IATTC 2ND CLIMATE CHANGE WORKSHOP
6-8 APRIL 2026

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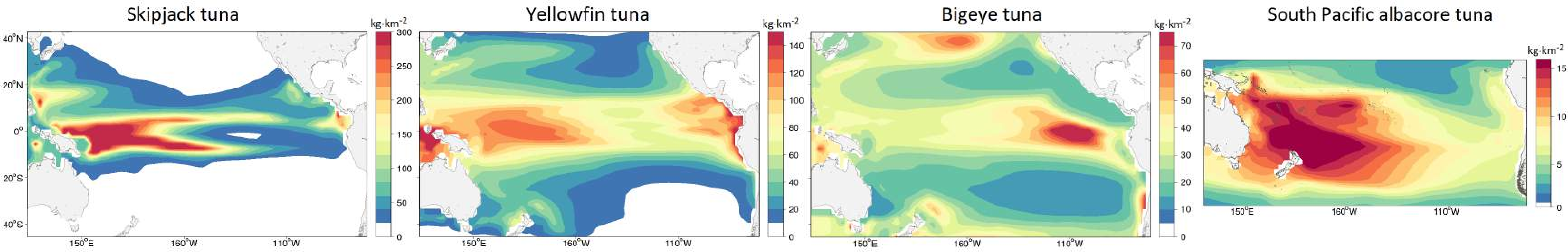
Pacific Community

SPATIAL ECOSYSTEM AND POPULATION DYNAMICS MODEL



Modelling the impacts of climate and climate change on Pacific tuna population dynamics

SEAPODYM in a Nutshell

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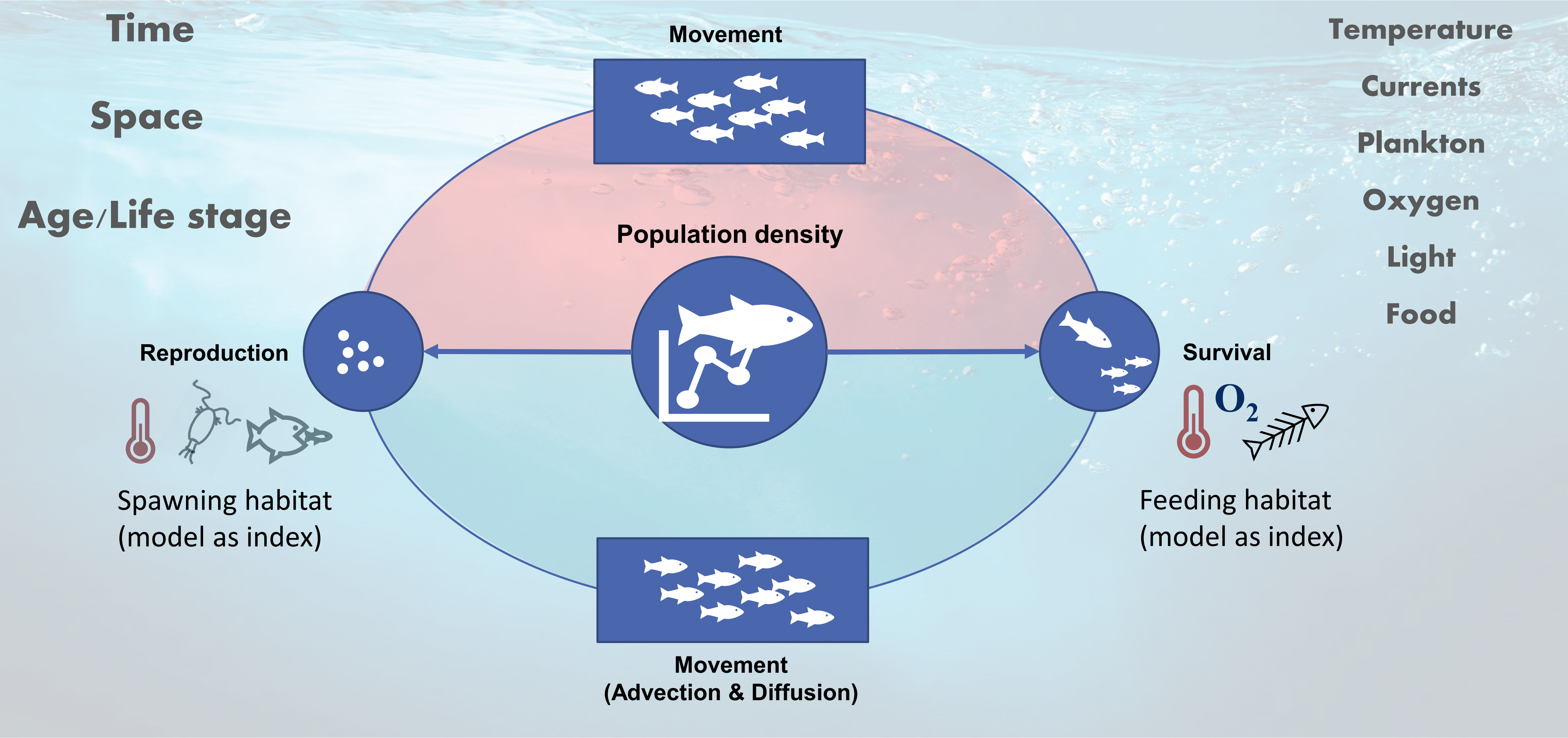
1. **The Model Basics**
   - Estimate and simulate the temporal and spatial dynamics of habitats, biomass distributions and abundance for each tuna species.
     - Estimate the impacts of fishing on distribution and abundance
     - Project future distribution and abundances due to a changing climate
2. **Learning from Data**
   - Model parameters are optimised using fisheries catch and effort data, length data, tagging data and spawning data.
   - Quantify model uncertainties and sensitivities and typically apply a model ensemble approach.

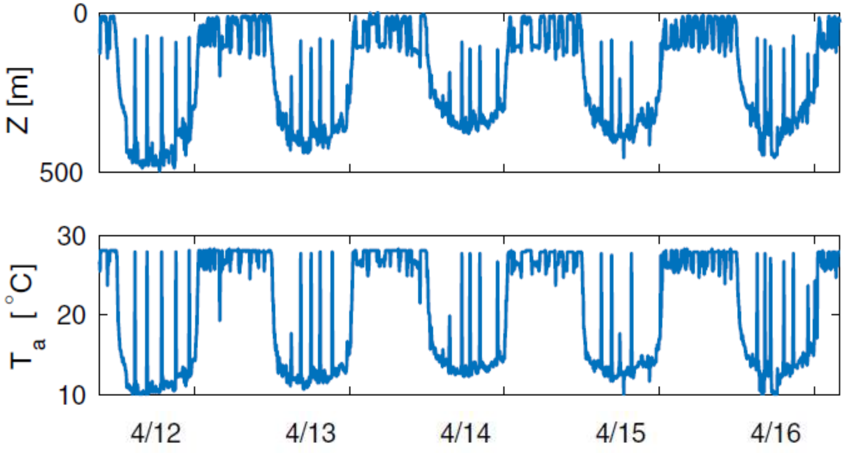
Conceptual model of population dynamics



Defining Tuna Environment

Bigeye tuna

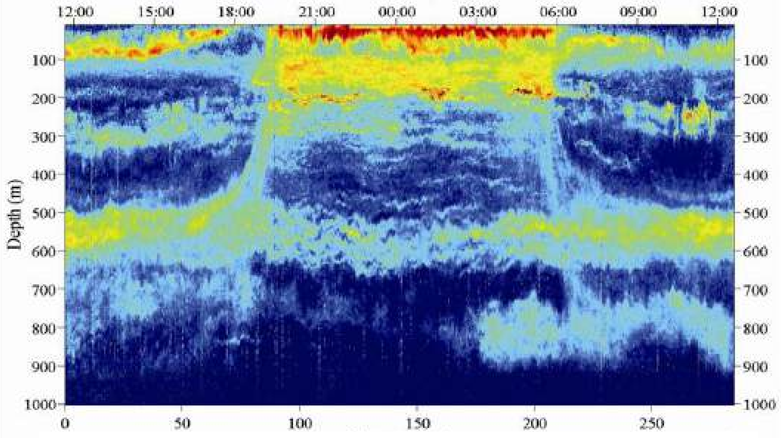
(Western Coral Sea, April 2002)



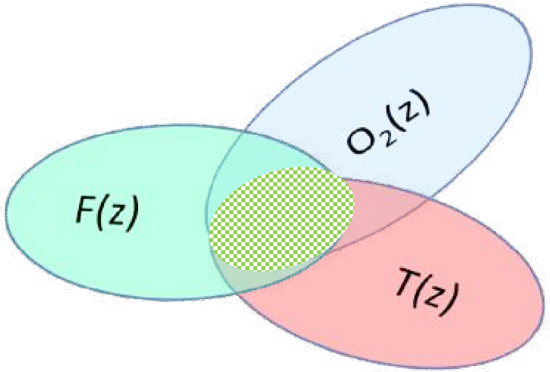
From: Thygesen et al., 2016; Evans et al., 2008

Prey of tuna

(micronekton)



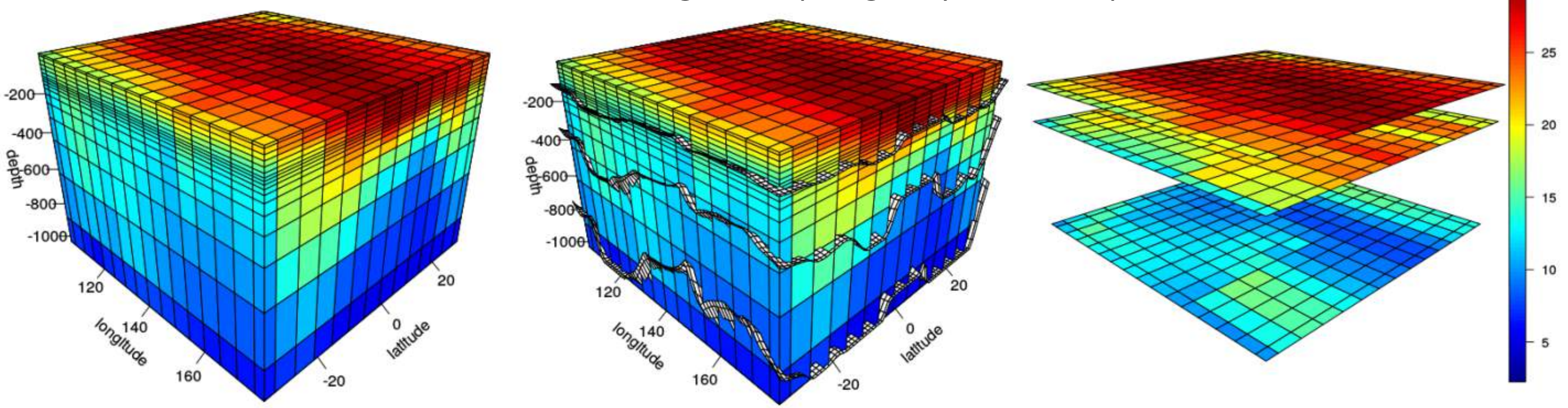
Credit: Réka DOMOKOS (NOAA)



3D variable

Average over pelagic layer

Simplified vertical structure



- *Feeding habitat index is* ***accessible micronekton density***

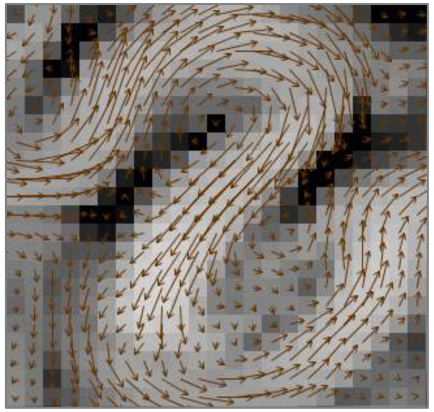
Modelling movement: directional and non-directional

passive | active

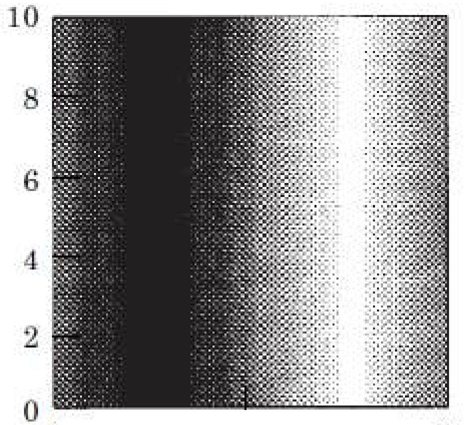
directional | non-directional

Ocean currents

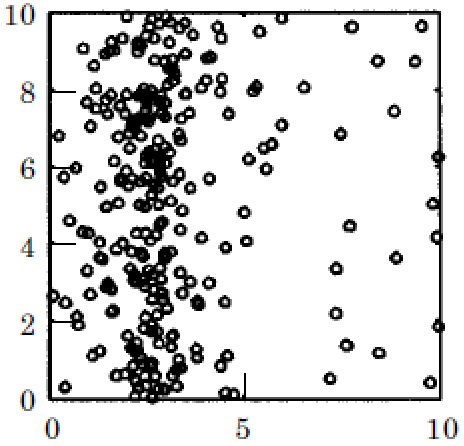
Prey biomass distribution



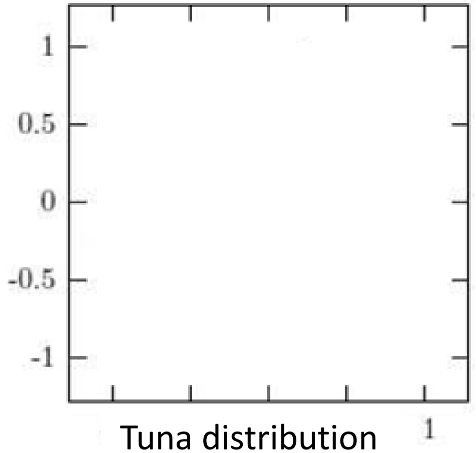
Habitat



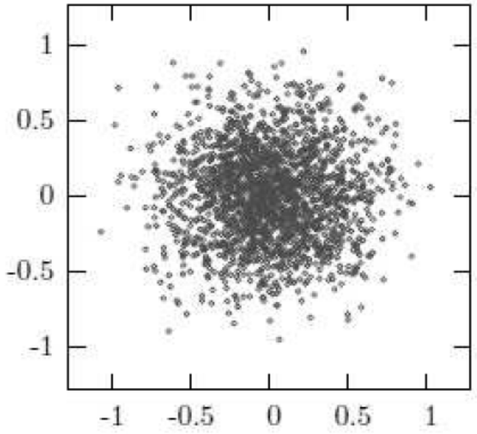
Tuna distribution



Habitat



Tuna distribution



From: Grunbaum, 1999; Flierl et al., 1999; Fougeras et Maury, 2007

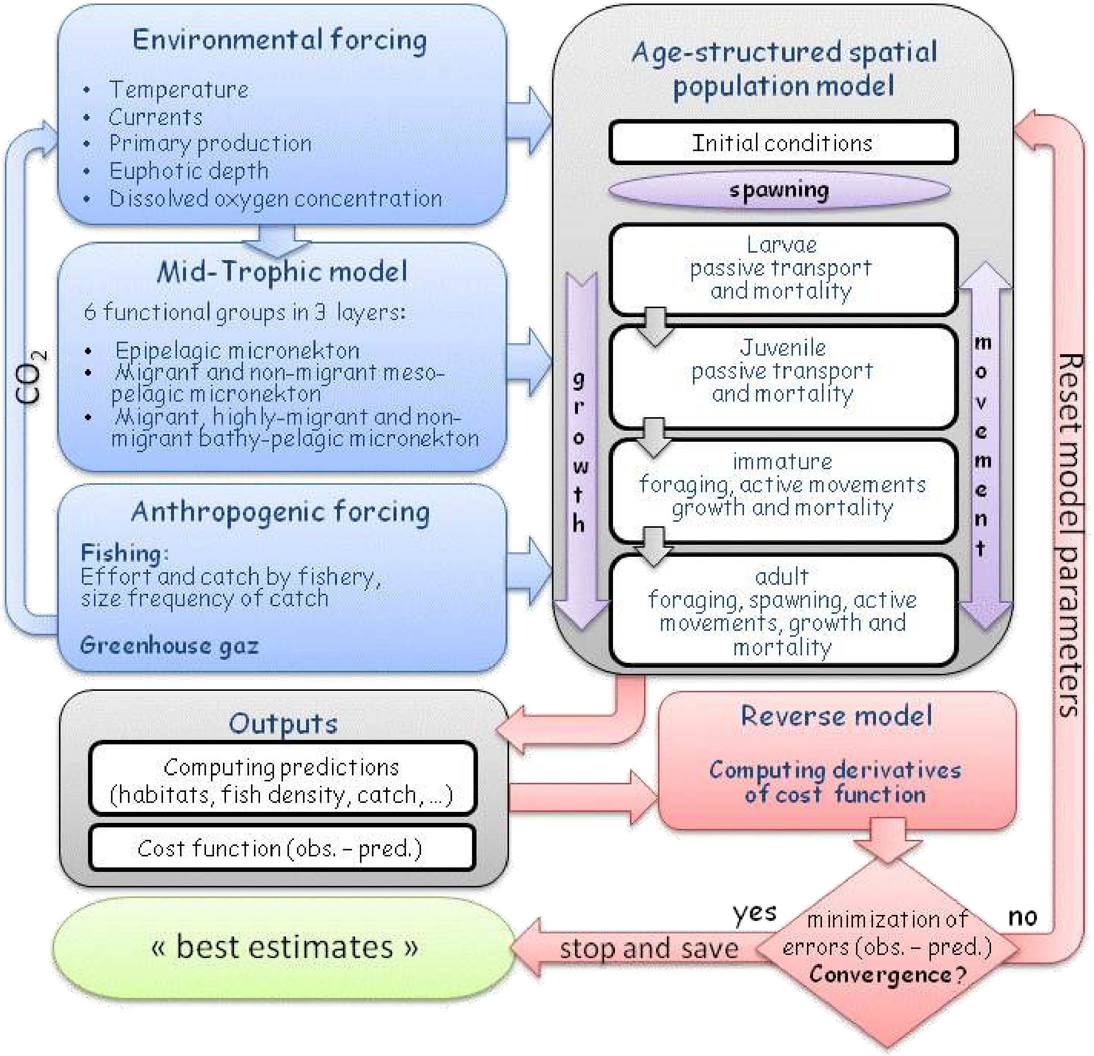
Data inform modelled processes

What we need to estimate:

1. Reproduction rate
2. Mortality rates, including fishing mortality
3. Habitats: spawning (temperature, food, predators) + feeding (preferred temperature, accessibility to prey organisms)
4. Movement rates (excluding transport with ocean currents)
5. Abundance in space (spatial distributions) and time
6. #2-5 along the species life span

Sources of data:

1. Industrial fishing: effort, catch, length-at-catch
2. Scientific campaigns: archival and conventional tagging data; larval survey data
3. Broken into training and validation sets

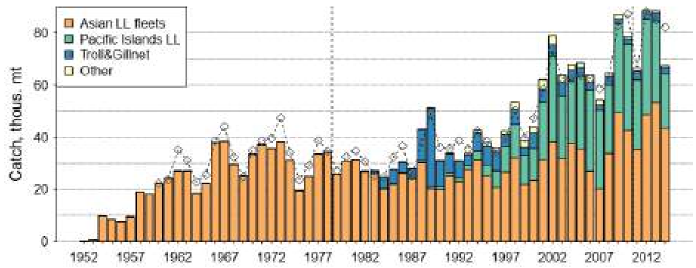


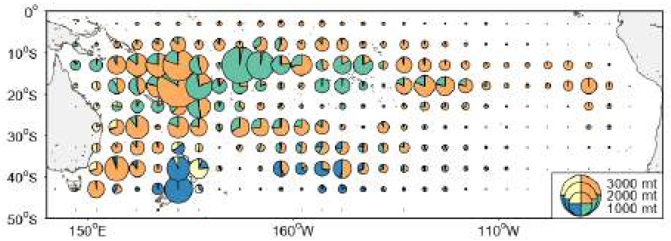
Data inform modelled processes

Industrial fishing (example - albacore)

Scientific campaigns (skipjack)

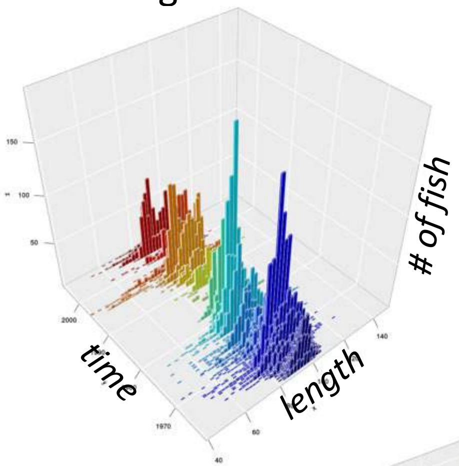
1 - Catch (and effort) data:





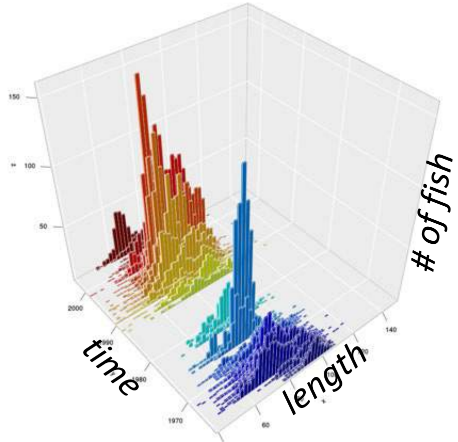
Poor: abundance, natural and fishing mortality
Bad: spatial distributions, habitats and movements, spawning sites

2 - Length data:



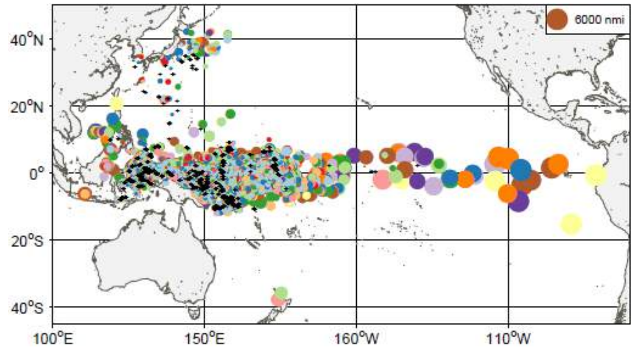
LL north of 25S

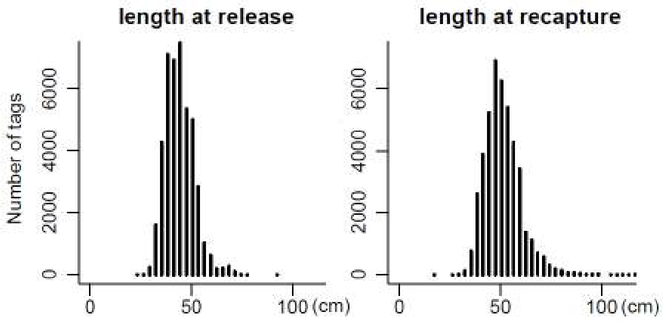
LL south of 25S



<u>Catch + Length</u>
Good: reproduction and mortality rates, spatial extent
Poor: spatial distributions and movements

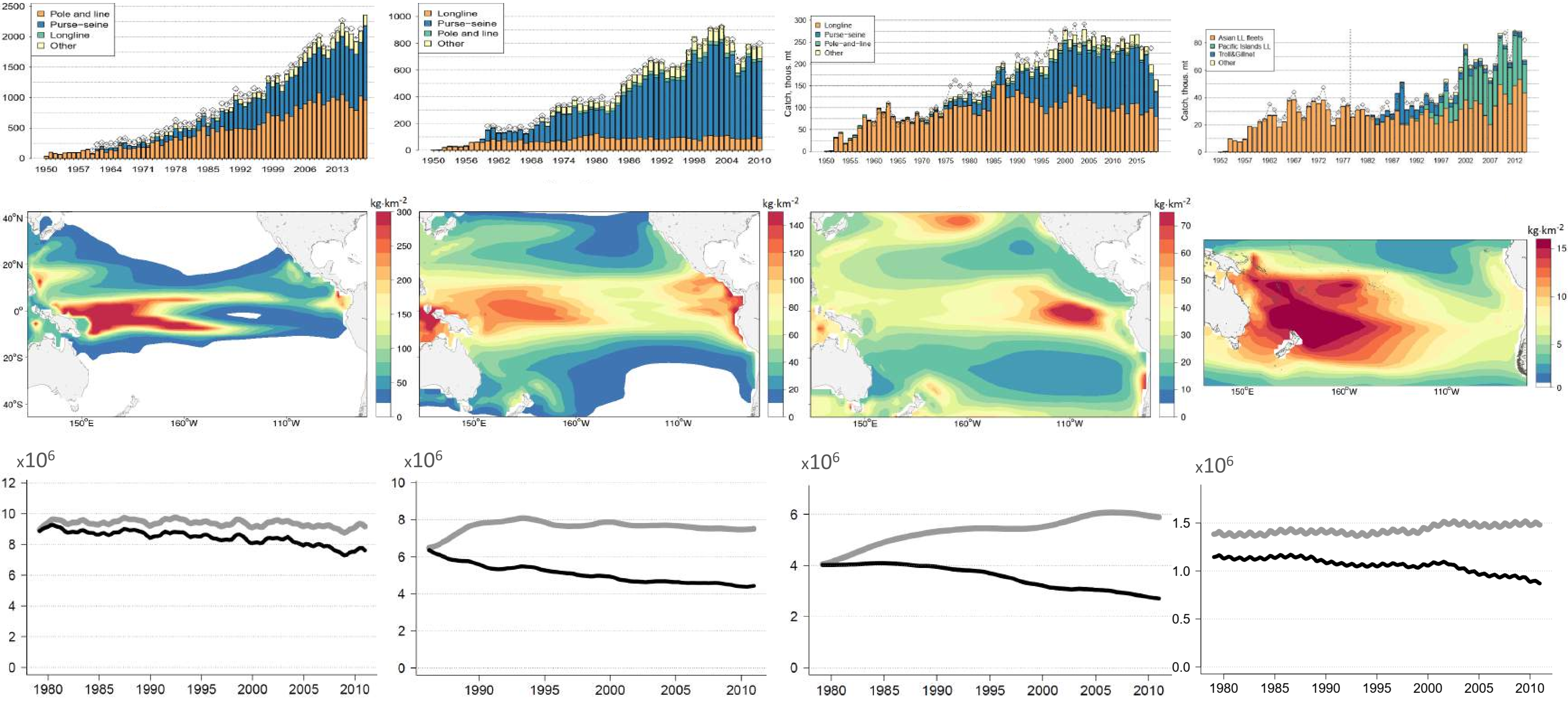
3 – Conventional tagging data:





Good: habitats, movement rates, spatial distribution

Differences among the four target tuna species



Uncertainties in quantitative modelling

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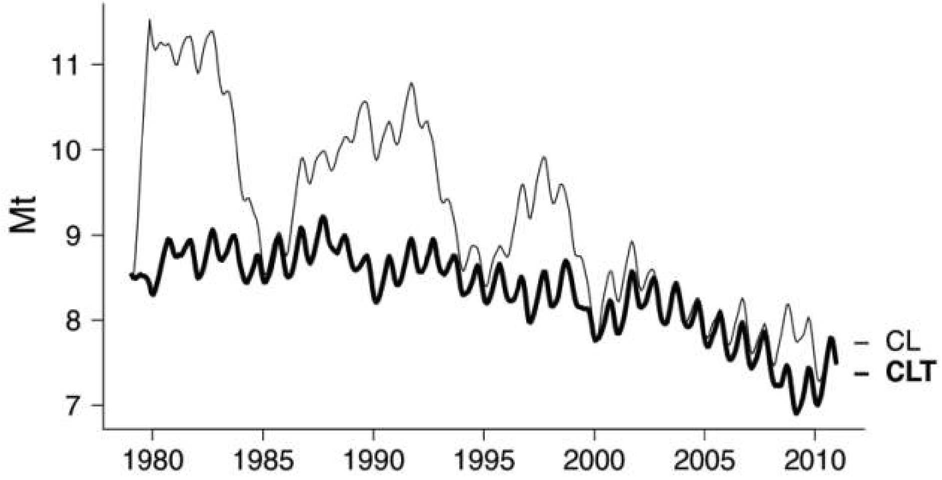
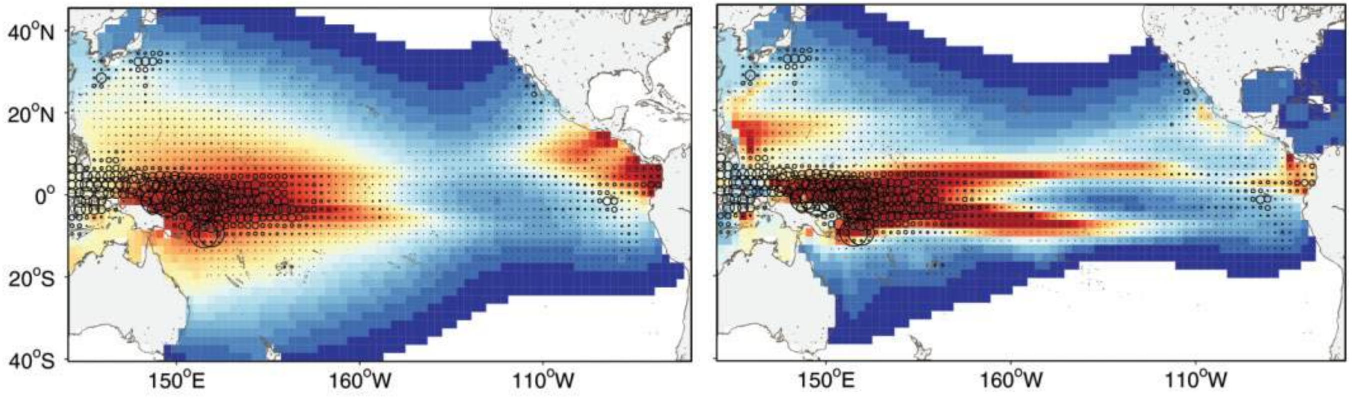


Catch + Length data

Catch + Length + Tagging data



1-5. **Tuna model structural uncertainties;**

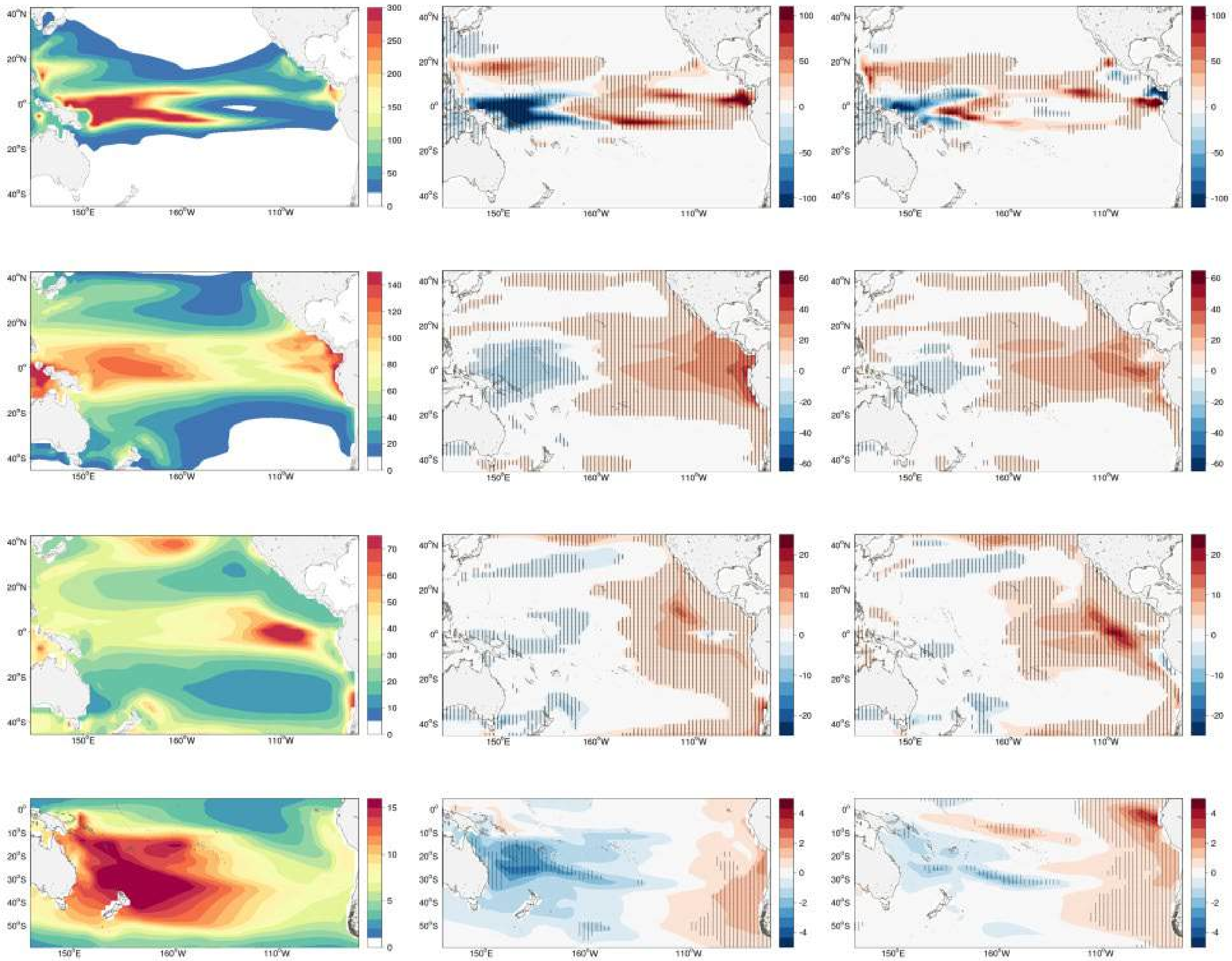
6. **Parameter estimation sensitivity to**
   1. **data (fisheries) structures and errors in the data**
   2. **ocean forcings (*as fixed parameters*) and their biases**
   3. **data coverage / parameter observability from data**
   4. **time window selection**
   5. **model resolution**

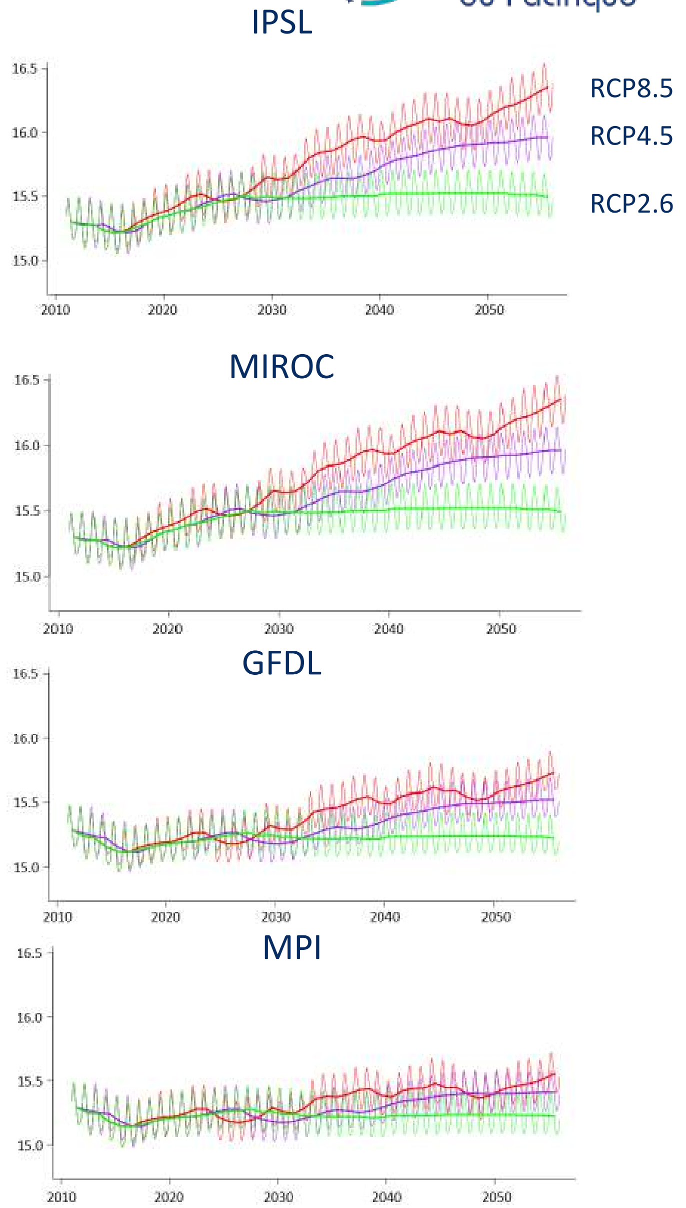
Tuna projections under global warming with RCP8.5 and RCP4.5

2011-2020

RCP 8.5 2050

RCP 4.5 2050





Tuna projections under global warming with RCP8.5 and RCP4.5

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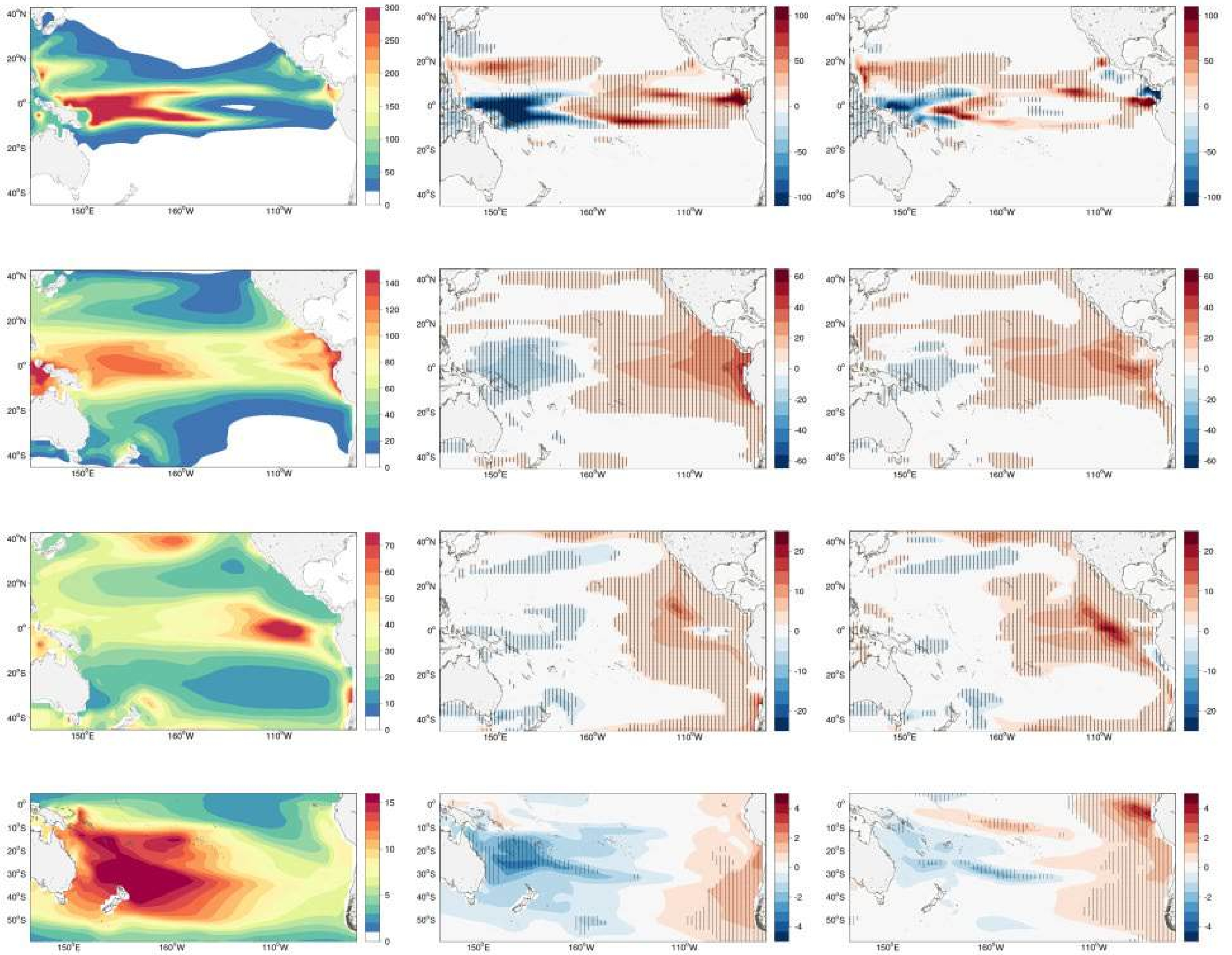
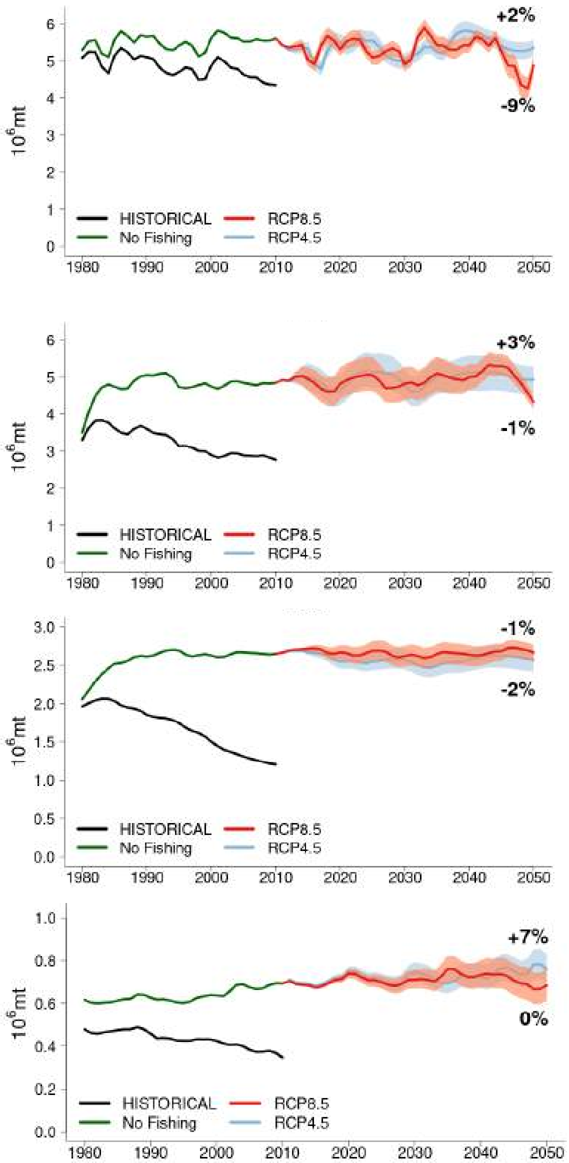
2011-2020 | **RCP 8.5 2050** | **RCP 4.5 2050**



WCPO



Take home messages

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- SEAPODYM has been developed over 30 years and has matured into a robust framework for assessing the impacts of past and future climates. We've had a long and highly effective and appreciated collaboration with IATTC throughout this development.

- At the basin-scale model interpretation of trends in distribution are relatively insensitive to the climate forcings used to paramterise the model. Conversely, at sub-regional and more localised scale the results are sensitive to the climate forcings used.

  - The degree of investment in model optimisation <u>is application dependent</u>

- Quantitative (Predictive) modeling of fish populations dynamics requires data to observe <u>all modelled dynamic processes</u> and <u>realistic description of tuna environment</u> on historical, decadal and climate timescales.

- SPC's ongoing and future work is dedicated to:

  - reducing uncertainties linked to the model structure and parameter estimation.

  - providing better quantification of uncertainties related to climate modelling.

  - Coupling fleet dynamics to SEAPODYM to facilitate an integrated estimate of the impact of climate on fishing effort distribution and catch.

Take home messages

- Current results indicate agreement between the different models on distributional shifts suggesting that it’s not a question of ‘IF’ the tuna biomass will shift due to climate change in the Pacific, but ‘WHEN’ and ‘TO WHAT EXTENT’.

- Moderate redistributions of tuna under a lower-emissions scenario indicates that reductions in greenhouse gas emissions, in line with the Paris Agreement indicate a stabilization after 2050 in future distributions.

  - Higher emission scenarios suggest continued distributional shifts in tuna after 2050 and reduction in biomass across the Pacific basin.

Thanks – happy to take questions