Application of SEAPODYM to the Pacific Pelagic Ecosystem. Recent results and perspectives

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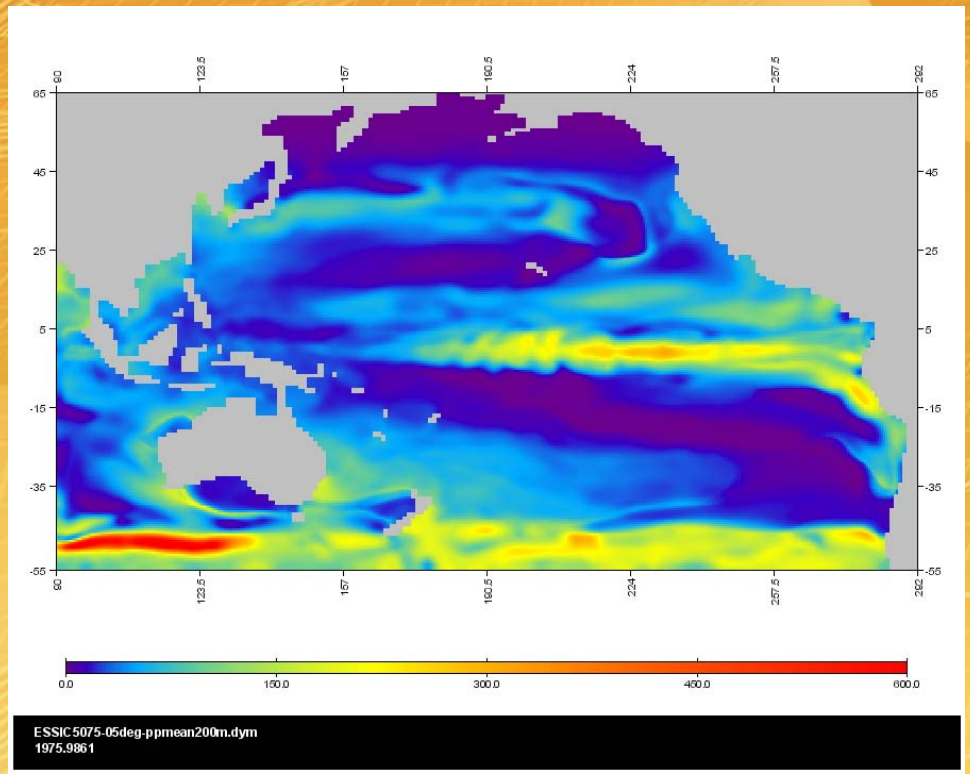
SEAPODYM: Spatial model driven by physical and “simplified” food-web interactions

Climate/environment variability



Temperature

Currents

Oxygen

Primary production

Mid-trophic levels

= predators forage

Interactions

Predators

= Tunas, billfish …

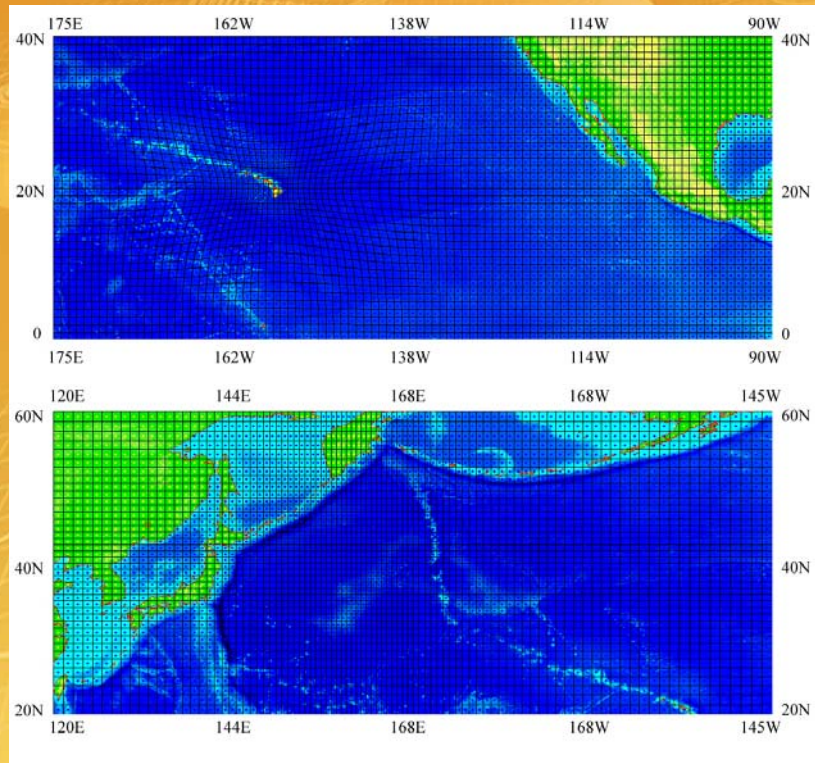
Interactions

Fisheries

Fishing impact

2004-05 achievements

- Model using a new numerical scheme for transport allowing to run the model with non-regular grid (ME-WP 2)



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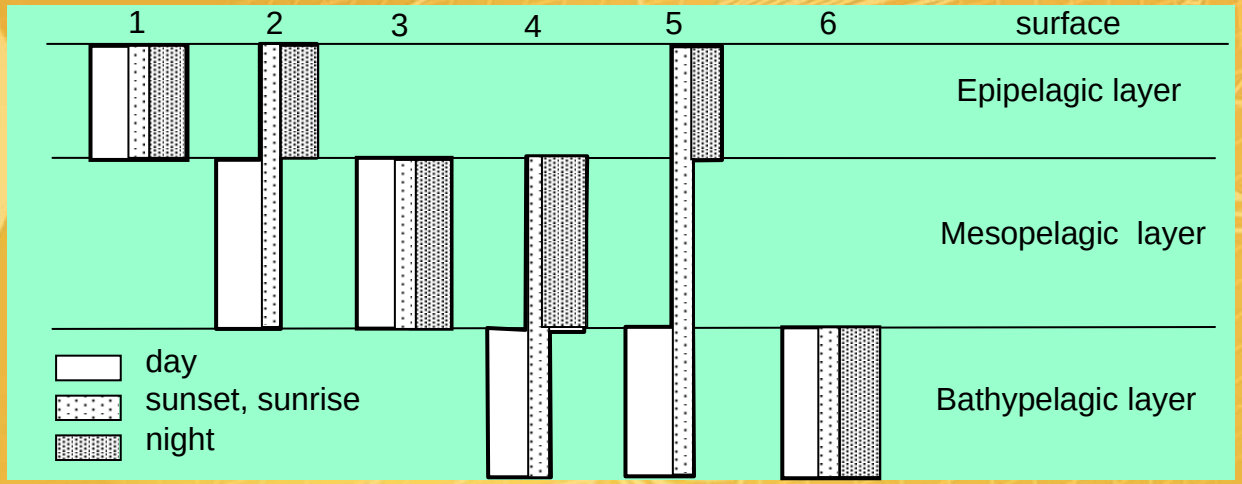

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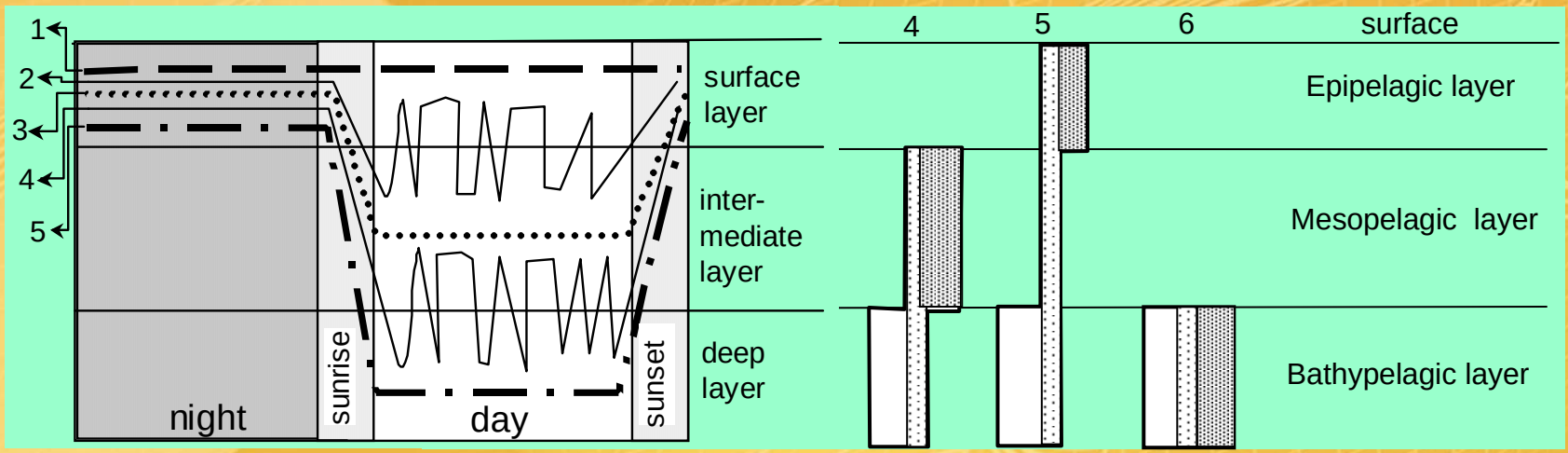

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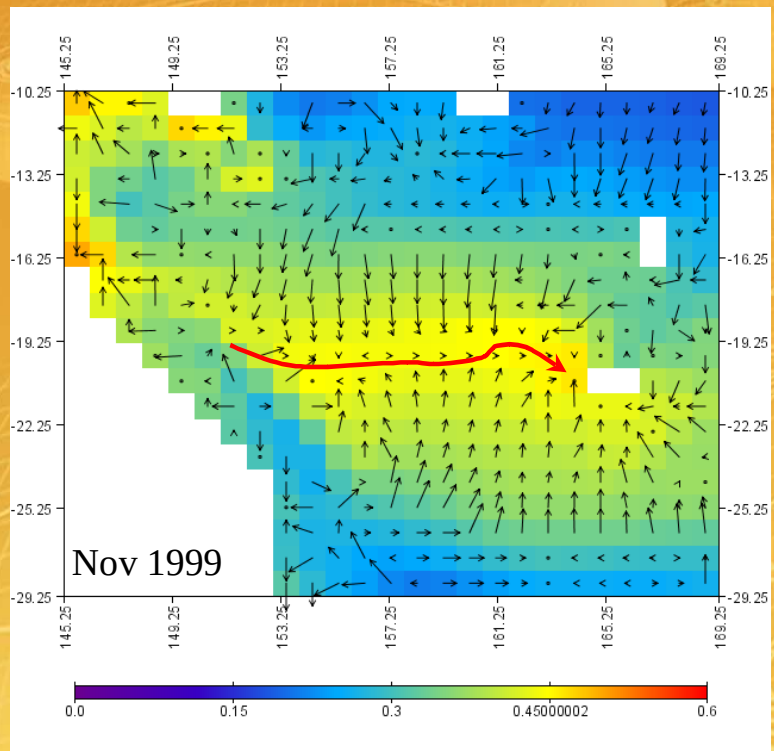

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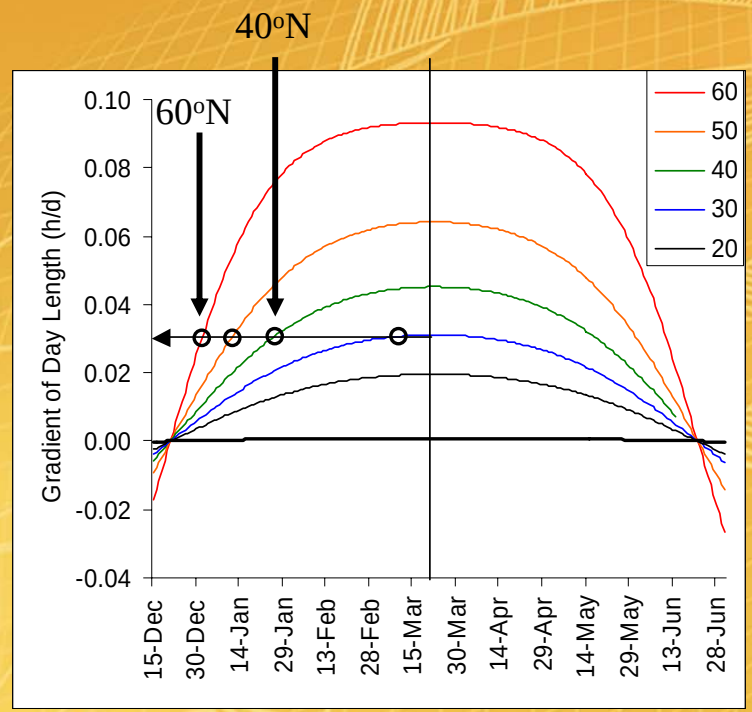

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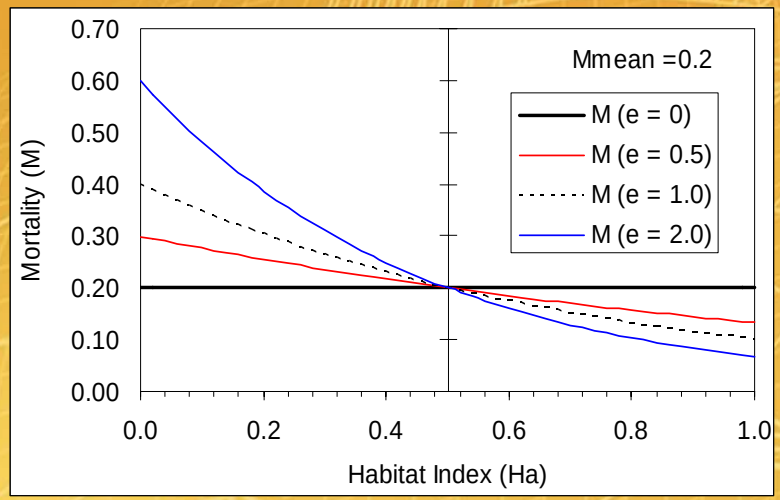

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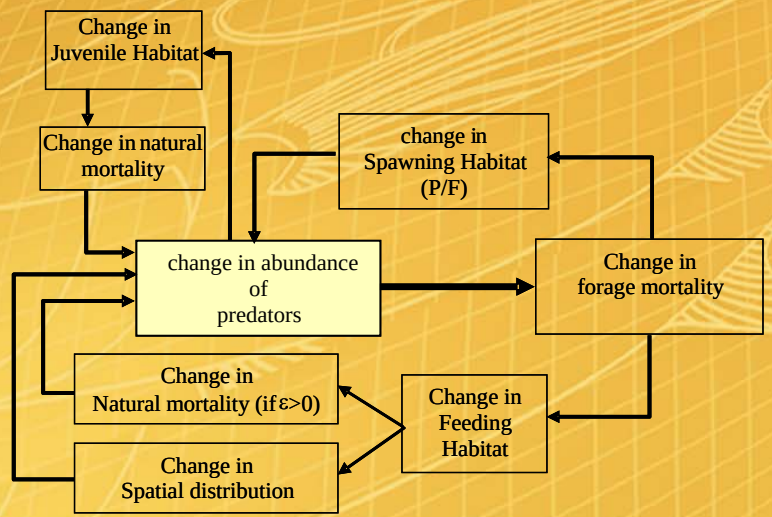

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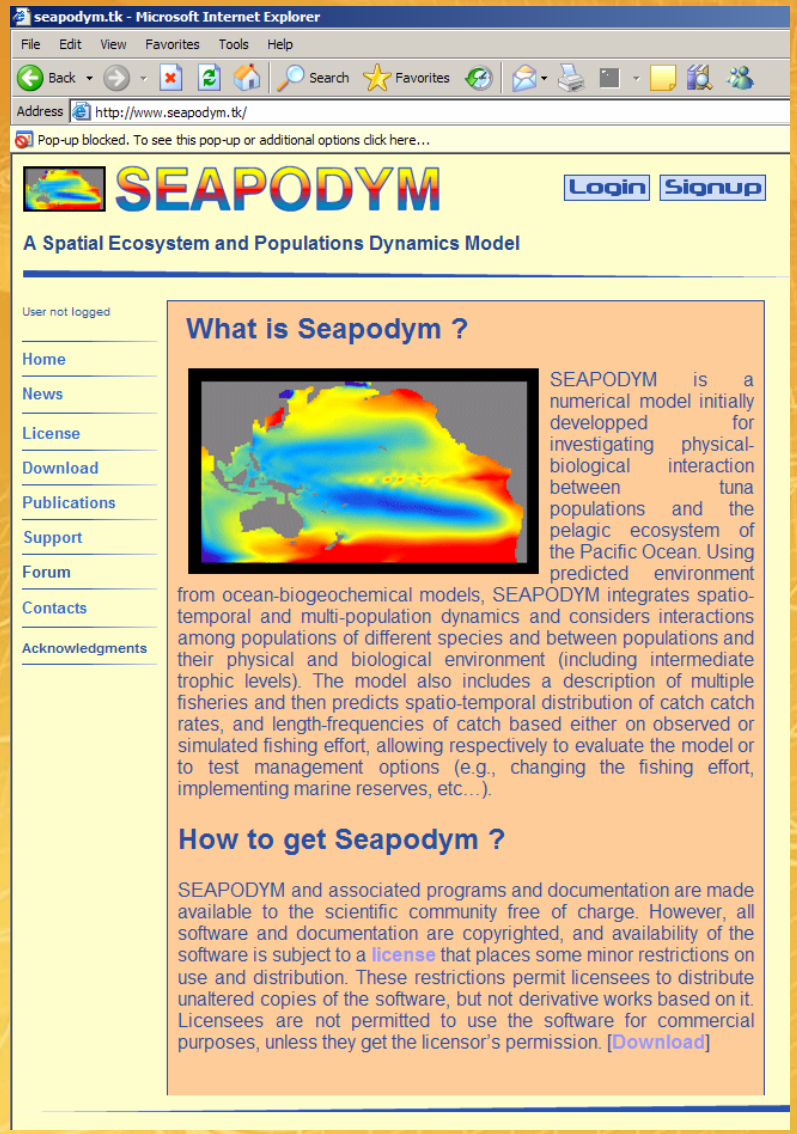
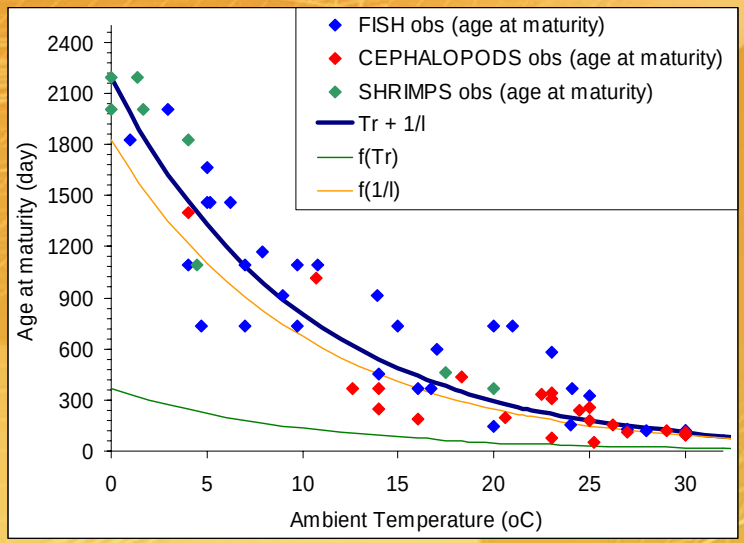
- Executable with documentation (cf. reference manual: ME IP 1), associated softwares and files needed to run simulation will be released on a dedicated web site



Results: mid-trophic levels

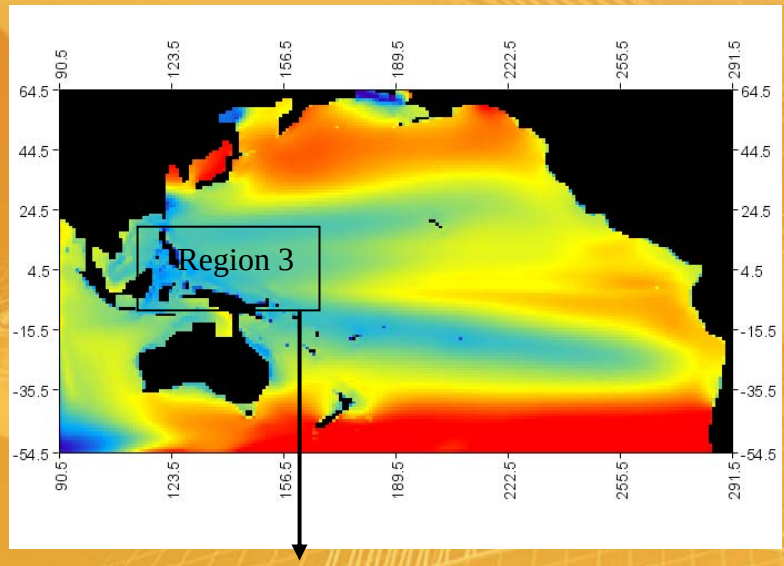
Running forage model alone:

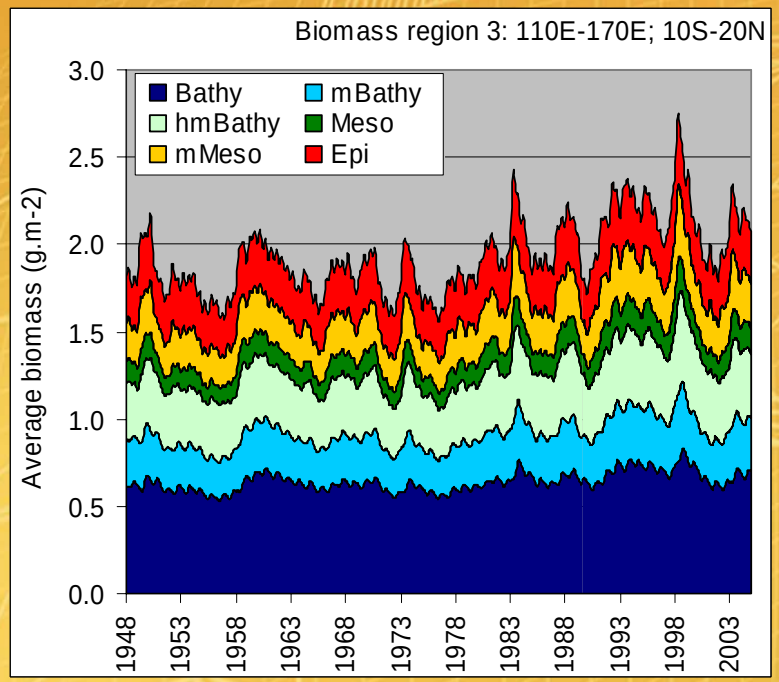
Turn-over of forage component is based on a relationship between temperature and age of maturity of organisms (Q10's rule)



-> this can be considered as a dynamic equilibrium state of the system

-> and then provides a limit of the carrying capacity of the ecosystem mid-trophic levels for top predators species



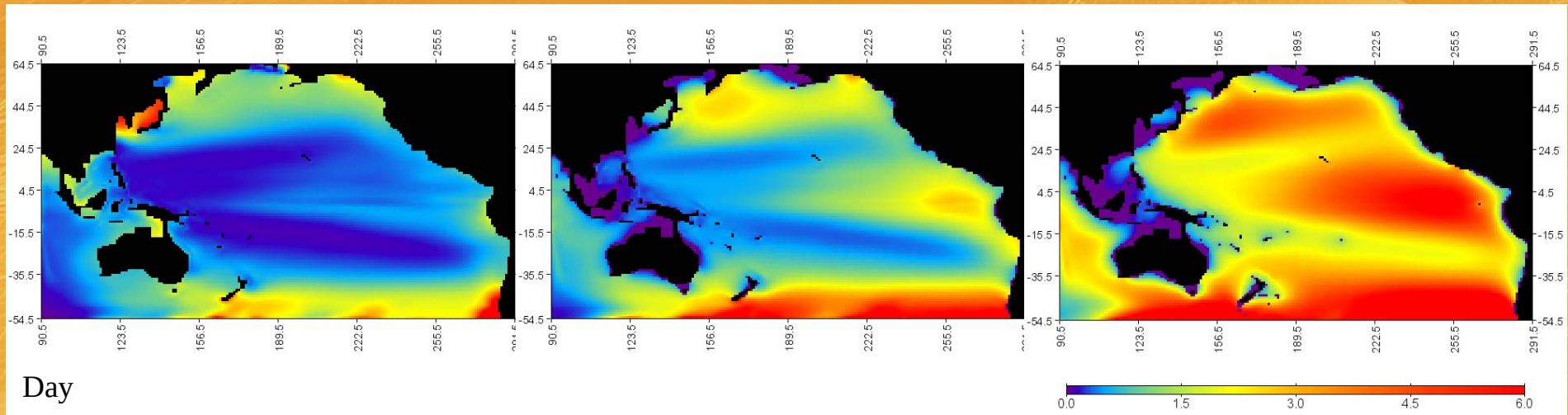


Results: mid-trophic levels

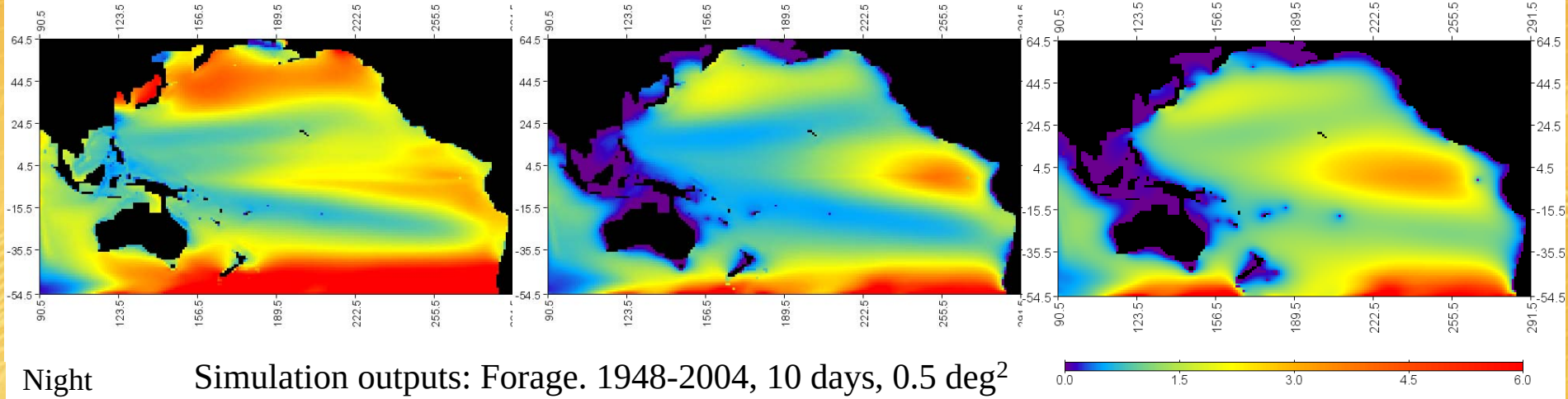
Epi-pelagic layer
(0-100m)

Meso-pelagic layer
(100-400m)

Bathy-pelagic layer
(400-1000m)



Day

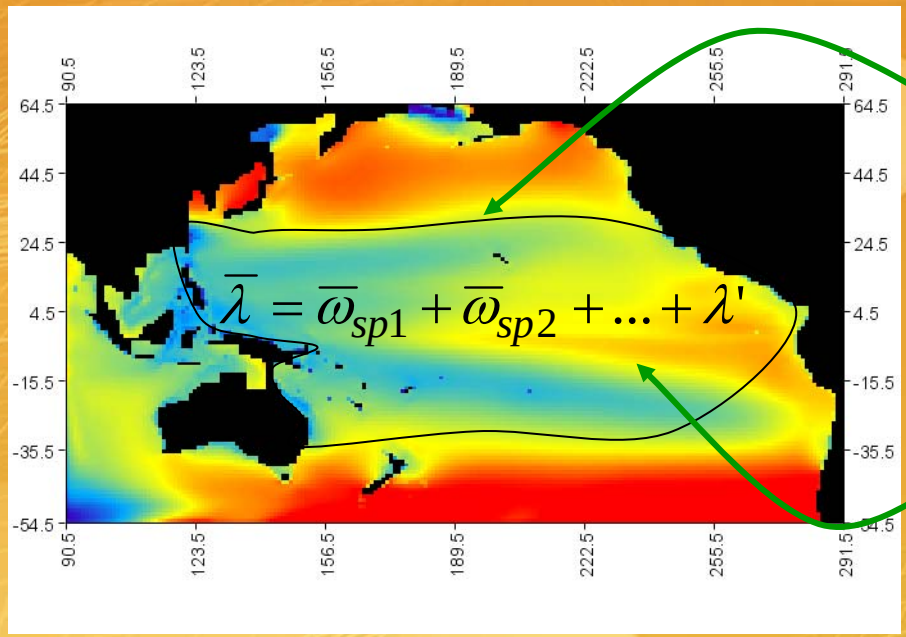


Night

Simulation outputs: Forage. 1948-2004, 10 days, 0.5 deg^2

Results: prey-predator coupling

- **it is possible to have from zero to N predators species explicitly described in the model.**



Over the "specific predator area", the mean forage mortality (for a given component) is the sum of the mortalities due to the predator species described in the model + a residual mortality λ' due to all other predators

Locally, in each cell, the forage mortality due to food requirements of described predators, $\omega_{i,j}$ is caculated according to physical accessibility of the predator species (age) to the forage component considered and to their daily ration (% of body mass)

If sum of $\overline{\omega}_{sp}$ above $\overline{\lambda}$

-> ERROR:

biomass of predators cannot be sustained by the forage component

Outside specific predator area,

forage m = λ(temperature)

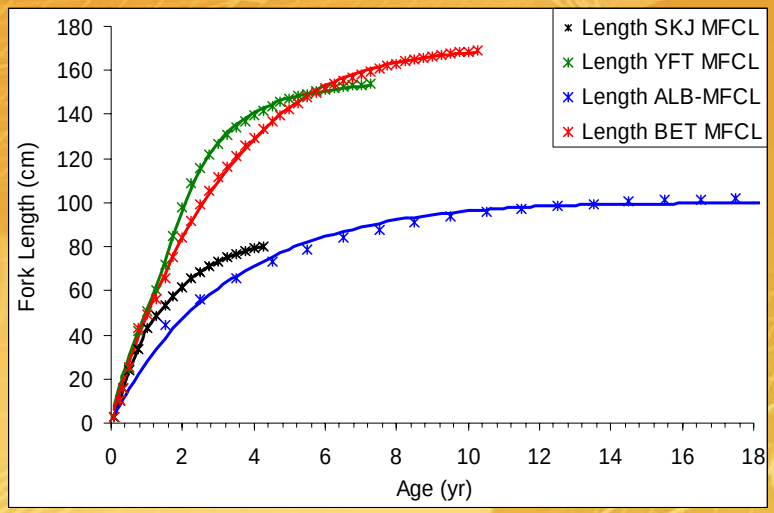
Inside specific predator area

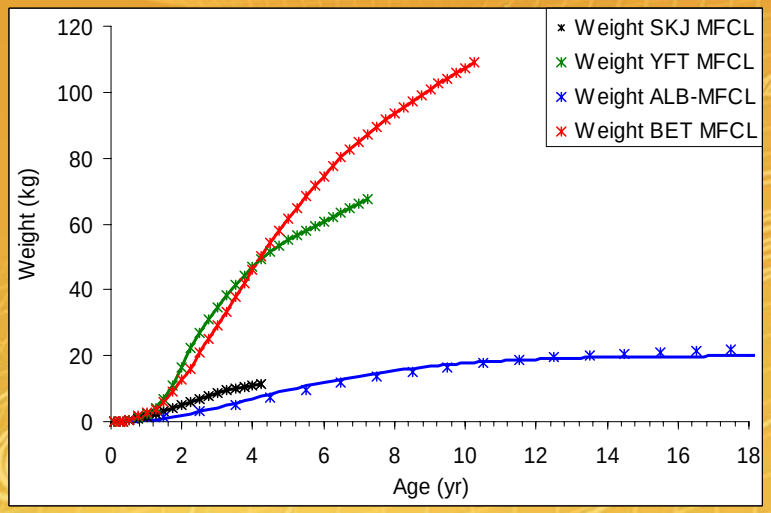
forage m = $\omega_{i,j}$ + λ'

Application to skipjack, yellowfin and bigeye tuna

Table 2. Parameterisation of the populations structure in SEAPODYM

	skipjack	yellowfin	Bigeye	
Number of age classes (quarter) after juvenile phase	**16**	**28**	**40**	
Age at first maturity (quarter)	**4**	**7**	**11**	
Age (quarter) at recruitment	**3**	**3**	**3**	





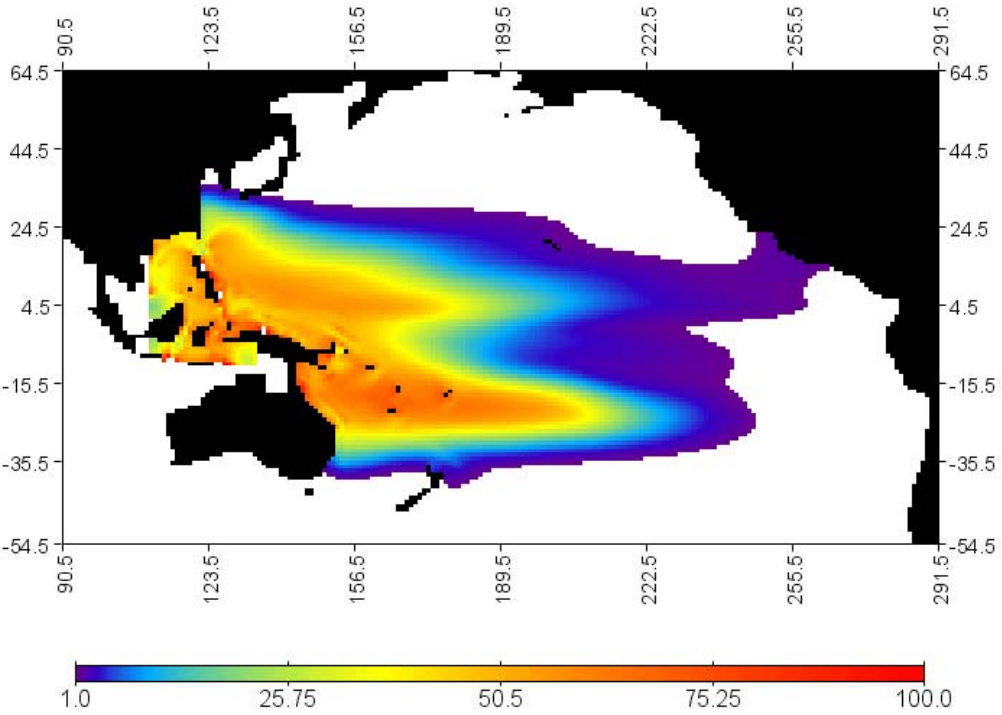
Length-at-age and weight-at-age coefficients estimated from MFCL analyses (crosses) and functions (curves) used to define the coefficient used in SEAPODYM simulations

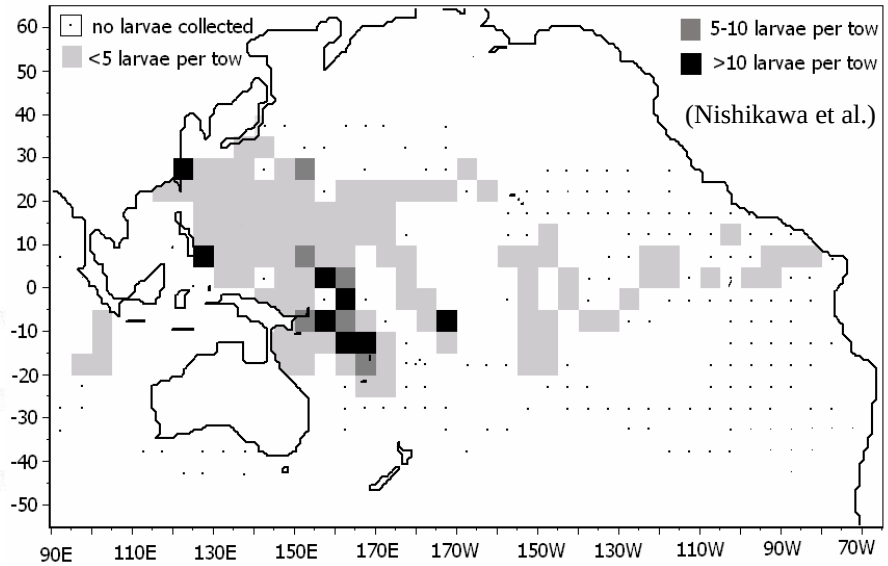
Fisheries

Category code	Description / source / resolution
PURSE SEINE	
WPSASS	Aggregated data of purse seine fisheries in the WCPO Sets associated to animals, log or FAD
WPSUNA	Aggregated data of purse seine fisheries in the WCPO Unassociated sets (i.e. free schools)
EPSASS	Aggregated data of purse seine fisheries in the EPO Sets associated to animals, log or FAD
EPSUNA	Aggregated data of purse seine fisheries in the EPO Unassociated sets (i.e. free schools)
POLE-AND-LINE	
PLTRO	Aggregated data of tropical (25^{o}N-25^{o}S) pole-and-line fisheries data
PLSUB	Aggregated data of sub-tropical pole-and-line fisheries (mostly Japanese domestic fleets)
LONGLINE	
LLP80	Aggregated data of longline fisheries before 1980 (The pre-1980/post-1980 categories was to (very roughly) define the change from targetting yellowfin to targetting bigeye)
LLSHW	Aggregated data of longline shallow after 1980 (mainly TW and mainland Chinese LL offshore fleets
LLDEEP	Aggregated data of deep longline fisheries after 1980
LLMIX	Aggregated data of “mixed” longline fisheries after 1980
DIVERSE	
RINGNET	Aggregated data of ringnet fisheries (mainly Philippines, Indonesia)
ARTSURF	Aggregated data of artisanal surface fisheries (including ringnet, mainly Philippines, Indonesia)
COMMHL	Aggregated data of commercial handline fisheries (Philippines, Indonesia, PNG, US)
GILLNET	Aggregated data of gillnet fisheries
TROLL	Aggregated data of troll fisheries

Spawning Habitat

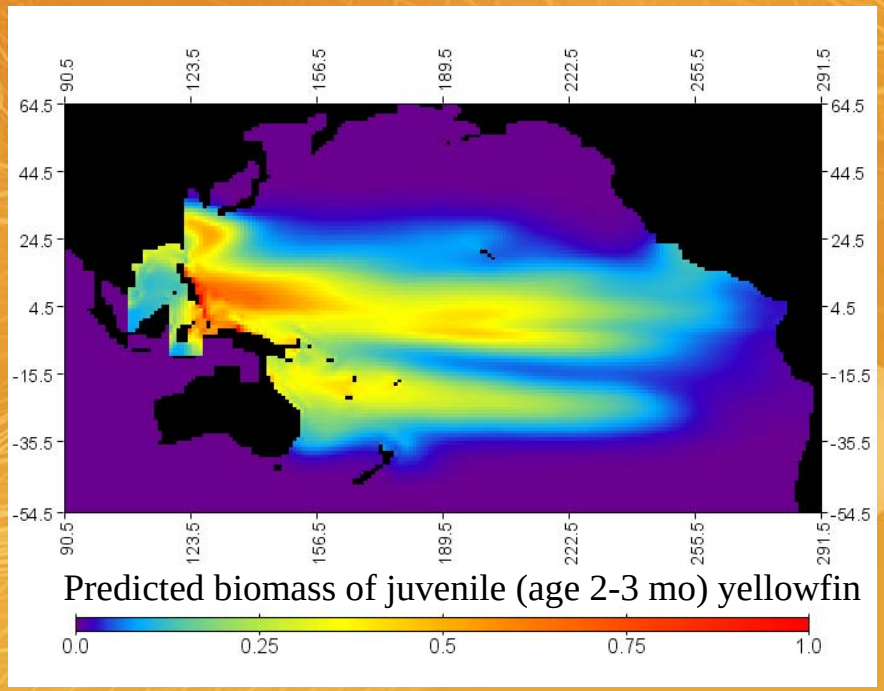
$$H_s = R_s \cdot I_{\theta s} \cdot e^{\alpha \cdot \log\left[1+\frac{P}{F_l}\right]}$$



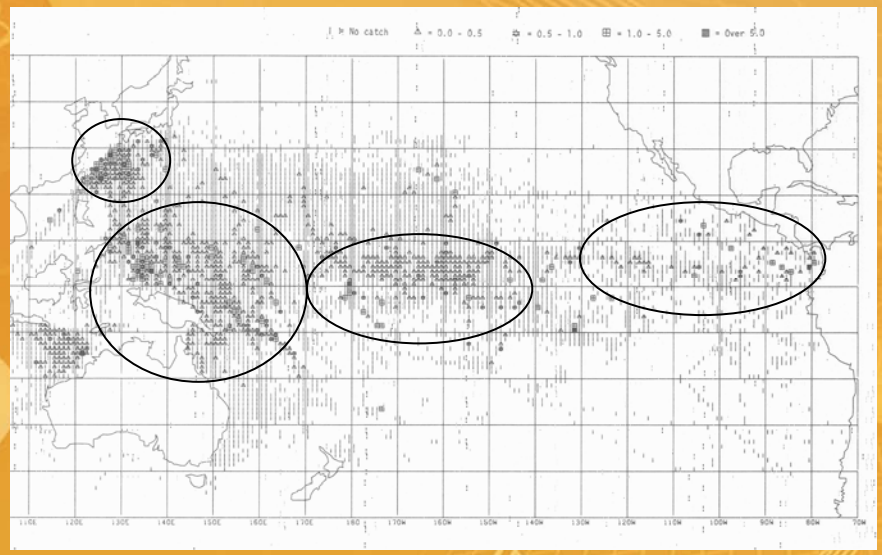


Average predicted distribution of skipjack larvae-juvenile (age-2-3 months) for 1950-75

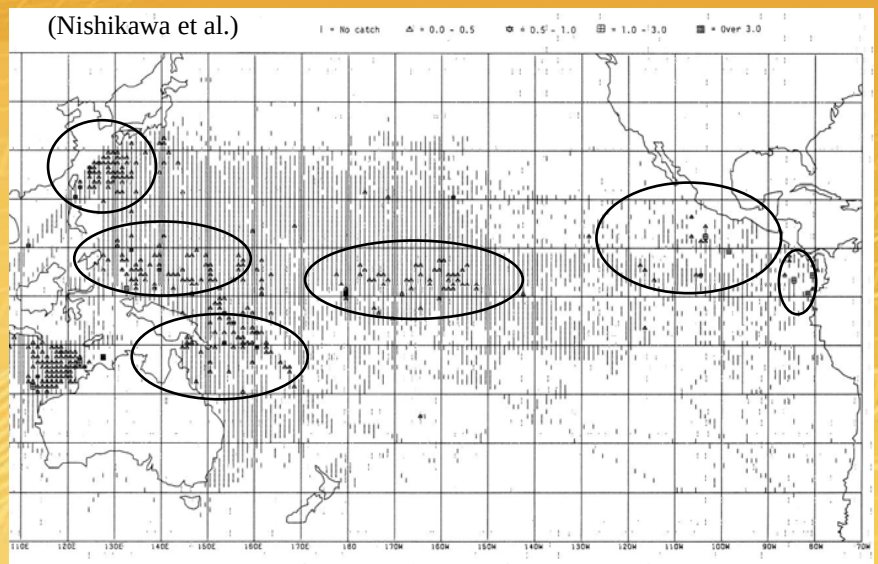
Distribution of skipjack larvae (Nishikawa et al, 1985)

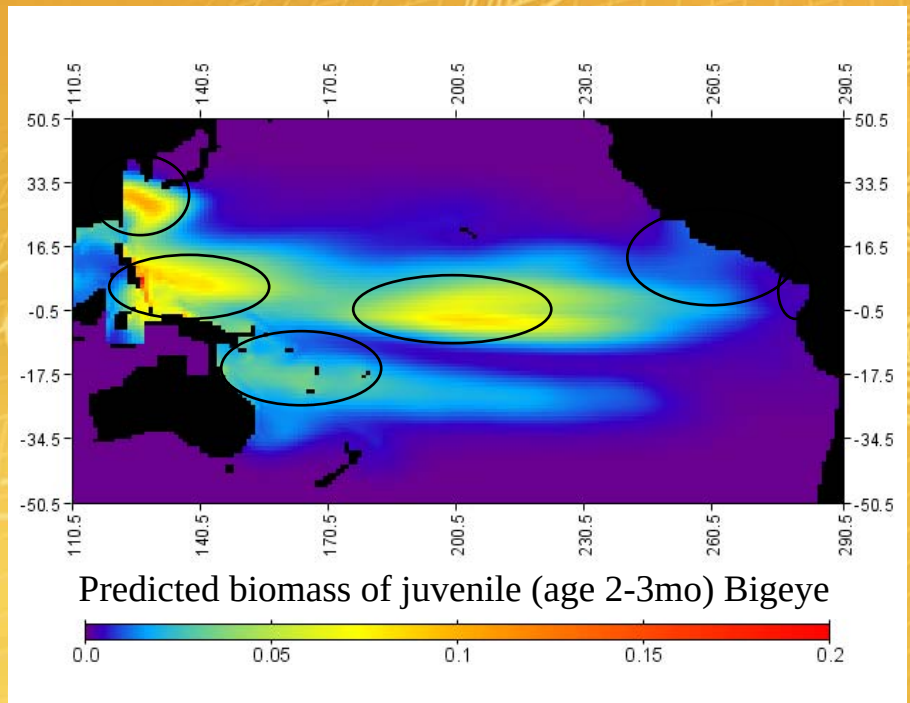


Predicted biomass of juvenile (age 2-3 mo) yellowfin



(Nishikawa et al.)

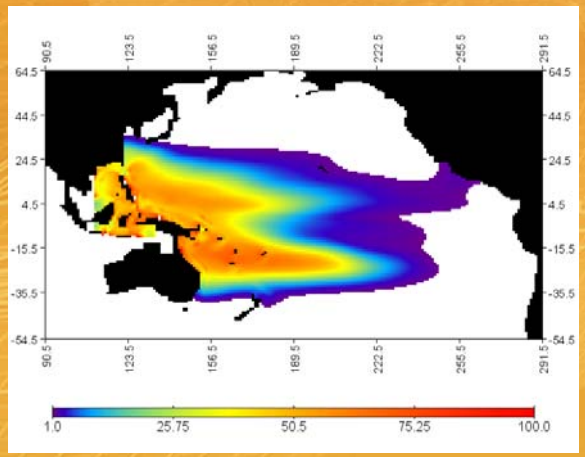


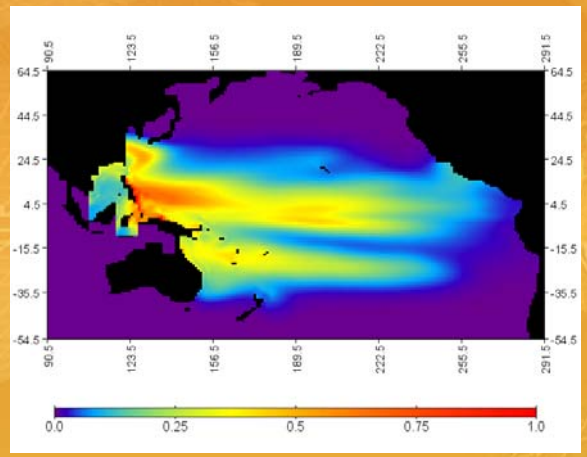


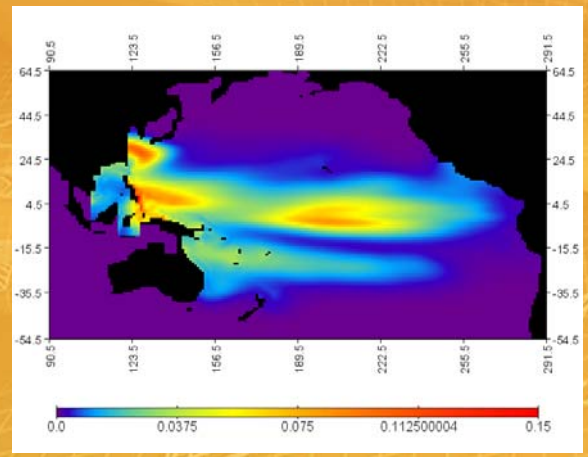
Predicted biomass of juvenile (age 2-3mo) Bigeye

Skipjack **Yellowfin** **Bigeye**

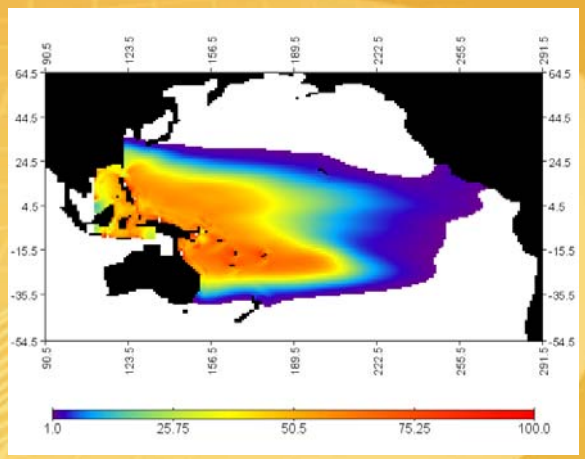
1950-75

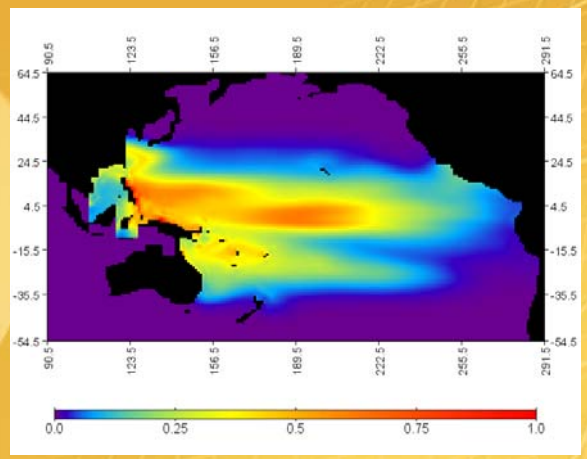


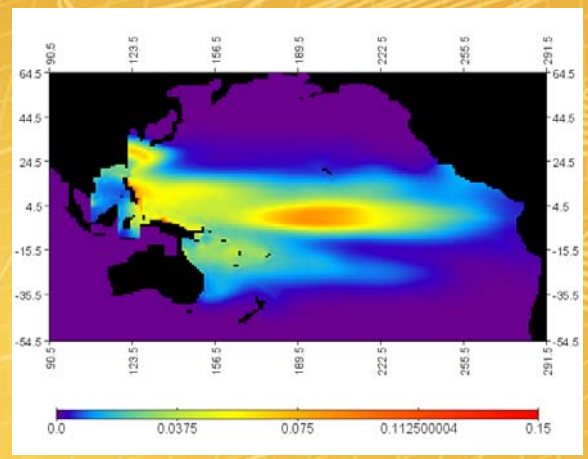




1976-98



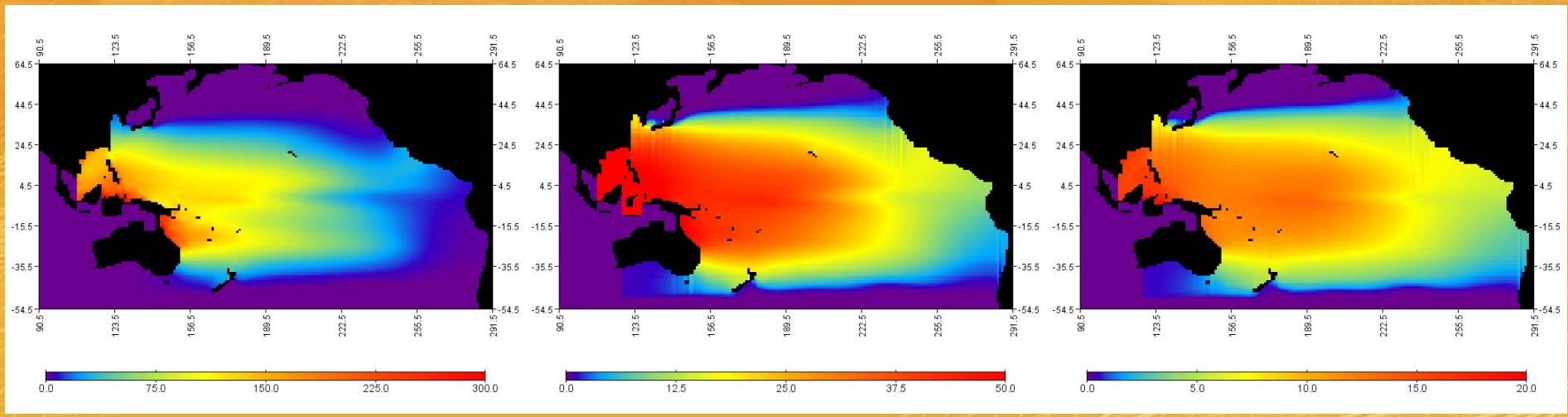




Average predicted distribution of juvenile (age 2-3 months) biomass during decadal period 1950-75 and 1976-98

Skipjack **Yellowfin** **Bigeye**

1950-75



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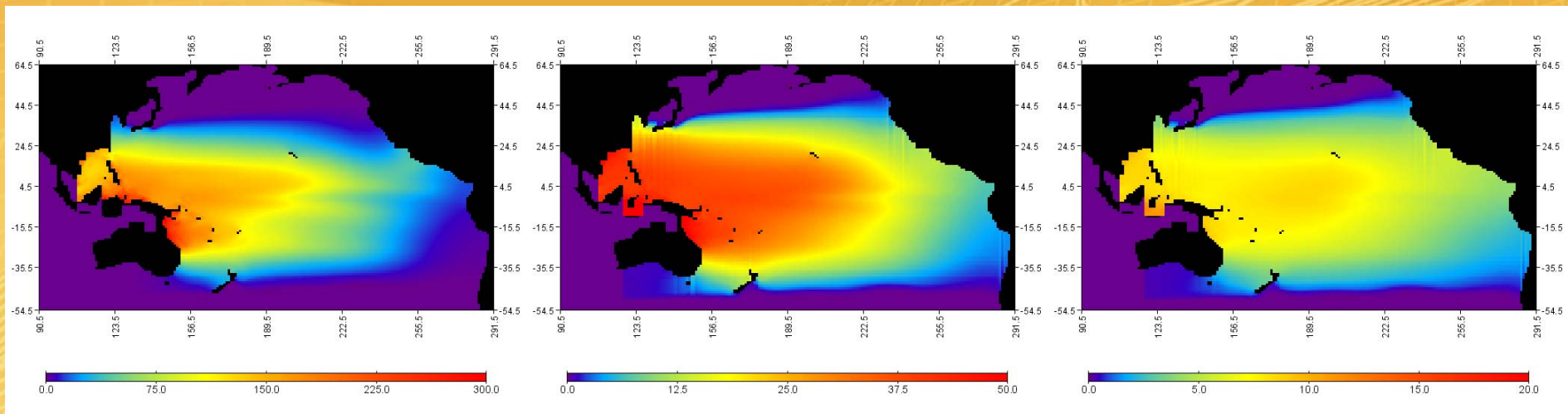
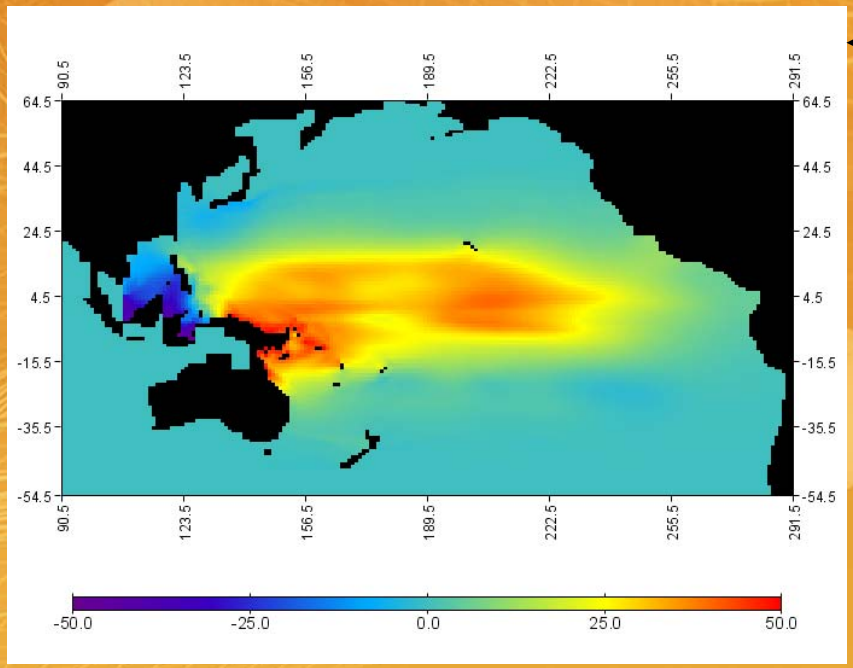
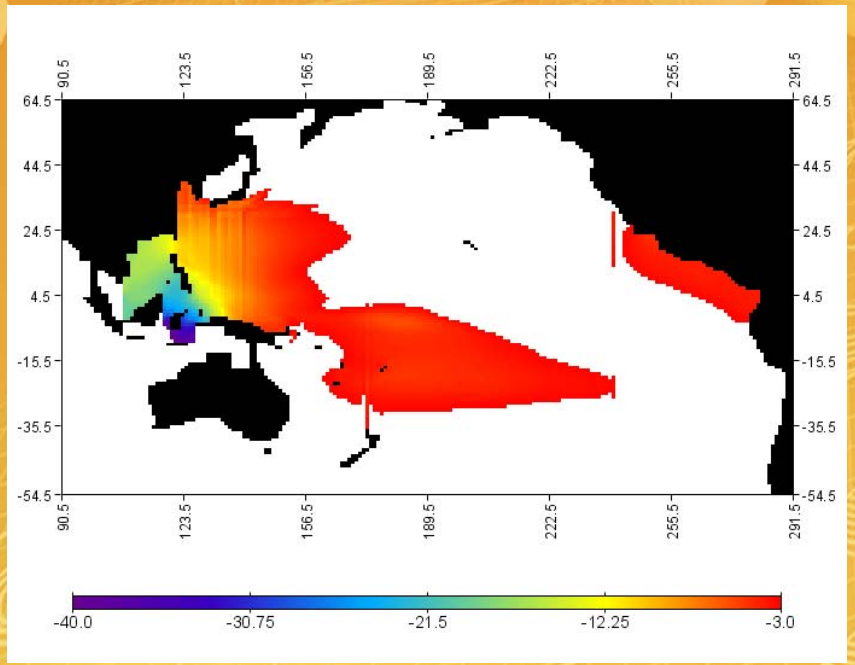


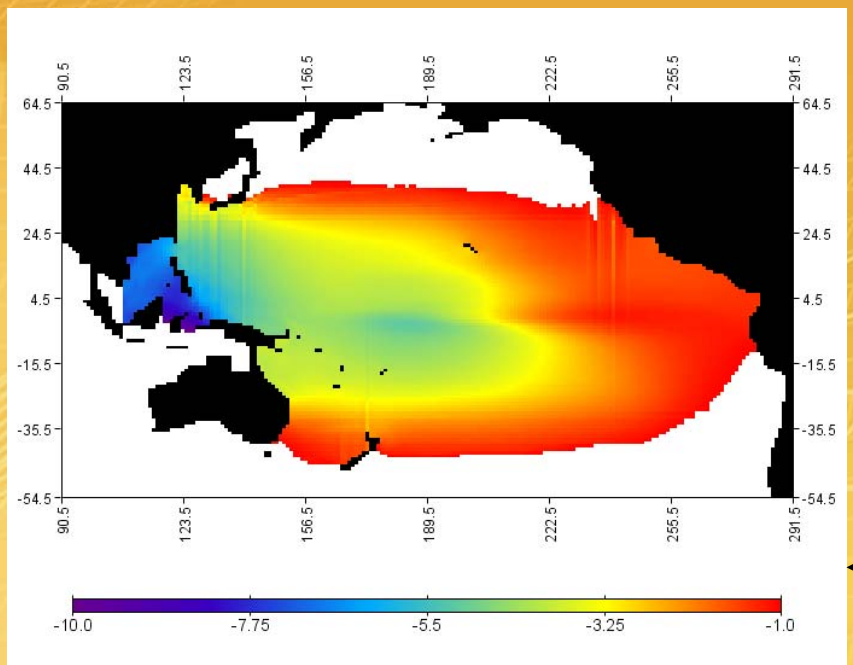
Average predicted distribution of **total biomass** during decadal period 1950-75 and 1976-98



Skipjack anomaly (1976-98) – (1950-75)

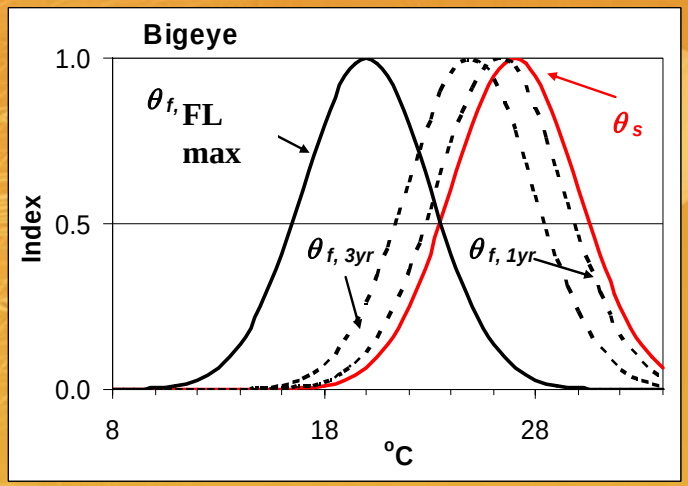
Yellowfin anomaly (1976-98) – (1950-75)

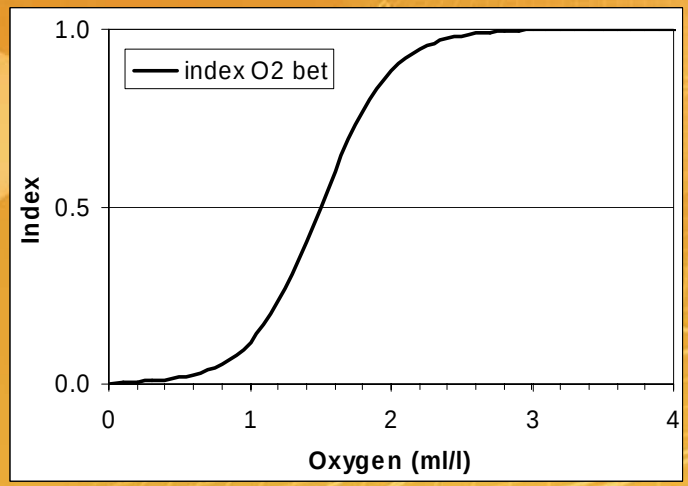


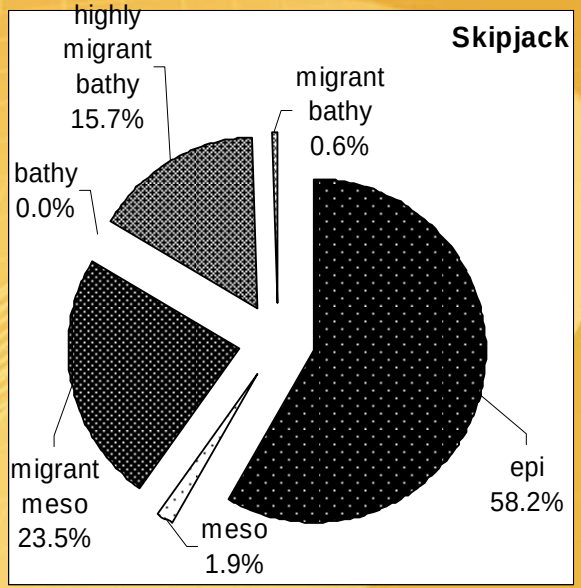


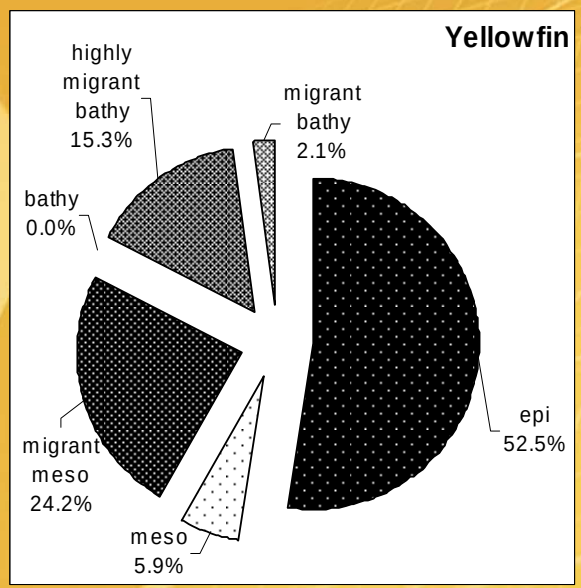
Bigeye anomaly (1976-98) – (1950-75)

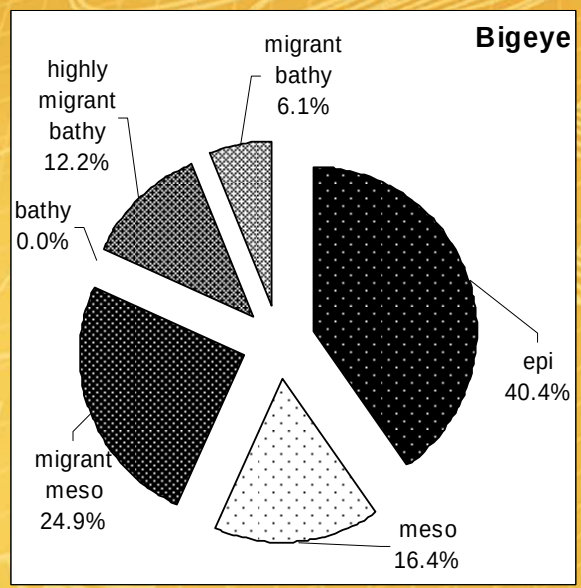
Average forage consumption by species (all age classes) based on accessibility to forage components



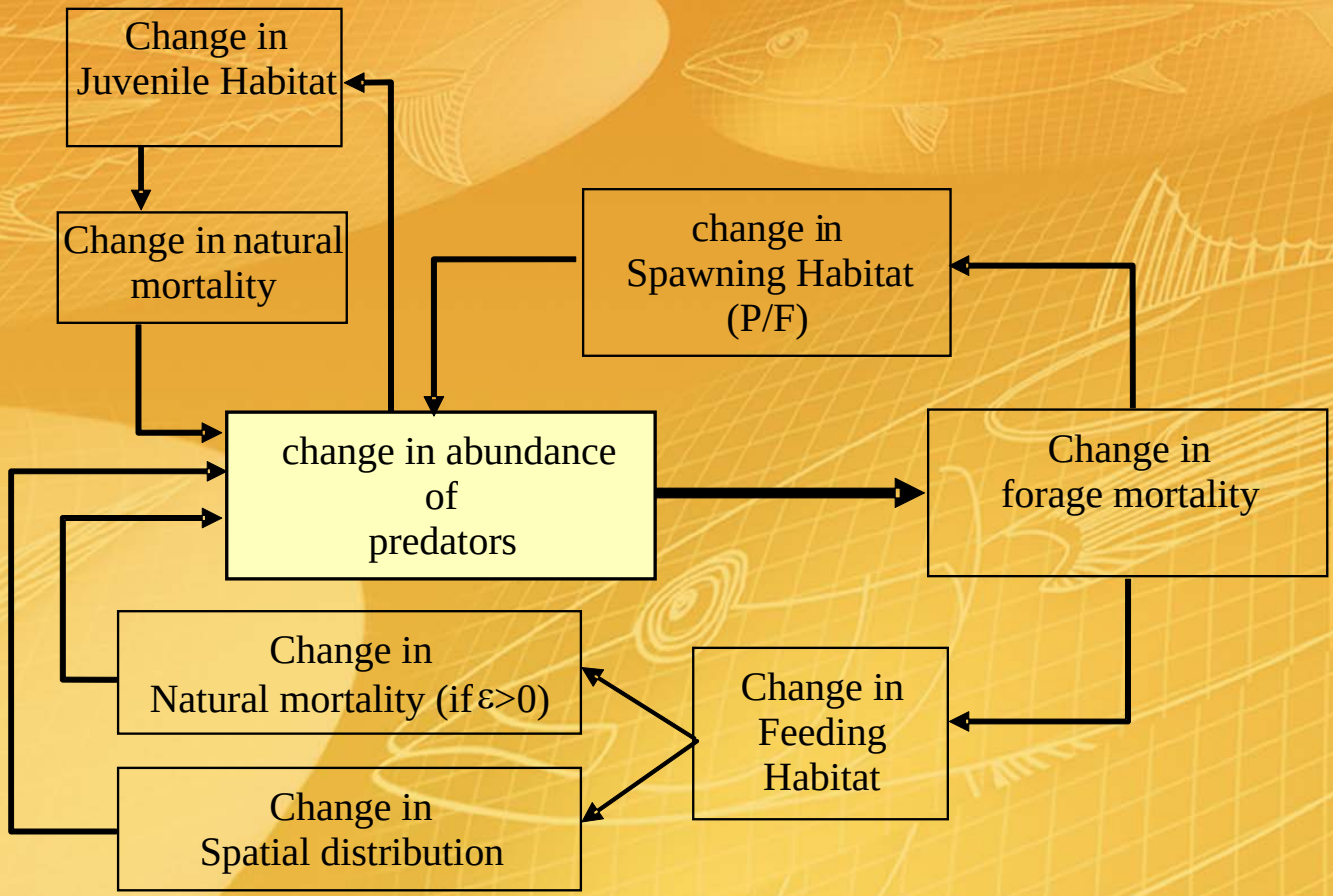








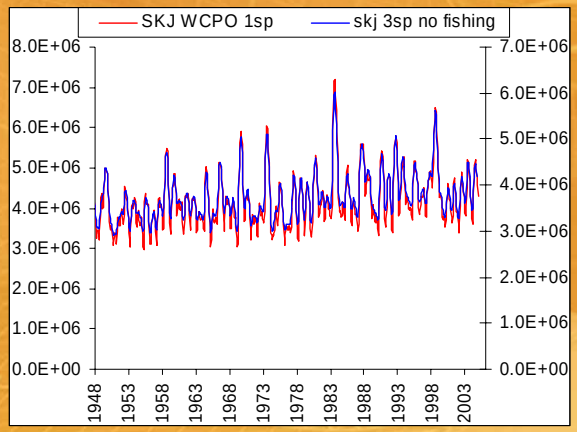
Running single vs multi-species simulations with SEAPODYM: What are the effect of interaction between top predator species like tuna?

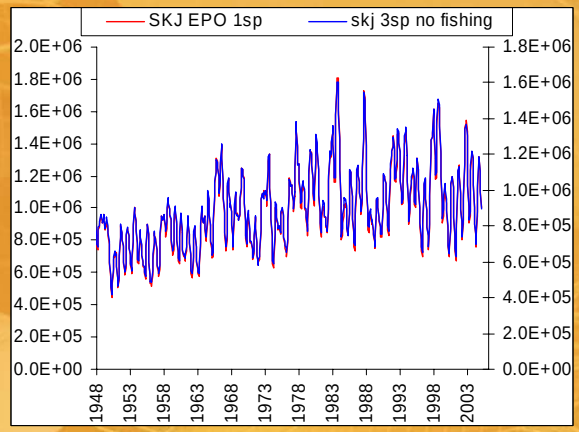


SKJ

YFT

BET


SKJ WCPO 1sp
skj 3sp no fishing


SKJ EPO 1sp
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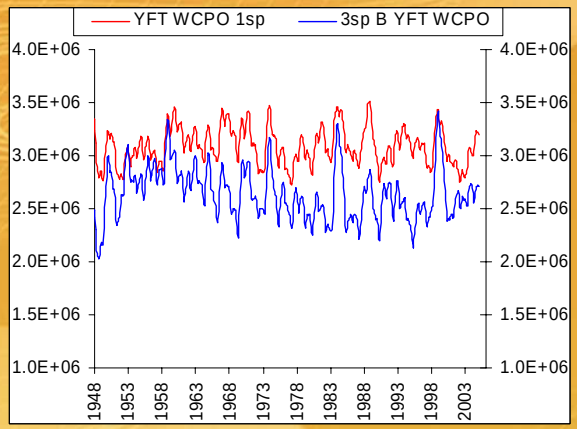
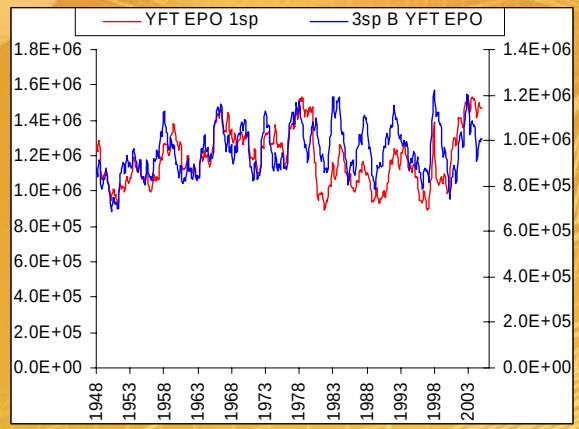
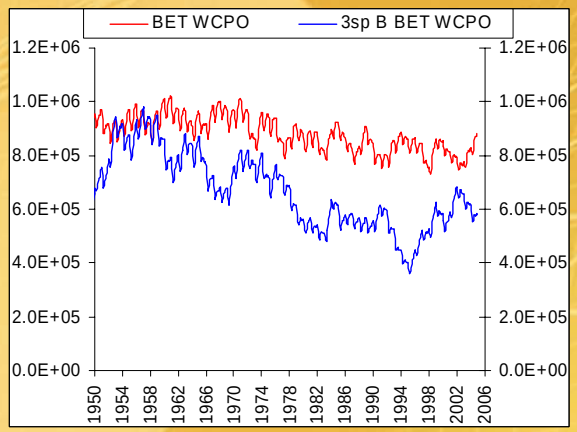

YFT WCPO 1sp
3sp B YFT WCPO


YFT EPO 1sp
3sp B YFT EPO


BET WCPO
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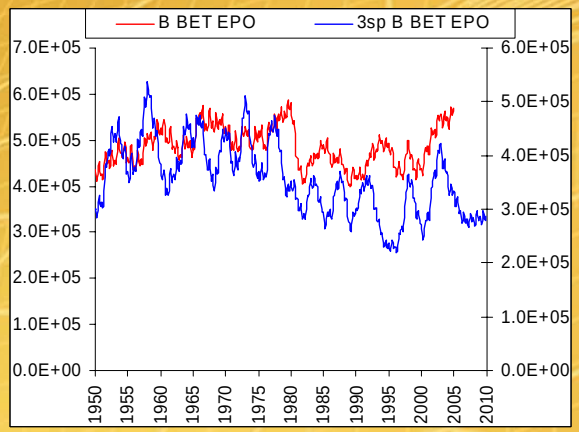
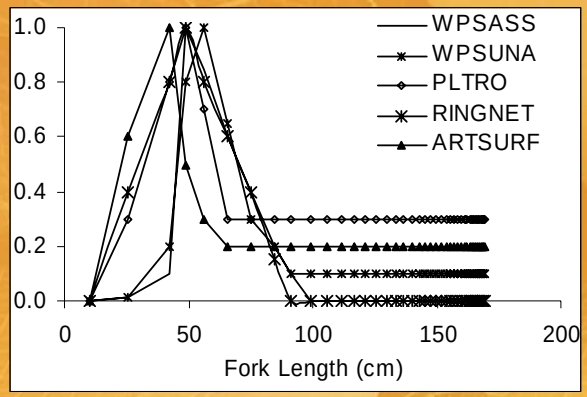
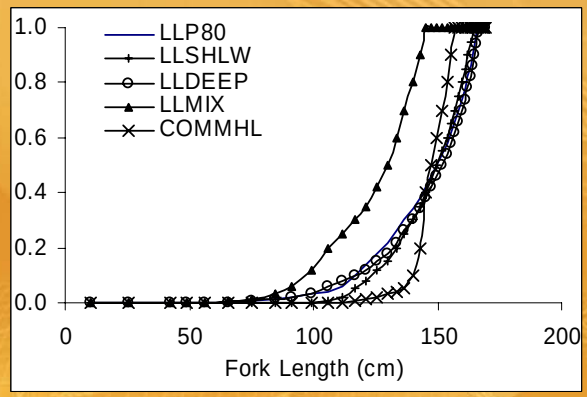

B BET EPO
3sp B BET EPO

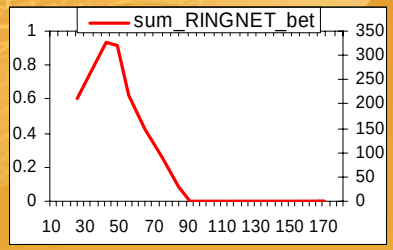
Some more results on bigeye…

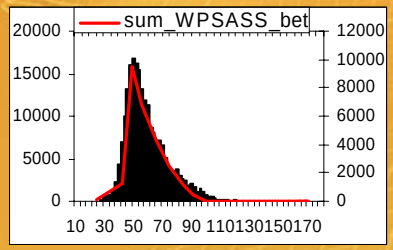
Selectivity

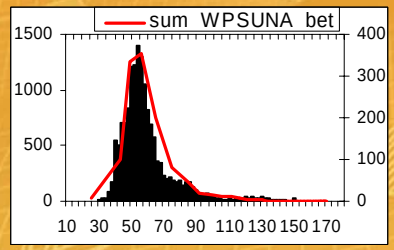
bigeye

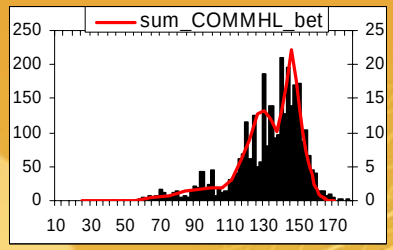


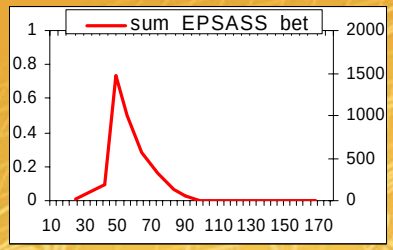


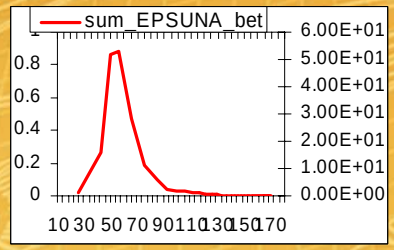


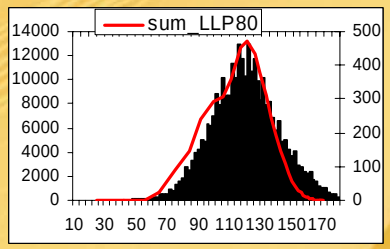


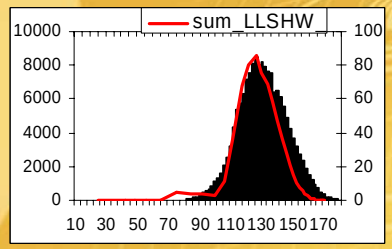


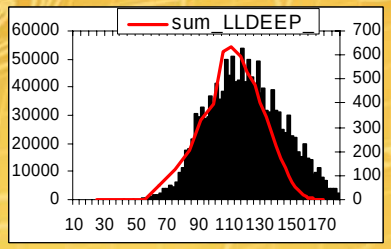


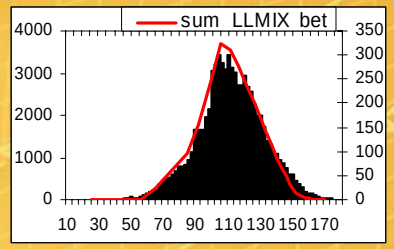




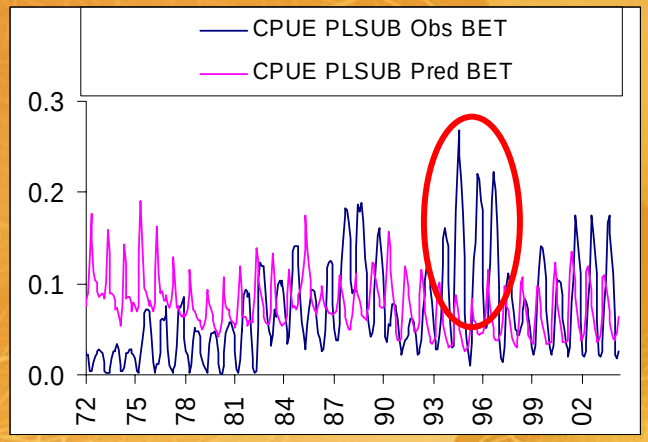


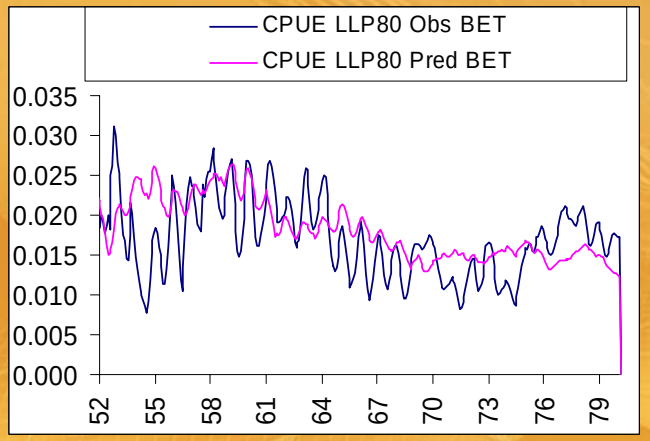


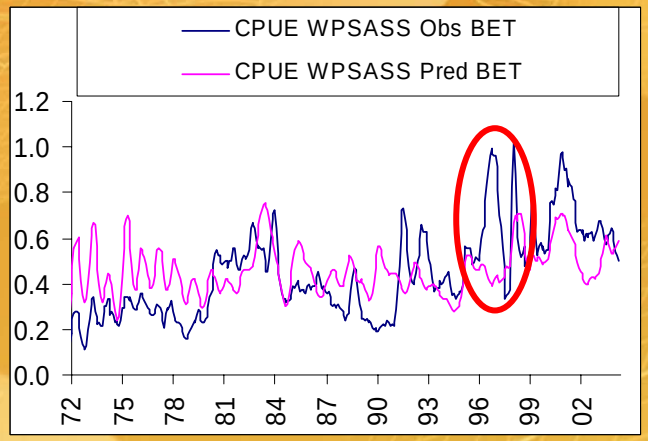


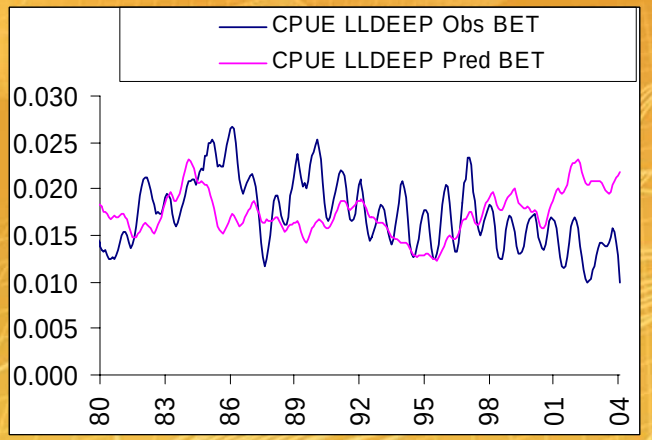


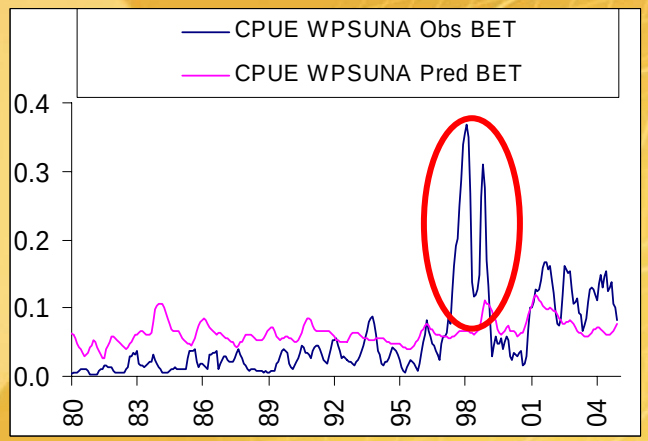
Predicted and observed CPUE

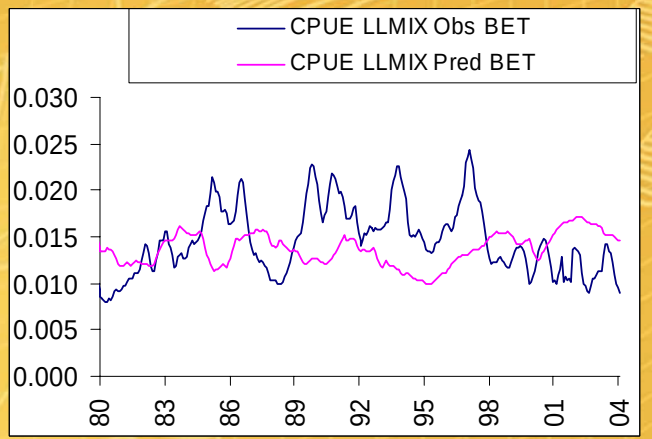












BET

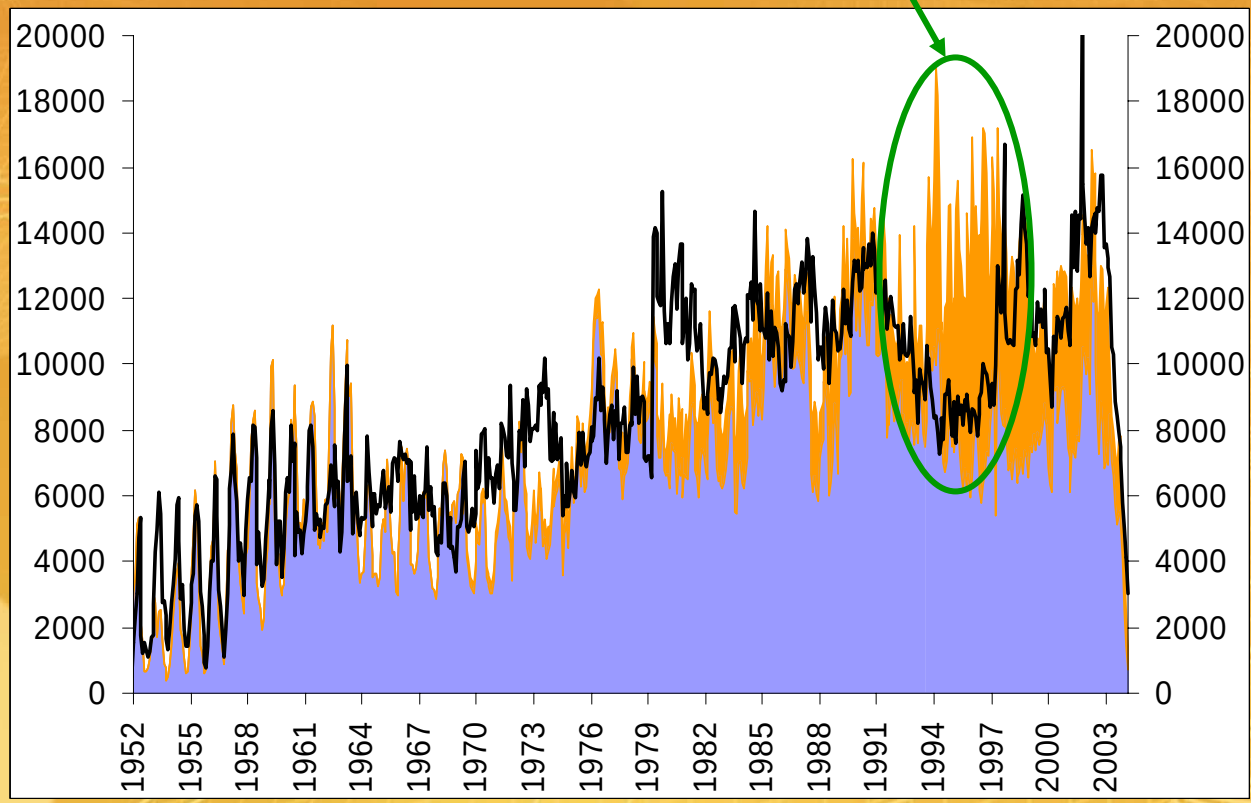
Observed total catch (t)

Blue = LL

Orange = Others (surf. Gears)

Predicted LL catch

Predicted total catch

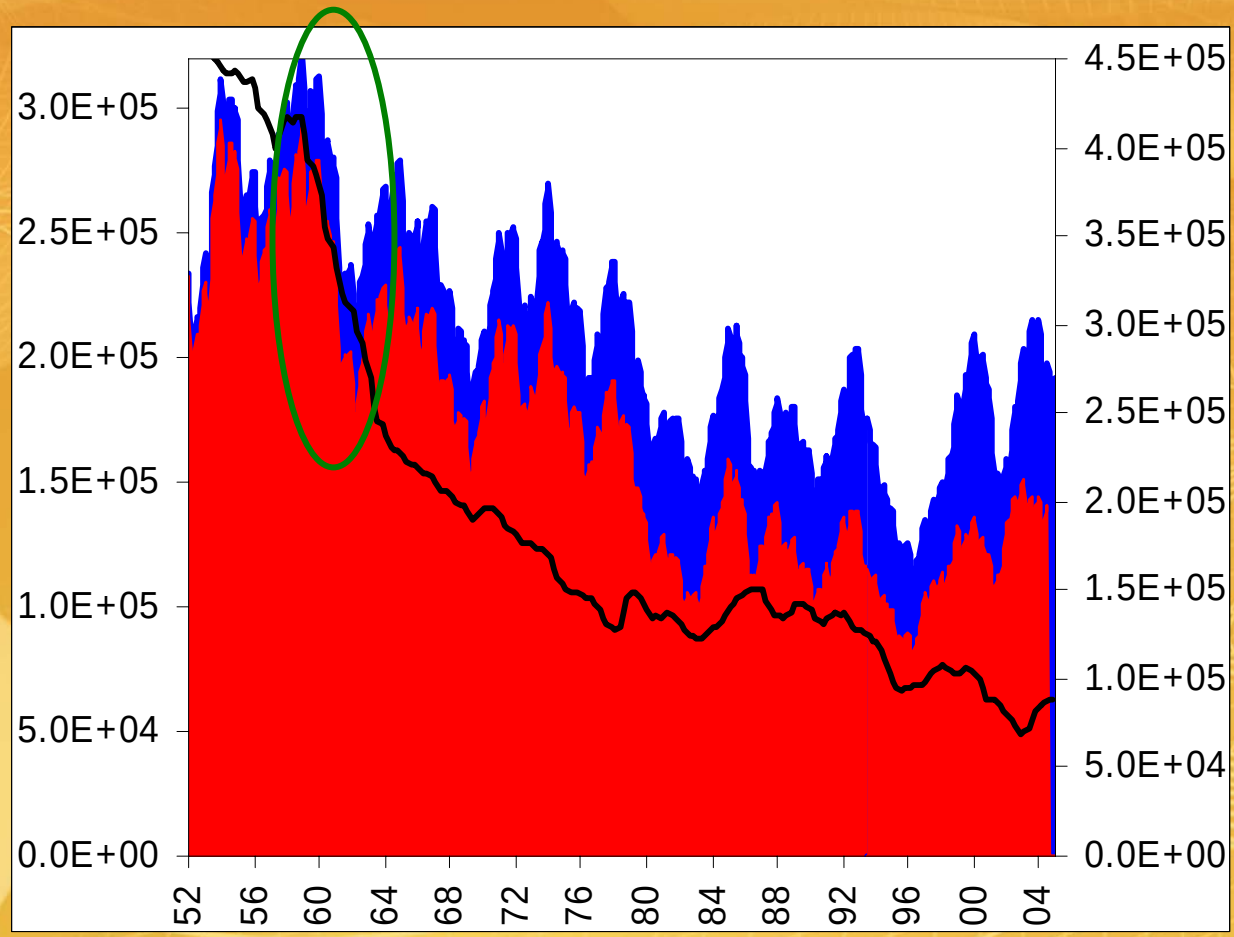


BET - WCPO

Adult total biomass

SEAPODYM (3-species simulation) estimates with (red) and without (blue) fishing

Black curve: MULTIFAN-CL estimate (with fishing)



Conclusions

• In absence of an optimization function, a reasonable parameterization for 3 species (skj, yft and bet) and their fisheries was obtained.

• The model capture important changes in the population dynamics that explain a large part of time space variability in the catch and CPUE.

• Multi-species simulations make big differences and produce better results.

• Decline in bigeye stock in the late 1950's and during 1960's is reproduced by the model and predicted to be largely due to *natural variability* AND *species interactions*.

• You can do it yourself: www.seapodym.org

Perspectives

- There is still room for improvement in the parameterization
- Develop a version with an optimization function
- Include albacore

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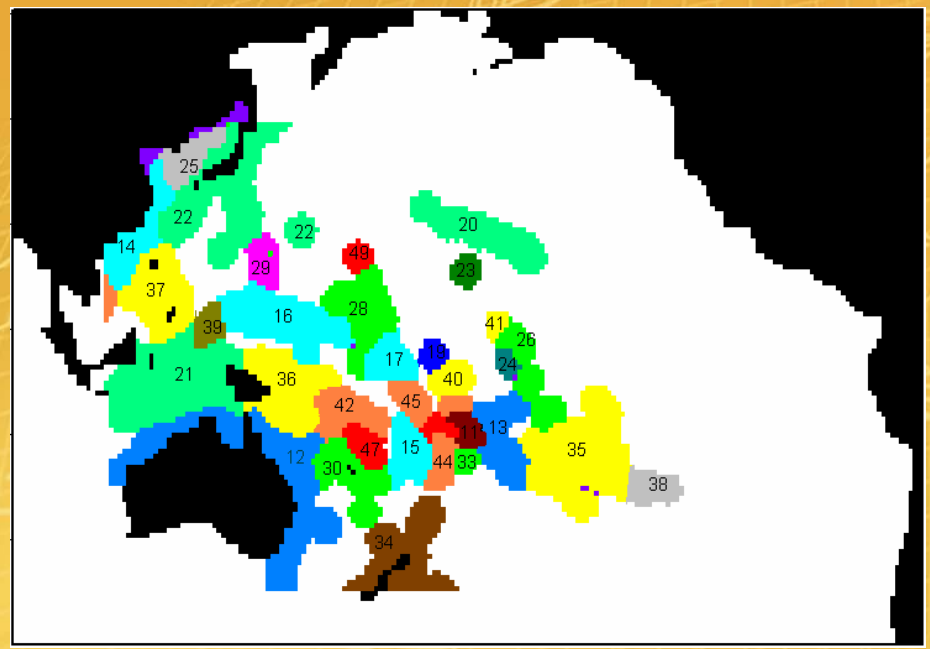
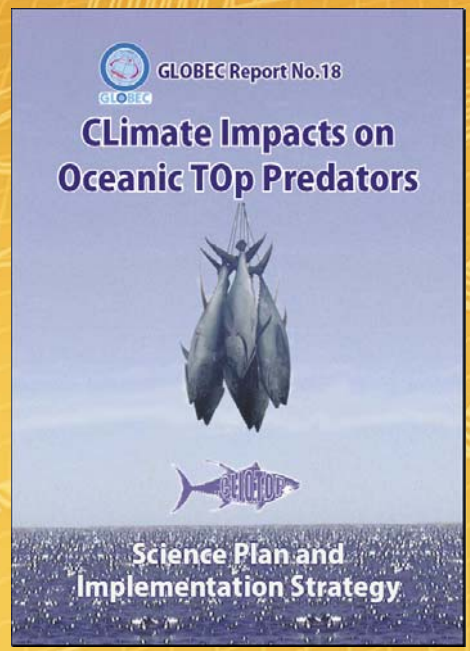


Perspectives

- There is still room for improvement in the parameterization
- Develop a version with an optimization function
- Include albacore
- Test management scenarios
- Export the model to other Ocean: GLOBEC CLIOTOP Modelling working group



Perspectives

- There is still room for improvement in the parameterization
- Develop a version with an optimization function
- Include albacore
- Test management scenarios
- Export the model to other Ocean: GLOBEC CLIOTOP Modelling working group
- Test first simulation with climate change scenario (1860-2100)

-> Exploratory analysis to identify main mechanisms that need more studies (for WG 1 2 3 in CLIOTOP)