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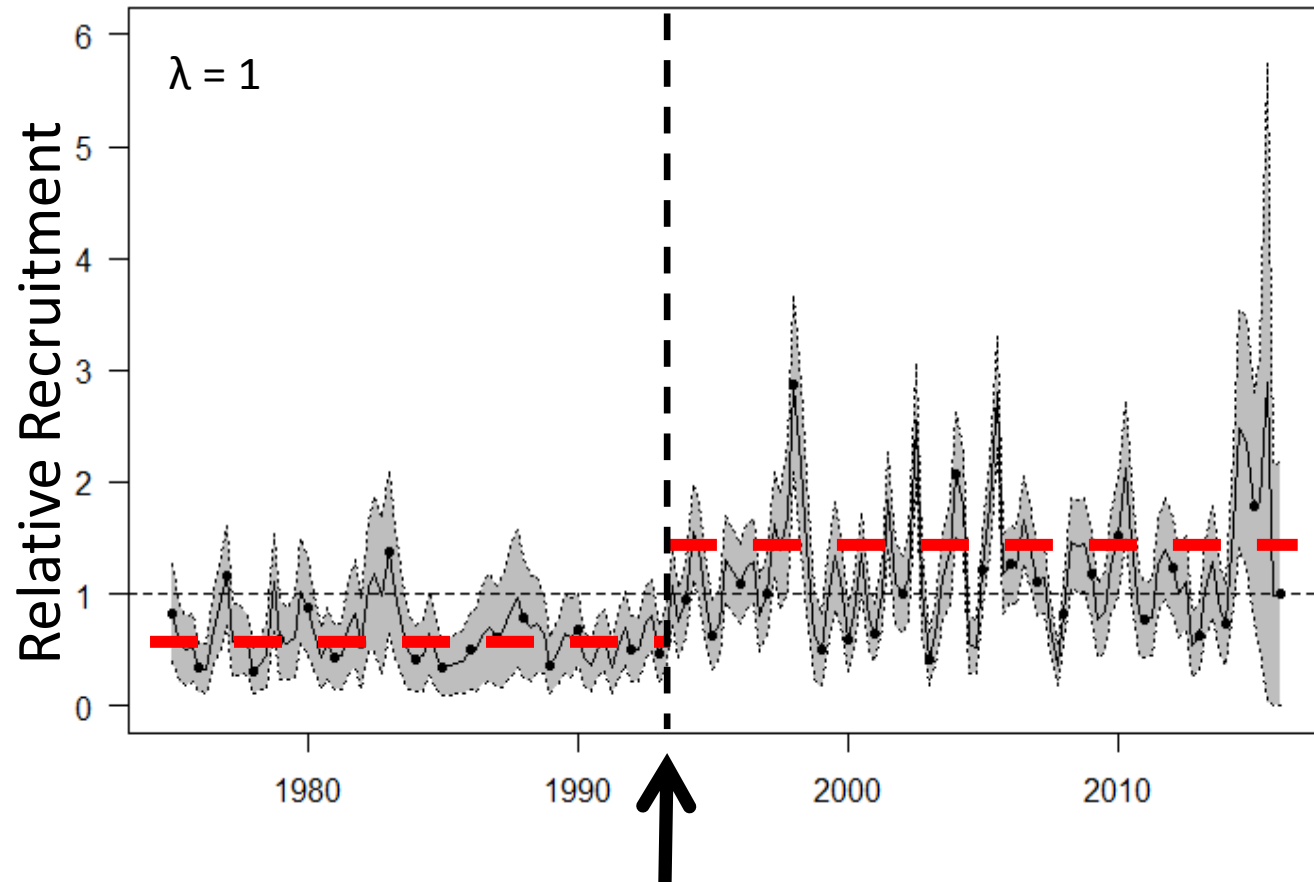
EXPLORATORY SPATIALLY-STRUCTURED ASSESSMENT MODEL FOR BIGEYE TUNA
IN THE EASTERN PACIFIC OCEAN (SAC-09-08)

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Outline

- Motivation for this work
 - Resolve BET stock assessment model misspecifications (Spatial mismatch)
 - Improve BET stock assessment
 - Develop more realistic operating models for ongoing Management Strategy Evaluation (MSE)
- Approach
 - Age-structured production models (ASPM) for alternative spatial sub-areas of the EPO
 - Integrated model for EPO's Central area (largest spatial mismatch between PS catch and LL index)
- Results
- Summary conclusions
- Future directions

The two-regime BET recruitment pattern

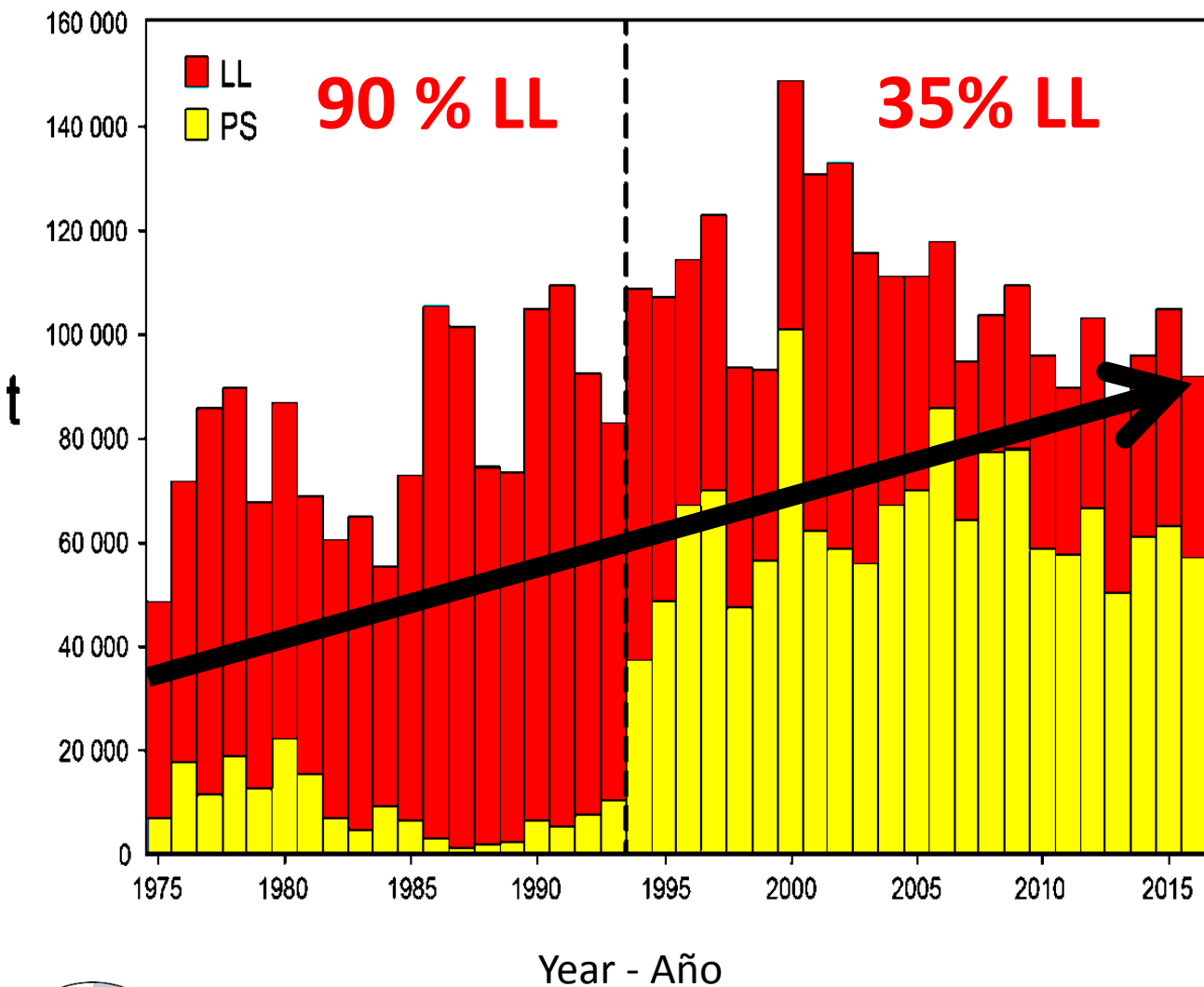


Expansion of FAD fishery

Recurrs in BET assessments since 2003
Alternative hypotheses:

- **Environmental shift** (Fonteneau and Ariz, 2008)
- **Underestimated early FAD catch** (Idem)
- **Higher natural mortality** (Idem)
- **Density-dependent growth** (Hoyle, SPC)
- **Migratory pattern changes** (Harley, SPC)
- **Artifact due to large catches of small individuals** by the purse-seine fishery (Maunder et al., 2010)
- **Spatial mismatch** between PS catch and LL CPUE index (Aires-da-Silva and Maunder, 2010)

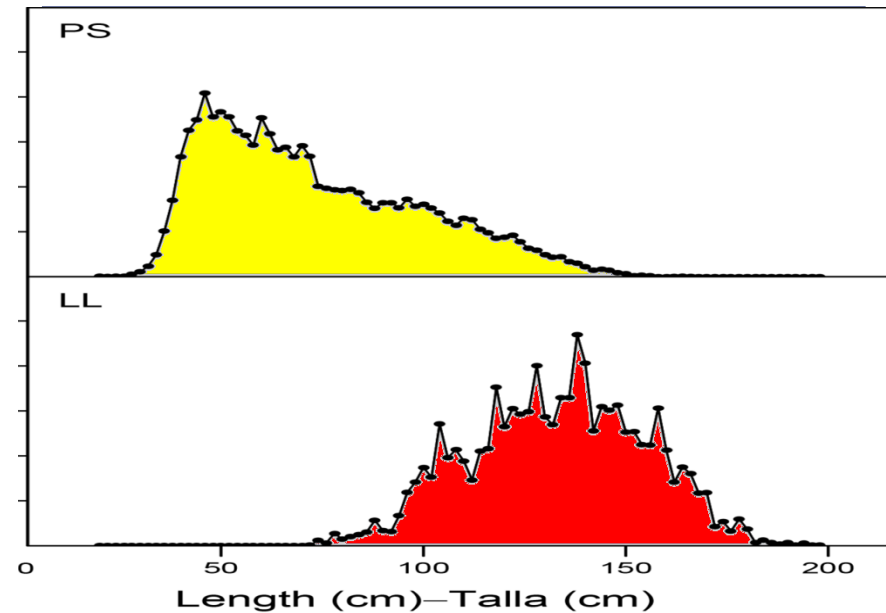
Expansion of FAD fishery



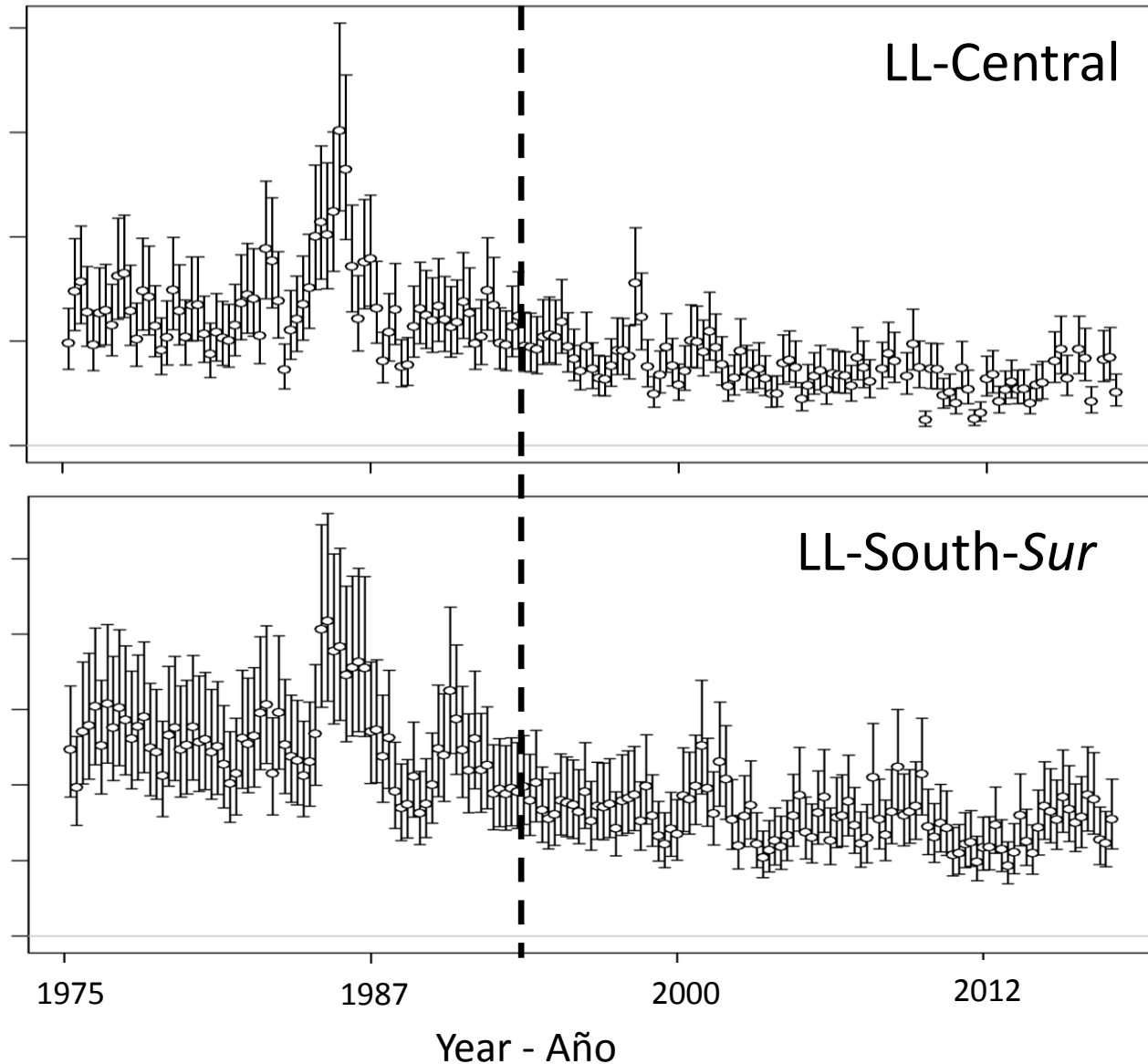
Expansion of **Purse Seine** fishery

Increased **TOTAL** catch

Smaller fish in **Purse Seine** fishery



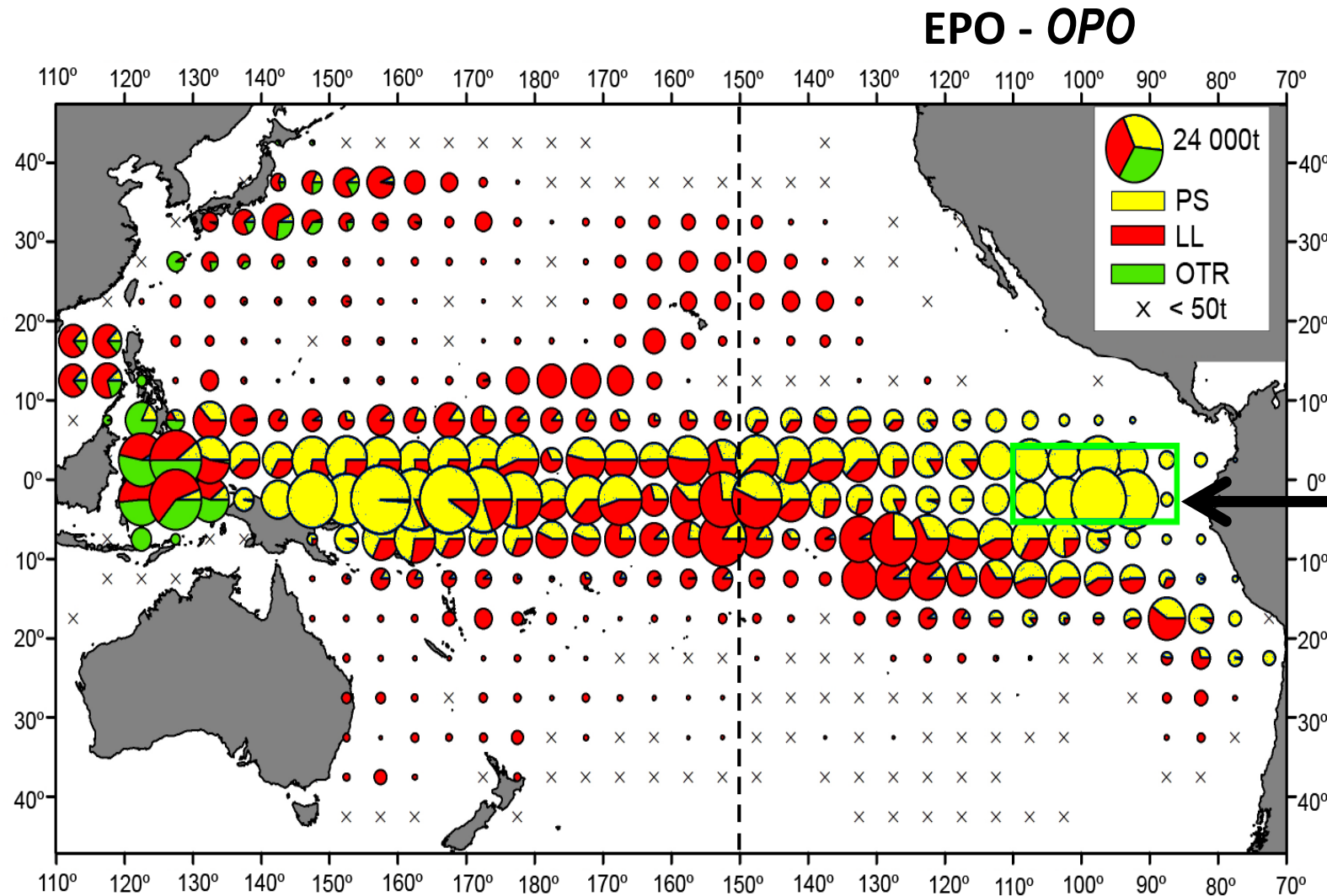
Longline CPUE main source of information



Current BET assessment

- Longline CPUE indices are the main source of information in the BET stock assessment
 - Purse seine CPUE indices are not used in the assessment
 - Size composition data is greatly down weighted (0.05 of original weight)

Spatial heterogeneity among fishery catches

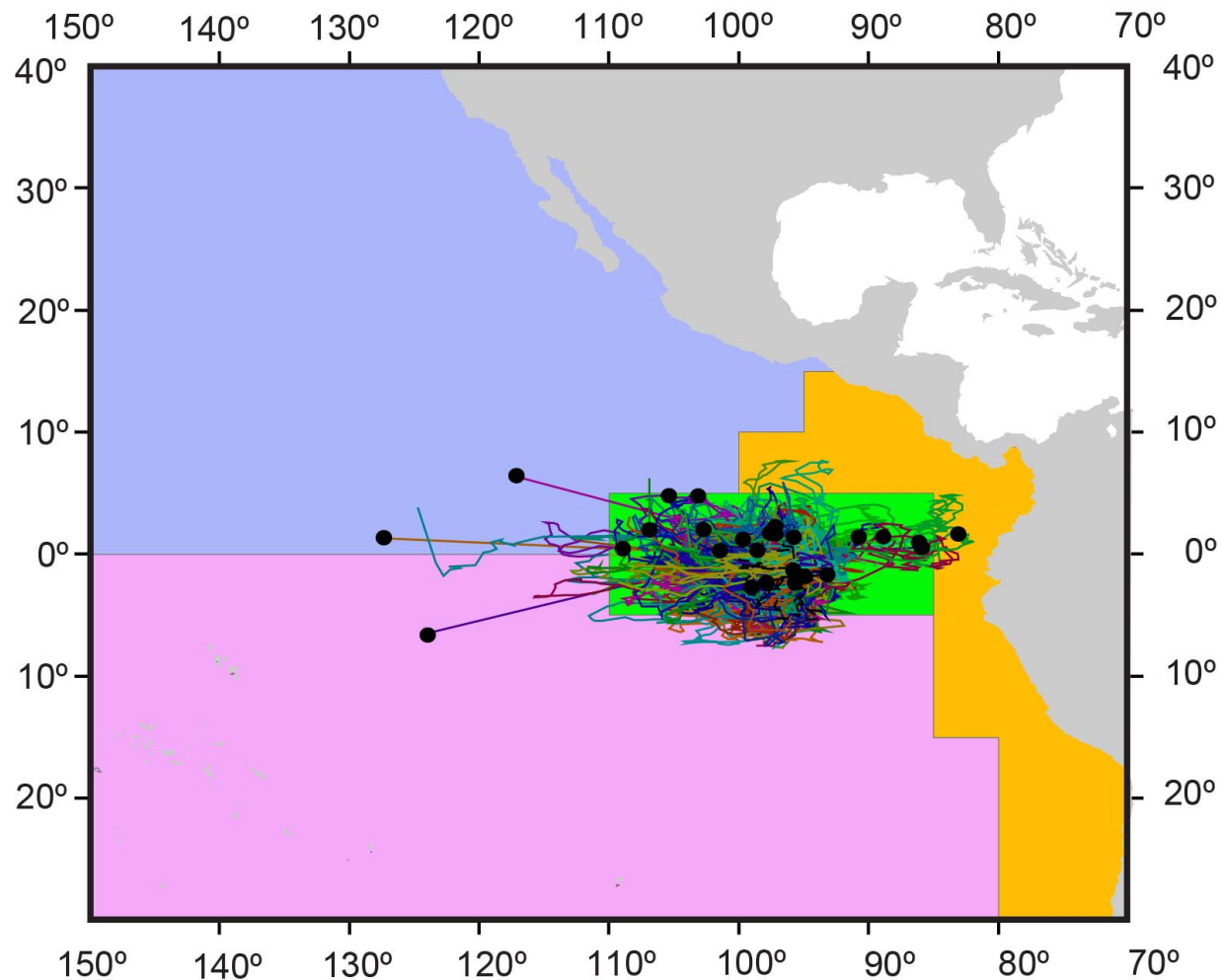


- Most of PS catches from Equatorial area
 - Between 5°N and 5°S
- Little LL catch in Equatorial area
 - Between 5°N and 5°S from 110°W to 85°W

Central Area



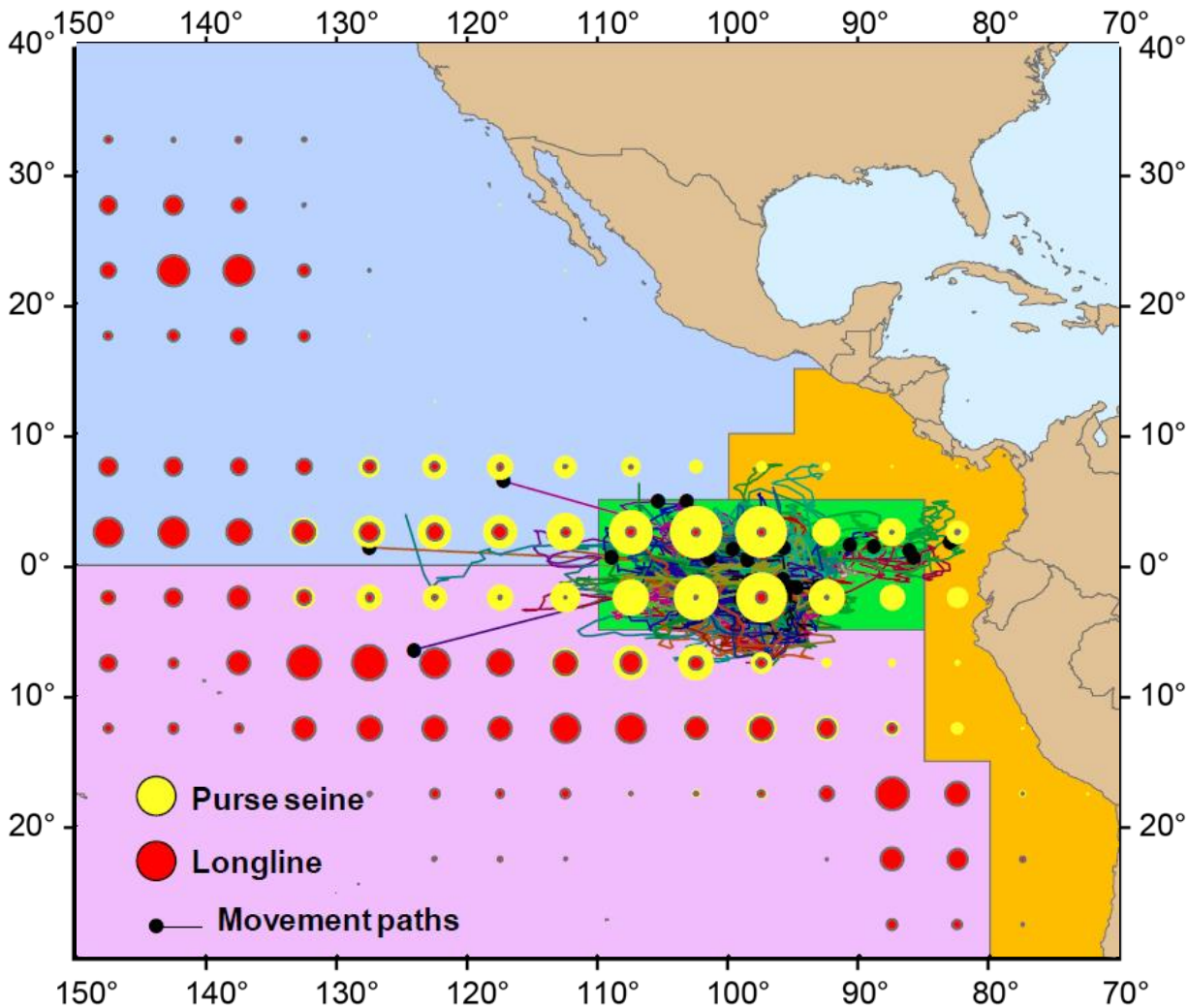
Spatial heterogeneity in BET movements



Movements of BET for >30 days, archival tagging data from 2000-2006 (Schaefer and Fuller 2009)

- Current BET assessment uses a single area, **assuming stock is randomly mixed** within the EPO, with no localized spatial dynamics
- However, tagging indicate restricted movements for some areas, **regional fidelity** in particular in the Central area
- Restricted movements in some areas, combined with spatial heterogeneity of catches, suggest that **localized depletion** of BET sub-stocks may exist in the EPO

The “spatial mismatch” hypothesis

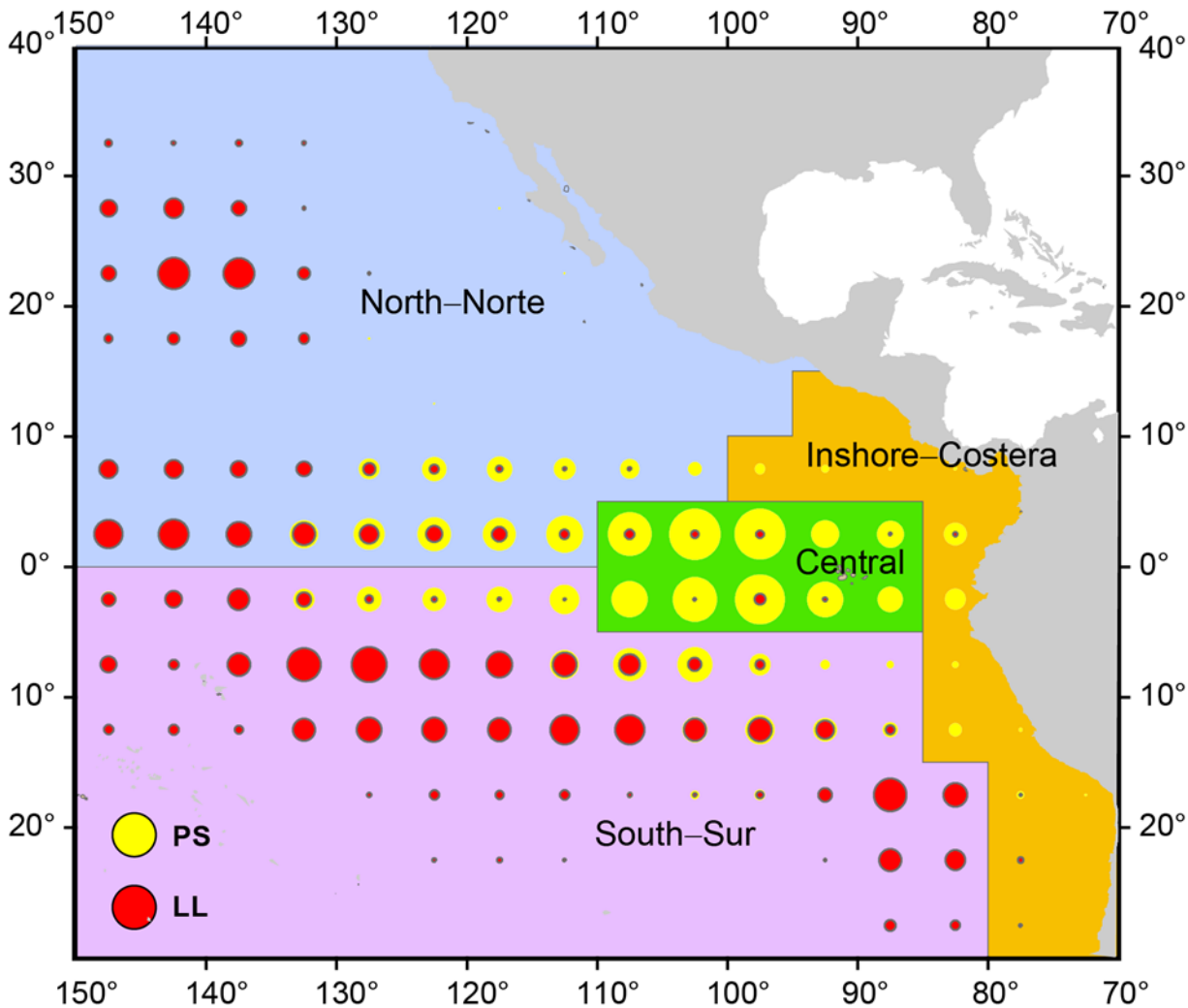


BET catch during 2000-2006 (From Aires-da-Silva and Maunder, 2010)

This hypothesis postulates that:

- The two-recruitment pattern results from **spatial misspecification in the assessment**
- The increase in purse seine-catch in the equatorial area is not reflected in a reduction in longline CPUE due to:
 - Restricted BET movements, leading to **local depletion**, and
 - The **longline CPUE corresponding to a wider, or different**, area than where the increased purse-seine catch occurred

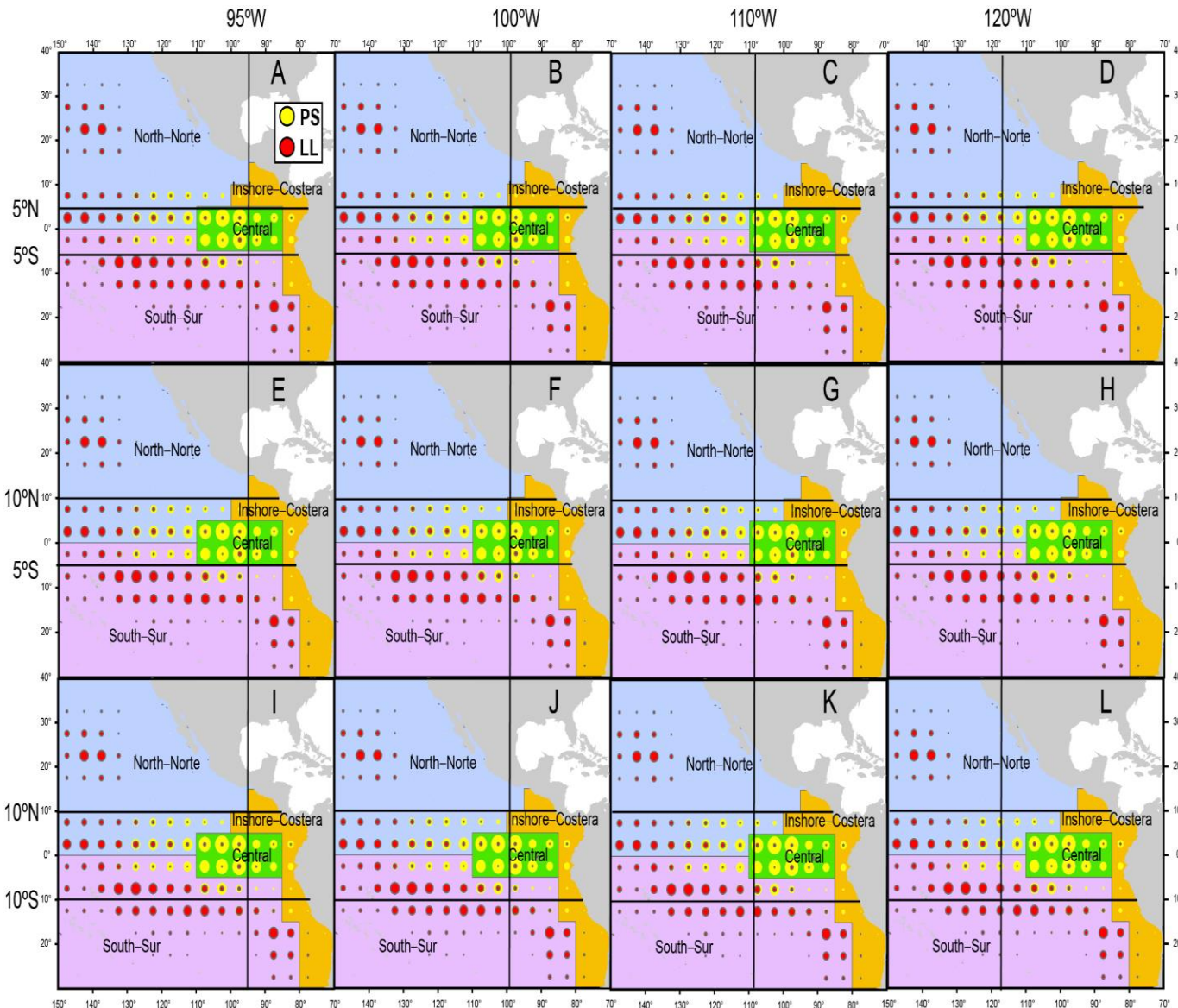
The “spatial mismatch” hypothesis



- If the spatial mismatch hypothesis is correct, a **spatially-structured BET** assessment should **correct** the two-regime recruitment pattern
- Aires-da-Silva and Maunder (2010) tested this hypothesis fitting spatially independent models for four EPO areas, resulting in **different trends and depletion levels among areas** and a partial correction of the recruitment pattern-

BET catch during 2000-2006 (From Aires-da-Silva and Maunder, 2010)

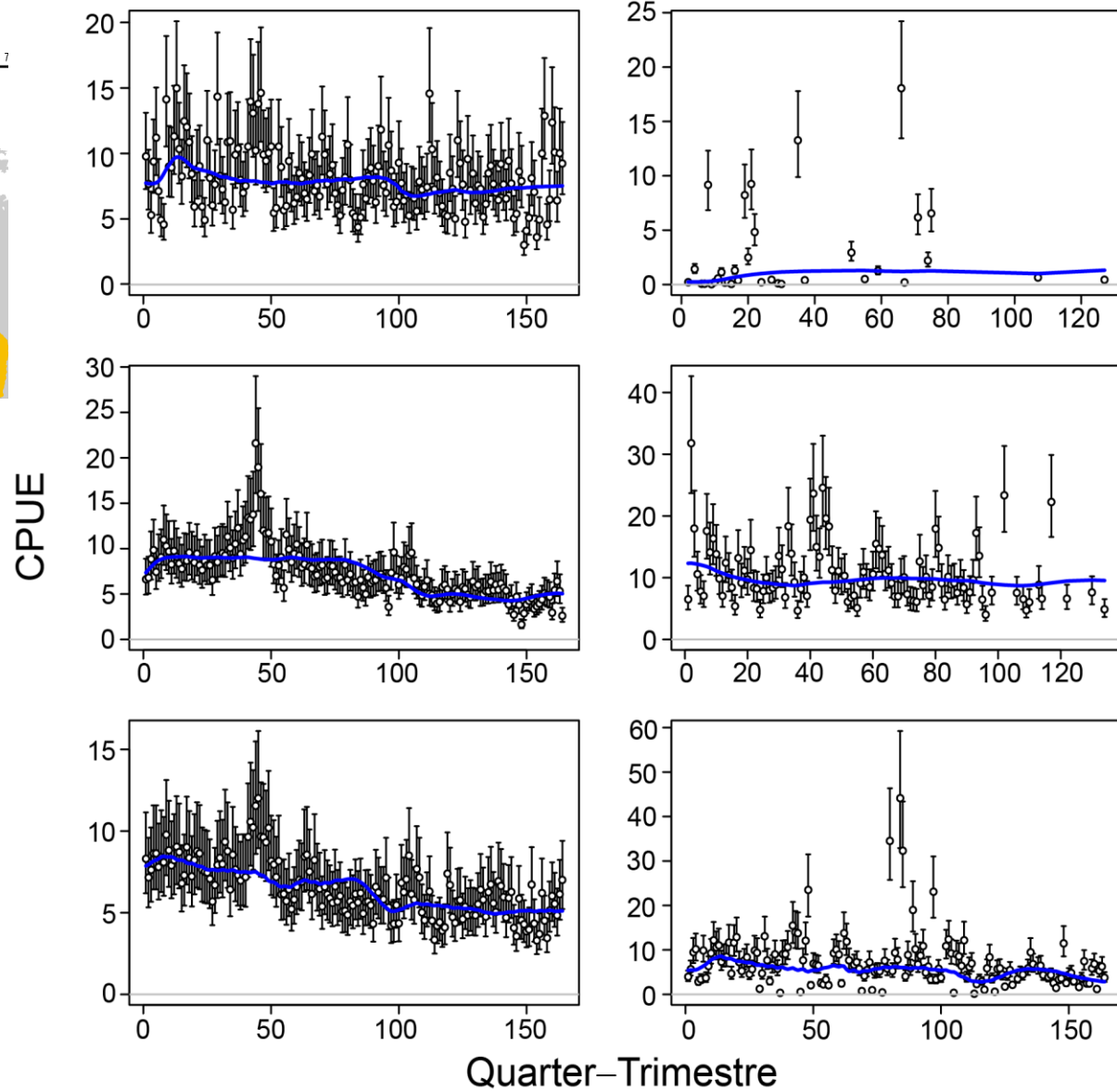
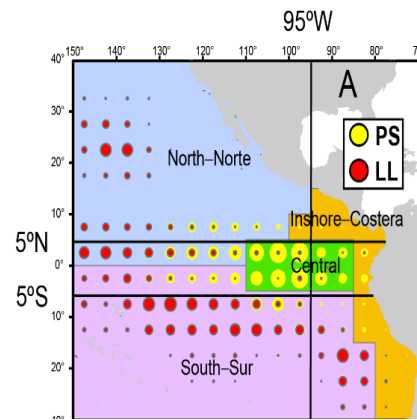
Age-structured production model (ASPM)



Evaluates consistency between catch & CPUE

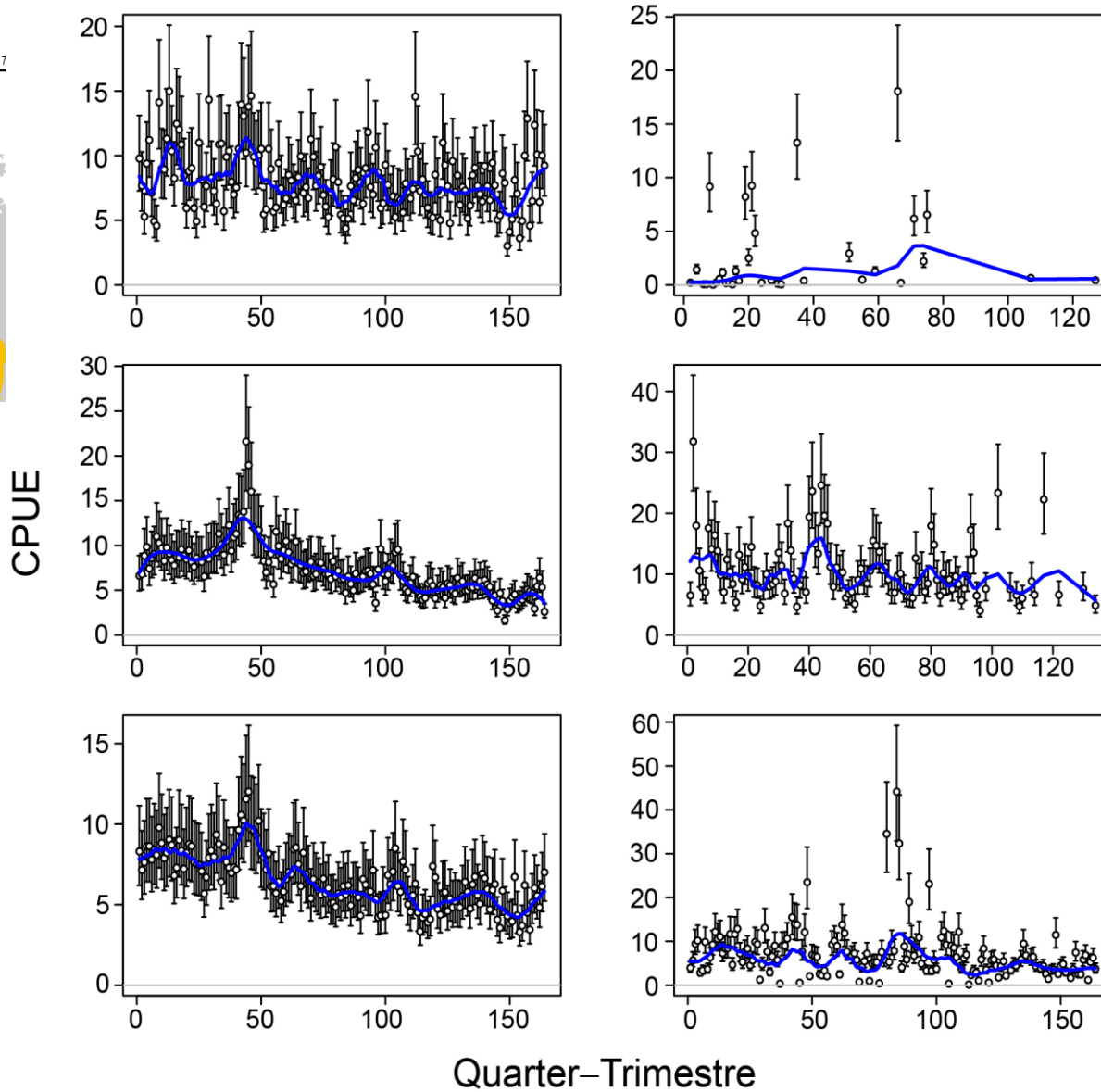
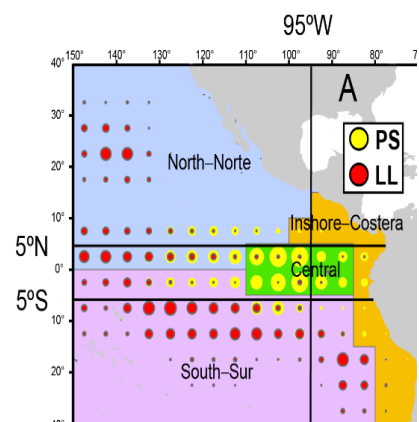
- Systematically divide the EPO into 12 grids of 6 areas each (72 total areas)
- Fit an independent ASPM to each area's total catch by fleet and LL CPUE
- Estimate quarterly biomass, fishing mortality, (with and without recruitment deviates)

Age-structured production model (ASPM)



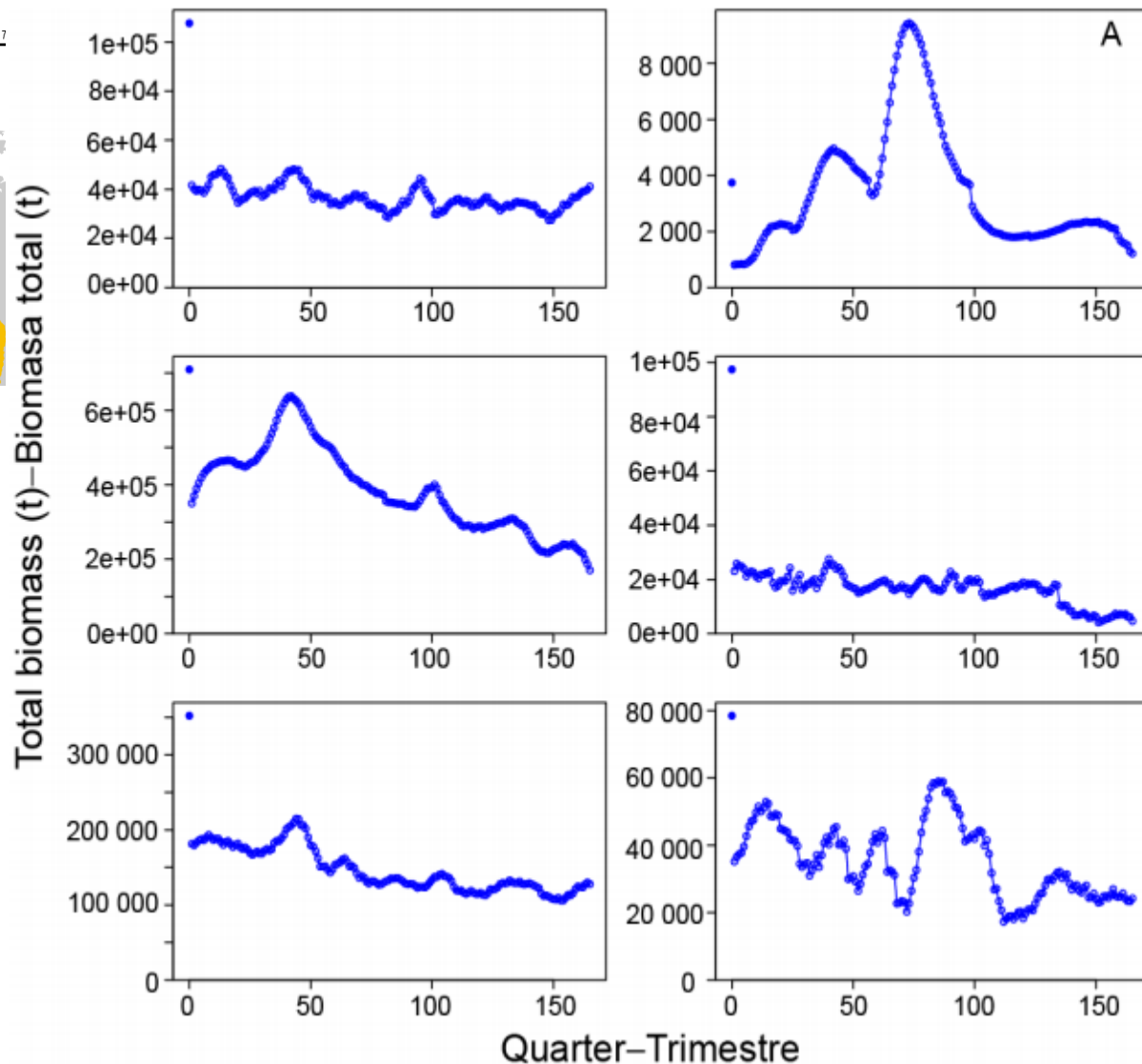
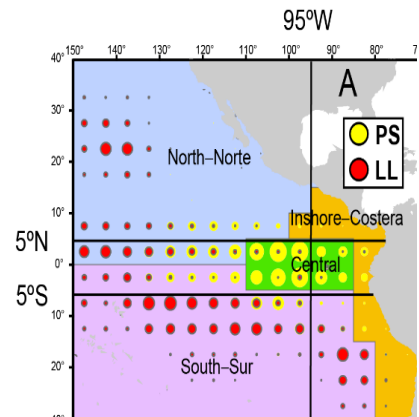
- Initial runs **without** recruitment deviates produce poor fits to the longline CPUE

Age-structured production model (ASPM)



- Runs **with** recruitment deviates produce better fits to the longline CPUE
- **Recruitment is driving abundance** more than catch is. **Problematic** when relying on the effect of catch on CPUE to inform absolute abundance

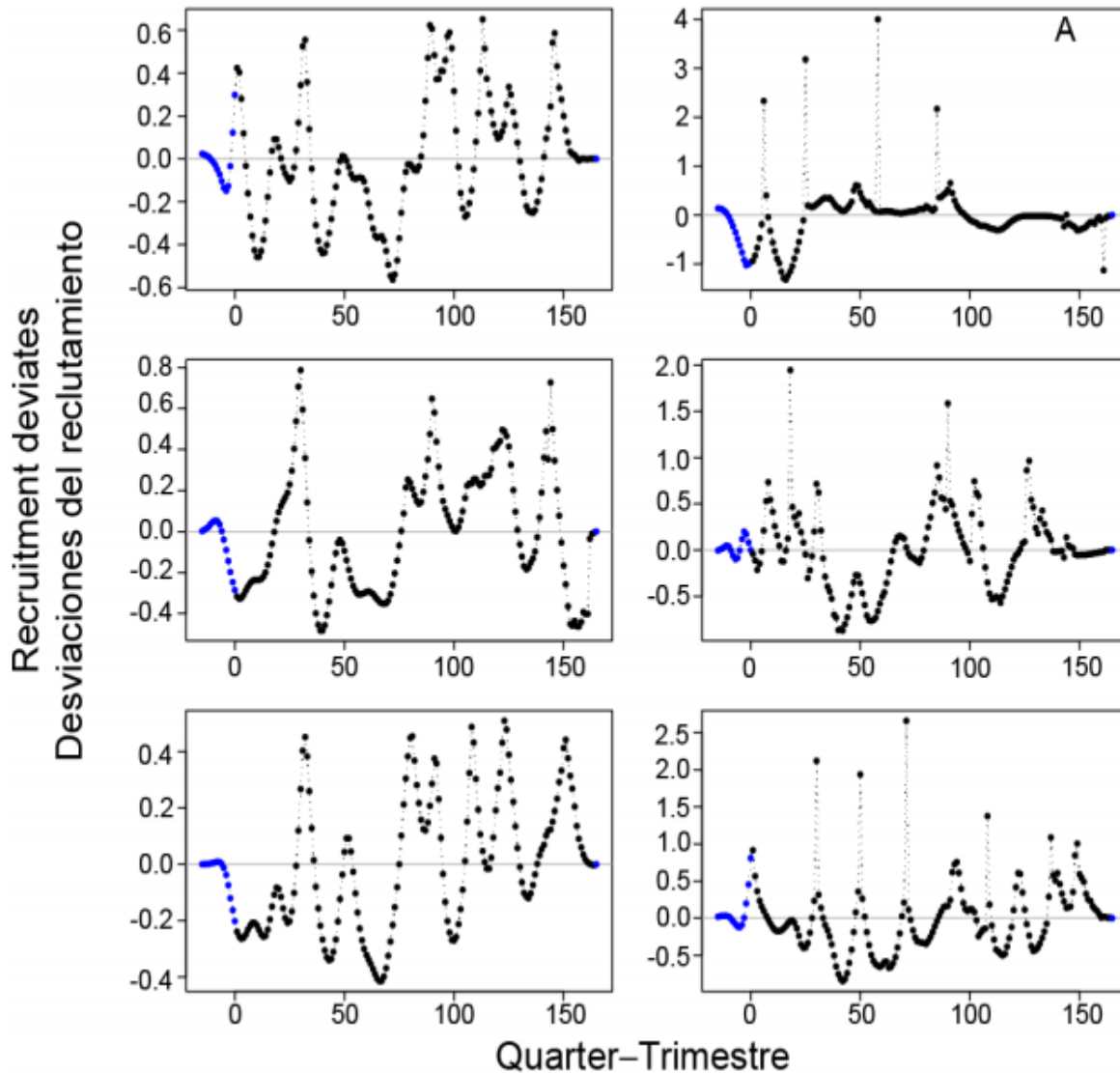
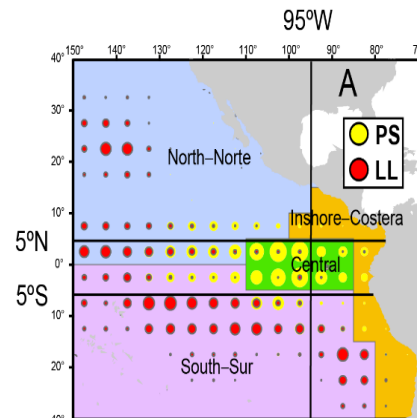
Age-structured production model (ASPM)



General ASPM results

- Largest estimated biomass **declines in Equatorial areas**
- Some area combinations have too sparse data for meaningful results
 - **Fewer areas and alternative divisions**

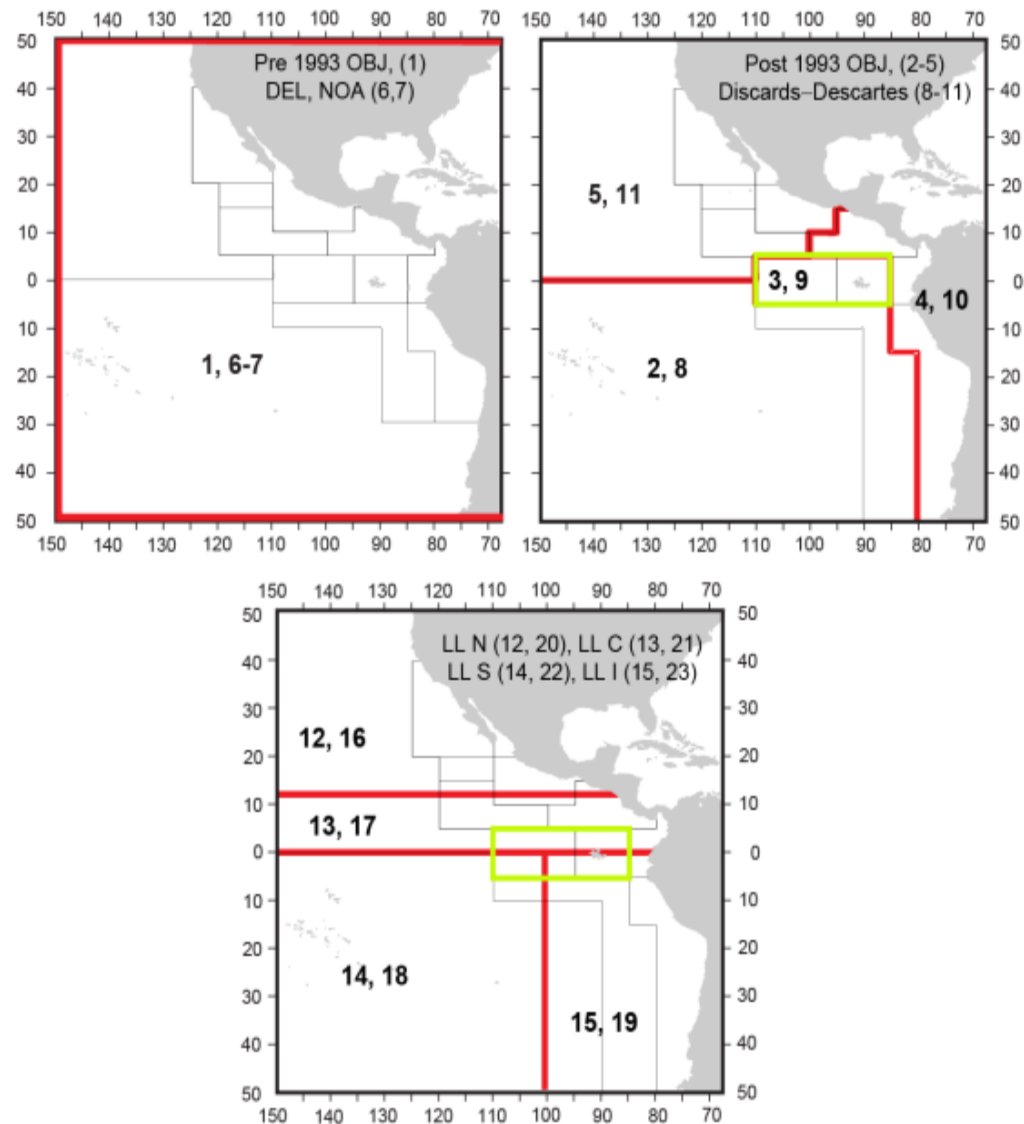
Age-structured production model (ASPM)



General ASPM results

- **Two-regime recruitment pattern estimated** in several area combinations
- Recruitment pattern is **independent of length compositions**, which are not used in the ASPM

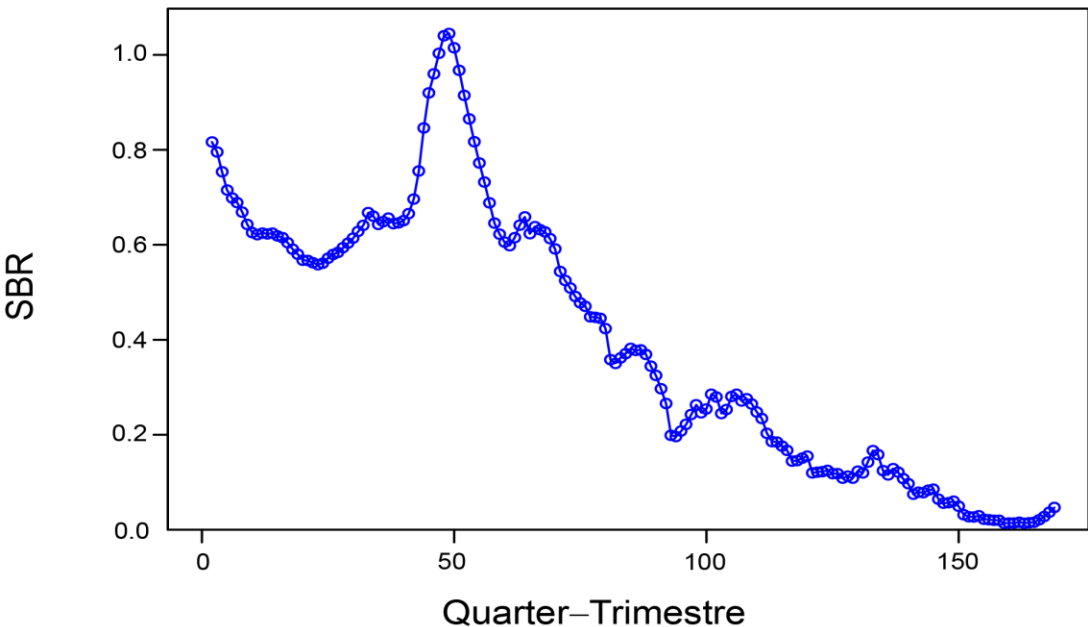
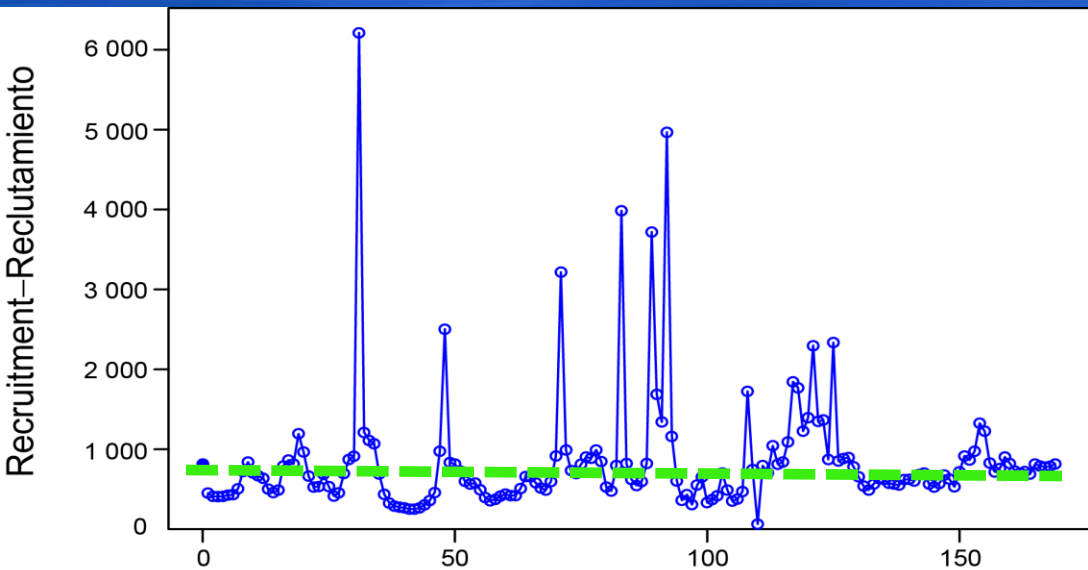
Integrated model



Similar to BET base model but restricted to the Central Area, where the increased purse-seine catch occurred

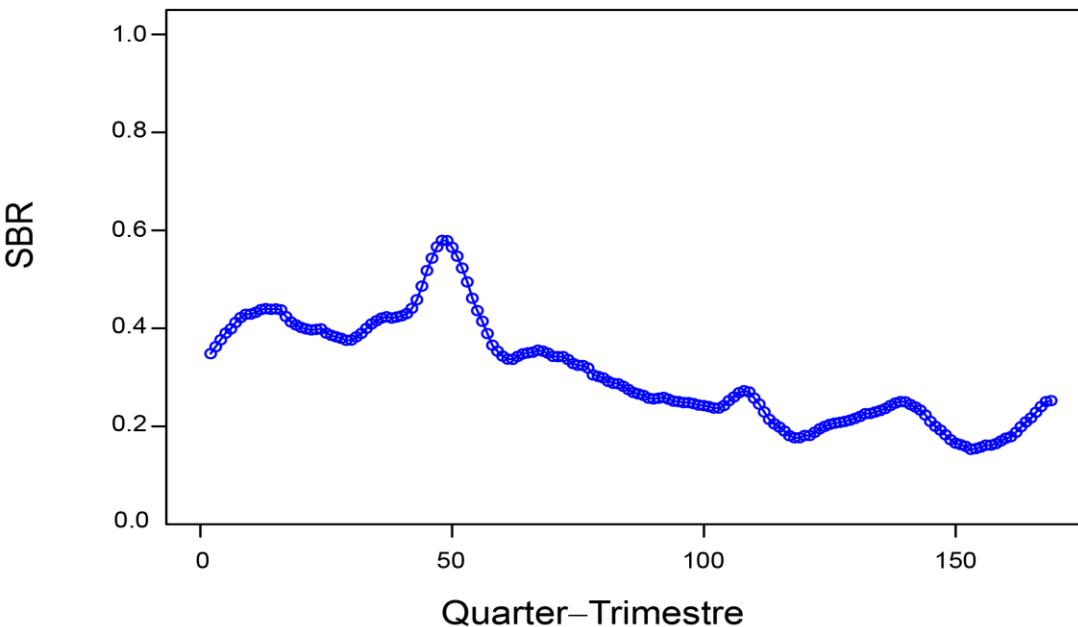
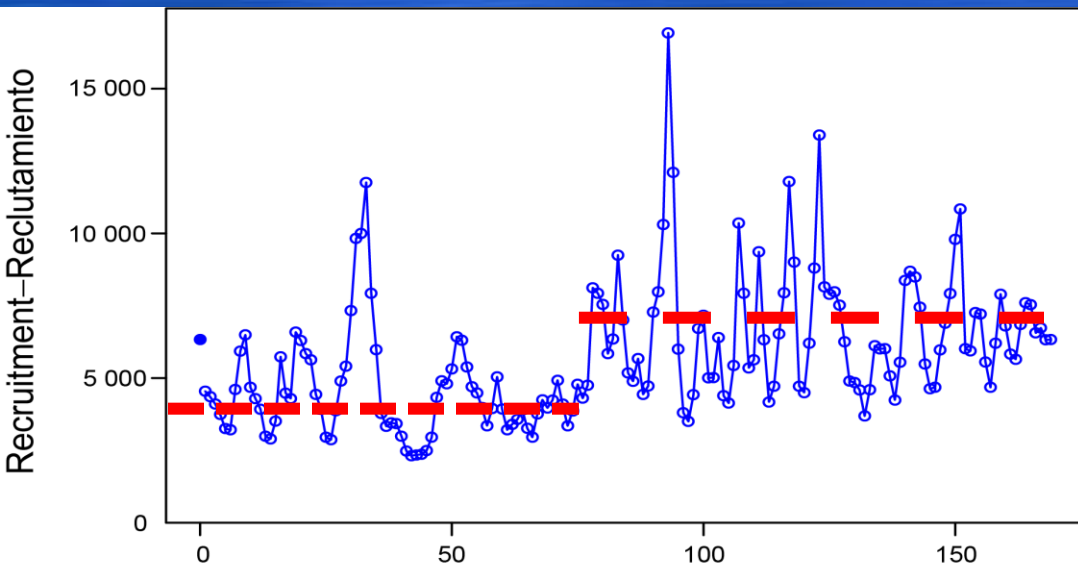
- Fisheries redefined on spatial overlap with Central area
- Only post-1993 catch and length-composition data were used, prior to 1993 there no spatial overlap with the Central area
- Three alternative weightings of the composition data: ($\lambda = 0.05$, $\lambda = 1$, and Francis (2011) iterative weighting)

Integrated model (Central area)



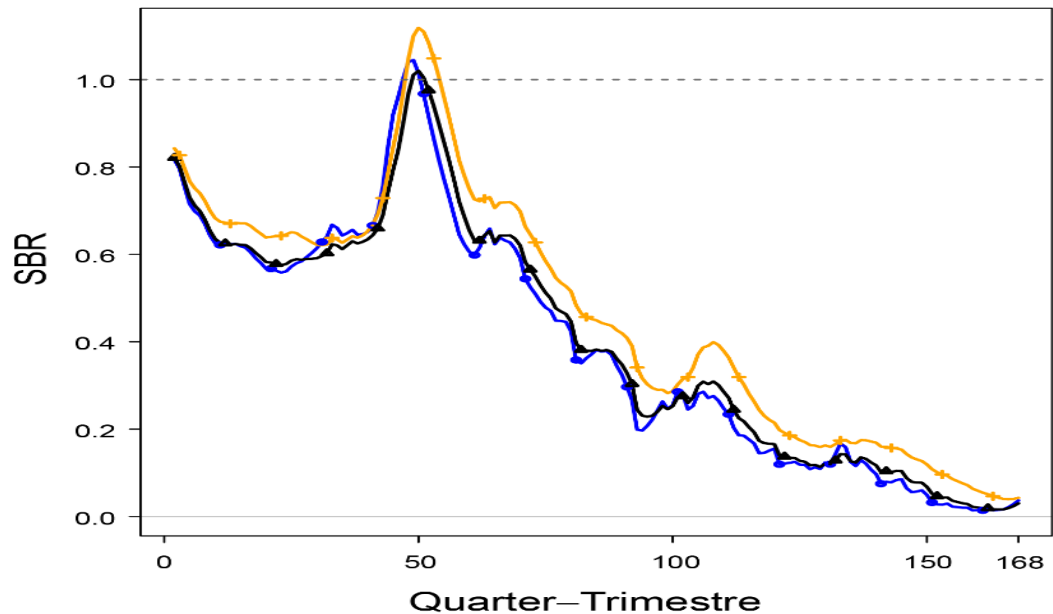
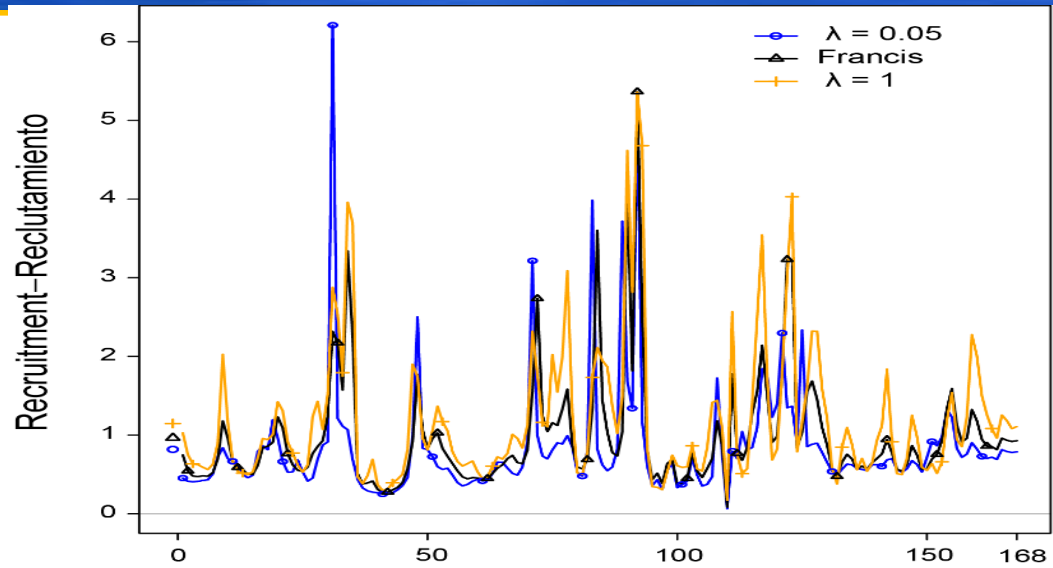
- The integrated model estimates a steeper **declining trend** in the spawning biomass ratio (SBR), and a **more depleted stock status** in the Central area than is estimated by the base case stock assessment for the whole EPO
- Recruitment estimates for the Central area **do not show the two-regime** pattern typical of previous models
- Results are consistent with those of Aires-da-Silva and Maunder (2010)

Integrated model (Base case SAC 08)



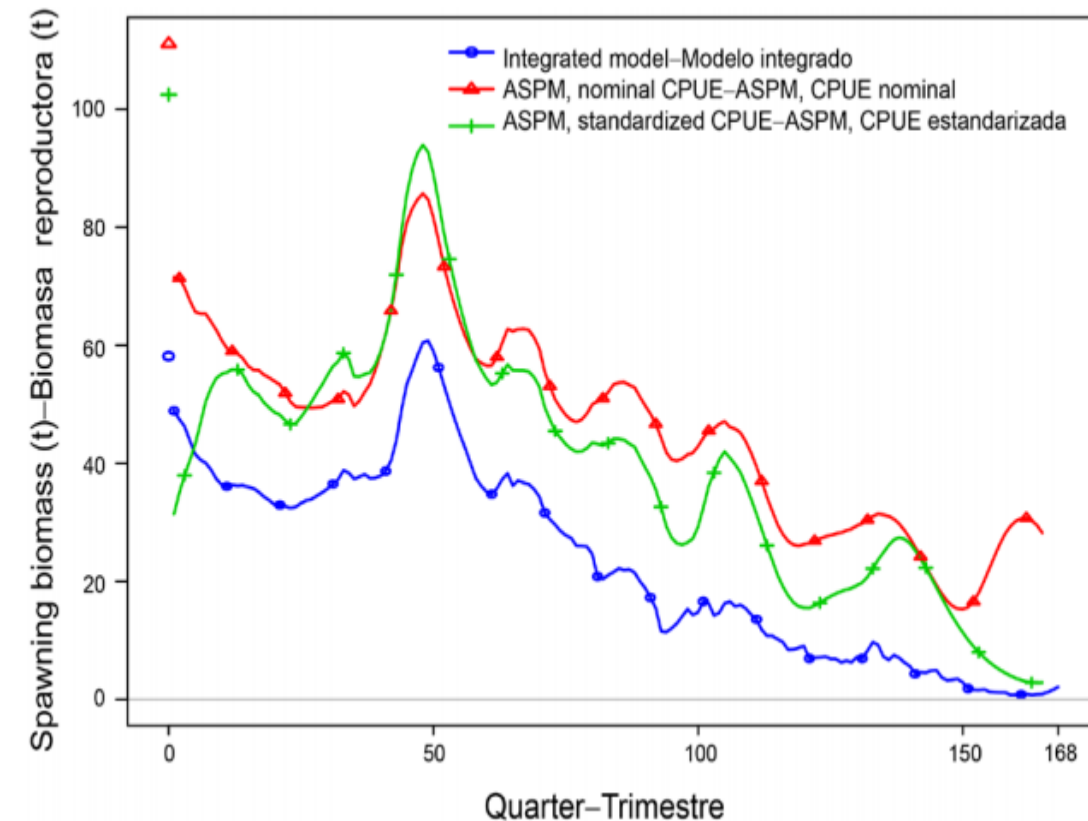
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Integrated model (Central area, data weighting)



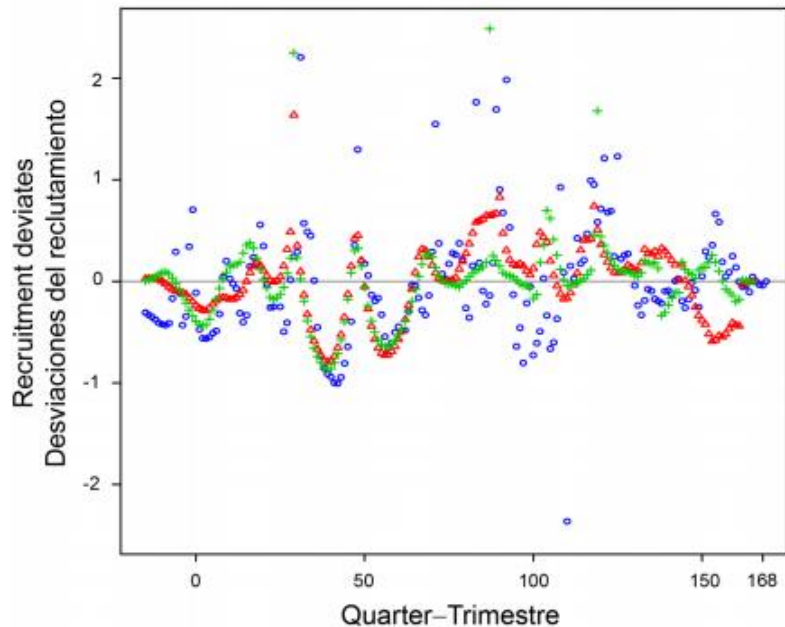
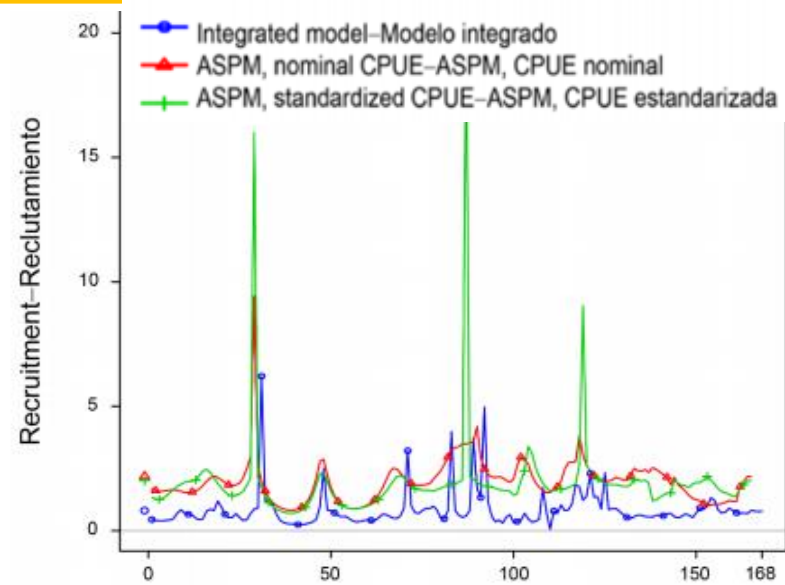
- Alternative length-composition **data-weighting does not change overall results** in the Central area model
- In contrast, length-composition data are down-weighted ($\lambda=0.05$) in the **base case assessment**. **Up-weighting ($\lambda = 1$) worsens the two-regime pattern** and leads to a more pessimistic stock status
- Francis (2011) method **suggests increasing λ for all fisheries**, to around 0.5 for purse-seine fisheries and to between 0.8 and 2.5 for longline fisheries

Comparison between Integrated model and ASPM



- Declining biomass trends are similar between the Integrated model and ASPM (both with and without standardization), **the biomass scale is lower for the Integrated model**

Comparison between Integrated model and ASPM



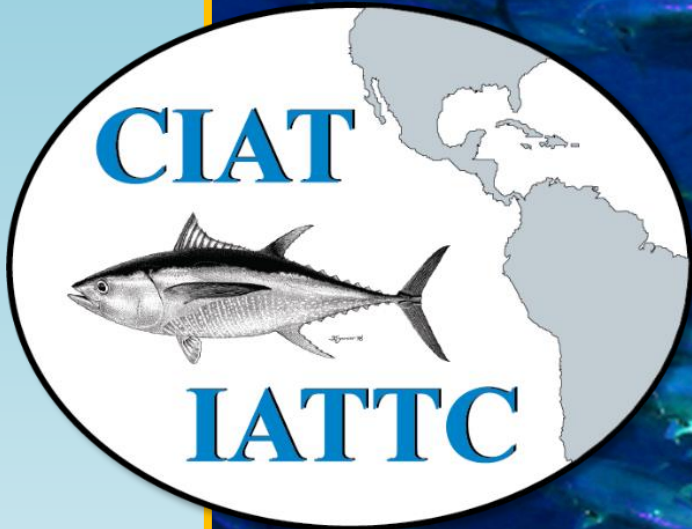
- Although the two-regime pattern is not evident in the integrated model, it is evident in the ASPM, whether standardized or nominal CPUE is used
- Using smaller areas to resolve the spatial mismatch between purse-seine catches and longline CPUE may be only partially successful unless length-composition data are included

Conclusions

- Spatially disaggregating the BET assessment removes the recruitment two-regime pattern, **consistent with the spatial mismatch hypothesis**
- The **two-regime pattern seems to be an artifact** of treating the EPO as a single homogeneous area when in fact there are **localized dynamics** of the stock and the fisheries that should be taken into account to remove model misspecification
- **Alternative spatial management measures should be evaluated for BET in the EPO**

Future Work

- **Spatial model configurations** based on:
 - Multivariate regression tree analyses on length distributions and CPUE
 - Mismatch between the spatial distribution of purse-seine and longline fisheries
 - Tagging data (both for defining areas and estimating movement rates)
- Alternative **standardization of CPUE** indices
- **Pacific-wide** assessment with SPC
- Better understanding of BET **spatial structure** and dynamics will improve not only stock **assessments**, but also operating models for **ongoing MSE** work.



Questions

