

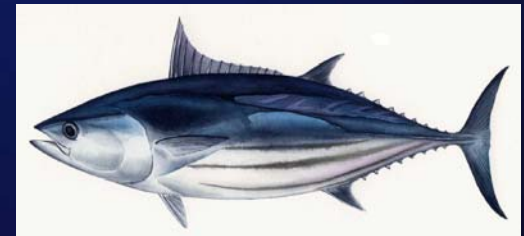
# Application of SEAPODYM to the Pacific Pelagic Ecosystem. Recent results and perspectives

Patrick Lehodey

Oceanic Fisheries Programme

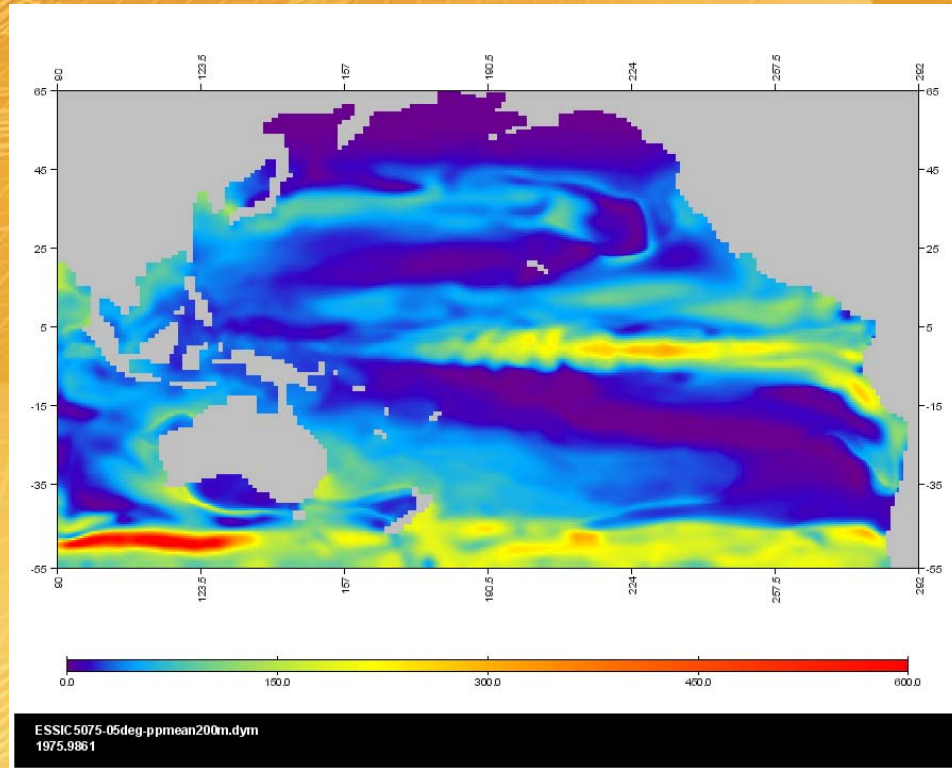
Secretariat of the Pacific Community

Noumea, New Caledonia

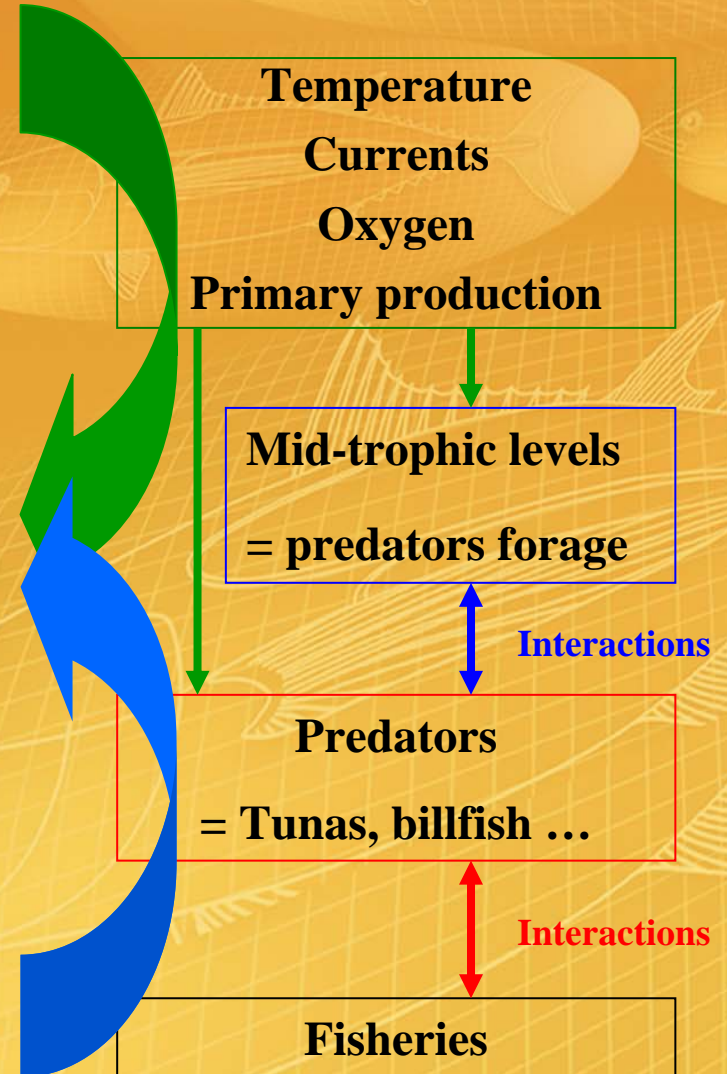


# SEAPOODYM: Spatial model driven by physical and “simplified” food-web interactions

Climate/environment variability



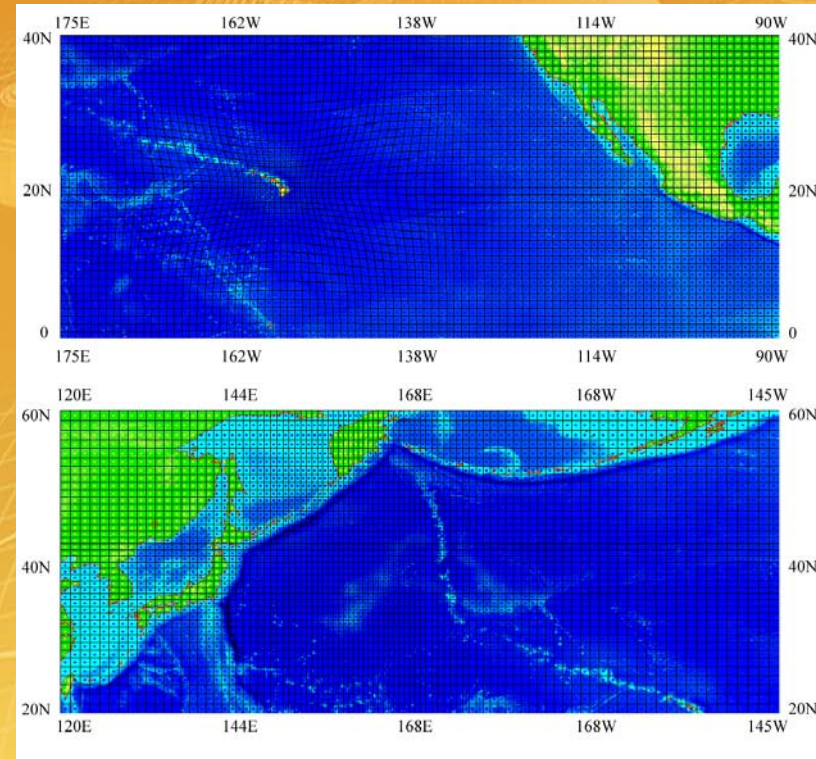
Fishing impact





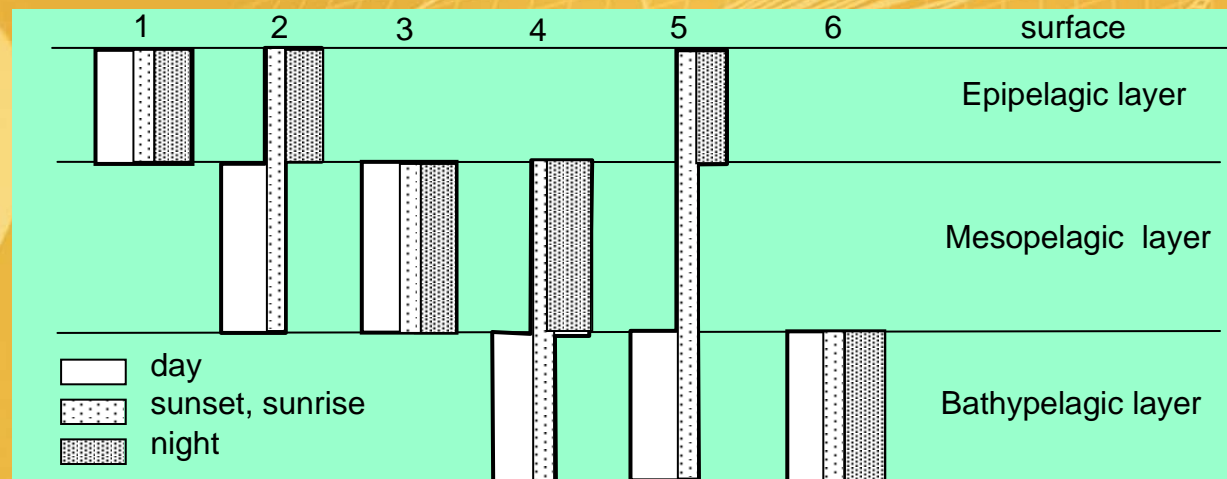
# 2004-05 achievements

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



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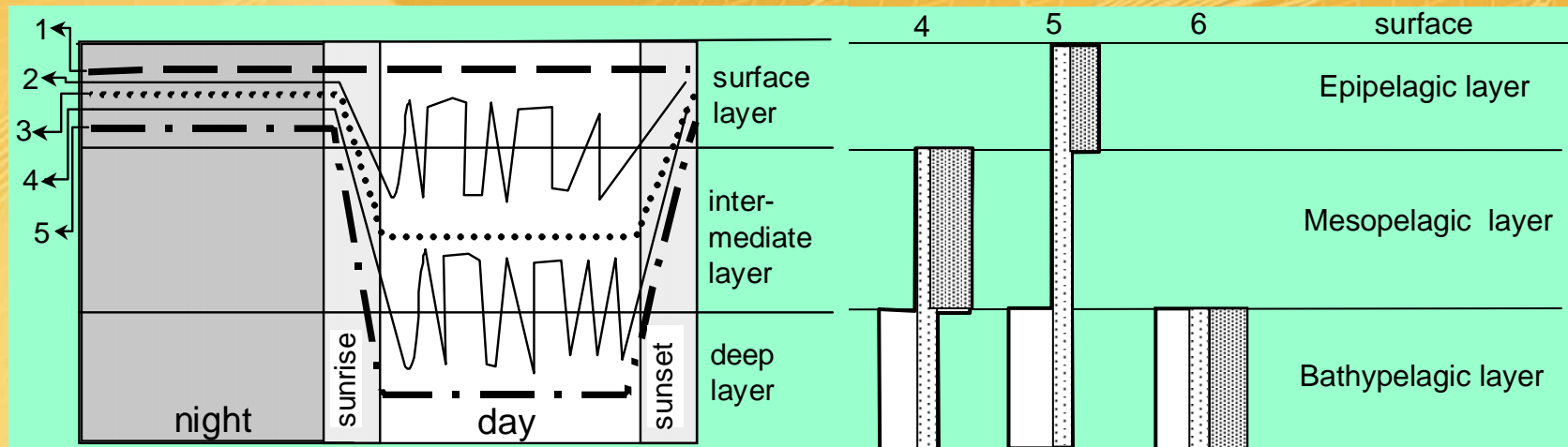
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- Mid-trophic levels sub-model (6 components in 3 vertical layers)





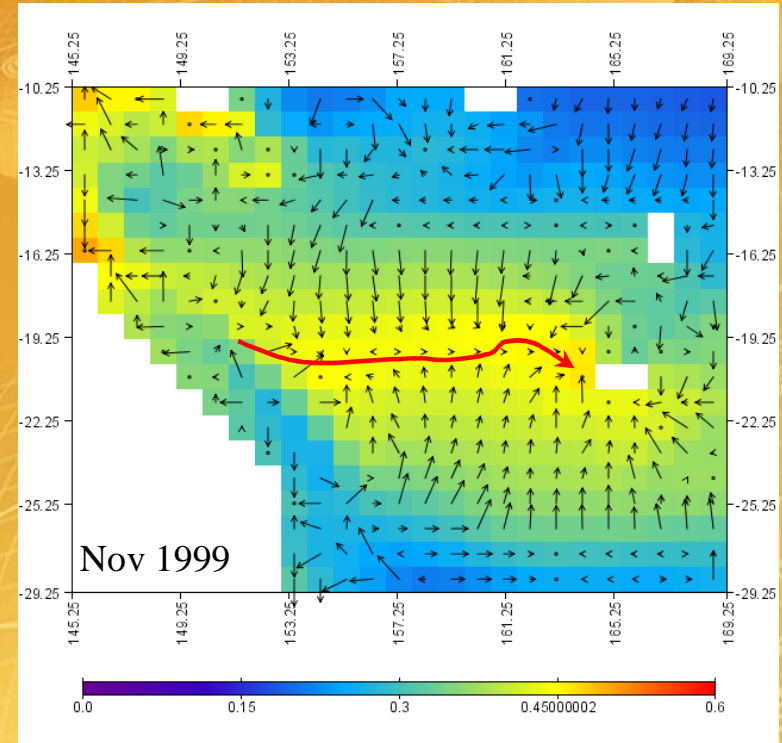
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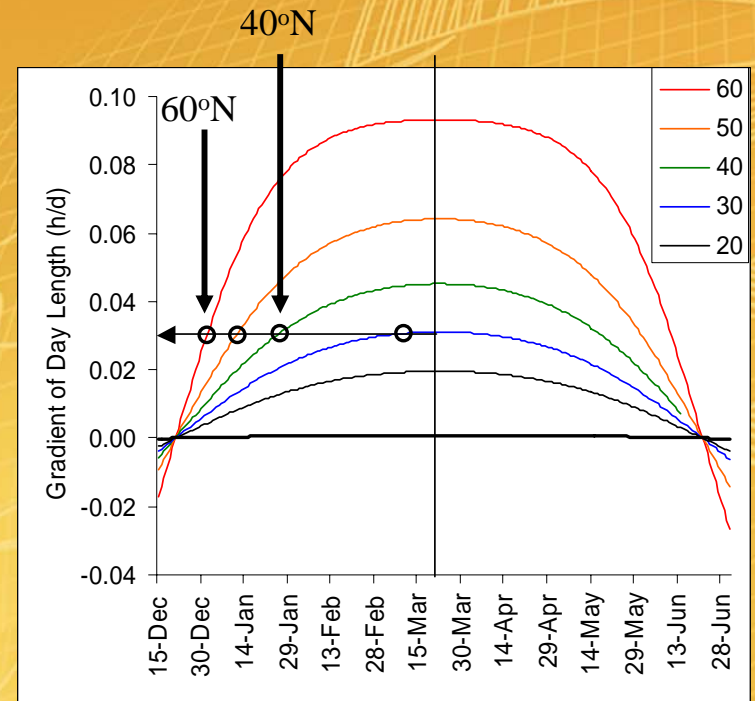
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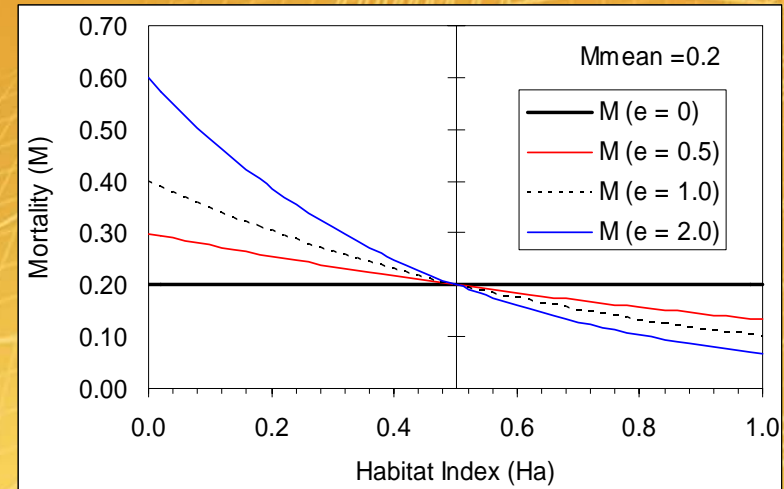
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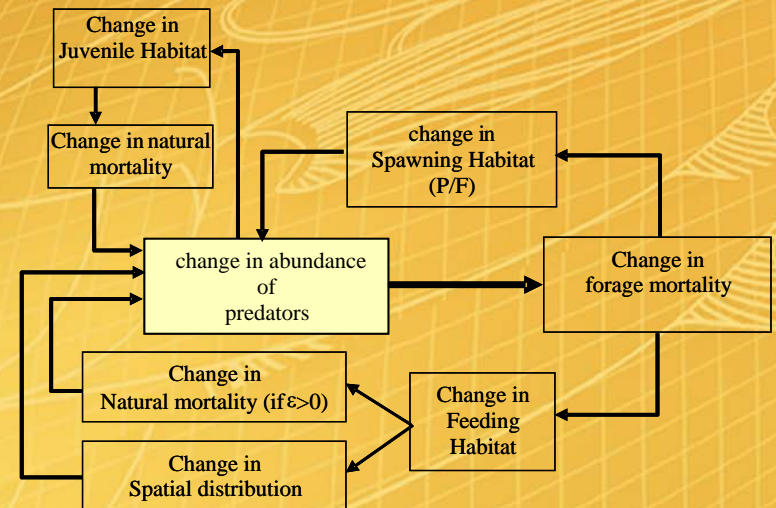
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- Model is fully operational and can be used to run multi-species multi-fisheries simulations
- Executable with documentation (cf. reference manual: ME IP 1), associated softwares and files needed to run simulation will be released on a dedicated web site


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A Spatial Ecosystem and Populations Dynamics Model

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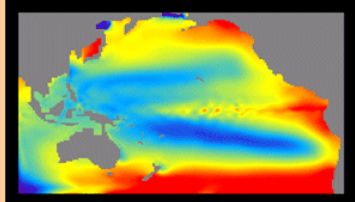
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### What is Seapodym ?



SEAPODYM is a numerical model initially developed for investigating physical-biological interaction between tuna populations and the pelagic ecosystem of the Pacific Ocean. Using predicted environment from ocean-biogeochemical models, SEAPODYM integrates spatio-temporal and multi-population dynamics and considers interactions among populations of different species and between populations and their physical and biological environment (including intermediate trophic levels). The model also includes a description of multiple fisheries and then predicts spatio-temporal distribution of catch rates, and length-frequencies of catch based either on observed or simulated fishing effort, allowing respectively to evaluate the model or to test management options (e.g., changing the fishing effort, implementing marine reserves, etc...).

### How to get Seapodym ?

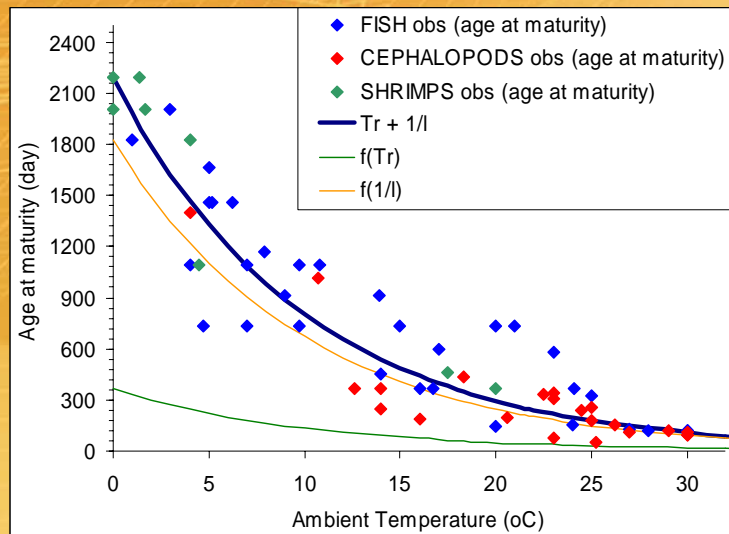
SEAPODYM and associated programs and documentation are made available to the scientific community free of charge. However, all software and documentation are copyrighted, and availability of the software is subject to a [license](#) that places some minor restrictions on use and distribution. These restrictions permit licensees to distribute unaltered copies of the software, but not derivative works based on it. Licensees are not permitted to use the software for commercial purposes, unless they get the licensor's permission. [Download](#)



# Results: mid-trophic levels

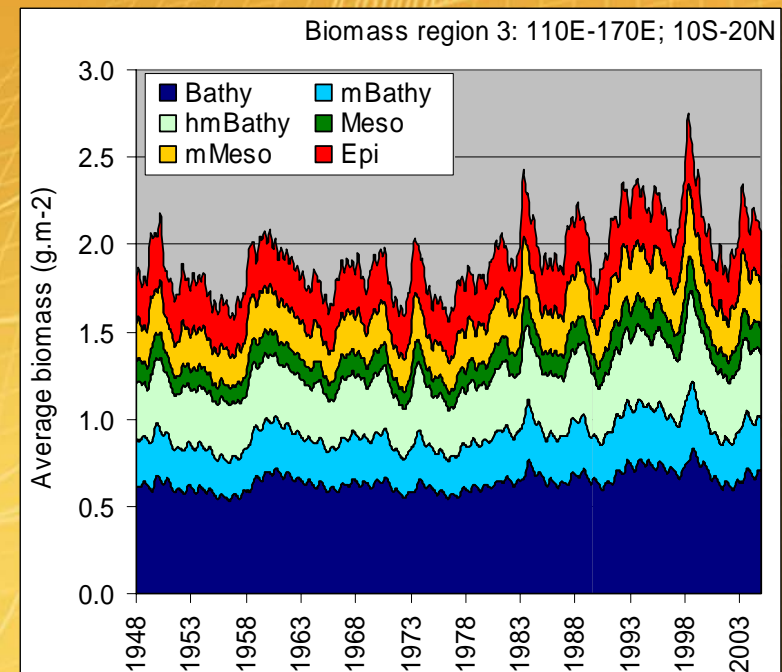
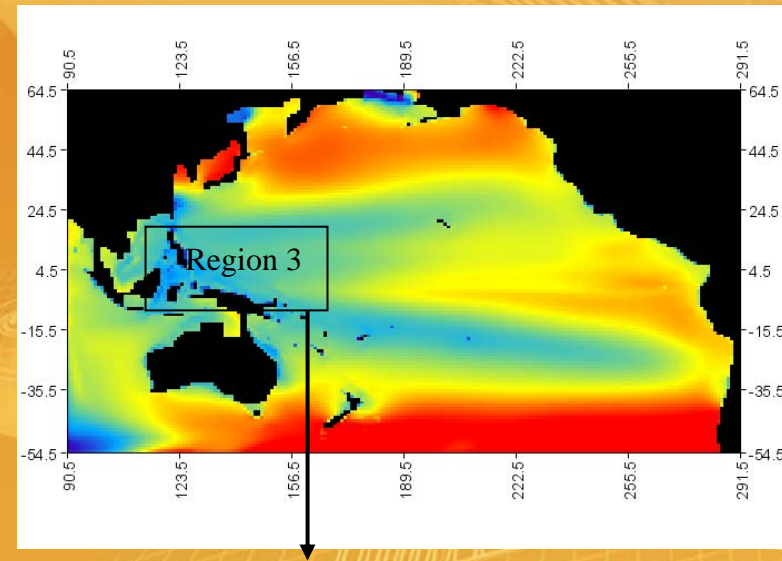
## Running forage model alone:

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

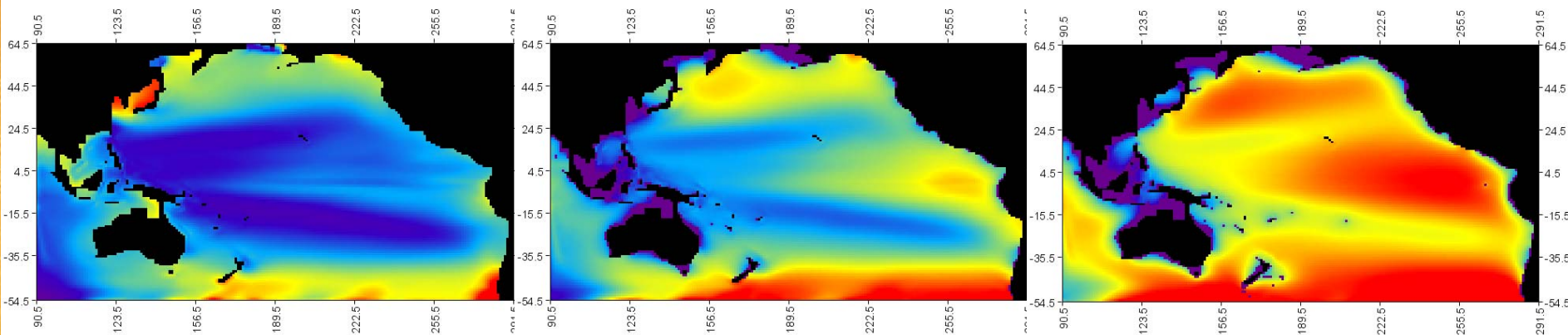


# Results: mid-trophic levels

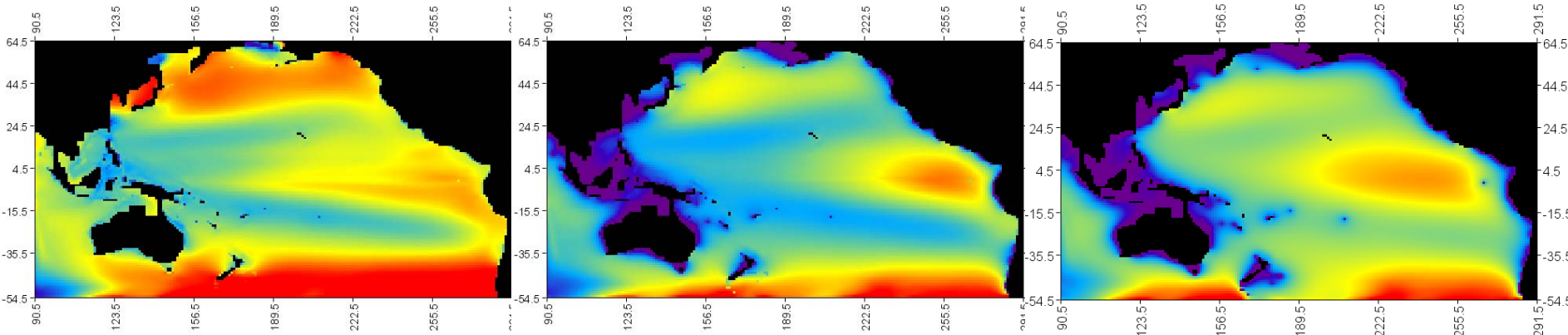
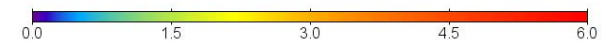
Epi-pelagic layer  
(0-100m)

Meso-pelagic layer  
(100-400m)

Bathy-pelagic layer  
(400-1000m)

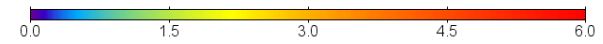


Day



Night

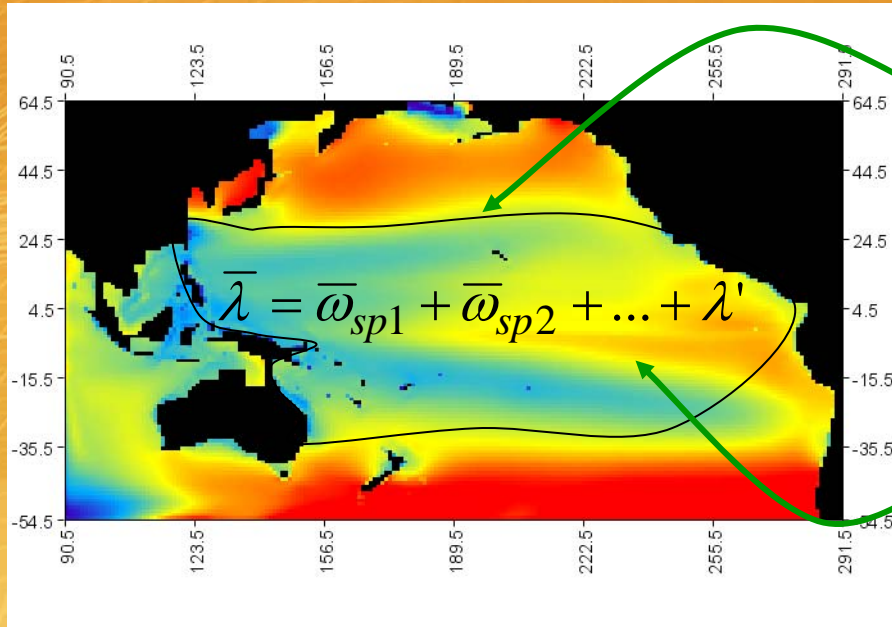
Simulation outputs: Forage. 1948-2004, 10 days, 0.5 deg<sup>2</sup>





# 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  $\lambda'$  due to all other predators

Locally, in each cell, the forage mortality due to food requirements of described predators,  $\omega_{i,j}$  is calculated 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  $\bar{\omega}_{sp}$  above  $\bar{\lambda}$   
-> ERROR:  
biomass of predators cannot be sustained by the forage component

Outside specific predator area,  
forage  $m = \lambda(\text{temperature})$   
Inside specific predator area  
forage  $m = \omega_{i,j} + \lambda'$

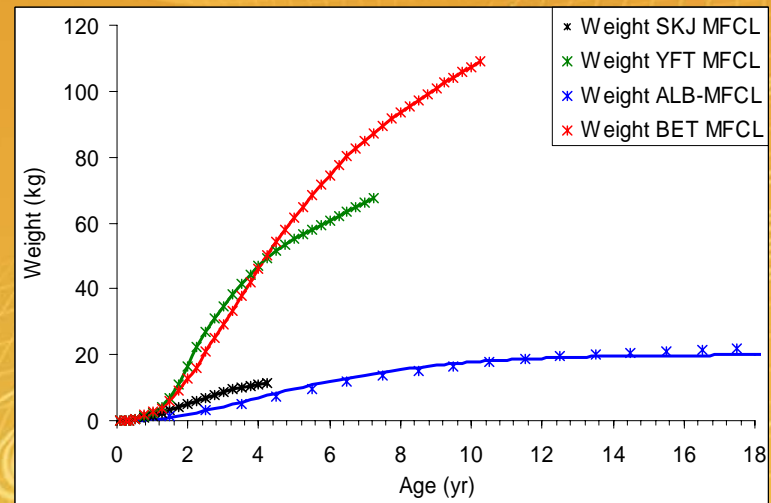
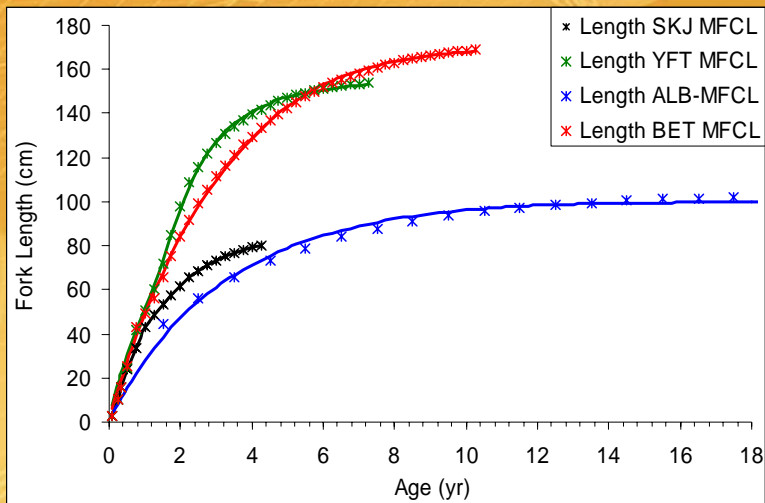
The background is a warm, golden-yellow color. It features several faint, stylized illustrations of fish, including skipjack, yellowfin, and bigeye tuna, rendered in a light, sketchy style. A subtle grid pattern is overlaid on the background, creating a textured effect.

**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

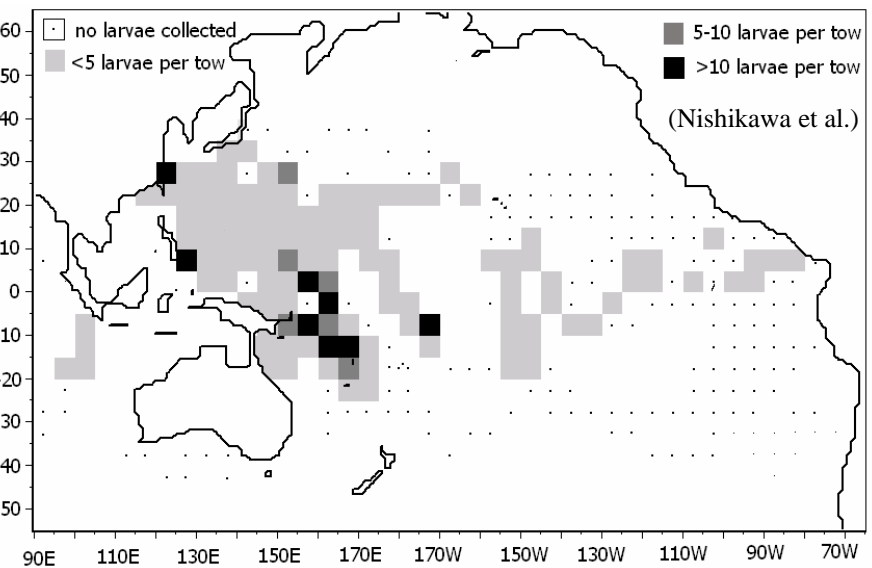
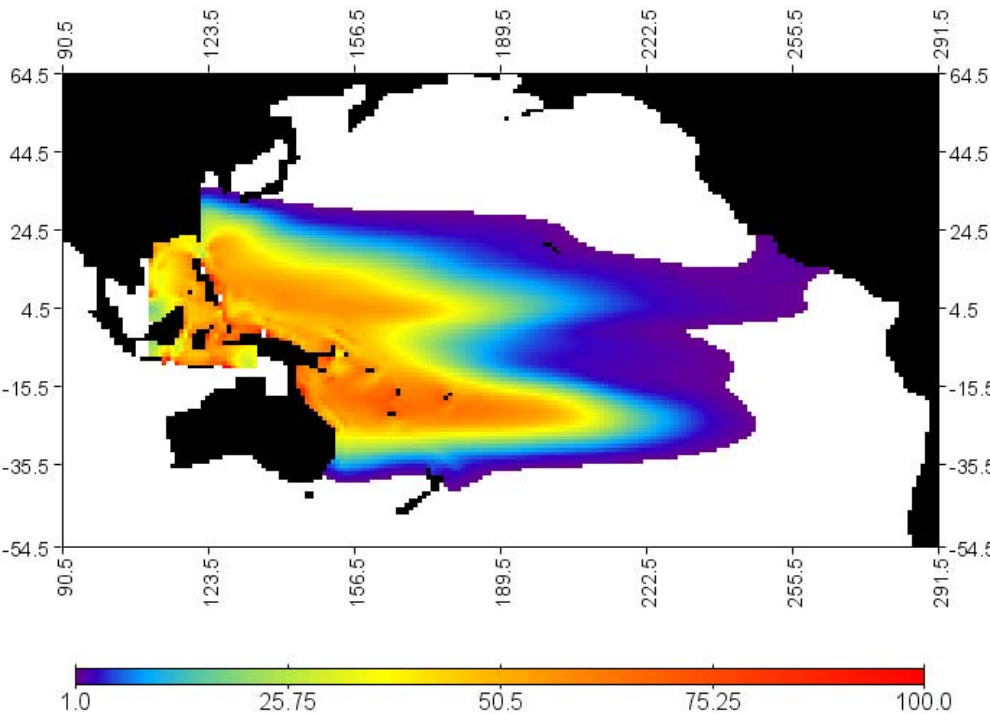
# Fisheries

Category code	Description / source / resolution
<b>PURSE SEINE</b>	
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)
<b>POLE-AND-LINE</b>	
PLTRO	Aggregated data of tropical (25°N-25°S) pole-and-line fisheries data
PLSUB	Aggregated data of sub-tropical pole-and-line fisheries (mostly Japanese domestic fleets)
<b>LONGLINE</b>	
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
<b>DIVERSE</b>	
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



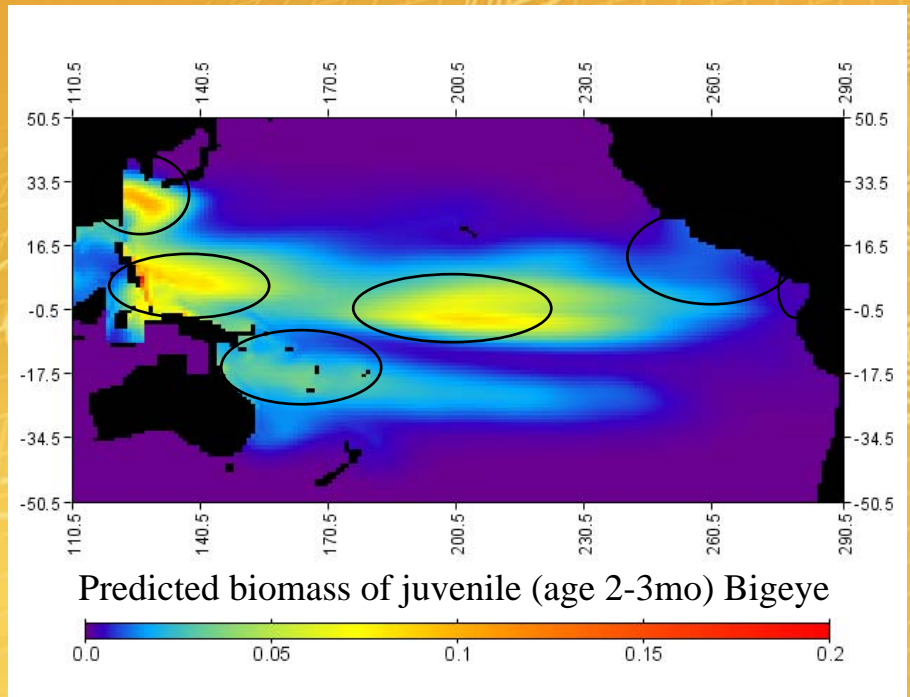
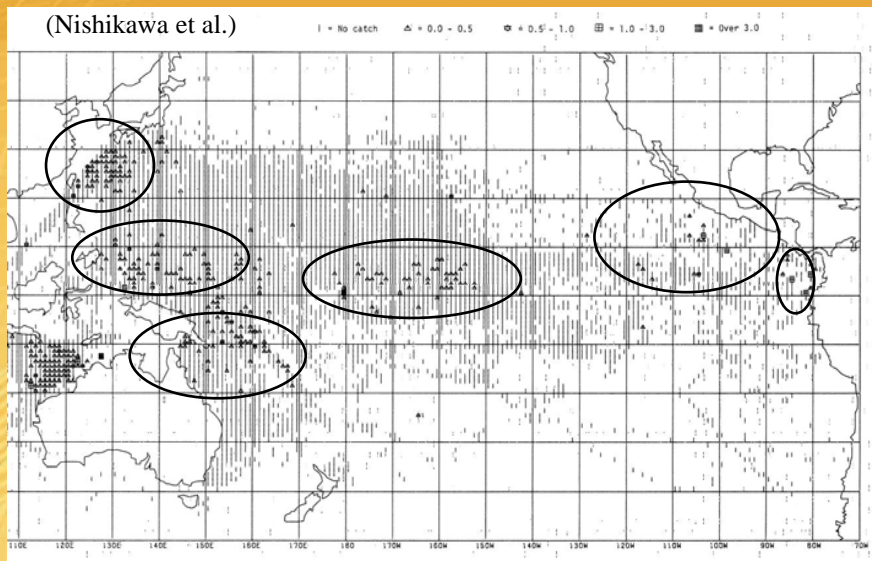
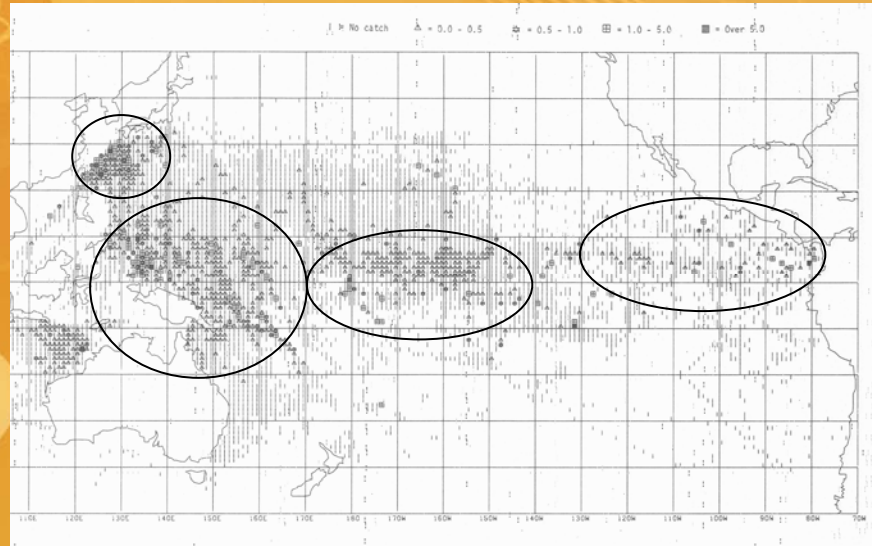
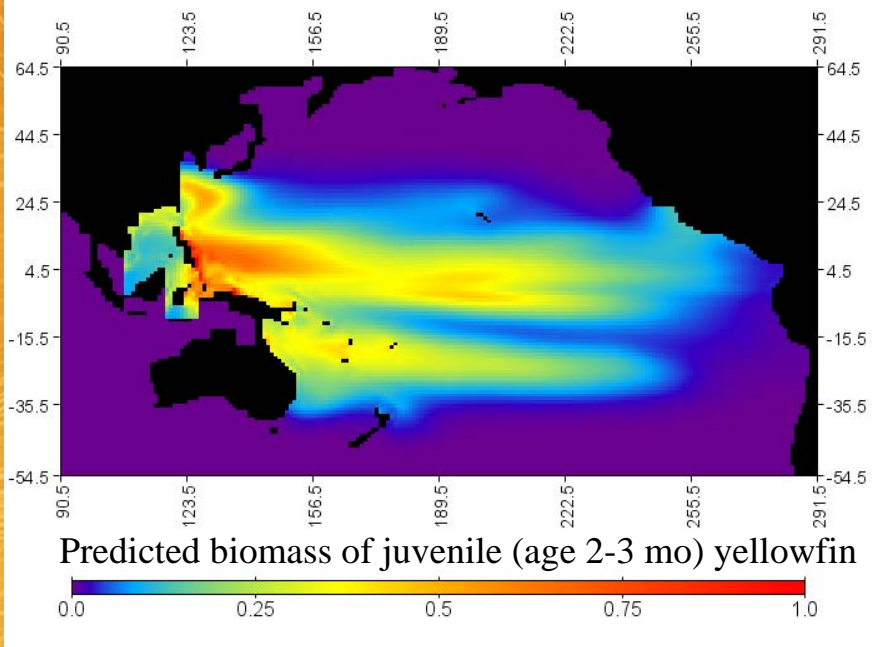
# Spawning Habitat

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



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

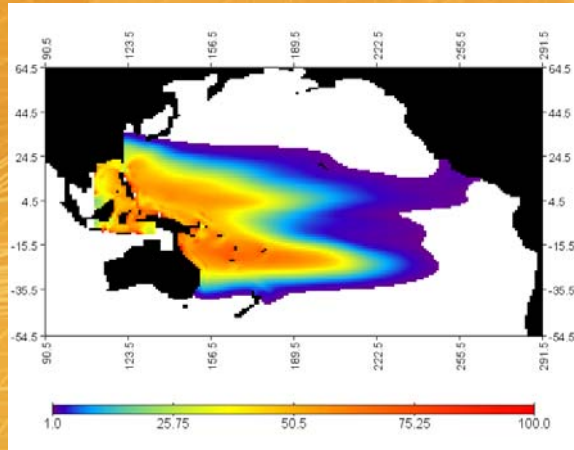
**Distribution of skipjack larvae (Nishikawa et al, 1985)**



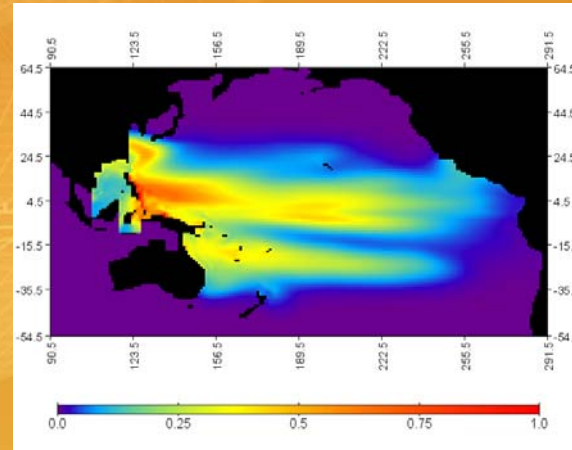


## Skipjack

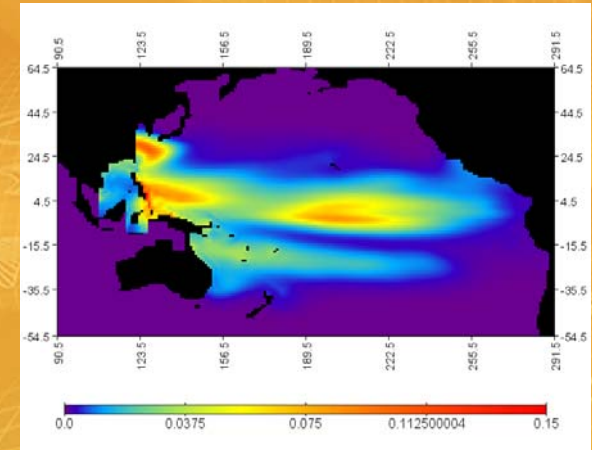
1950-75



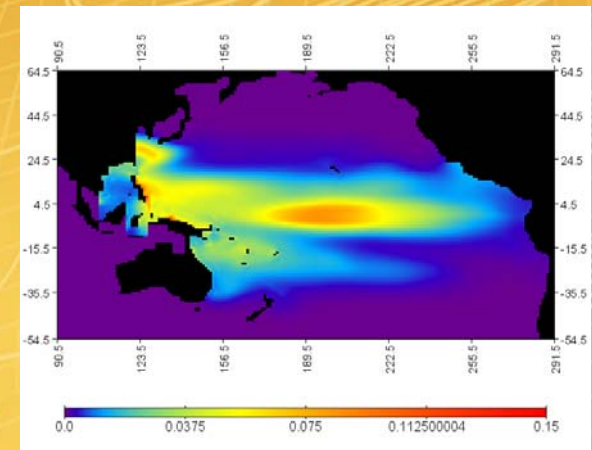
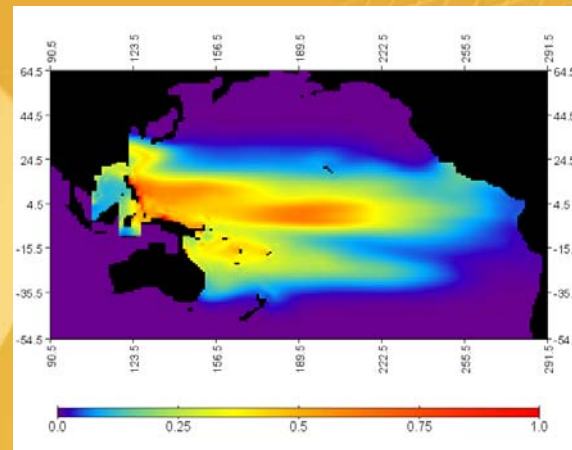
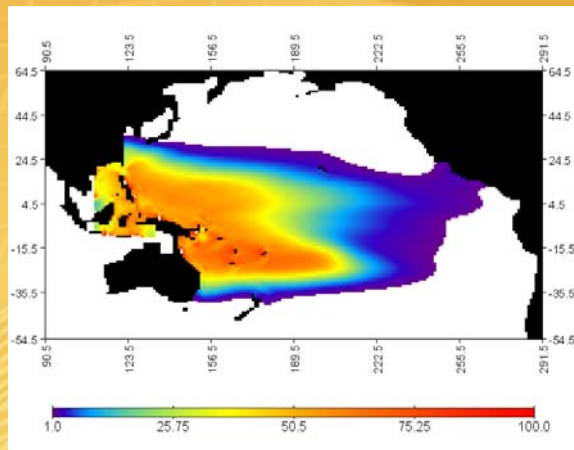
## Yellowfin



## Bigeye



1976-98



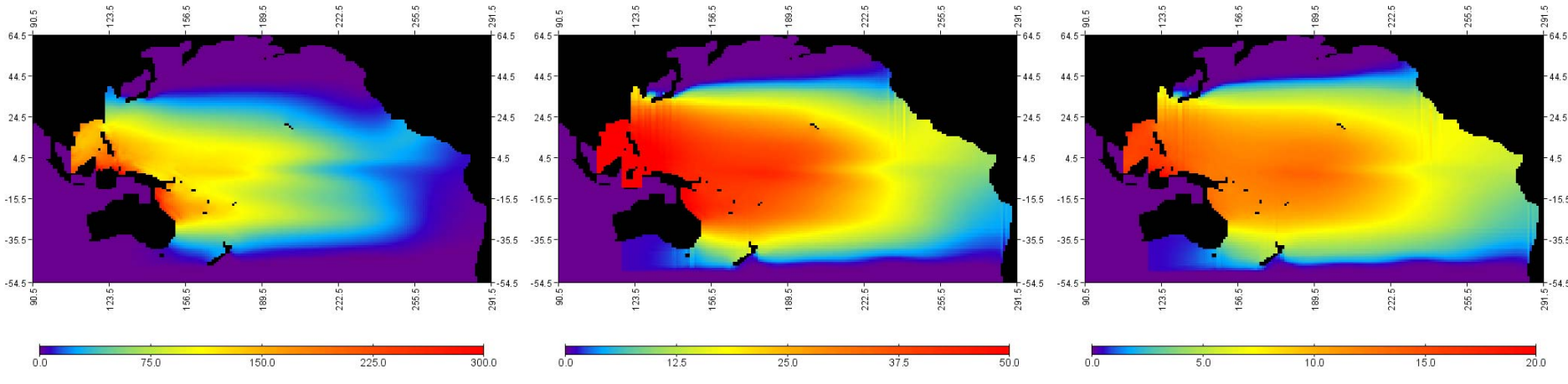
Average predicted distribution of juvenile (age 2-3 months) biomass during decadal period 1950-75 and 1976-98

# Skipjack

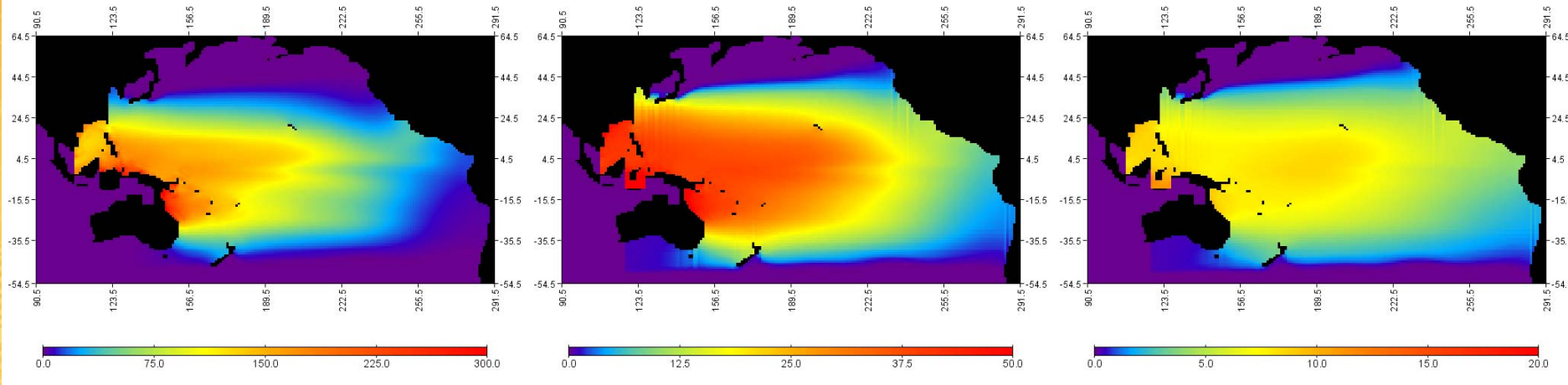
# Yellowfin

# Bigeye

1950-75



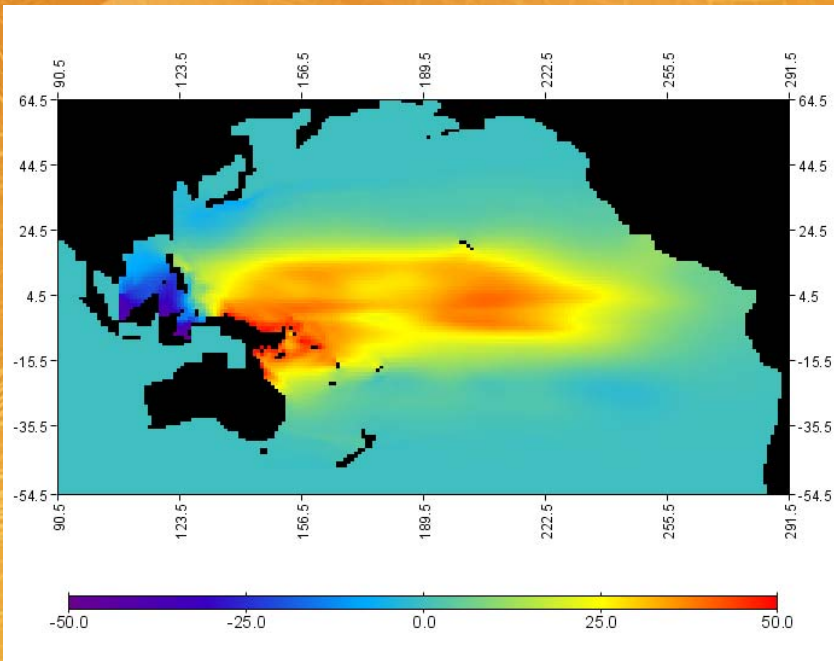
1976-98



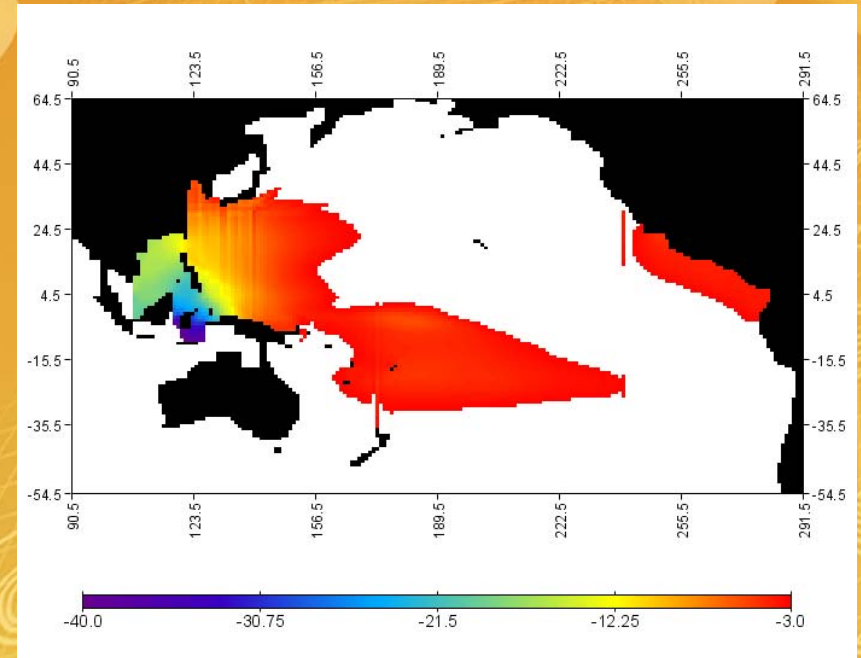
Average predicted distribution of **total biomass** during decadal period 1950-75 and 1976-98



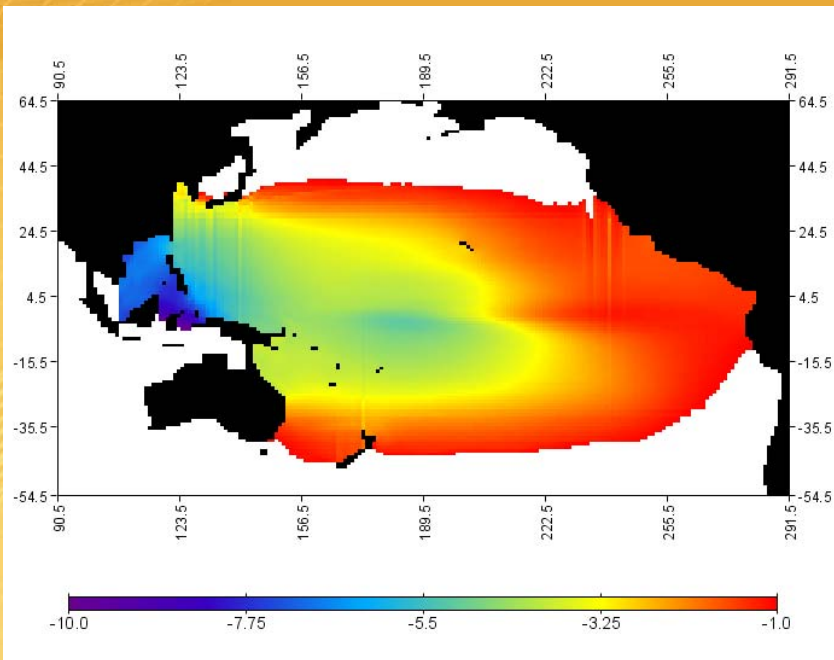
← Skipjack anomaly (1976-98) – (1950-75)



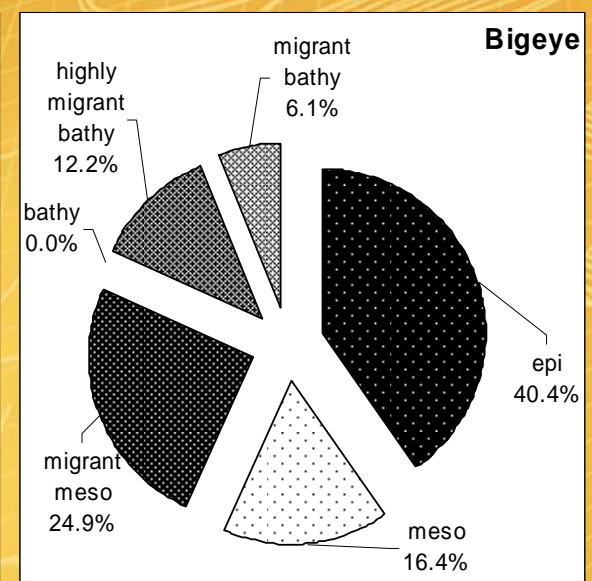
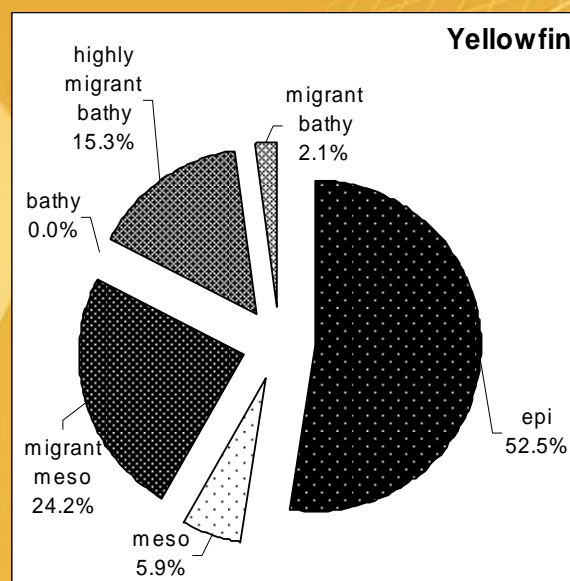
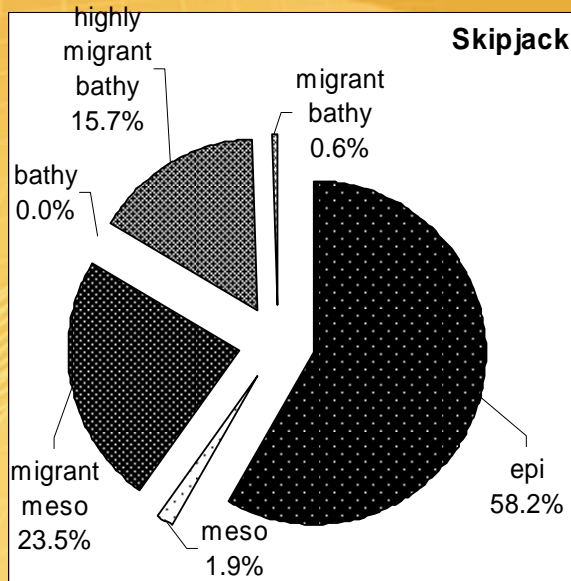
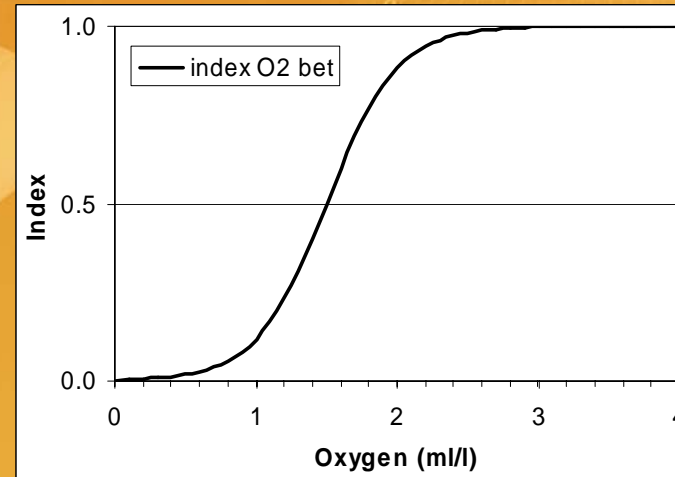
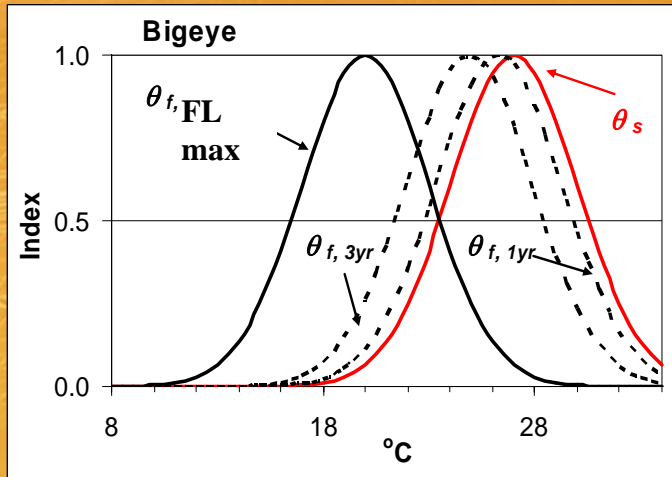
Yellowfin anomaly (1976-98) – (1950-75)



← Bigeye anomaly (1976-98) – (1950-75)

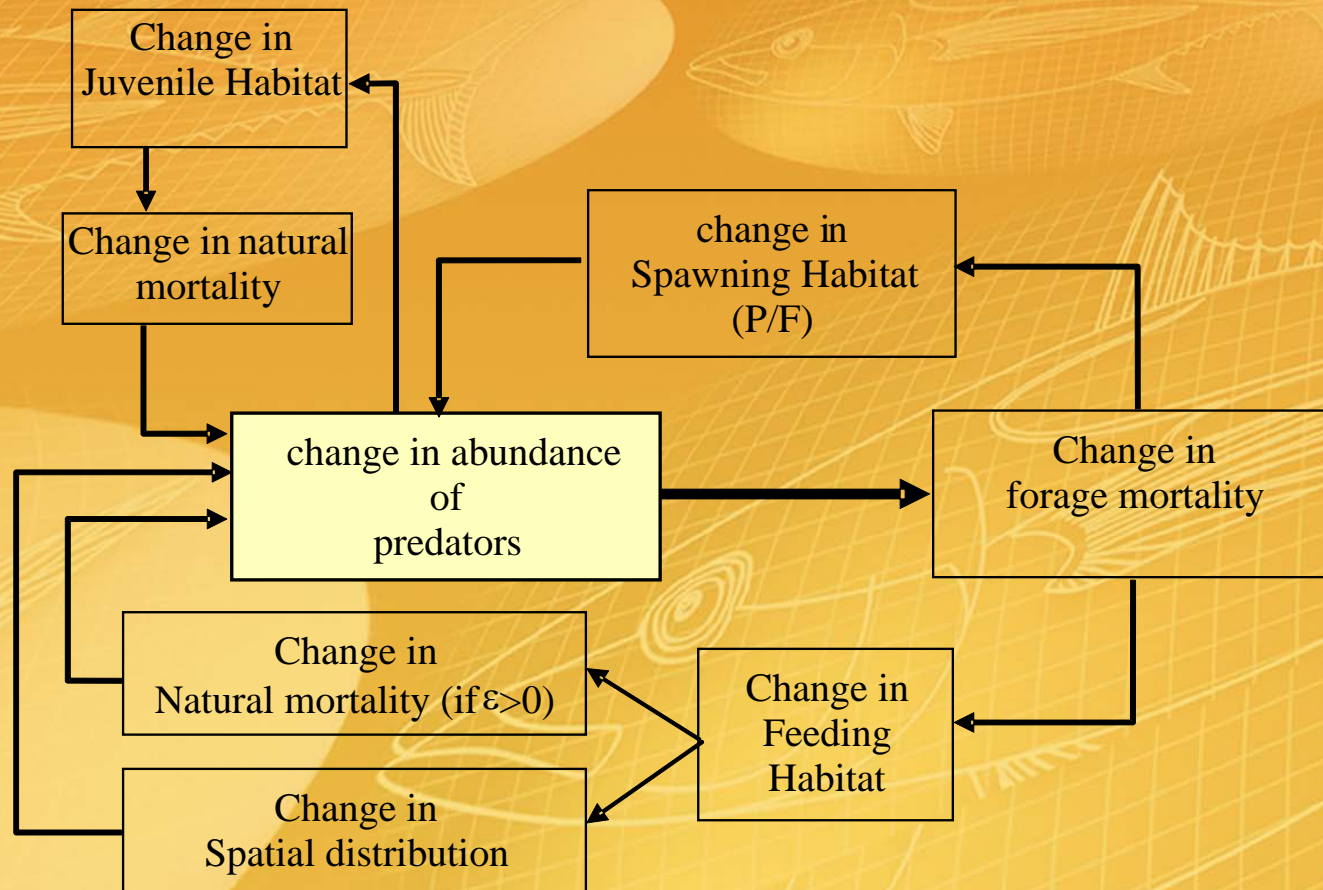


# Average forage consumption by species (all age classes) based on accessibility to forage components

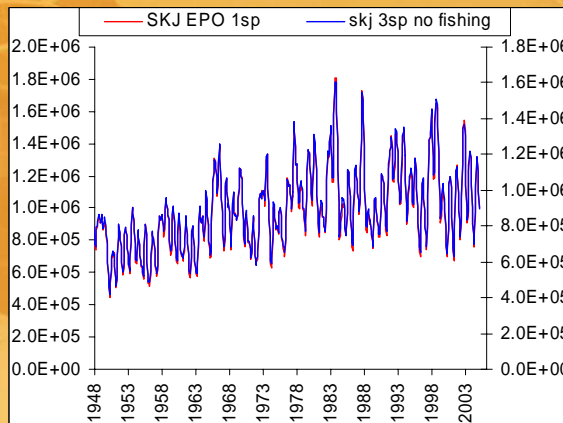
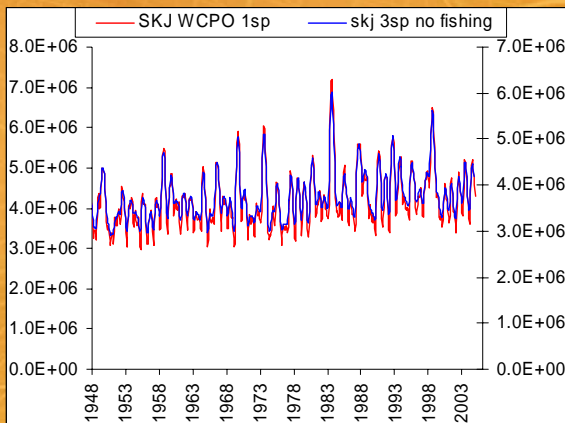




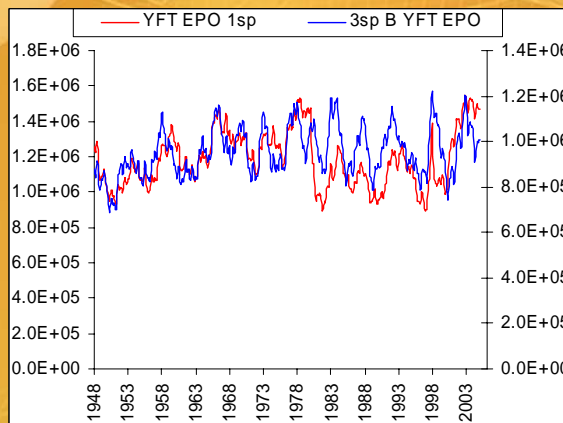
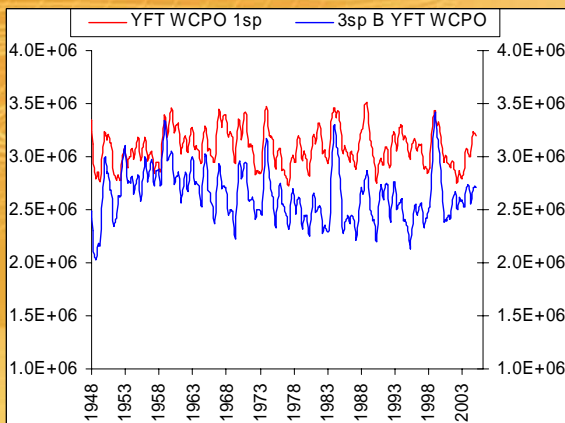
# Running single vs multi-species simulations with SEAPODYM: What are the effect of interaction between top predator species like tuna?



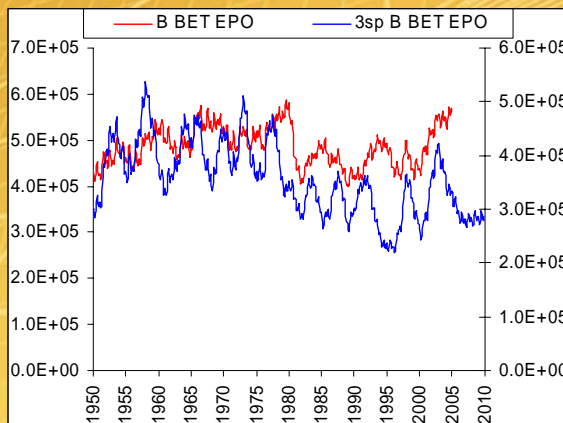
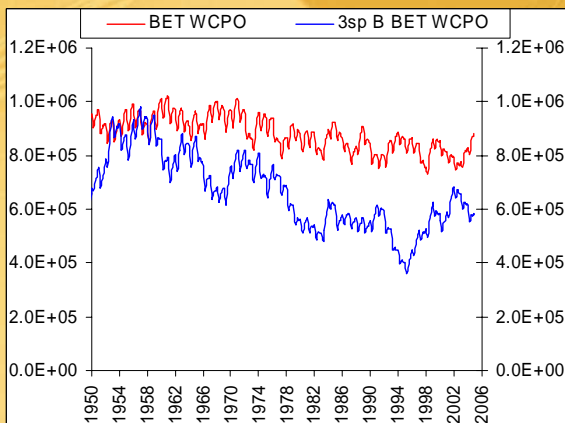
# SKJ



# YFT



# BET



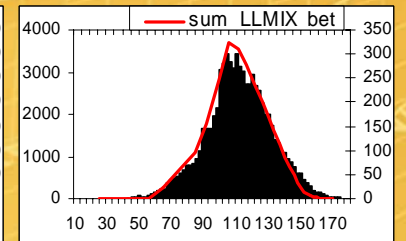
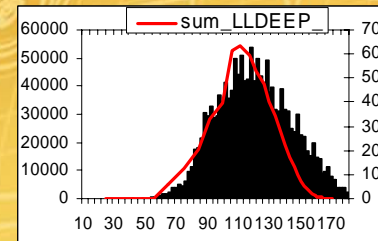
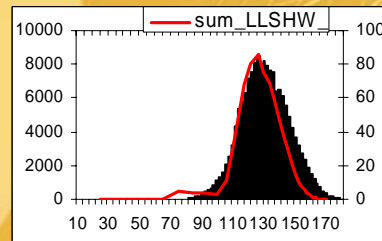
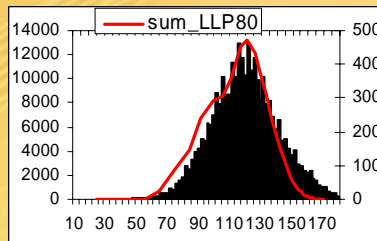
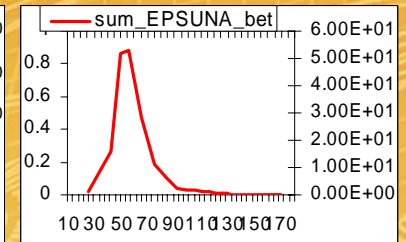
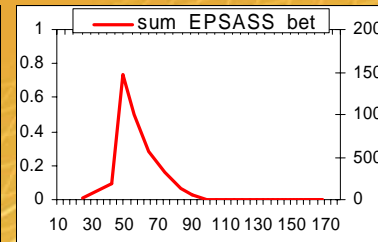
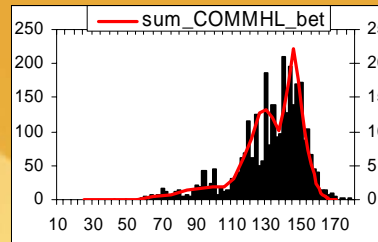
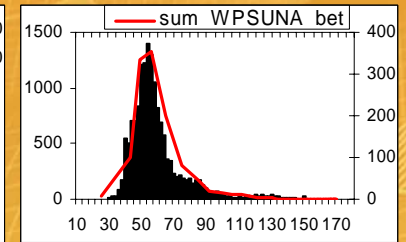
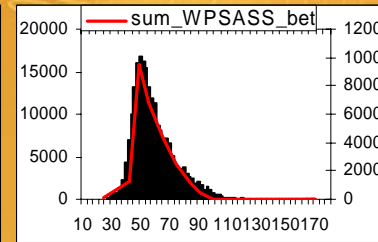
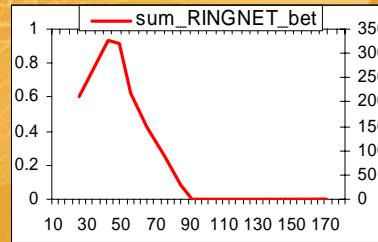
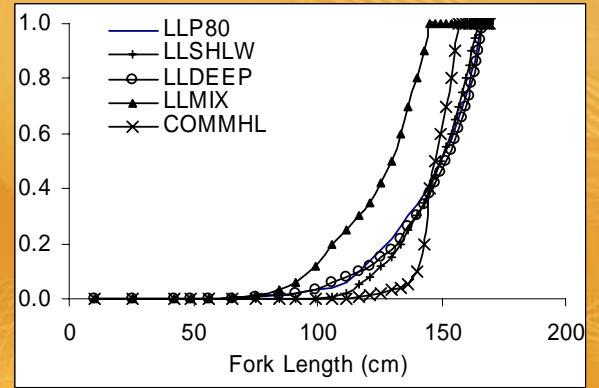
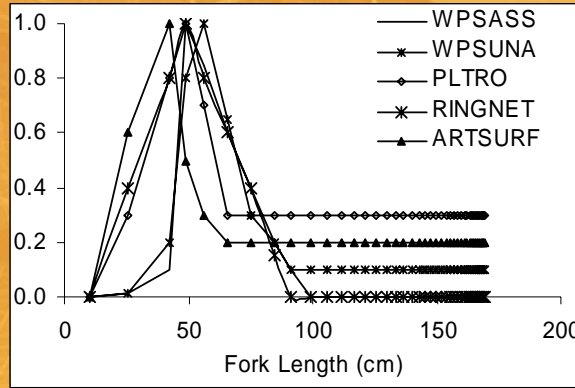


The background is a warm, golden-yellow color. It features several stylized, white line-art illustrations of fish, including what appear to be bigeye tuna, swimming in various directions. A faint, light-colored grid pattern is overlaid on the entire background, creating a textured effect.

Some more results on bigeye...

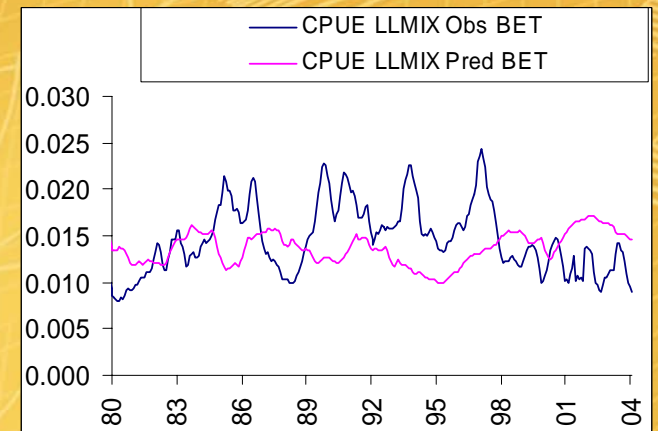
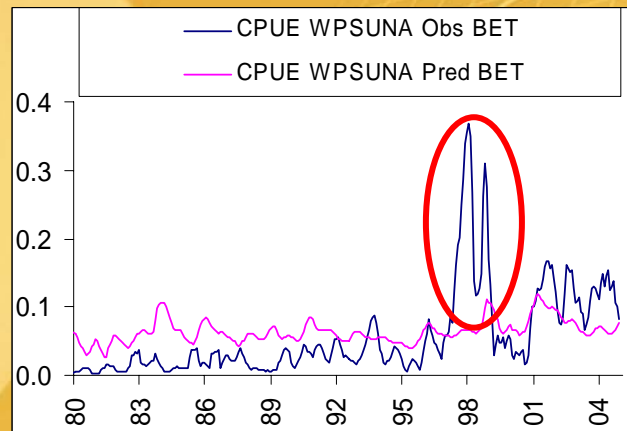
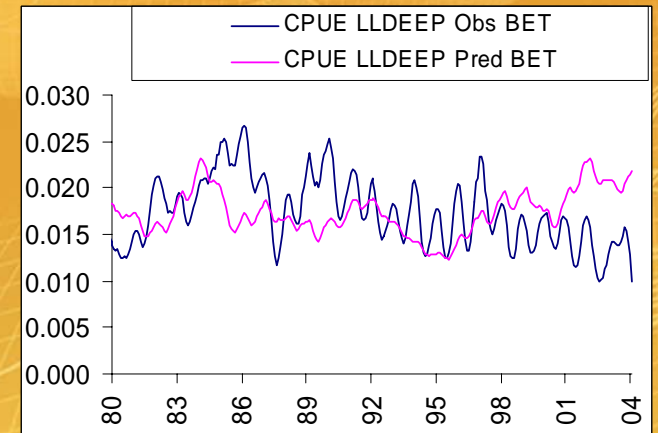
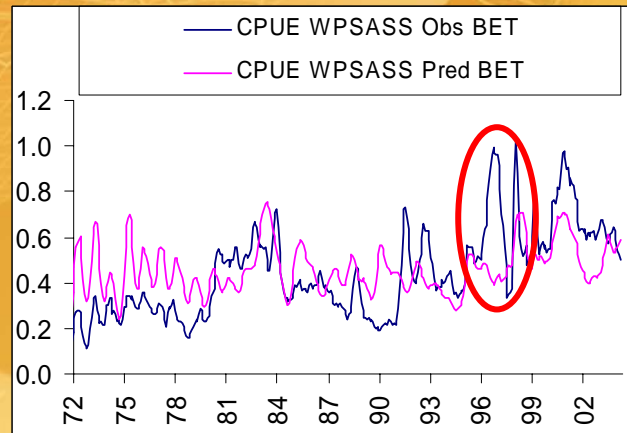
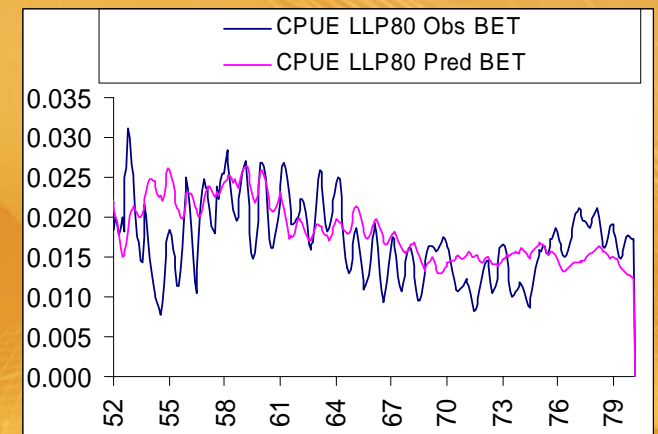
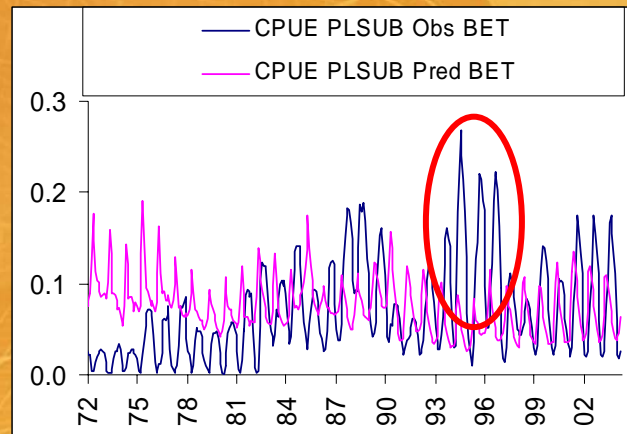
# Selectivity

## bigeye





# Predicted and observed CPUE



**BET**

**Observed total catch (t)**

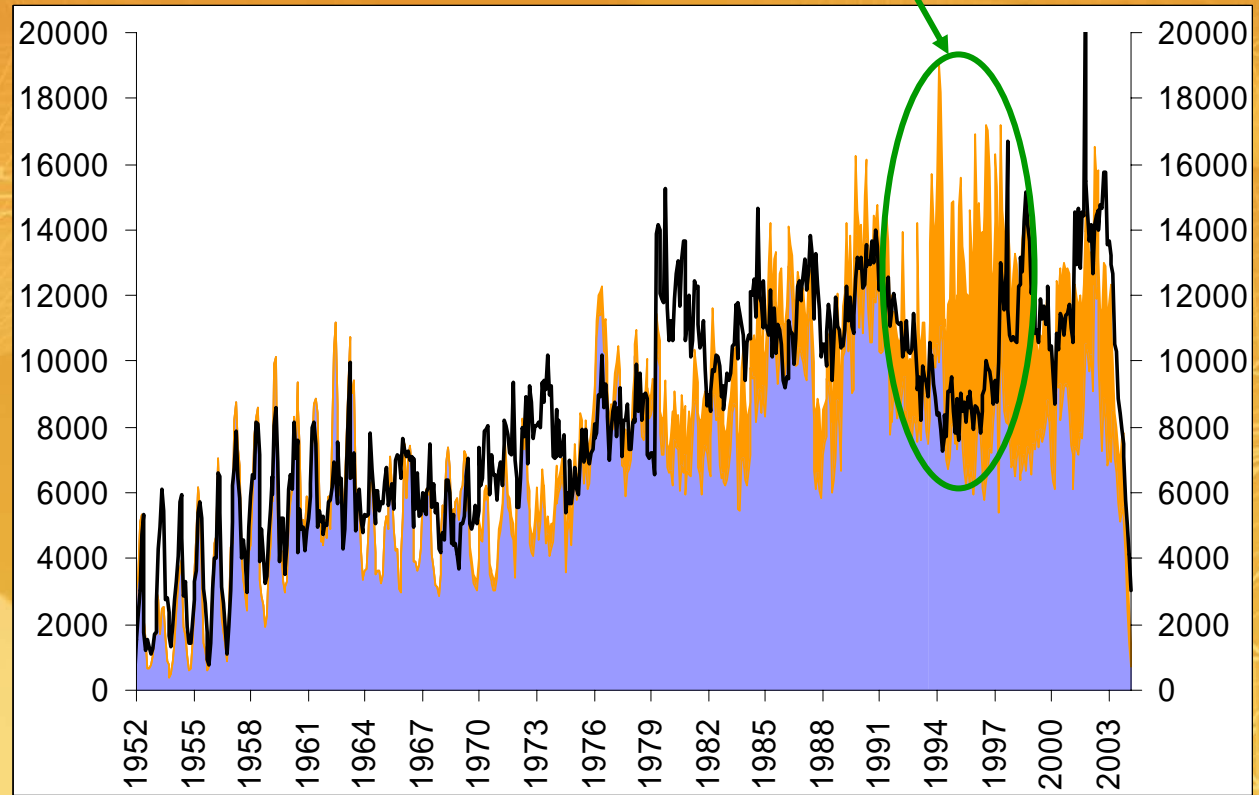
Blue = LL

Orange = Others (surf. Gears)

Predicted LL catch

Predicted total catch

High level of catch by surface gears in 1994-97 not predicted



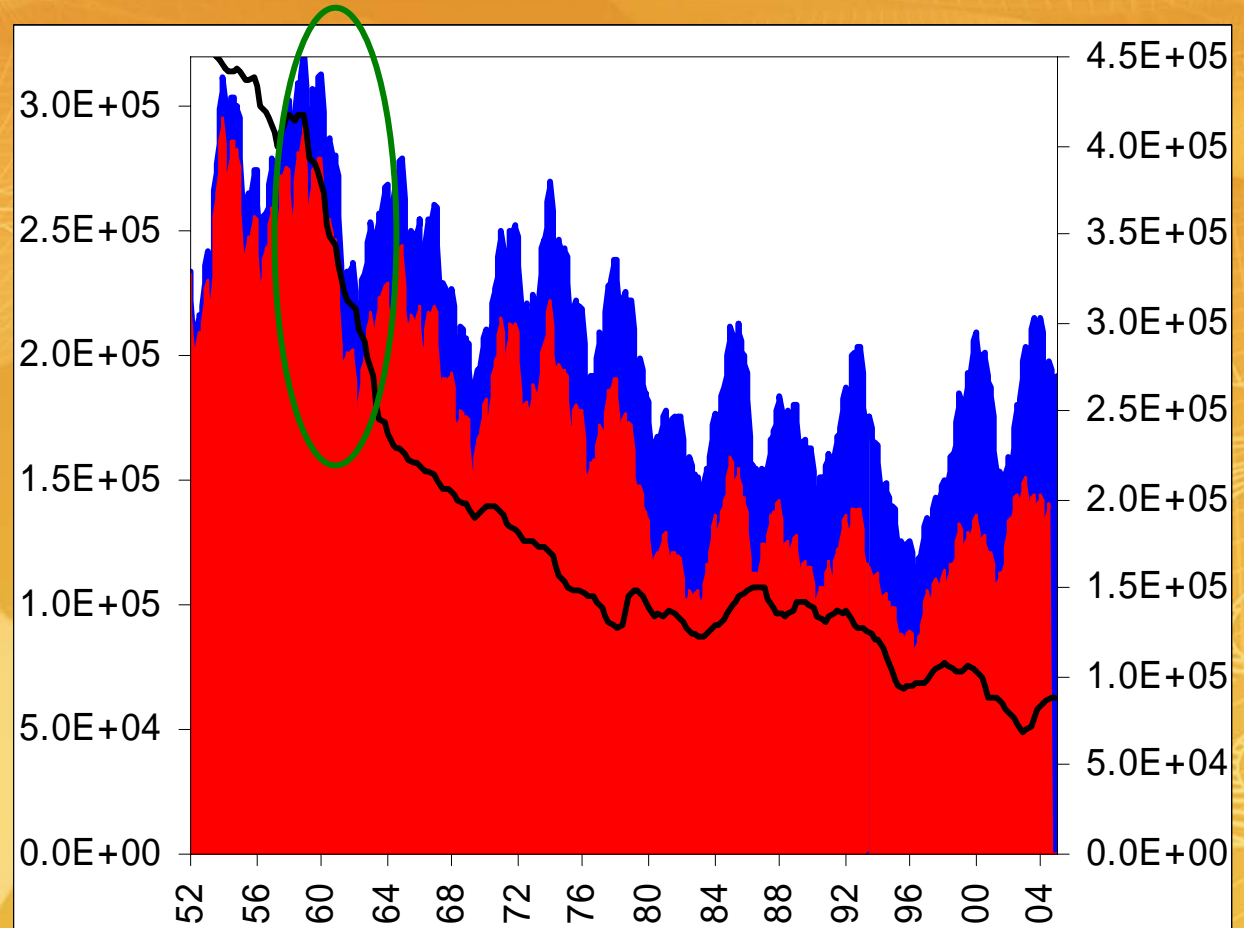


## BET - WCPO

### 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](http://www.seapodym.org)

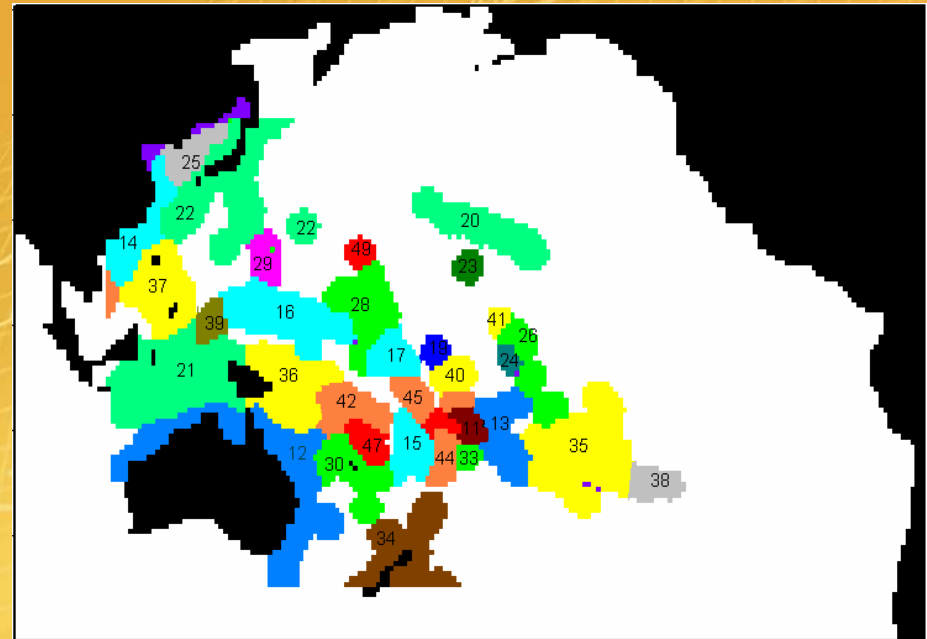


# Perspectives

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

# Perspectives

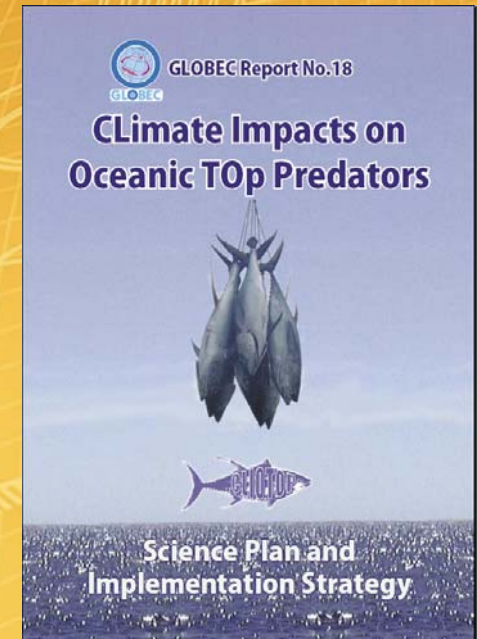
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- Develop a version with an optimization function
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- Export the model to other Ocean:  
GLOBEC CLIOTOP Modelling  
working group



# 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)

