
# EVALUACION EXPLORATORIA E INDICADORES DE LA CONDICION DE LA POBLACION DE ATUN ALETA AMARILLA EN EL OPO (SAC-15-03)

# EXPLORATORY ASSESSMENT AND STOCK STATUS INDICATORS FOR YELLOWFIN TUNA IN THE EPO (SAC-15-03)

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# Outline

1. 2020 assessment
   - Major changes
   - Remaining issues
2. Research
   - Stock-structure
   - Natural mortality
   - Growth
   - Fishery definitions
3. 2024 assessment
   - Issues
   - Reference model assumptions
   - Sensitivity analyses
   - Results and stock status
4. Spatial stock status indicators
5. Workplan towards the 2025 benchmark assessment and beyond

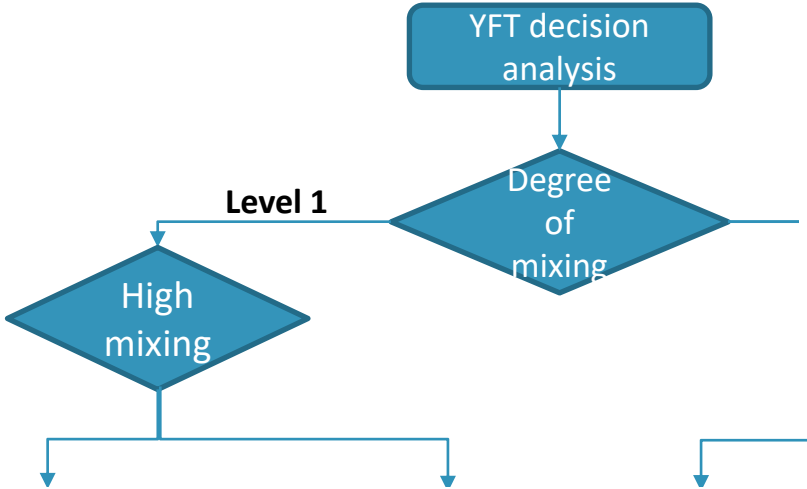
# 1. 2020 Assessment SAC-11-07

- Risk analysis framework SAC-11-Inf-J
- Major uncertainties addressed:
  - Oversensitivity to the inclusion of new data, mainly from the longline index of abundance and inconsistencies between longline and the purse-seine indices
  - Misfit to length-composition data for the fishery that with asymptotic selectivity (growth, selectivity)
  - Steepness of the stock-recruitment relationship
  - Changes in length composition in PS-DEL (around 2000, after 2010)
  - Relationship between purse-seine index and population abundance

# 1. 2020 Assessment SAC-11-07

## ssues that remained:

- Stock structure/spatial structure (explorations on how to “split” stocks inconclusive)
- Bimodal/multimodal patterns in length composition of fisheries and index
- Uncertainty in growth and natural mortality




## Pragmatic solutions adopted:

- Focus of the model on the core area of the catches (e.g. main index is purse-seine index north of 5°N)
- Model selectivities using flexible curves (splines)
- Time-blocks in selectivity

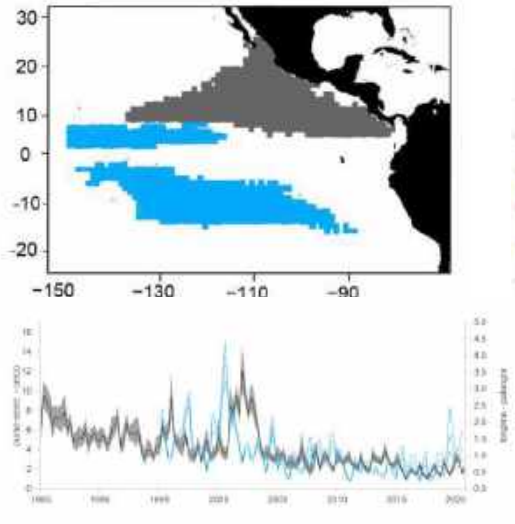
# 2. Research I: stock structure and conceptual model SAC-14-06

I.Genetic and genomic data is sparse but points towards spatial structure (NE vs SW)

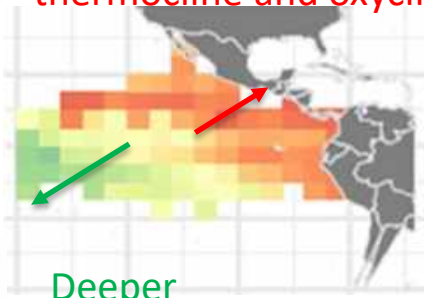
II.Archival tagging data shows limited movement

III.**PS-DEL index** and **LL index**:

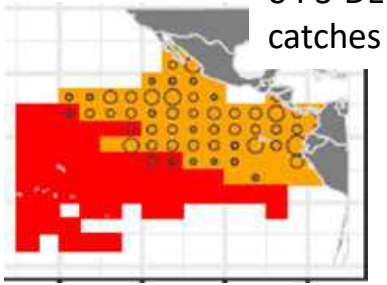
do not overlap in space and are dominated by different cohorts




IV. "Stock" structure may be related to broad oceanographic patterns, and may vary temporally



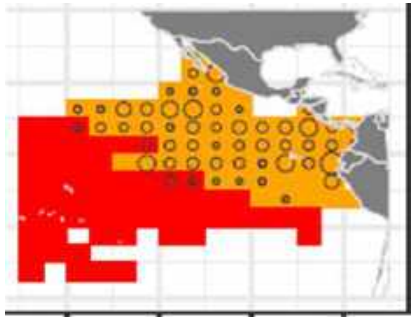

V. Stocks" may occupy irregular areas, not able to split using latitude and longitude".
PS-DEL fishery may be all one "stock"




Areas based on habitat and tree analysis of PS-OBJ length frequencies

# 2. Research I: stock structure and conceptual model

2023



- Purse-seine fishery associated with dolphins (PS-DEL) exploits one “stock”/group
- External review: Evidence suggestive rather than conclusive about stock structure

**Current understanding**

Research related to selectivity

2024

- there is spatial structure even withing PS-DEL area
- May be related to stock structure

# 2. Research II: Natural mortality

Assumed to:

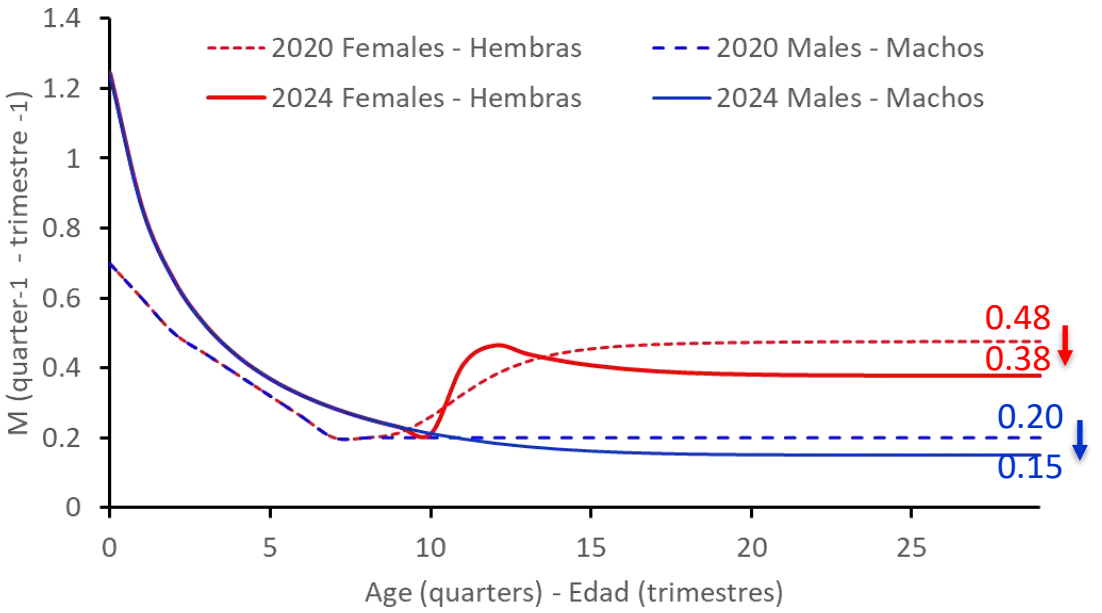
- Differs by age and sex
- Increase when females mature (changes in sex-ratio at size)

2020:

- From previous assessments
- Based on WCPO tagging data and EPO sex ratios

2024:

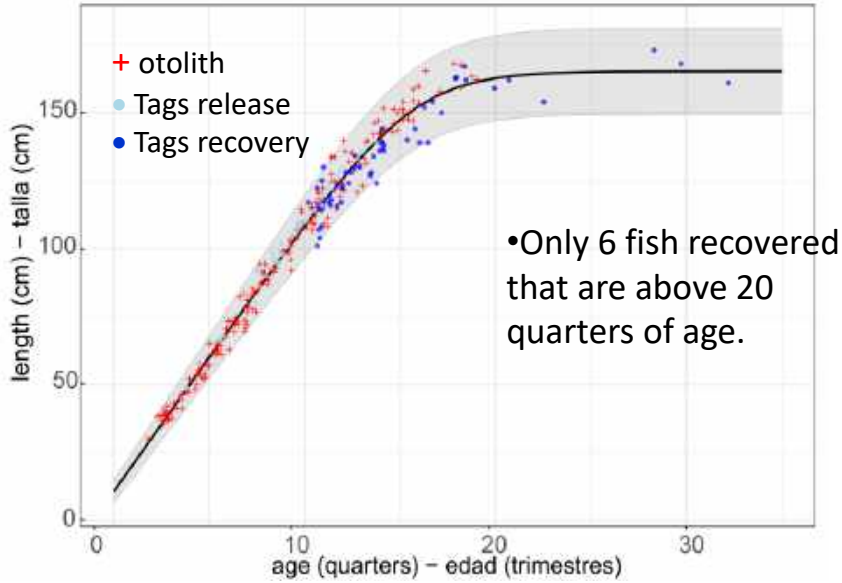
- Cohort analysis:
  - models “tagging cohorts”
  - addresses non-mixing on fishing mortalit
  - assumes no tagged fish are alive after the last recapture
- Functional form:
  - Lorenzen: M declines with length (at age)
  - Logistic offset for females
- Data:
  - **new EPO tagging** data
  - sex ratio data (combined from PS and LL fisheries)

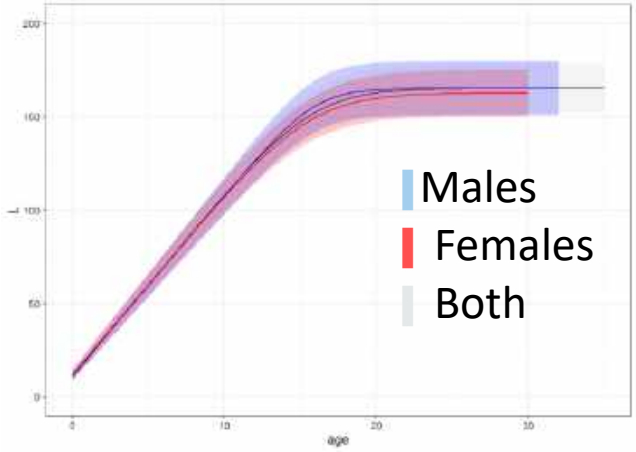


# 2. Research III: Growth

- Substantial influence on estimates of absolute abundance when fitting to length composition data
- Growth cessation model (sexed combined) fit to:
  - otolith daily increment data (reliable up to 4 years of age)
  - **IATTC tag-recapture** data (few recaptured at large size)

Sex specific growth was also investigated.



# 2. Research III: Growth

Similarities with:

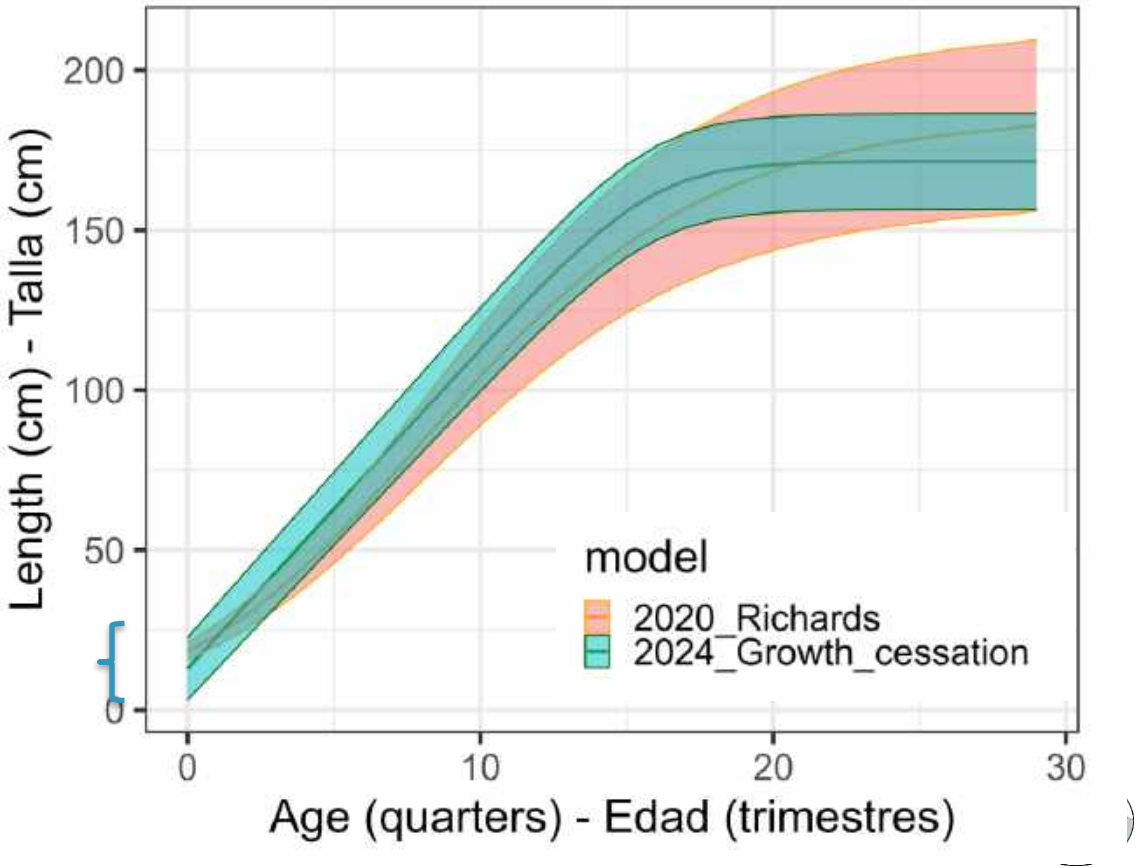
- linear growth for younger ages

Difference with 2020 fixed growth assumptions:

- New model (growth cessation vs Richards)
- Smaller Linf (171.4 vs 182.8)
- Smaller variability

Application in 2024 assessment models:

- All parameters fixed at new values
- Except **variability: SD(L_age_0) estimated**

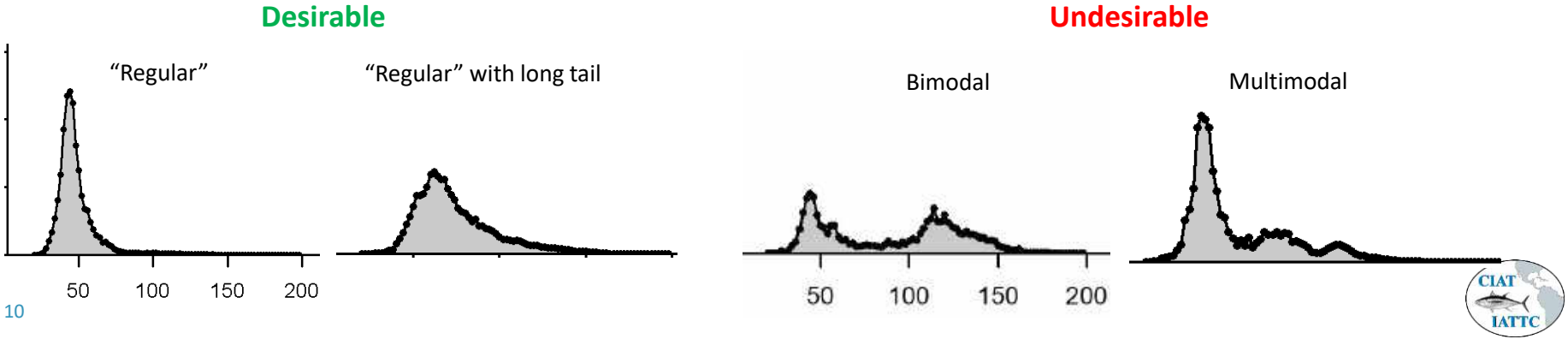


# 2. Research IV: Selectivity

## Philosophy

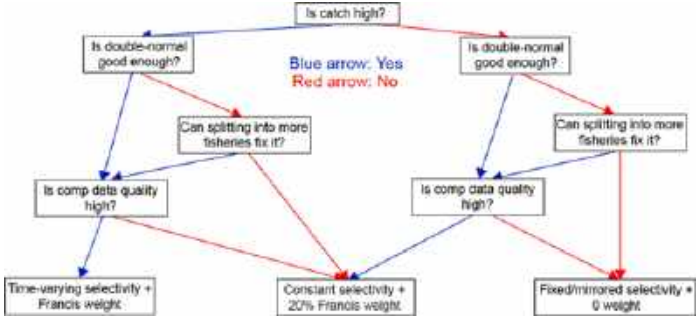
- Index of abundance should provide the main source of information on abundance
- Fisheries should be modelled to remove the catch at the right age and provide limited information on abundance
- Fisheries should exhibit “regular” length composition distributions

Example of fisheries length composition distributions



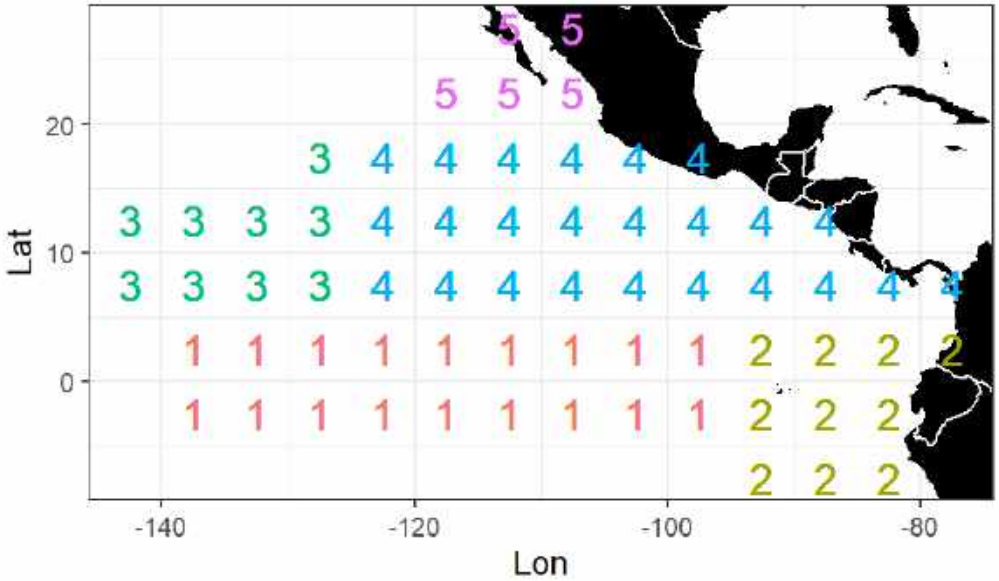
# 2. Research IV: Selectivity

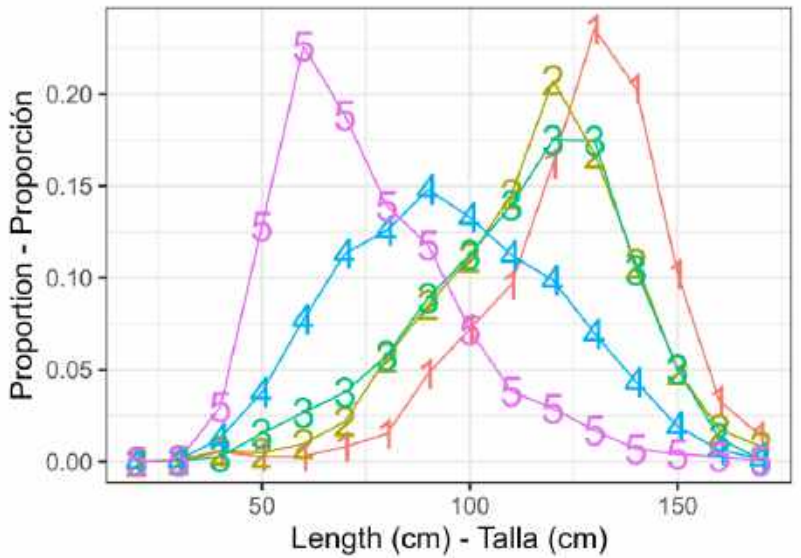
- Previous assessment used splines to represent irregular selectivity
- Framework
  - Fishery definitions: use regression tree analysis on length composition data to find areas and/or seasons where the length compositions are similar.
  - If not regular either
    - More work is needed to define the fisheries, or
    - Composition data are 1) down weighed or 2) eliminated and the selectivity fixed appropriately



# 2. Research IV: Selectivity

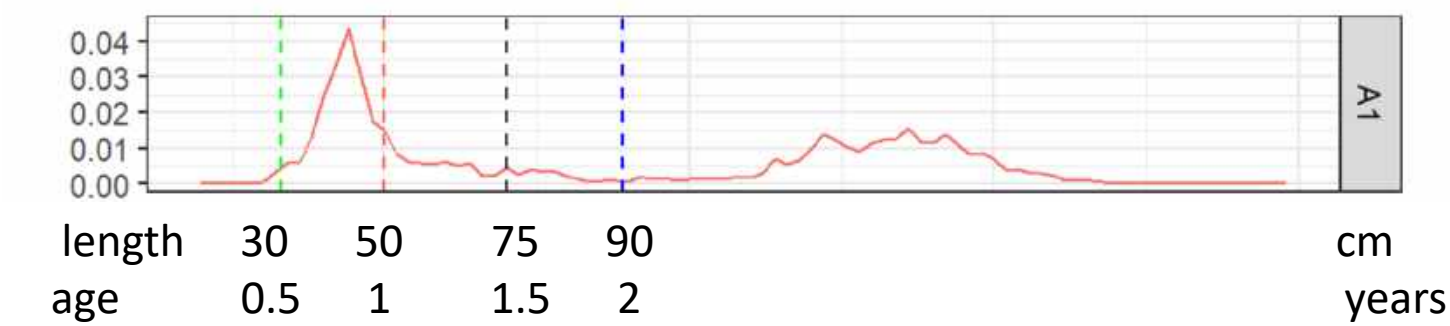
- DEL fisheries example



# 2. Research IV: Selectivity

- NOA fisheries example
- Bimodal pattern persist even after spatial splits
- Reason: length compositions are set specific
- Solution: split the fishery at size 90 cm (about 2 years –old)



# 3. 2024 assessment SAC-15-03

# 3. 2024 assessment: similarities to 2020

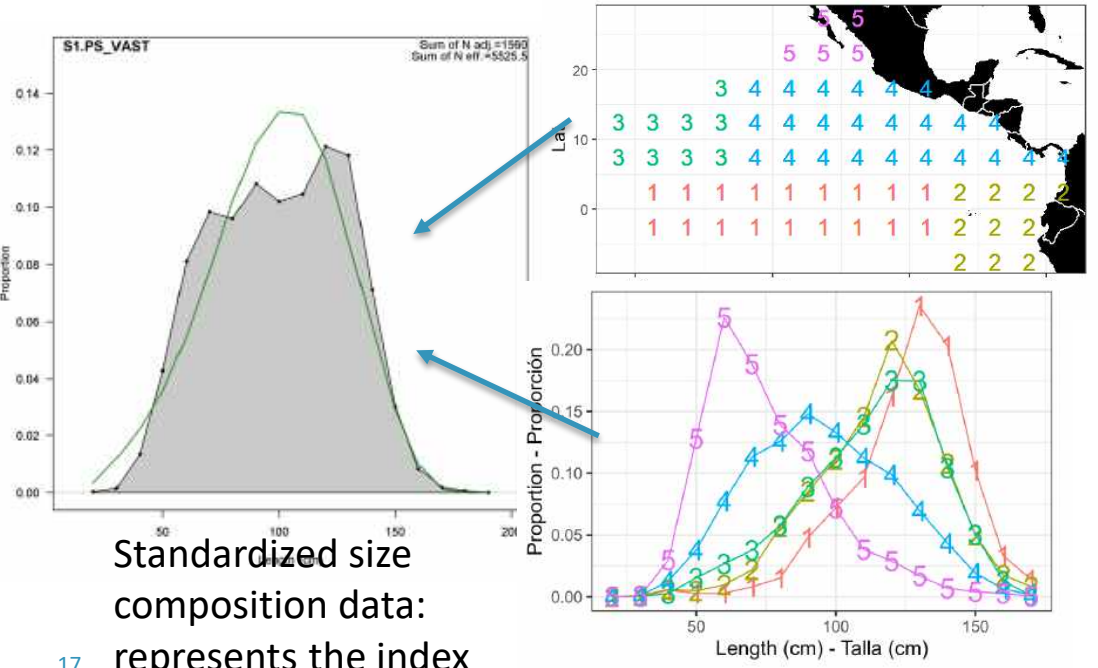
- Integrated age-structure length-based population dynamic model
- Implement in Stock Synthesis
- “Areas-as-fleets” approach
- Focus on fitting data from area with core of the catches
- Two sexes, natural mortality is sex-specific
- Start year: 1984 – when the index of abundance starts
- Time step: quarter (four recruitments per year)
- Initial conditions:
    - Starts from fished condition (estimates one Finit),
    - Age-structure is flexible ( estimates 12 init rec devs),
    - Rinit= R0+dev, where R0 and dev are estimated

# 3. 2024 assessment: differences to 2020

- Spatial structure:
  - Core area definition is more restrictive (differences in length composition)
  - Models for core area only
- Biological assumption:
  - New growth
  - New natural mortality
- Selectivities:
  - Double normal
  - Fixed, except for core PS-DEL and index

# 3. 2024 stock assessment issues: stock-structure

- DEL fishery spatio-temporal index of the whole EPO
- Assessment can't fit standardized size composition data

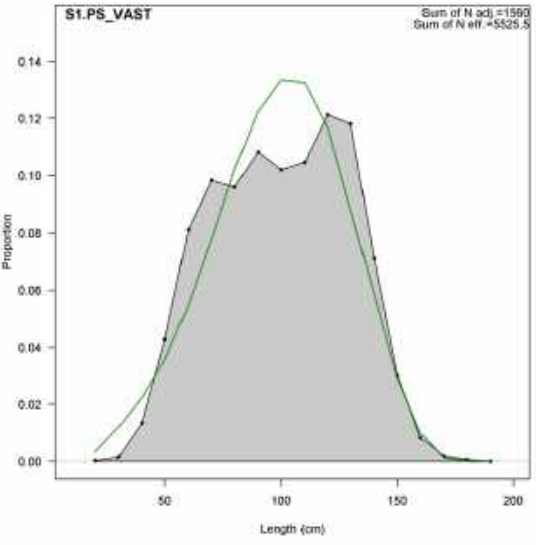


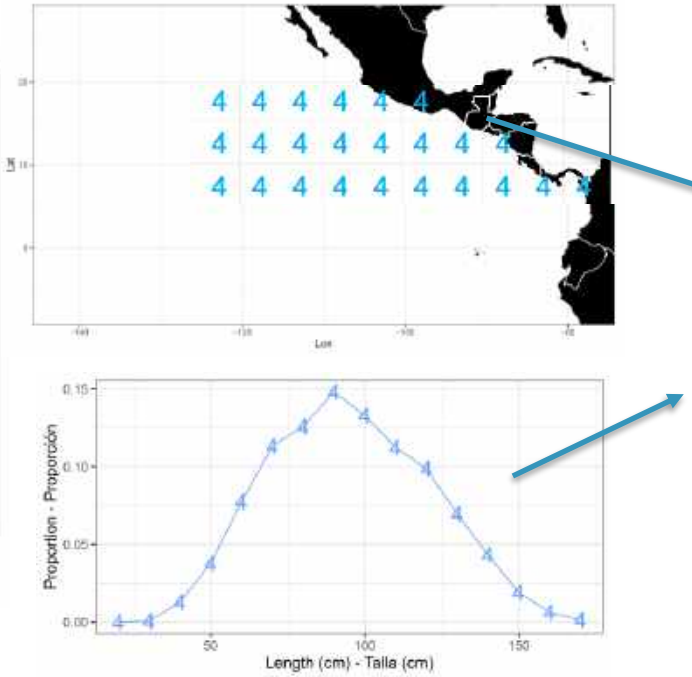

Standardized size composition data: represents the index

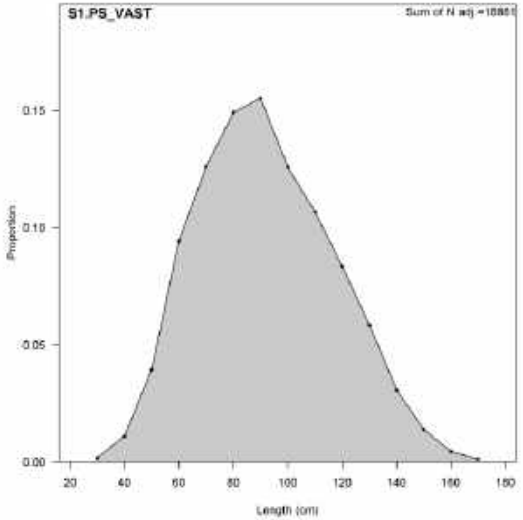
Spatial differences in length composition, even with standardization

# 3. 2024 stock assessment issues: stock-structure

- Possible local depletion
- Model core DEL area: composition data improved

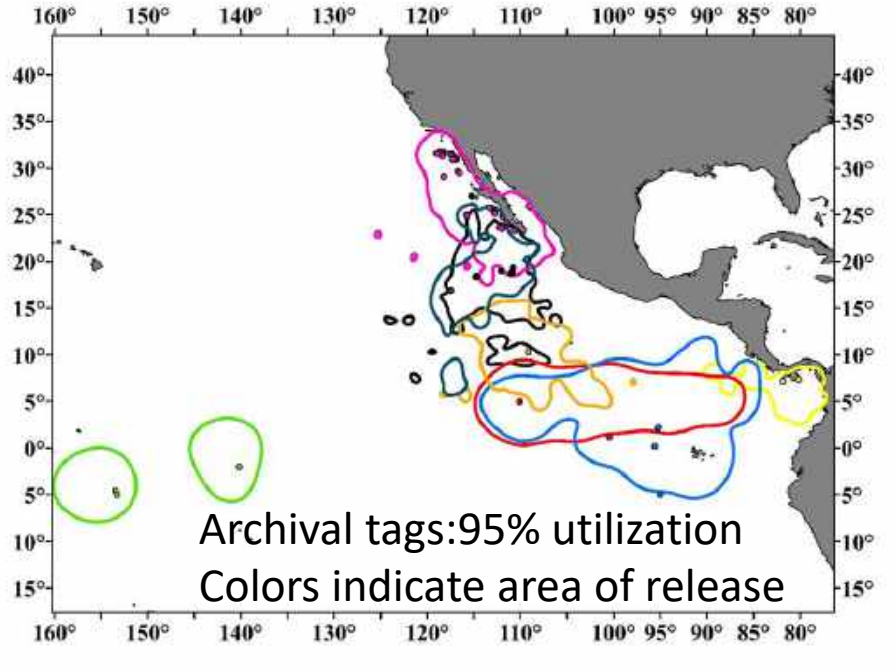


# 3. 2024 stock assessment issues: stock-structure

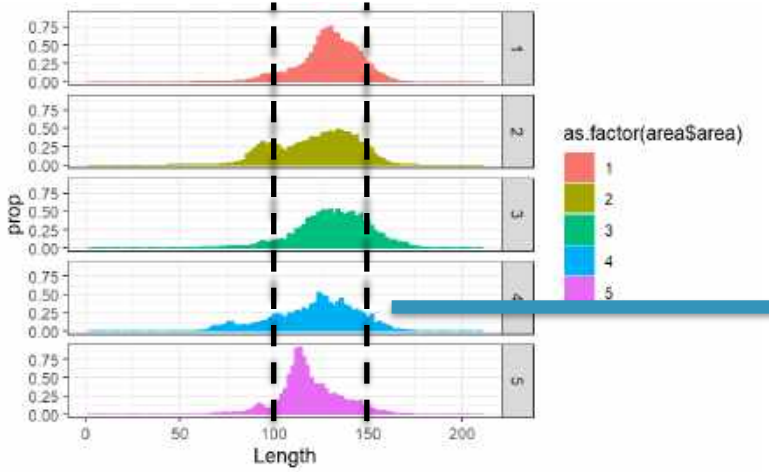
- Tagging data suggests limited movement
- Possible isolation by distance, stock-structure, and local depletion



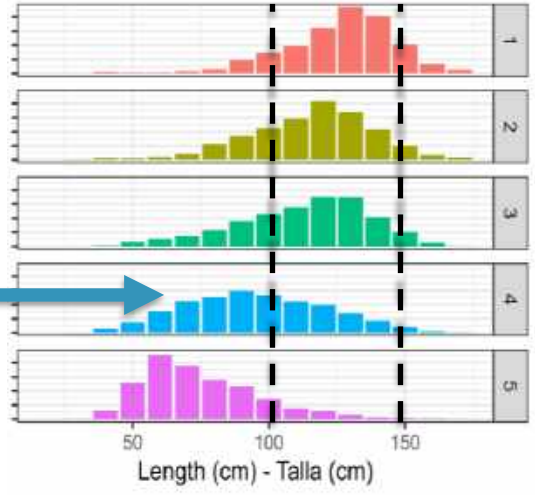
# 3. 2024 stock assessment issues: stock-structure

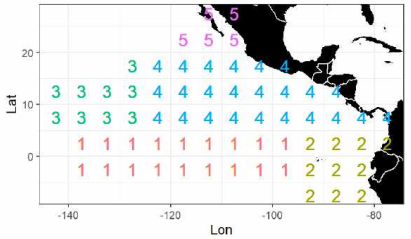
- Current and historic Japanese data compared to current DEL length composition data indicate persistent pattern over time and potential local depletion

Longline fleet size data (JPN)
1960 and 1970



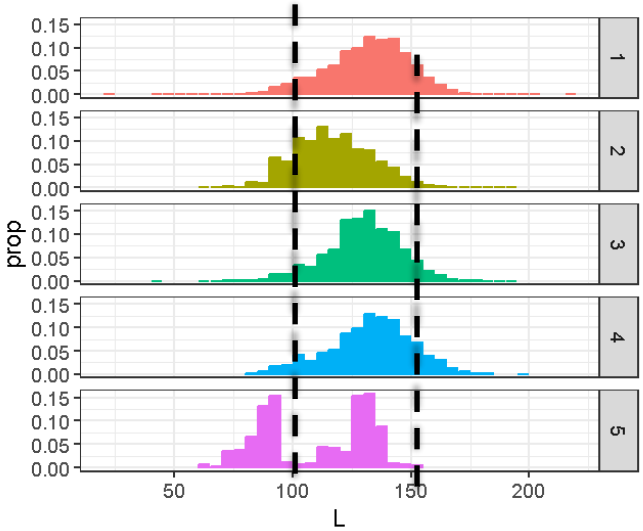

Current dolphin associated PS

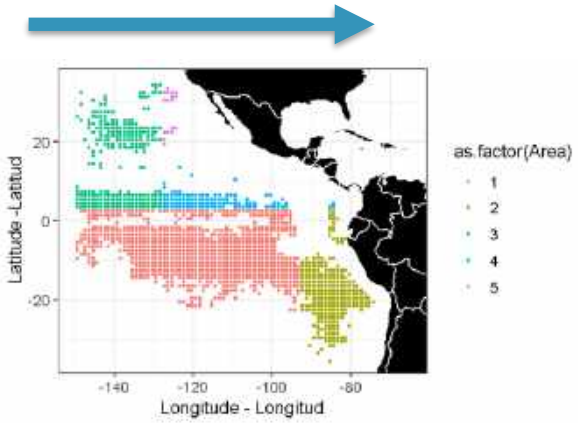


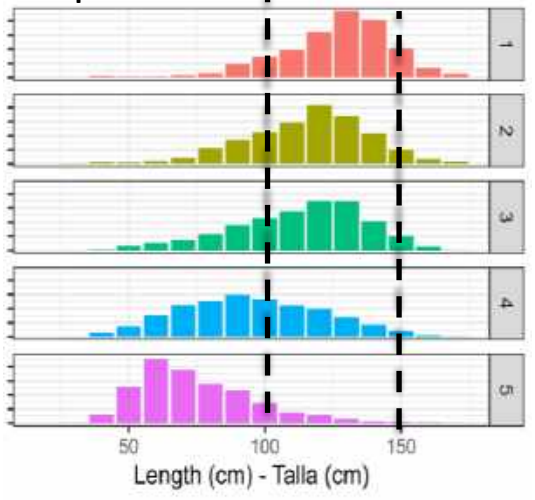
# 3. 2024 stock assessment issues: stock-structure

- Current and historic Japanese data compared to current DEL length composition data




Dolphin associated PS

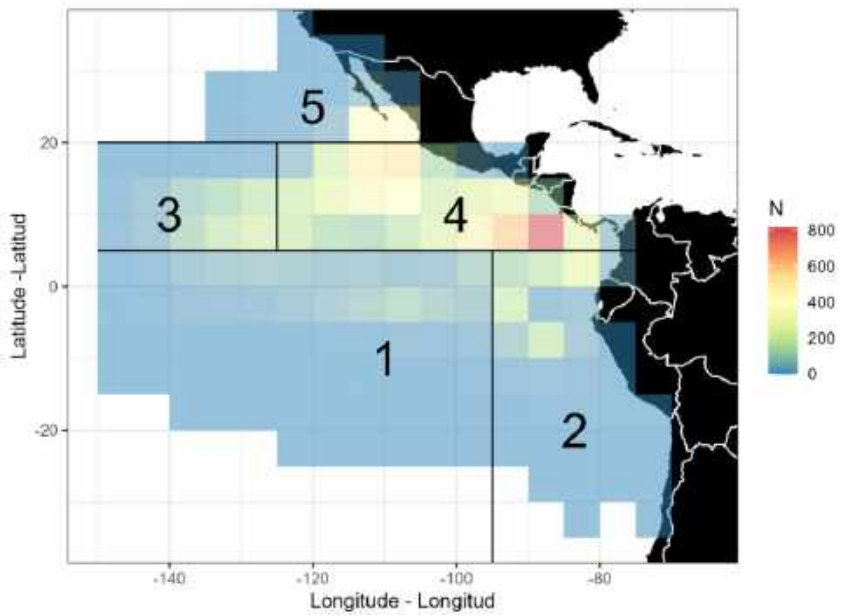



JPN data
1990- 2010

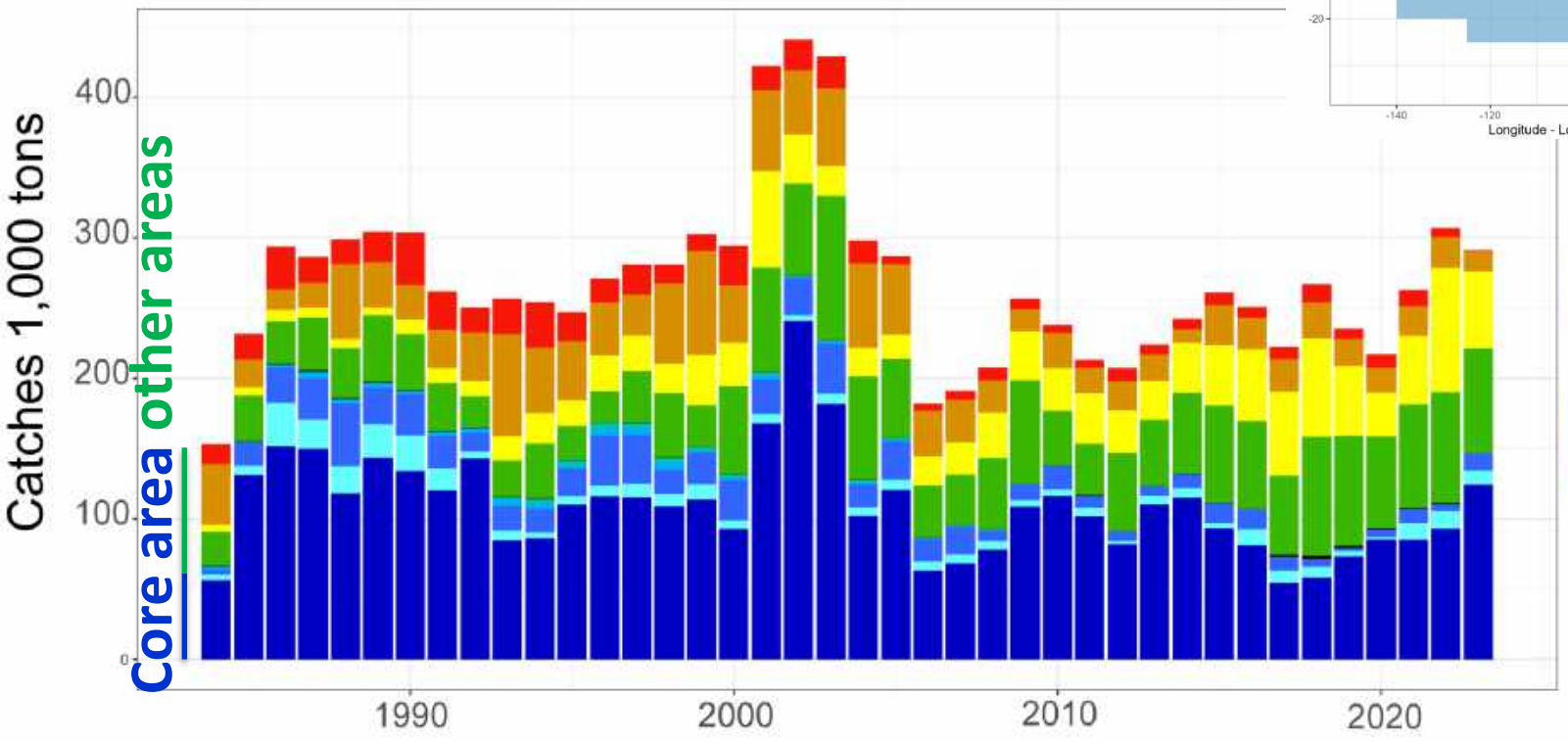
2000-2023

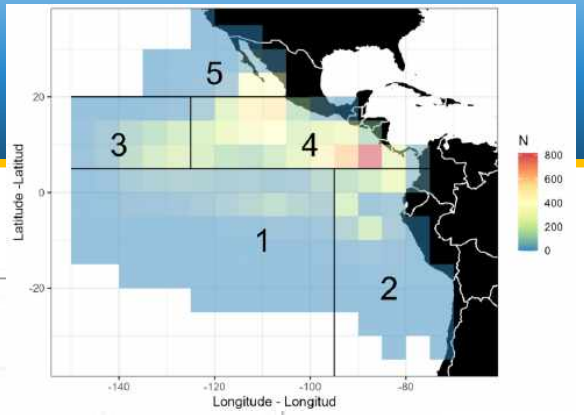
# 3. 2024 stock assessment: Reference model assumptions

- Model only the area (4) of the core DEL fishery
- Only fit to
  - DEL index and composition data
  - DEL fishery composition data
- Other selectivities fixed
  - OBJ and NOA have highly variable composition data



# 3. 2024 stock assessment: catches



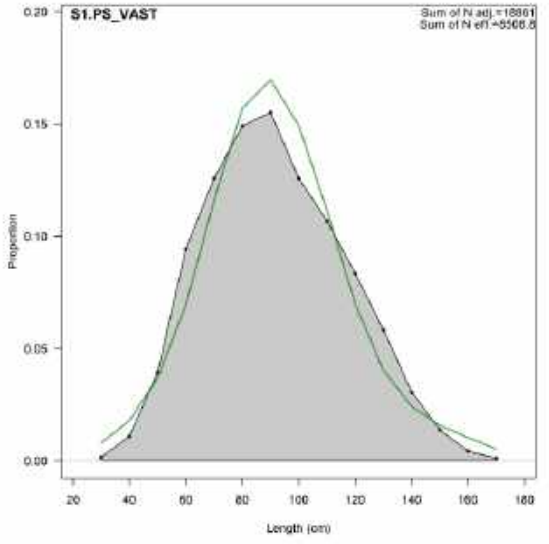
# 3. 2024 stock assessment: Sensitivity analyses

- Use the whole EPO catch, don't fit to composition data
- Don't see fish at asymptotic length (171.46 cm)
  - Estimate the asymptotic length
  - Use dome-shape selectivity
- Steepness h = 0.8

| Model | Catch | Index and DEL fishery selectivity | Asymptotic length | Steepness (h) |
|---|---|---|---|---|
| Core_Asymp | Core | Asymptotic | Fixed | 1.0 |
| Core_Asymp h 0.8 | Core | Asymptotic | Fixed | 0.8 |
| Core_Asymp_Linf | Core | Asymptotic | Estimated | 1.0 |
| Core_Dome | Core | Dome | Fixed | 1.0 |
| EPO_Asymp | EPO | Asymptotic | Fixed | 1.0 |
| EPO_Asymp_Linf | EPO | Asymptotic | Estimated | 1.0 |
| EPO_Dome | EPO | Dome | Fixed | 1.0 |

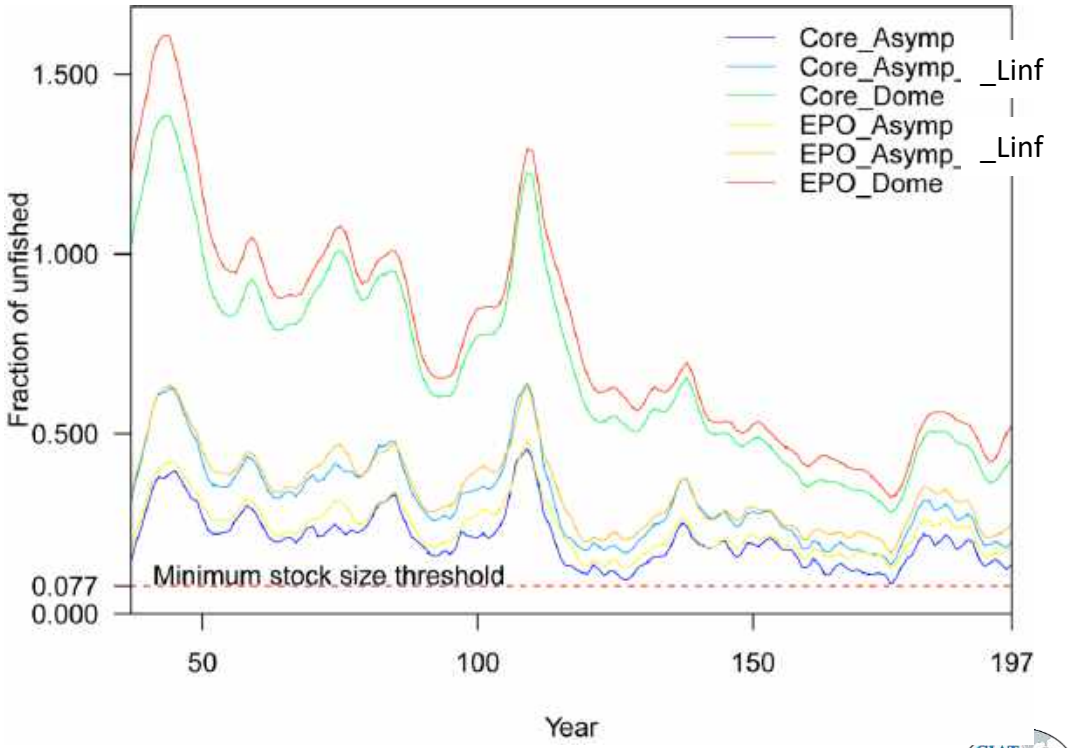
# 3. 2024 stock assessment: Results

- Asymptotic selectivity using the double normal does not fit the comp data well
- Splines too flexible, can’t estimate the peak, and unstable
- Practical solution: use double normal



# 3. 2024 stock assessment: Results

- Trends in abundance are similar
- Absolute abundance and depletion levels differed among the three model assumption scenarios (asymptotic selectivity, estimate asymptotic length, dome-shaped selectivity)
- EPO catch scenarios similar trends and depletion levels to the core area
- Models that estimated the asymptotic length were more optimistic
- Models that assumed a dome shape selectivity estimated an unrealistically high biomass level and a low level of depletion



# 3. 2024 stock assessment: Results

- Most pessimistic model assuming h=1 estimates dynamic depletion at 22%, which is above the BMSY/B0 = 16%*
- Model h = 0.8 estimates the dynamic depletion at 16%, which is below the corresponding BMSY/B0 level of 31%.
- Much less than a 10% probability that the limit reference point has been exceeded for all scenarios (less than 0.1%)

| Model | $S_{MSY}/S_0$ | $S_{cur}/dS_0$ | $S_{cur}/S_0$ |
|---|---|---|---|
| Core_Asymp | 0.16 | 0.22 | 0.14 |
| Core_Asymp h 0.8 | 0.31 | 0.16 | 0.13 |
| Core_Asymp_Linf | 0.11 | 0.33 | 0.20 |
| Core_Dome | 0.10 | 0.80 | 0.43 |
| EPO_Asymp | 0.22 | 0.25 | 0.19 |
| EPO_Asymp_Linf | 0.16 | 0.35 | 0.25 |
| EPO_Dome | 0.12 | 0.91 | 0.52 |

* This is equilibrium B0, the target RP is evaluated at the dynamic B0, see slide 29 for dynamic quantities

# 3. 2024 stock assessment: Results Fishing mortality

F/FMSY < 1

Much less than a 10% probability that the limit reference point has been exceeded (less than 0.1%)

| | Crecent/msy_d | Fmultiplier | Frecent/Flim | P(Frecent>Flim) | Frecent/Fmsy | P(Frecent>Ftarget) |
|---|---|---|---|---|---|---|
| core_Asymp | 0.88 | 1.46 | 0.42 | 0.00 | 0.69 | 0.00 |
| core_Asymp_Linf | 0.74 | 2.74 | 0.31 | 0.00 | 0.39 | 0.00 |
| core_Dome | 0.18 | 13.56 | 0.07 | 0.00 | 0.08 | 0.00 |
| EPO_Asymp | 0.73 | 1.35 | 0.44 | 0.00 | 0.78 | 0.00 |
| EPO_Asymp_Linf | 0.64 | 2.27 | 0.31 | 0.00 | 0.46 | 0.00 |
| EPO_Dome | 0.73 | 26.95 | 0.03 | 0.00 | 0.04 | 0.00 |

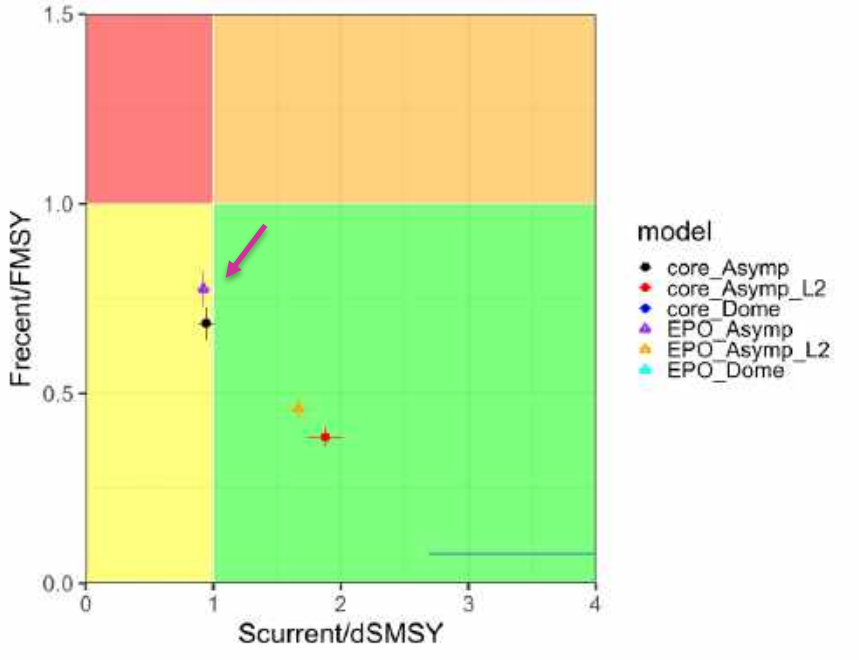
# 3. 2024 stock assessment: Management table

Models with h=1

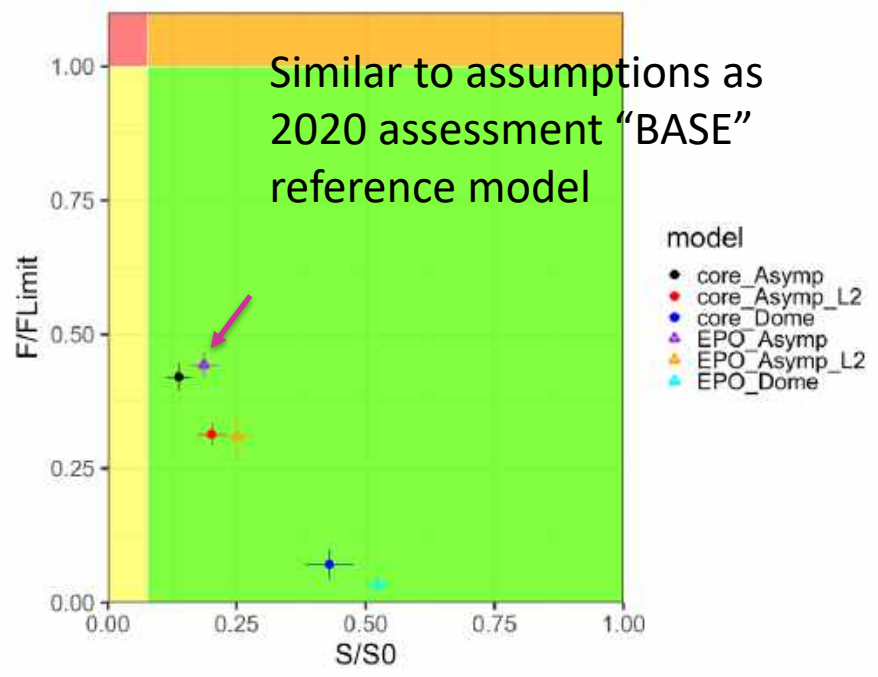
| | core_Asymp | core_Asymp_L2 | core_Dome | EPO_Asymp | EPO_Asymp_L2 | EPO_Dome |
|---|---|---|---|---|---|---|
| MSY | 194931 | 222937 | 794012 | 382603 | 432600 | 3271628 |
| MSY_d | 166460 | 196869 | 793282 | 398354 | 453187 | 397476 |
| $CC$current/MSY_d | 0.88 | 0.74 | 0.18 | 0.73 | 0.64 | 0.73 |
| $S$MSY/S0 | 0.16 | 0.11 | 0.09 | 0.19 | 0.14 | 0.11 |
| SMSY_d/S0_d | 0.23 | 0.18 | 0.17 | 0.27 | 0.21 | 0.04 |
| Scurrent/S0 | 0.14 | 0.20 | 0.43 | 0.19 | 0.25 | 0.52 |
| Scurrent/SLIMIT | 1.79 | 2.62 | 5.58 | 2.43 | 3.27 | 6.80 |
| p(Scurrent<SLIMIT) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Fcurrent/FLIMIT | 0.42 | 0.31 | 0.07 | 0.44 | 0.31 | 0.03 |
| p(Fcurrent>FLIMIT) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $S$current/$S$MSY_$d$ | 0.95 | 1.88 | 4.62 | 0.92 | 1.67 | 24.25 |
| p(Scurrent<SMSY_d) | 0.88 | 0.00 | 0.01 | 0.96 | 0.00 | 0.01 |
| Fcurrent/FMSY | 0.69 | 0.39 | 0.08 | 0.78 | 0.46 | 0.04 |
| p(Fcurrent>FMSY) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

# 3. 2024 stock assessment: Results

Target Kobe plots




Limit Kobe plots



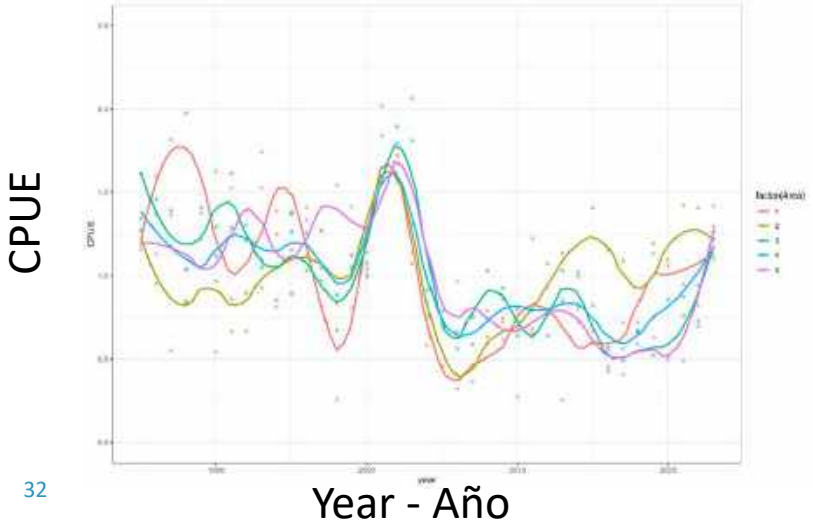

Similar to assumptions as 2020 assessment "BASE" reference model

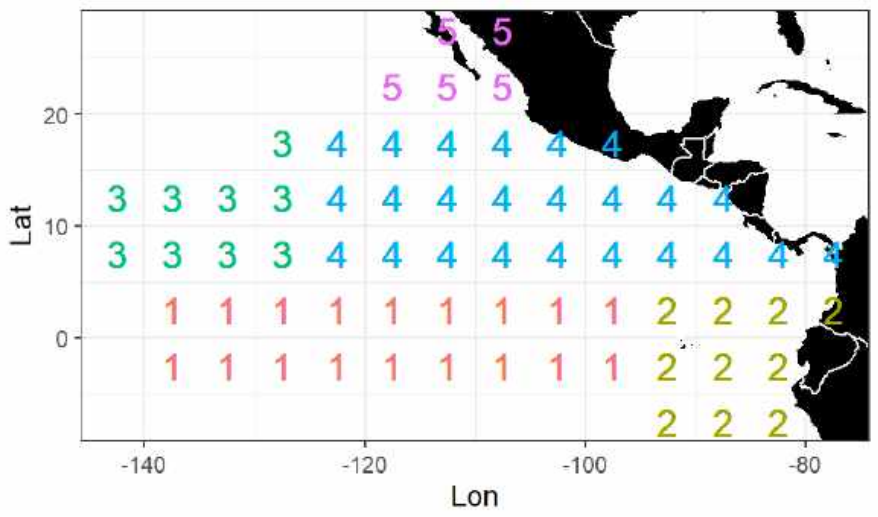
80% Confidence interval

# 4. Spatial stock status indicators SAC-15-03

# 4. Spatial stock status indicators: DEL CPUE

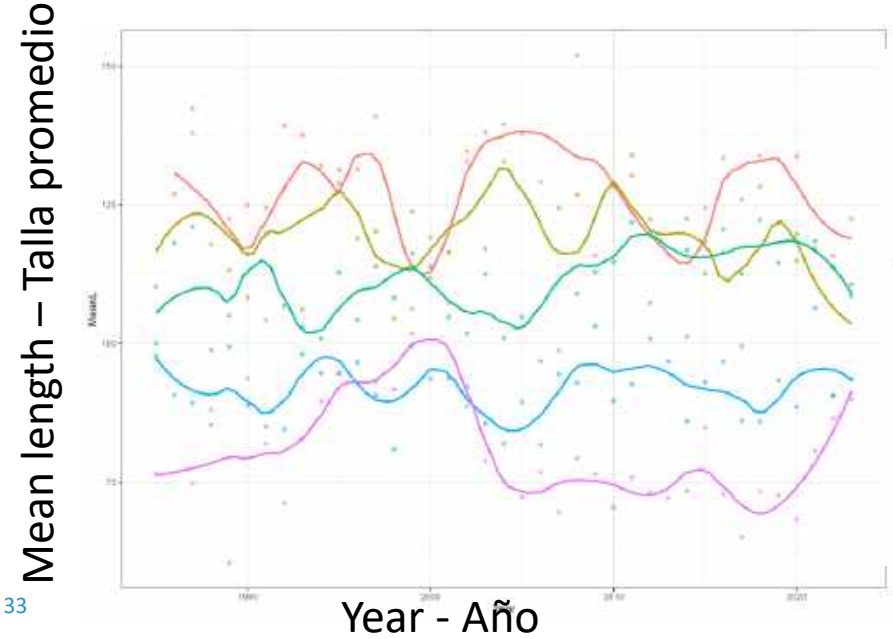
- **Area 2** has less of a decline
- Other areas are similar
- All have a peak in 2001
- No strong indication that other areas worse than core

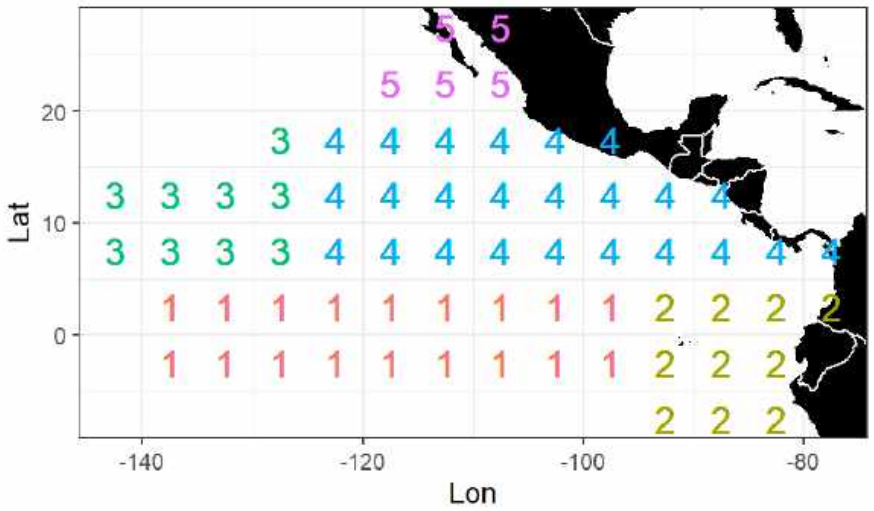


# 4. Spatial stock status indicators: DEL mean length

- Differences in mean length among areas persistent over time
- No strong evidence of trends suggesting the other areas are being more depleted than the core area



# 5. Workplan

# 5. Workplan: 2025 benchmark assessment

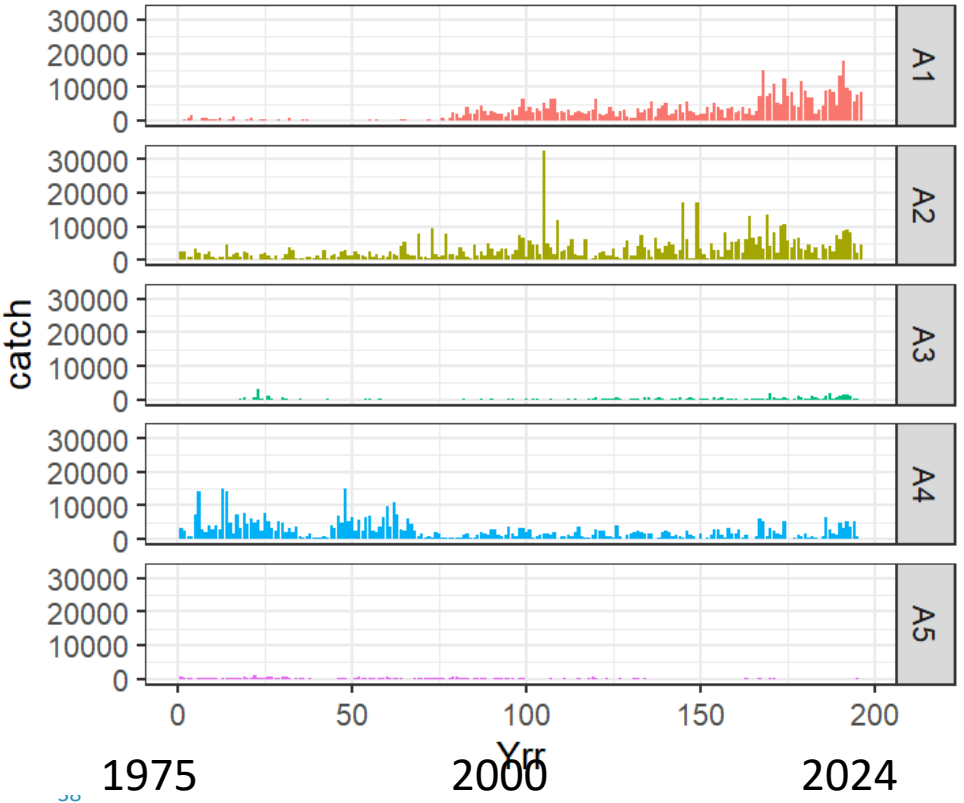
- Cluster analysis for irregular areas
- Flexible well-behaved asymptotic selectivity curves
- Spatio-temporal analysis of tagging data
- Longline CPUE index based on all distant water fleets
- Investigate dolphin associated fishery CPUE index
- Investigate within-year depletion in the DEL index
- Investigate changes in the ecosystem after the 1997-1998 el Niño
- Further develop models of stock structure

# 5. Workplan: Medium term research

- Collect more growth data :
  - Increase spatial coverage
- Collect more tagging data:
  - Increase spatial coverage

# Preguntas – Questions?

# Extra slide: Catches PS- OBJ by area and quarter




Effort distribution: average number of set by year (2000-2023)