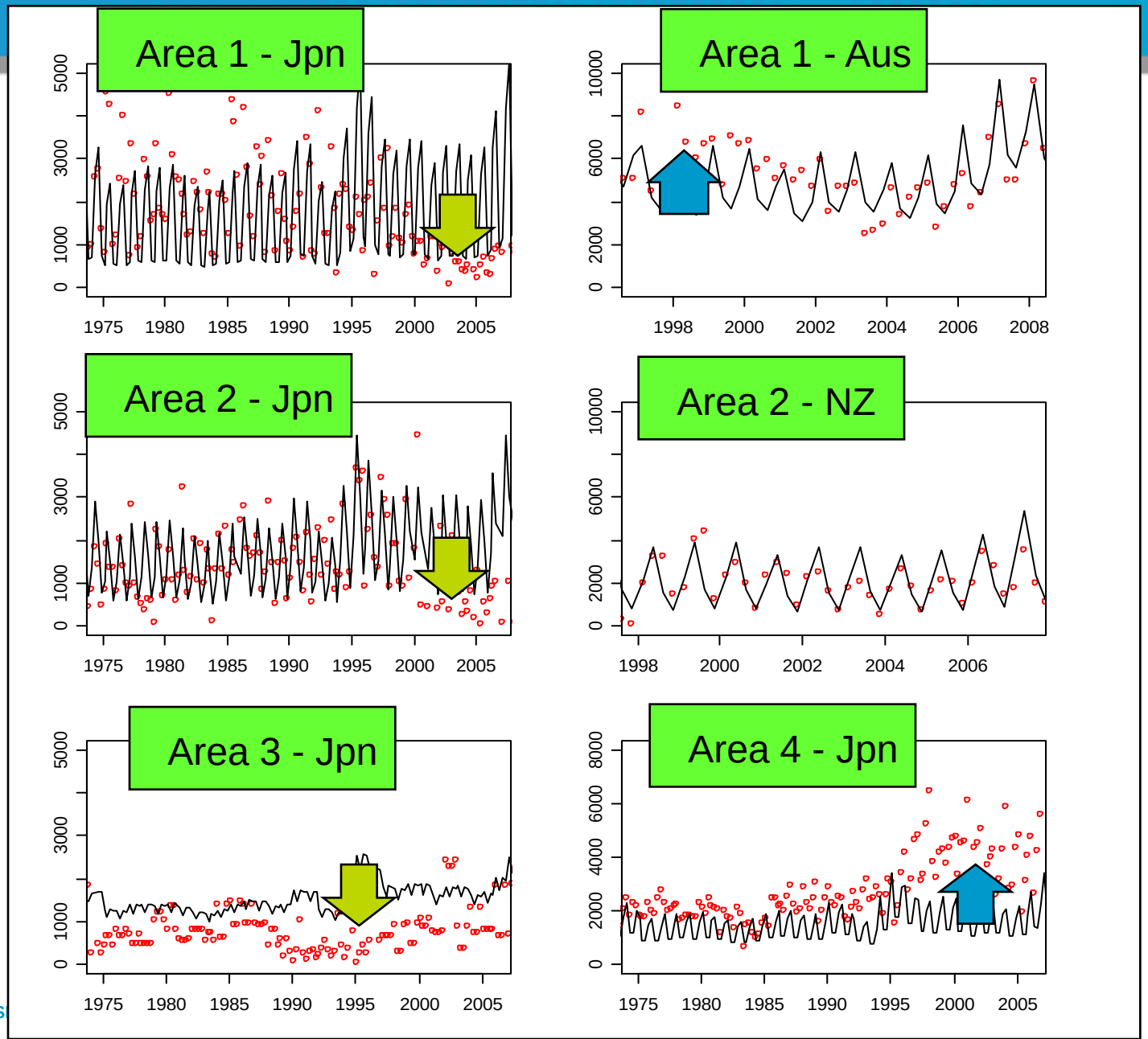
SW Pacific Current Stock Status Reference Points

- TSB(2007)/TSB(1997)
  - median = 0.69, range = (0.55 – 0.83)
- TSB2007 / TSB1997 = 0.69 (0.55-0.83)
- SSB2007 / SSB1997 = 0.58 (0.42-0.71)
- TSB2007 / TSBunfished = 0.58 (0.45-0.79)
- TSB2007 / TSBMSY = 1.57 (1.22 - 2.06)
- Aggregate F 2007 = 0.05 (0.03 - 0.11)
- F2007 / FMSY = 0.44 (0.18 - 0.67)
- max(F / FMSY); i.e. any year = 0.85 (0.43 -1.39)
- MSY (trunked mass tonnes) = 2381 (1722 – 4119)
- TSB2012 / TSB2007 = 1.19 (1.03 - 1.54)
- TSB2017 / TSB2007 = 1.24 (1.05 -1.64)
- TSB2017 / TSBMSY = 1.97 (1.43 - 2.99)

Combined South-West / South-Central Pacific Assessment



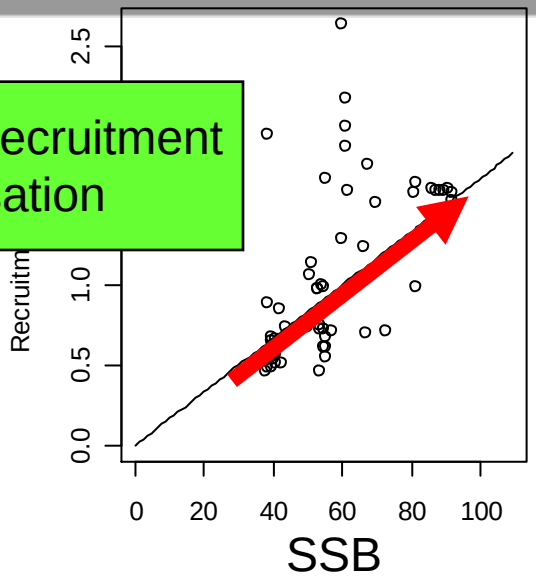
SWP/SCP
Predicted and Observed CPUE

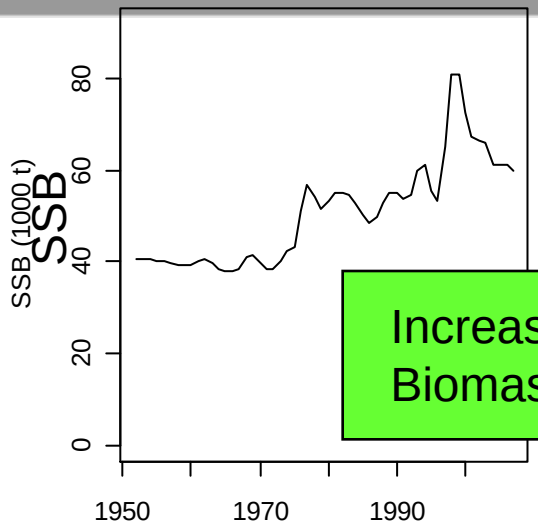


CSIRO

Type 1 Questionable SWP-SCP dynamics

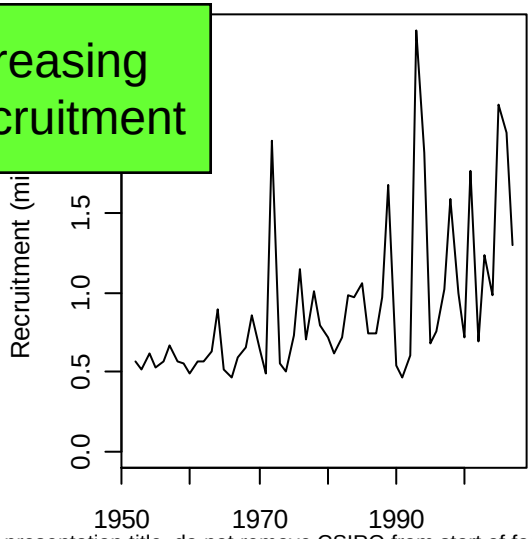
Limited Recruitment Compensation



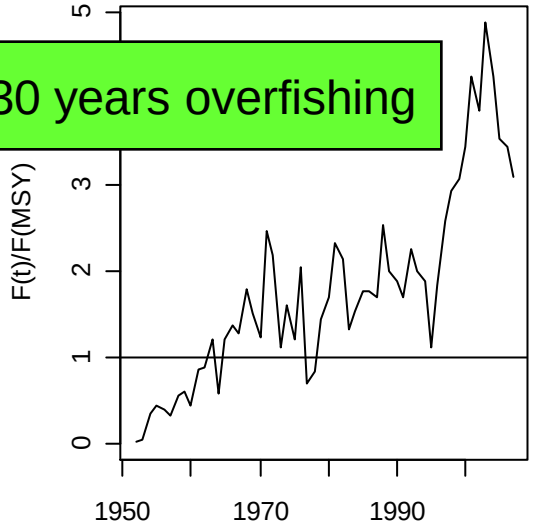


Increasing Biomass

Increasing Recruitment



30 years overfishing



Should we believe the SCP CPUE Series?

- If so:
  - Recruitment regime shifting in SCP
  - SWP and SCP swordfish are not well mixed
  - Current models and data not appropriate for describing dynamics

- If not:
  - Targeting shifts likely in SCP fleets
  - Cannot make any useful comments on abundnace of fishery impact

- Either way, we recommend:
  - Improved data collection and exchange
  - Collaborative analysis of operational level data
  - SCP relationship to EPO and North-Central Pacific should be explored further (tags)

Conclusions

1. An attempt was made to assess the southern hemisphere WCPO swordfish population.
2. All of the available fisheries data (catch, effort and size composition), and fisheries independent research (genetics, reproductive studies, PSAT and conventional tagging, growth rates) was collated for the assessment and analyzed in the context of developing the most appropriate spatial structure for the model.
3. A two-tiered approach to the assessment domain was adopted, with a higher priority for the south-west Pacific (SWP 140°E - 175°W), which is supported by reasonable data and evidence for a semi-independent population; and a lower priority for the south-central Pacific (SCP 175°W - 130°W), which has generally lower quality data and possibly stronger links with other Pacific populations to the east and/or north.
4. Declining catch rates and declining trends in size composition in the SWP, coincident with a decade of elevated catches indicate that the fishery has probably had a substantial impact on the population. Recent increases in CPUE in the Australian and New Zealand fleets, combined with decreased catches suggest that the stock may be rebuilding now. However, increasing CPUE trends in the SWP are less evident in the Japanese fleet.

Conclusions

- 5. Catches in the SCP are increasing, and of a similar magnitude to the SWP. CPUE trends are stable or increasing and the catch size composition data are poor, so it is difficult to make inferences about the fishery effect in the SCP.
- 6. A comprehensive attempt to model the southern WCPO population was undertaken involving two modelling approaches (CASAL and MULTIFAN-CL), three spatial domains (SWP, SCP, and combined SWP-SCP), and several hundred sets of model assumptions to describe the uncertainty. The MULTIFAN-CL models seemed to provide robust and plausible results for the SWP. The CASAL model suffered from numerical convergence problems, but did produce stock status estimates that were reasonably consistent with MULTIFAN-CL. The SWP MULTIFAN-CL assessment indicates:
  - Total biomass is estimated to have declined by 17-45% in the last ten years, and spawning biomass is estimated to have declined by 29-58%.
  - With respect to MSY-related reference points, the 2008 SWP assessment yields results that are consistent with those presented in the 2006 assessment, though with considerably reduced uncertainty. The reduced uncertainty is thought to be due to 1) the informative contrast in the recent catch and CPUE series (i.e. breaking the one-way-trip), and 2) the simplified spatial structure. The models estimate that biomass is above that which would sustain MSY: TSB(2007)/TSB(MSY) >1.22, SSB(2007)/SSB(MSY) >1.20 and fishing mortality is below F(MSY), (F(2007)/F(MSY) <= 0.67).
  - Stock projections (assuming deterministic future recruitment from the stock recruitment relationship, and constant catches at 2007 levels), suggest that biomass will increase over the next 5 to 10 years.

Conclusions

- 7. Model-based assessments including the SCP were not considered to be reliable:
- 8. None of the model options produced plausible estimates, and this was attributed to insufficient information being available for estimating the fishing impacts on the SCP population. Consequently, no stock status estimates were provided for the SCP.
- 9. If it is assumed that the SCP CPUE indices provide a true reflection of abundance trends then:
  - The SCP population is probably experiencing a gradual long-term increase in recruitment productivity such that the historical data provide little indication of what is going to happen in the future, and
  - The SCP swordfish population is not rapidly mixing with the SWP population, as the general CPUE trends in the two areas are in opposite directions despite a similar magnitude of catch removals.
- If so, it follows that the SWP population should be assessed independently of the SCP population (and the SCP population might be more appropriately assessed with the North-Central or Eastern Pacific populations).
- 10. At present there is no compelling evidence to indicate that the SCP swordfish fishery is over-exploiting the stock, but we do not consider the available data to be very convincing.
- 11. Research Recommendations are included in SA-WP-6 and SA-IP-1

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