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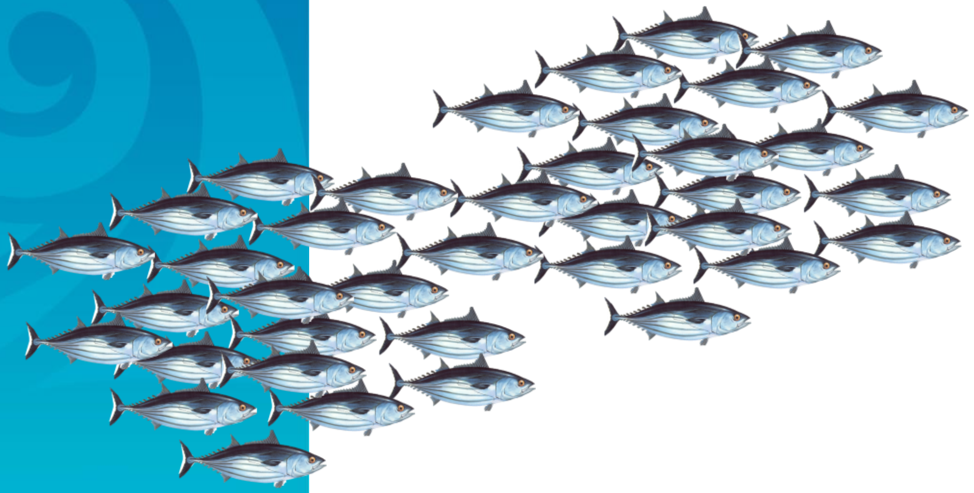
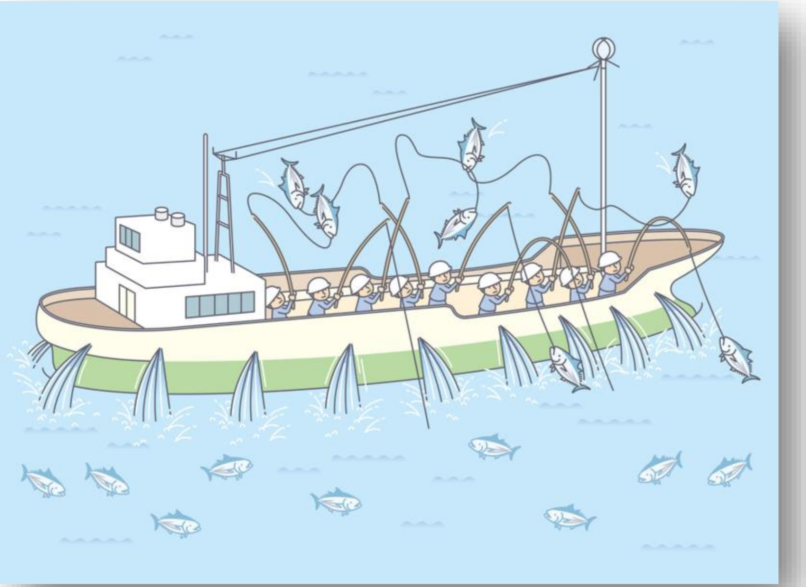
Project 115: Investigating long-term recruitment trend of skipjack tuna in the WCPO and effort creep in the Japanese pole and line skipjack fishery

WCPFC – SC20 – SA - WP06





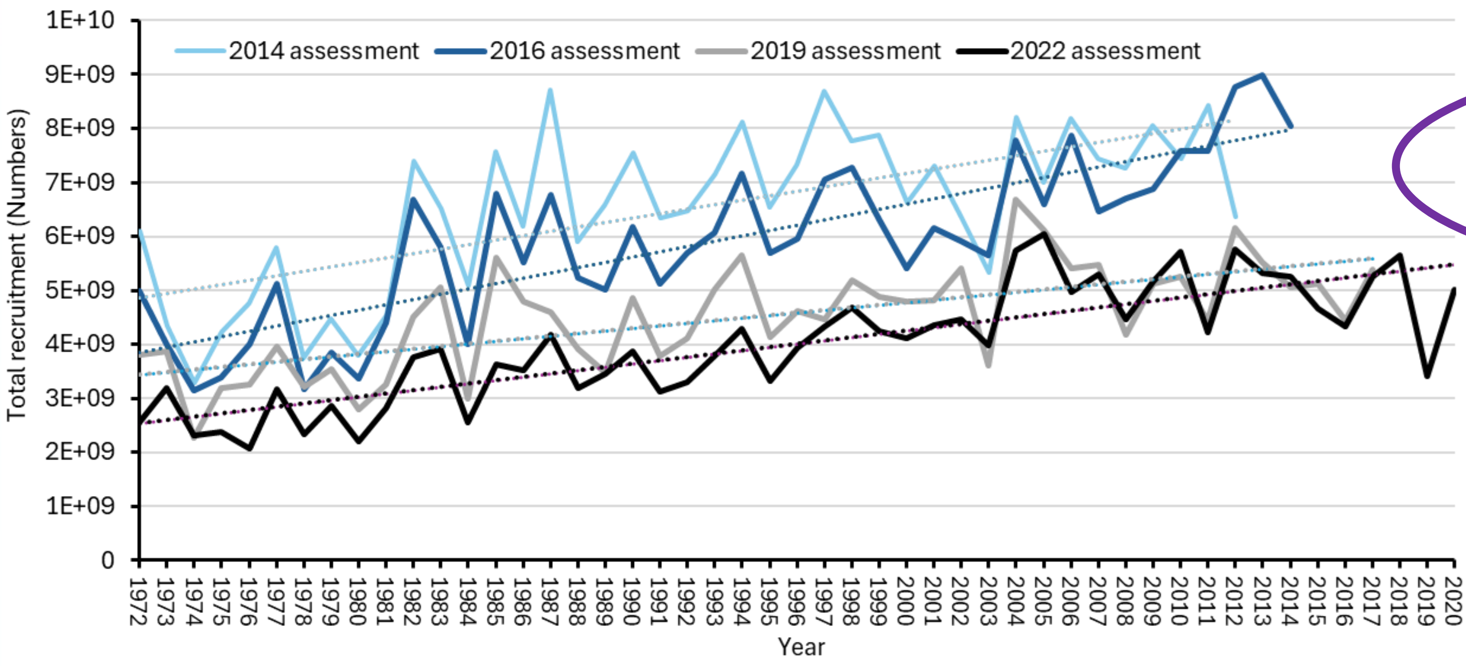
Outline

- Part 1 – skipjack recruitment trends - *SPC*

- Part 2 – pole and line effort creep: industry survey and modelling study - *Japan Fisheries Research and Education Agency (FRA)*

Background – Recruitment trend

- Successive WCPO skipjack assessments estimate an increasing trend in recruitment, moderated somewhat in recent assessments



Hypotheses

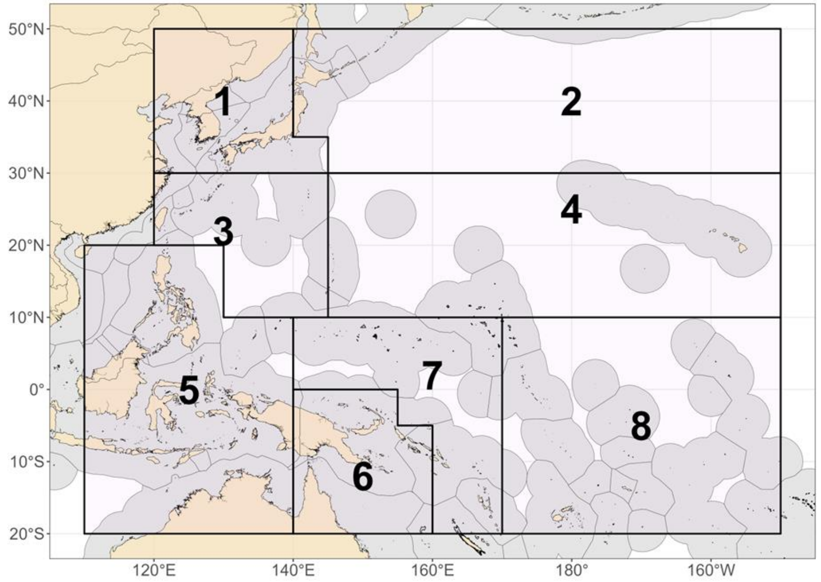
1. Trend is real – productivity for skipjack early life stages has increased over time

2. Trend is not real – but is generated by the assessment model to best fit the data

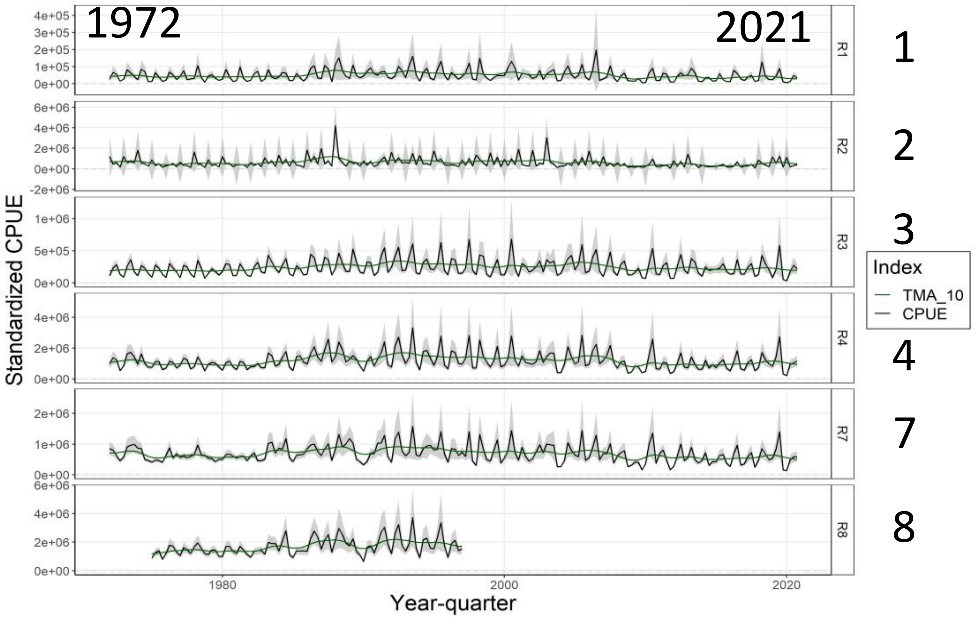
3. Trend is part real – part modelling artifact

Why is it important?

Implications for how we interpret the stock status from the stock assessment ($SB/SB_{F=0}$) and potential future resilience of the stock to current fishing levels.



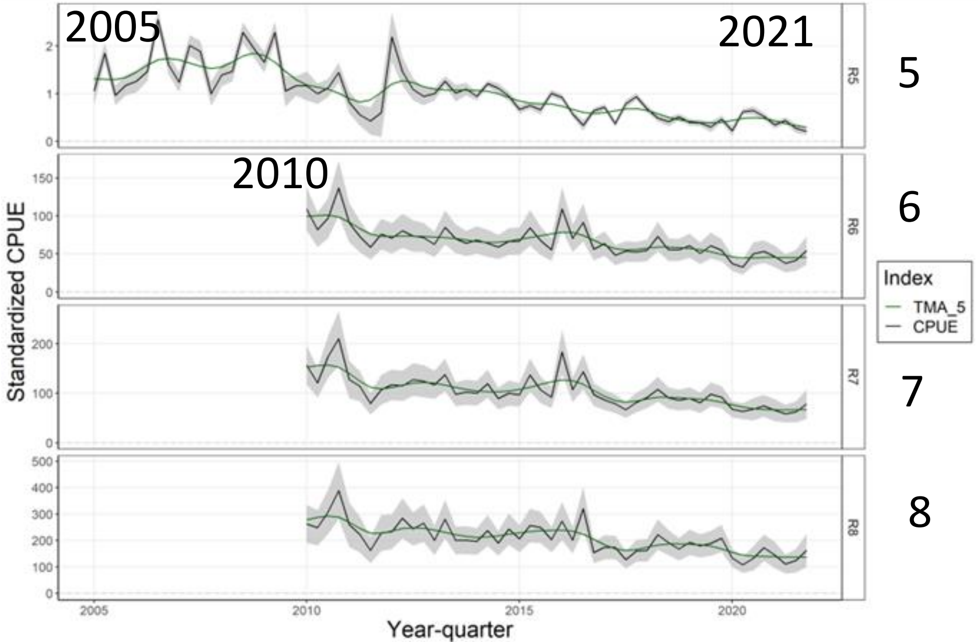
Pole-and-line CPUE indices



1
2
3
4
7
8

Long term indices

Purse seine CPUE indices



5
6
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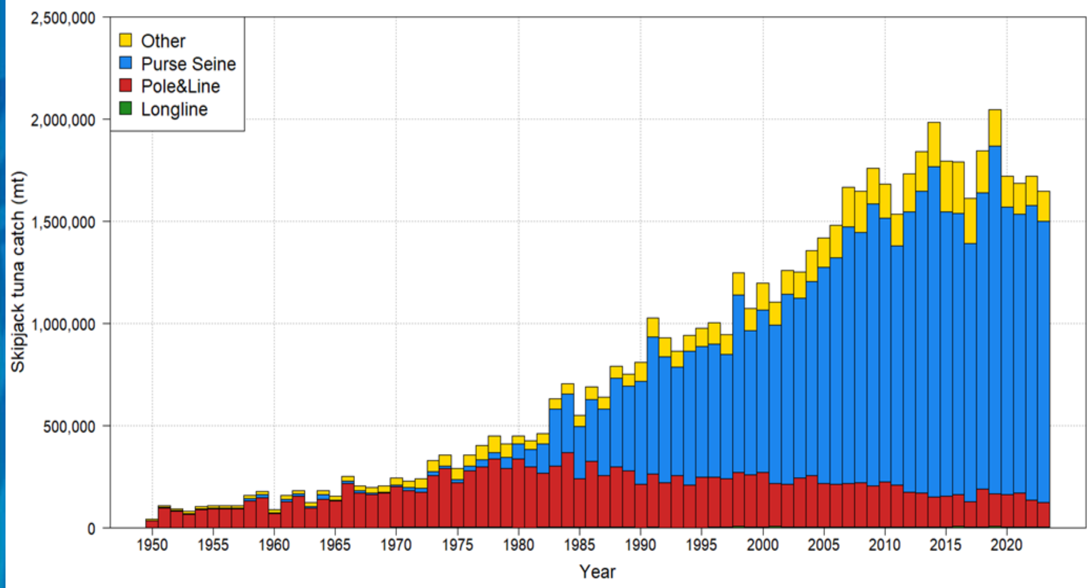
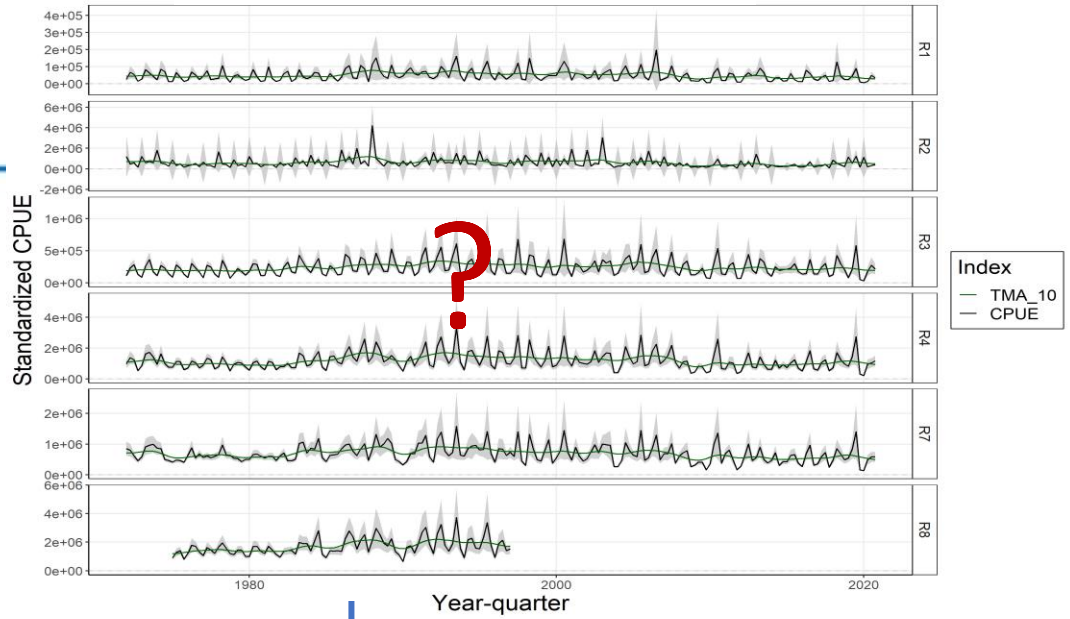
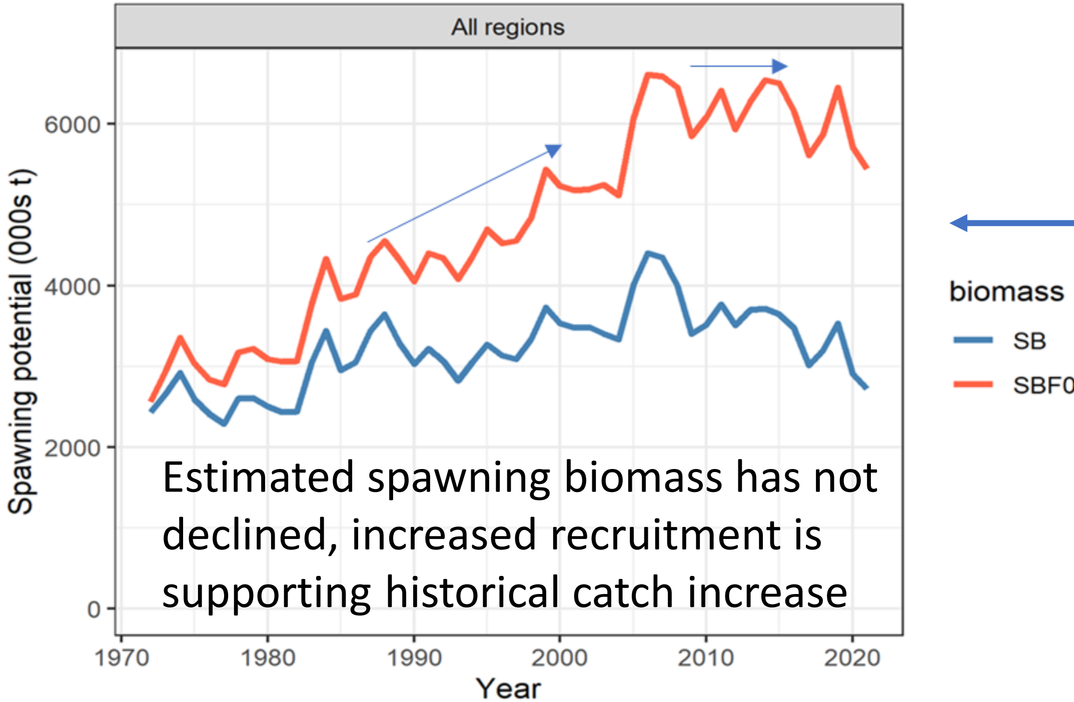
Recent indices

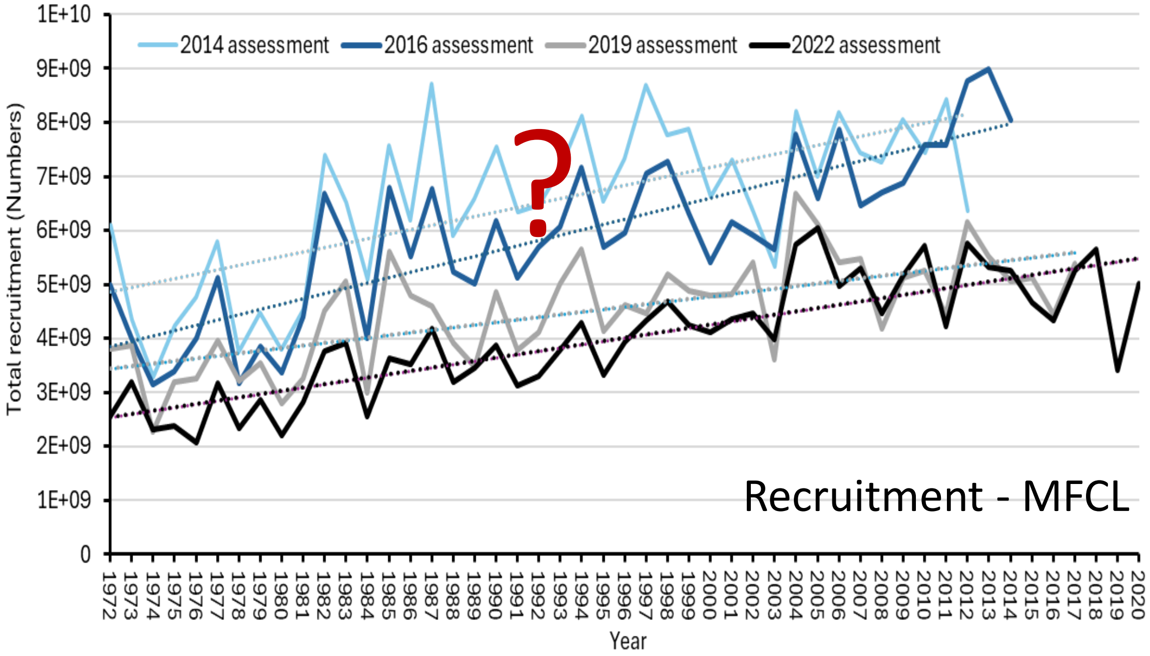


Pole-and-line CPUE indices





Estimated spawning biomass has not declined, increased recruitment is supporting historical catch increase

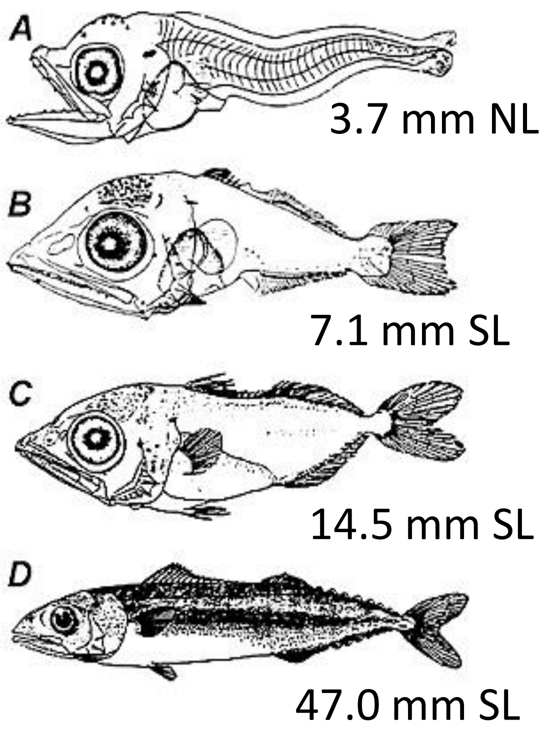


Recruitment - MFCL

Approach

- **Understand** skipjack early life history and recruitment processes - review
- Consider **hypotheses** of environmental/oceanographic drivers (possible proxy indicators) of recruitment trends and dynamics
- **Explore** the possible environmental/oceanographic drivers
- Analyse **relationships** between environmental/oceanographic drivers and skipjack recruitment estimates from recent skipjack assessment
- Consider **SEAPODYM** estimates of trends

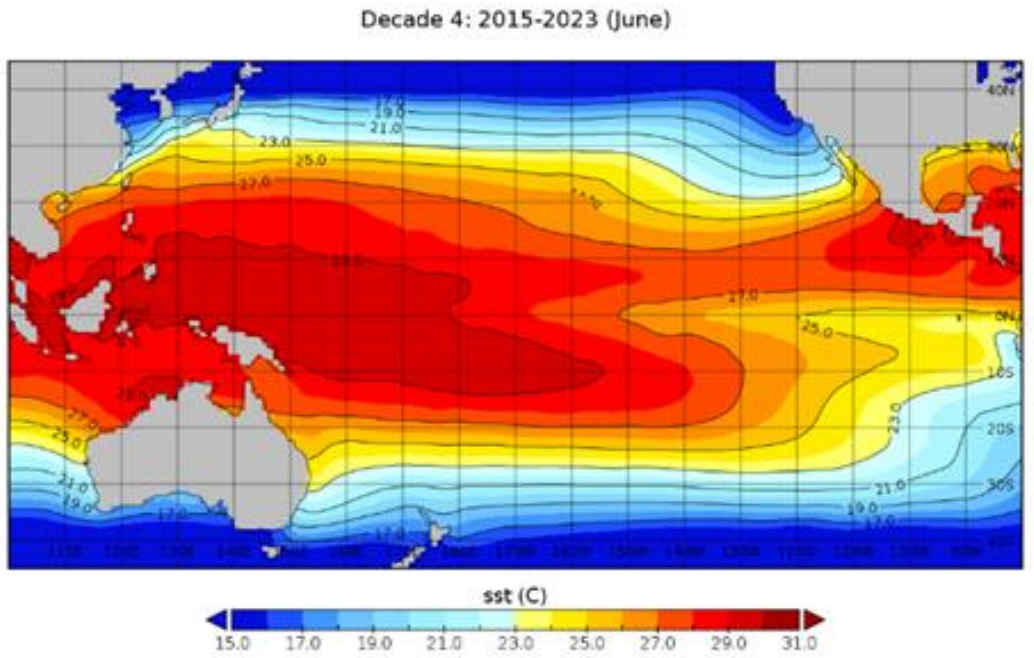
> - **There are no fishery independent data on skipjack recruitment trends/dynamics, not even decadal snapshots, not much to go by**
> - **Deplorable lack of field or lab studies of early life history of skipjack in WCPO – the world's largest tuna fishery!**
> - **Upcoming Japan/SPC research voyage in the Warm Pool – very important – focus on larval/juvenile tropical tunas**

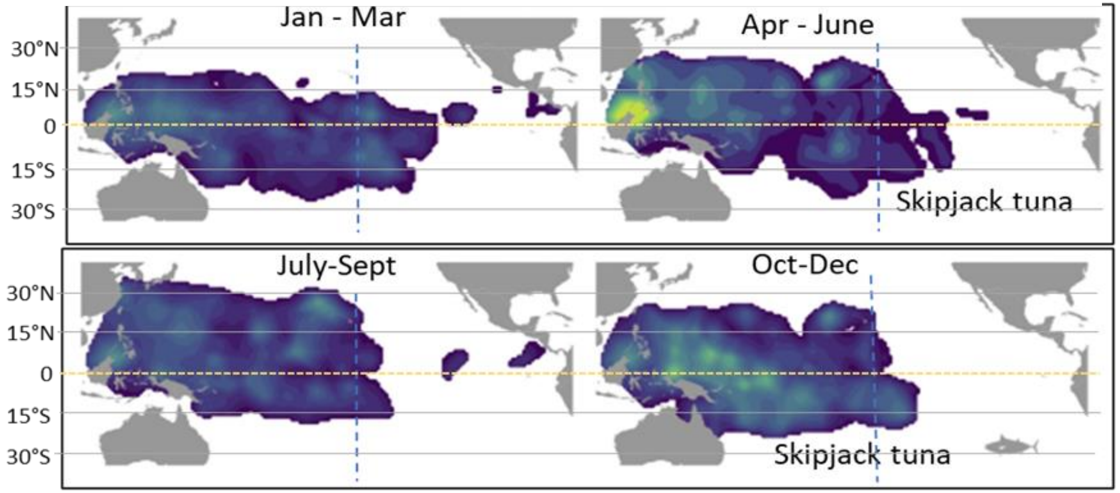


Matsumoto (1958)

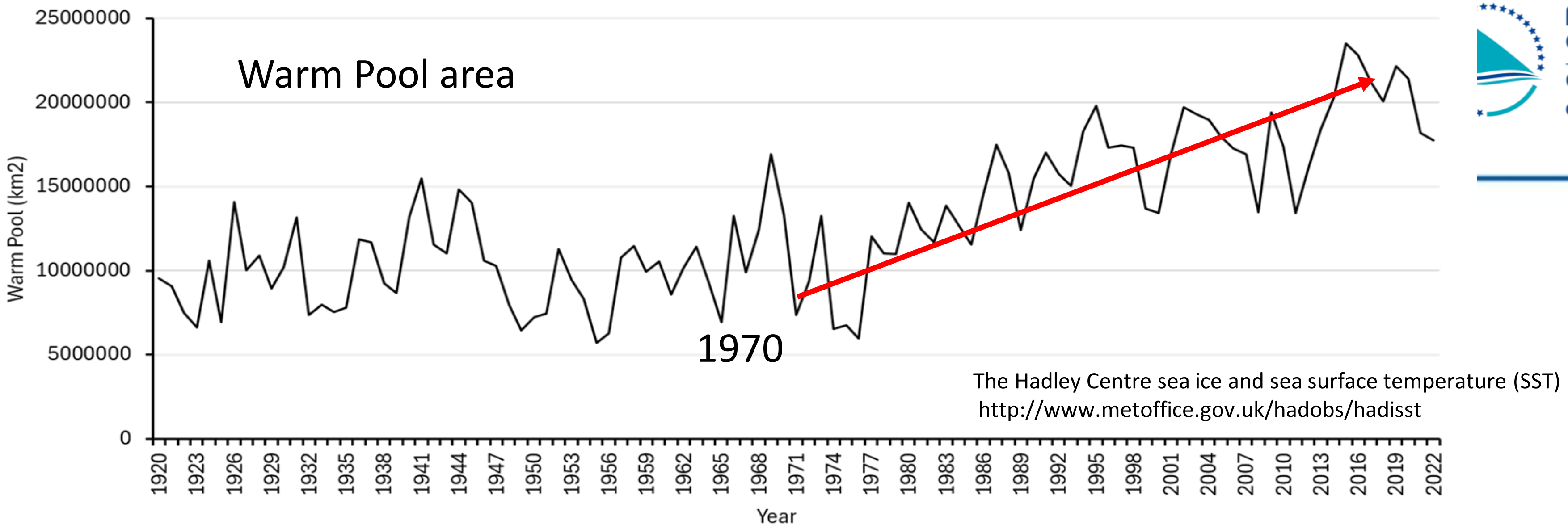
Western Pacific Warm Pool

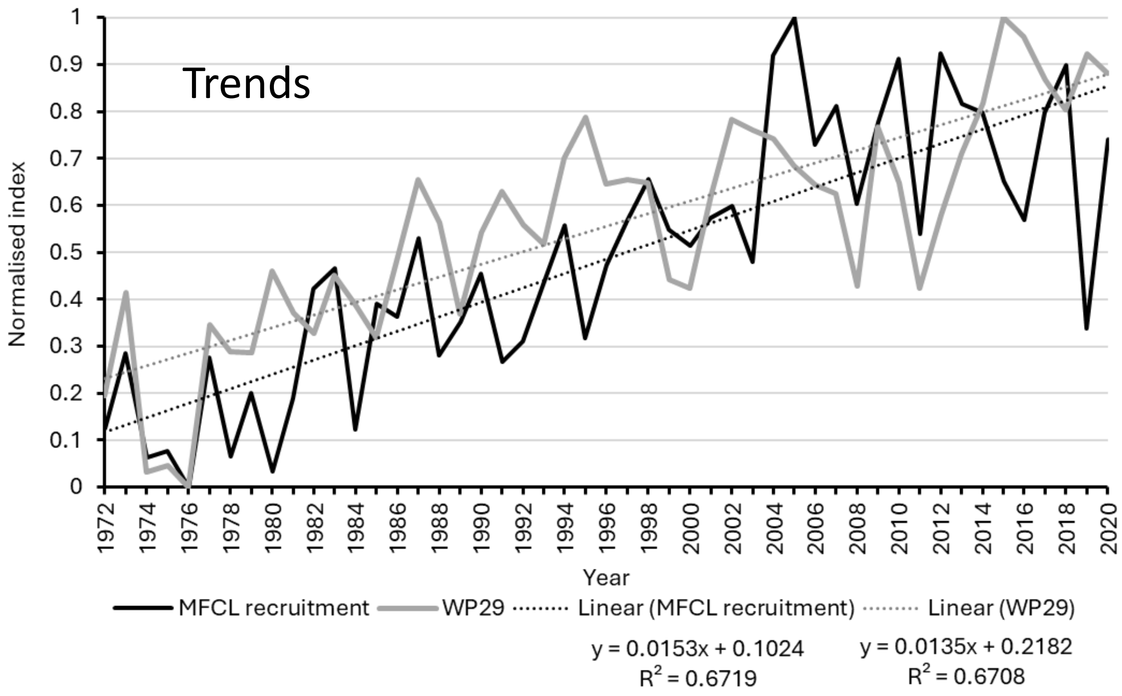
- Western Pacific Warm Pool: core skipjack spawning and larval/juvenile rearing area
- To understand skipjack early life history and recruitment – you have to consider the influence of the warm pool trends and dynamics
- Skipjack eggs – higher normal hatch rates/faster hatch times 28-31° (Fujioka et al. 2024)
- Fast larval growth – high starvation vulnerability – prey abundance is critical in early life
- Spawn all year – can take advantage of production pulses
- Primary/secondary production as a proxy

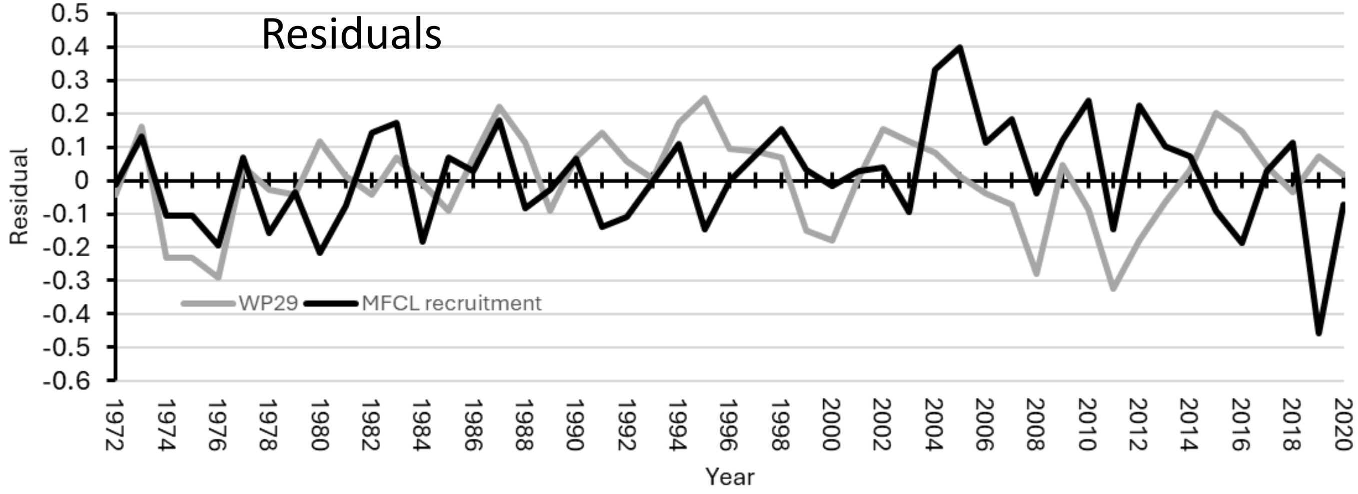




From Ijima and Jusup 2023, https://arxiv.org/abs/2304.09442

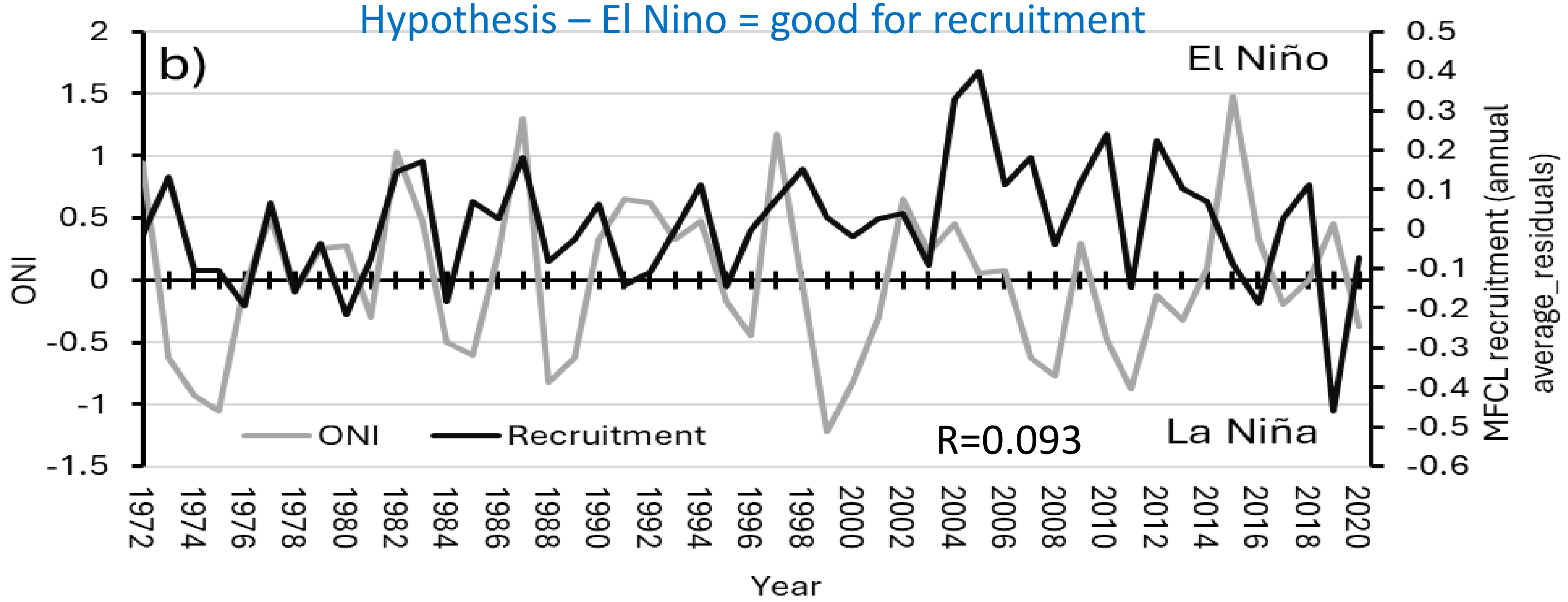


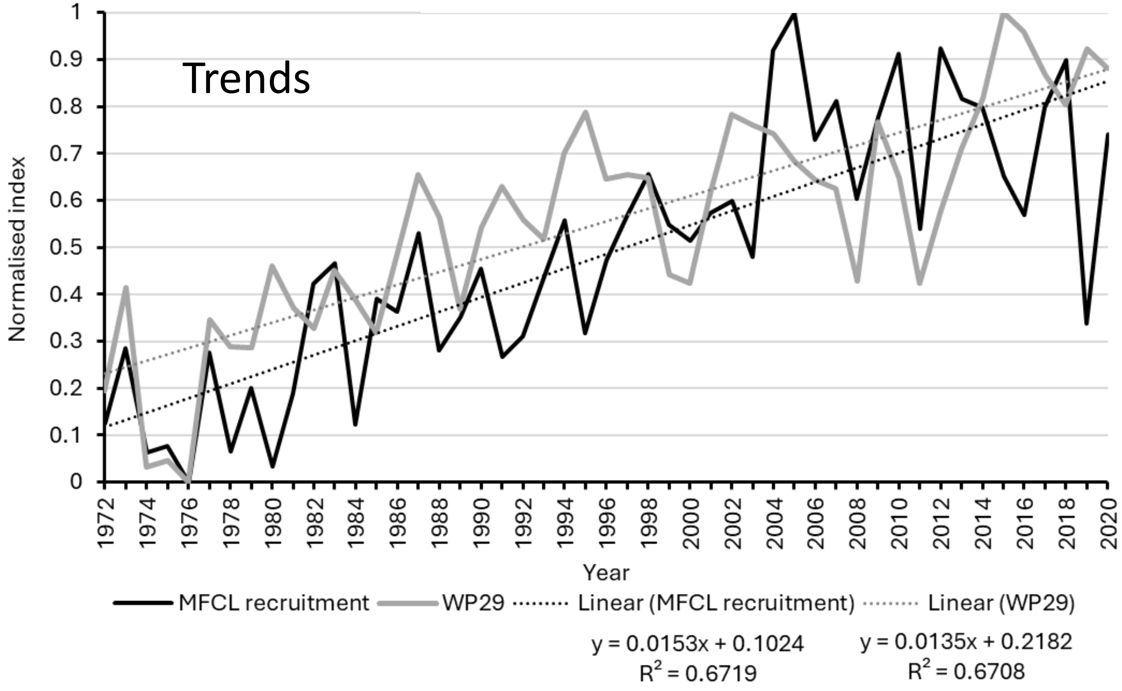


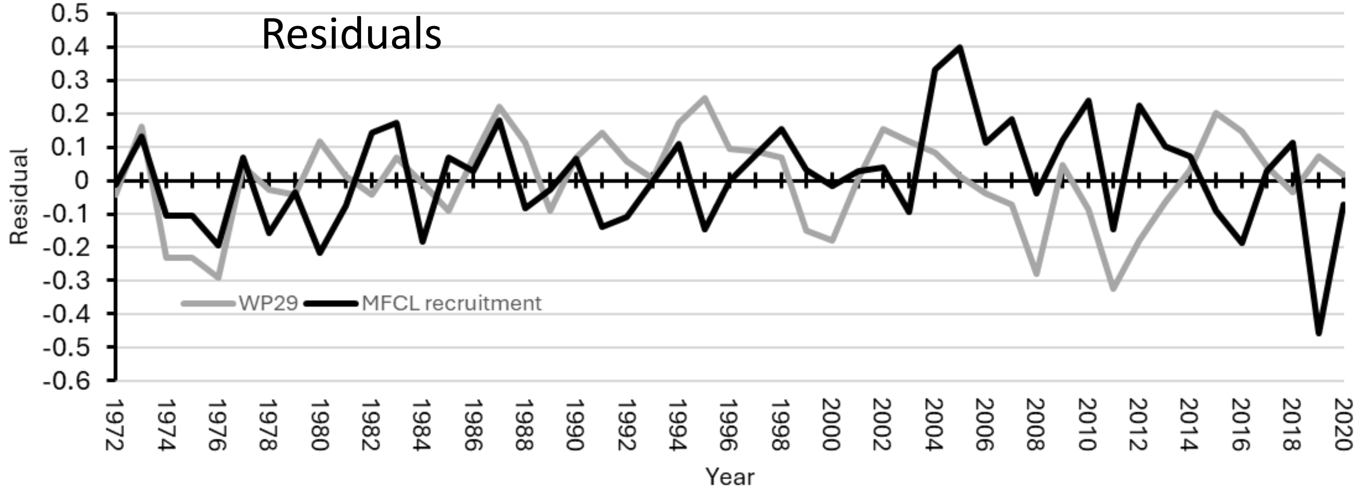


(1972-2020: R = 0.049, 1972-2002: R=0.291,)

Hypothesis – El Nino = good for recruitment







(1972-2020: R = 0.049, 1972-2002: R=0.291,)

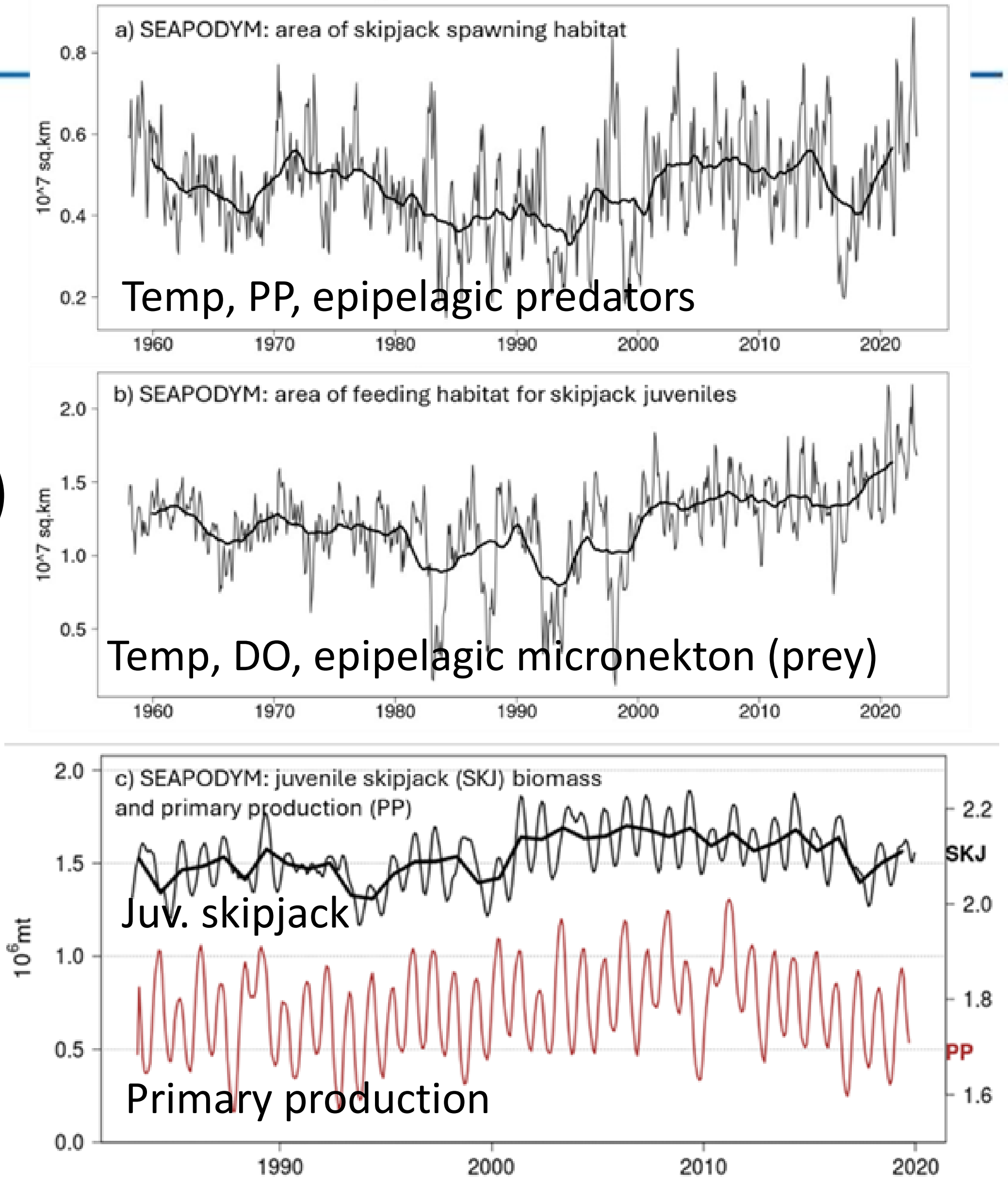
Planktonic production - prey

- Lacking in observational data on zooplankton dynamics in the Warm Pool - rely on models to provide time series of primary and secondary production

SEAPODYM (preliminary skipjack update)

- SEAPODYM's estimates of abundances of different life stages in space and time are **strongly influenced by the dynamics of environmental forcing variables** and their empirical relationships with skipjack biology and physiology.

- SEAPODYM **can estimate a persistent recruitment** trend due to environment, **only if there is such a signal in the model forcing information**.



coupled NEMO-PISCES model with atmospheric forcing JRA55

Summary and recommendations

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- Recruitment trend is consistent with Warm Pool expansion, but not related to interannual dynamics, or ENSO (ONI)
- SEAPODYM skipjack model – predicts recent increased juvenile abundance, no long-term recruitment trend
- **Lack of relationships between stock assessment recruitment estimates and the environmental data does not mean the environmental variables are not influencing recruitment**
  - recruitment may just be poorly estimated by the assessment,
  - environmental-recruitment signals are not strong in the fishery dependent data - they are possibly swamped by fishery dependent sampling influences and observation errors.
- Based on the information available there is a lack of irrefutable evidence **for or against** an increasing recruitment trend at some level, **the trend should be considered as an uncertainty in the stock assessment**.
- The most tractable way to develop models that moderate the recruitment trend is through adjustments to CPUE to force declining trends.
- **Declining trends in CPUE may be underestimated if effort creep is occurring** but not appropriately accounted for in CPUE standardisation.

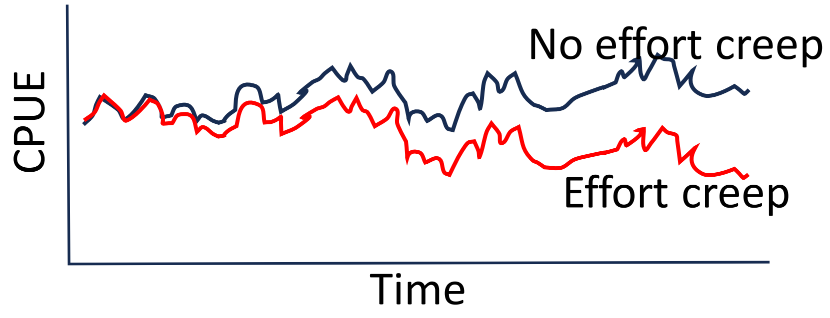
Effort creep

What is effort creep?

Catch (C) = catchability **(q)** x effort (E) x abundance (B)

Effort creep is increases in catchability (for whatever reason – but typically related to better fishing practices etc.)

C/E*q = B



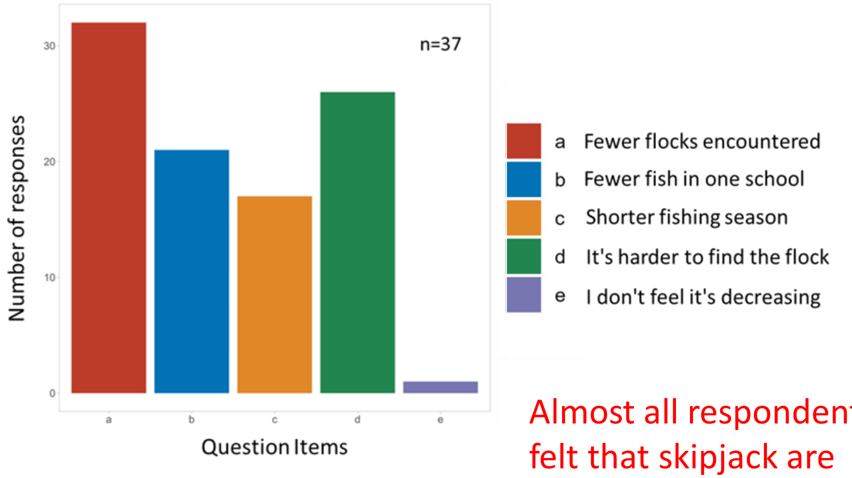
- If q is increasing over time CPUE indices need to account for this by increasing the ‘Effort’ component in CPUE
- Sometime changes in q can be accounted for in CPUE standardisation – but often it is unlikely that all is accounted
- Fishing improvement is driven by many interacting and compounded things that are difficult to measure, or lack data
- **We need to learn more from industry – develop plausible scenarios, accept there will be uncertainty in q overtime**

Part 2) Effort creep in the Japanese pole and line fishery

We conducted questionary survey for effort creep problem

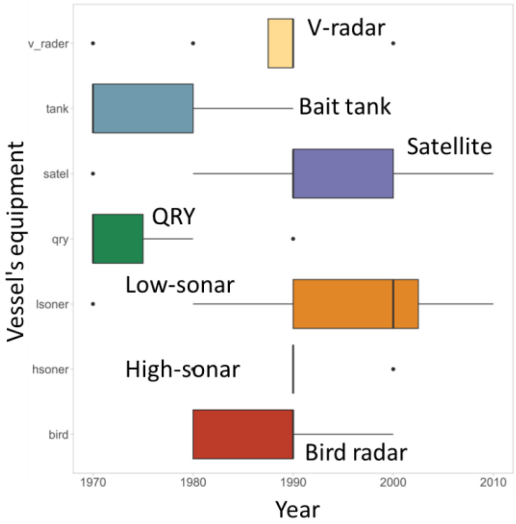
(1) to collect data on fishermen's perceptions on the skipjack resource off Japan
(2) to identify the period when the technological innovation occurred
(3) to assess fishermen's perception of the importance of new technology for catching skipjack (effort creep)

Results (n=37, JPPL fisherman)

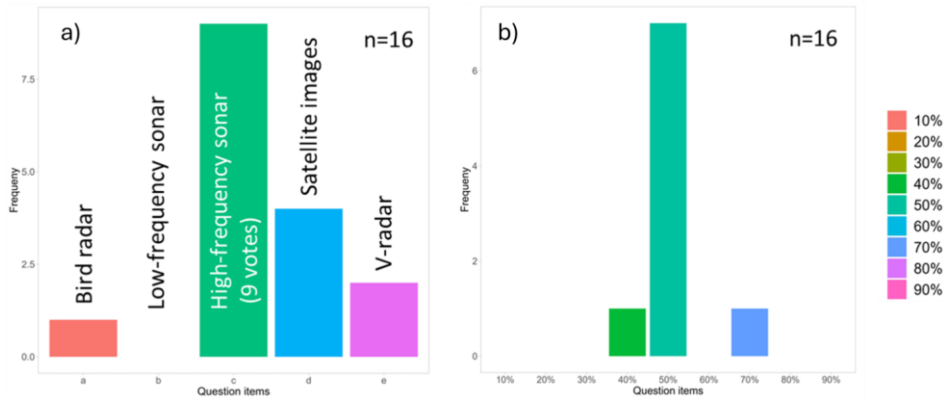


Fishermen's perceptions

Almost all respondents felt that skipjack are decreasing!

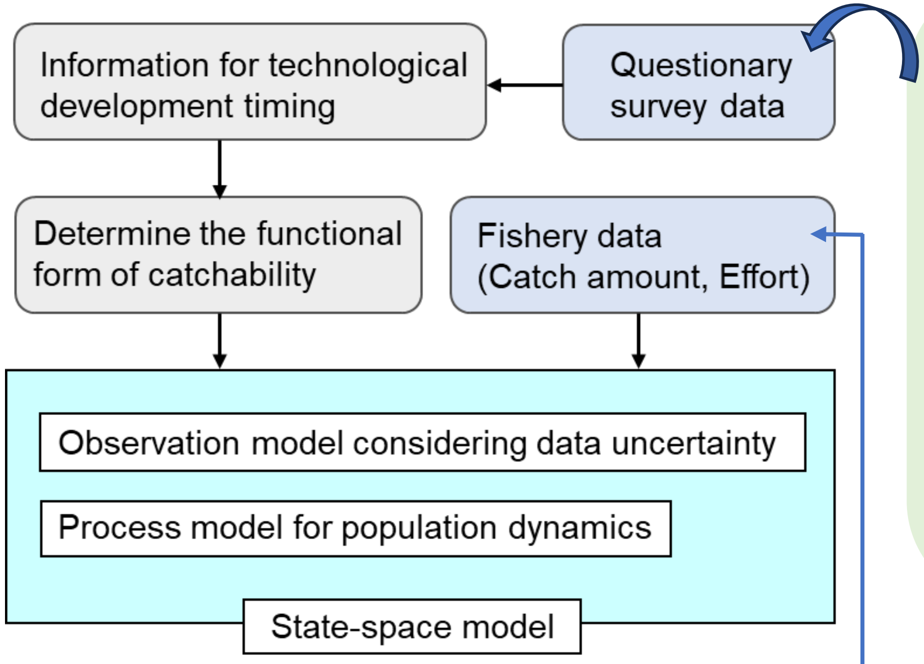


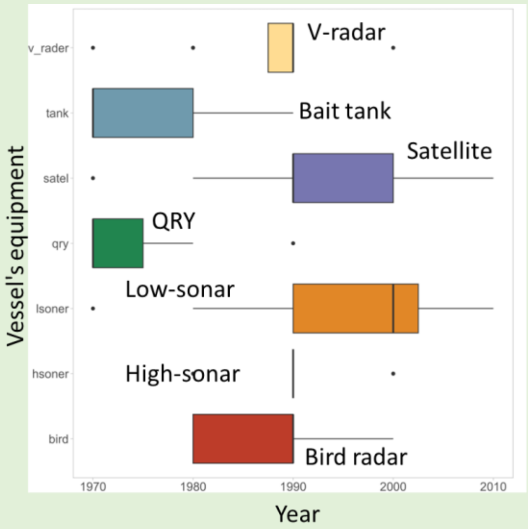
Introduction timing
1990s



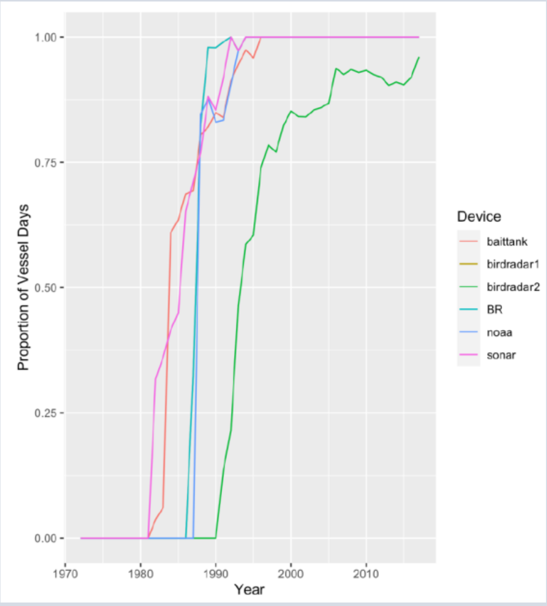
Most important gear for fisherman
High frequency sonar

Statistical framework for effort creep



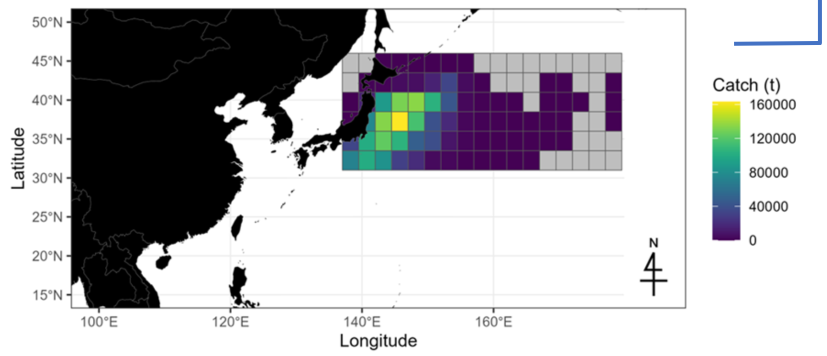


Introduction timing



S-shape catchability?

Technological innovations in large vessels (Matsubara et al. 2022)



JPPL data from 1972 to 2019

Catchability scenario;

①Constant scenario $q = w$

(w, a, b are parameters)

②S-shape scenario

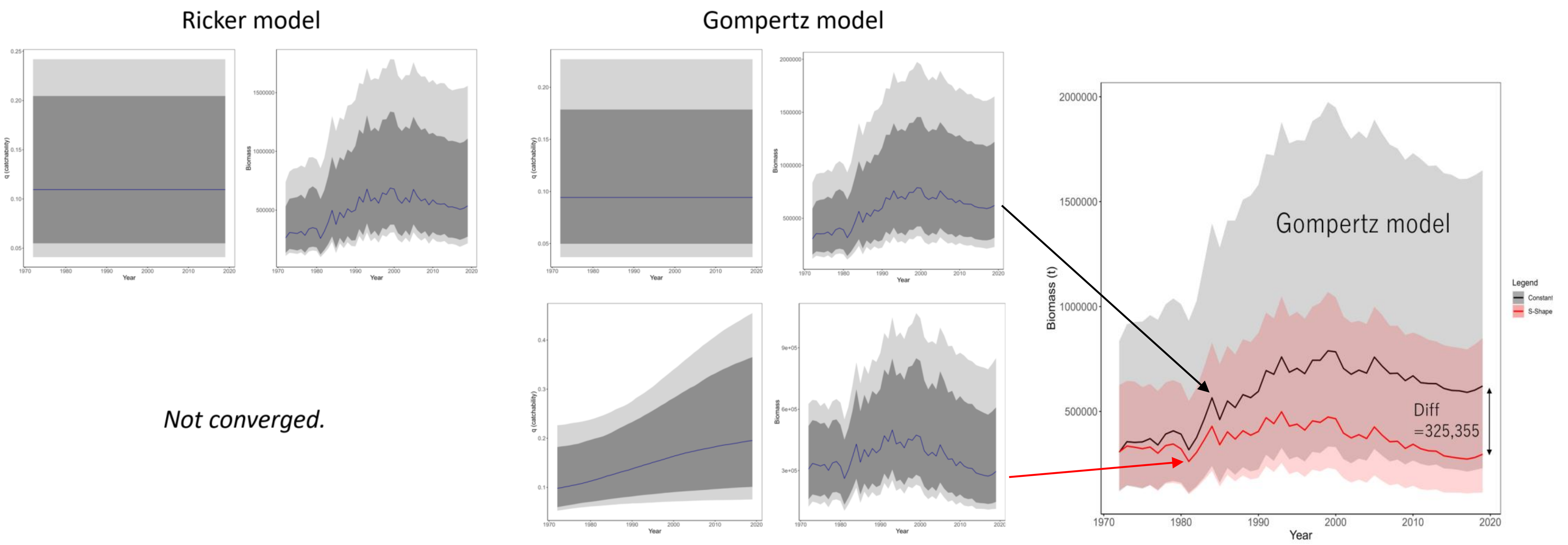
the questionnaire survey results ⇒ the prior distribution as

t': 1990 ± 5 years (t' ~ normal(1990, 2.5)).

$$q[t] = a + \frac{b}{1 + e^{-X[t-t']}}$$

Results of application to JPPL data

Bayesian estimation using MCMC language stan in Ricker and Gompertz models



- Under the S-shaped scenario, median catchability increased by 1.99 from 1972 to 2019.
- Ignoring the increase in catchability due to effort creep revealed that an overestimation of nearly twice the stock biomass can occur.

Part 2) Effort creep in the Japanese pole and line (JPPL) fishery

Summary

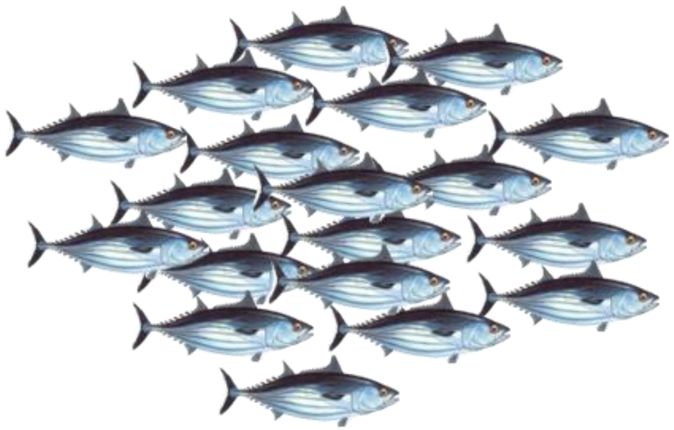
- Survey results indicate that JPPL and fishers sense that skipjack stocks are declining in their fishing region of Japan.
- Significant technology/equipment advances have occurred - the timing of equipment installation in the JPPL was concentrated in the 1990s.
- Both fisher perceptions and modelling suggest catchability for the JPPL increased by a factor of 1.99 from the 1970s to the present.
- The main reason for this increase is thought to be the introduction of high-frequency sonar, based on the results of the questionnaire survey, but other advancements have also been important.

Recommendation

- Effort creep should be considered in stock assessments using JPPL data for skipjack to prevent overestimation.
- Industry surveys are useful both for determining the functional form of catchability and for interpreting the results of statistical analyses.

Ongoing work leading to 2025 assessment

- Run alternative models that employ a broad range of effort creep scenarios (with some implausible levels) on the JPPL CPUE which will provide alternative recruitment trends.
- Present results of the alternative models to the Pre-assessment workshop for review.
- Based on project 115 and the model explorations choose plausible JPPL scenario(s) to include in the 2025 assessment uncertainty characterisation.



If increasing recruitment is not real – what might support the catch increases and continued high fishery production over a decade of more

Another interesting observation

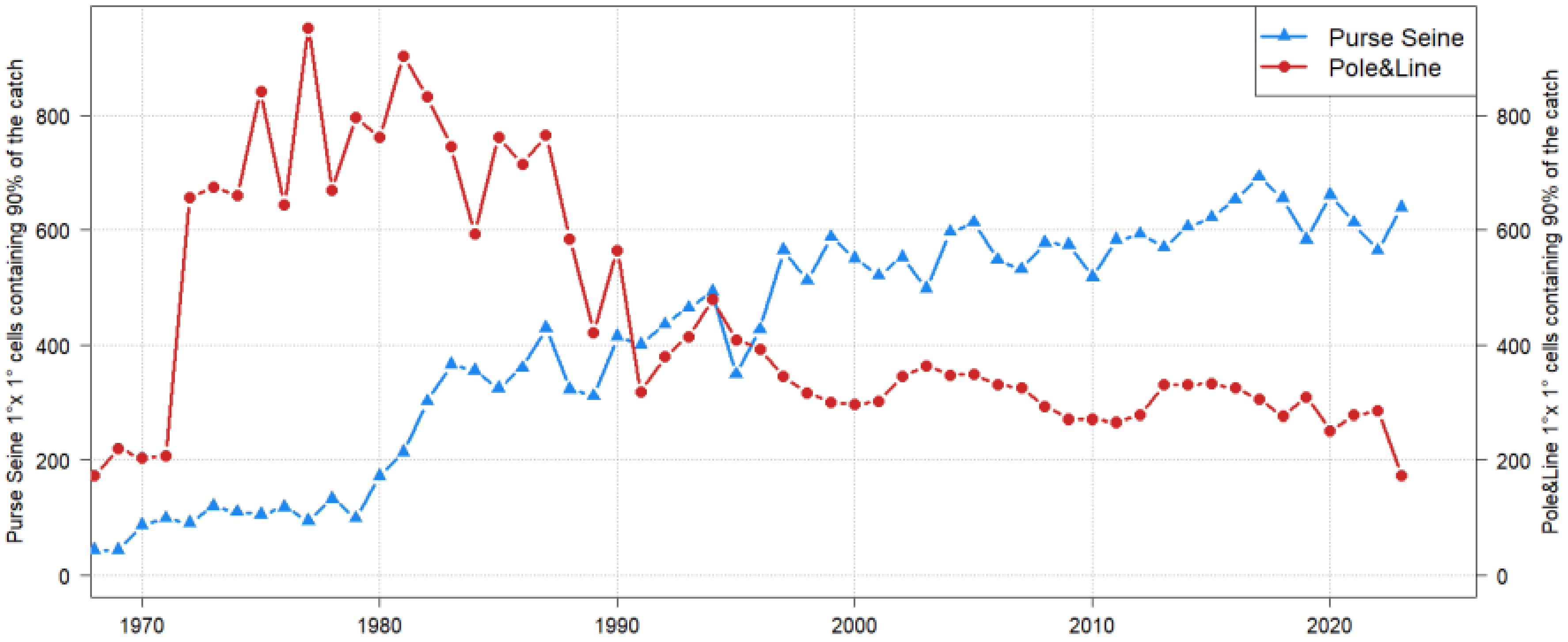


Figure 5: Spatial concentration of skipjack tuna catch for purse seine and pole and line fisheries by year for the WCPO.

To be continued……