

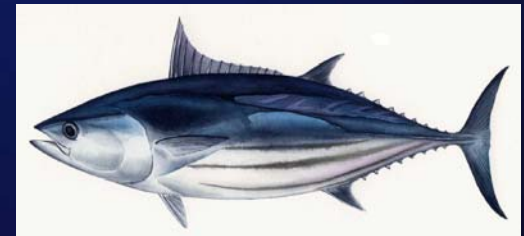
Application of SEAPODYM to the Pacific Pelagic Ecosystem. Recent results and perspectives

Patrick Lehodey

Oceanic Fisheries Programme

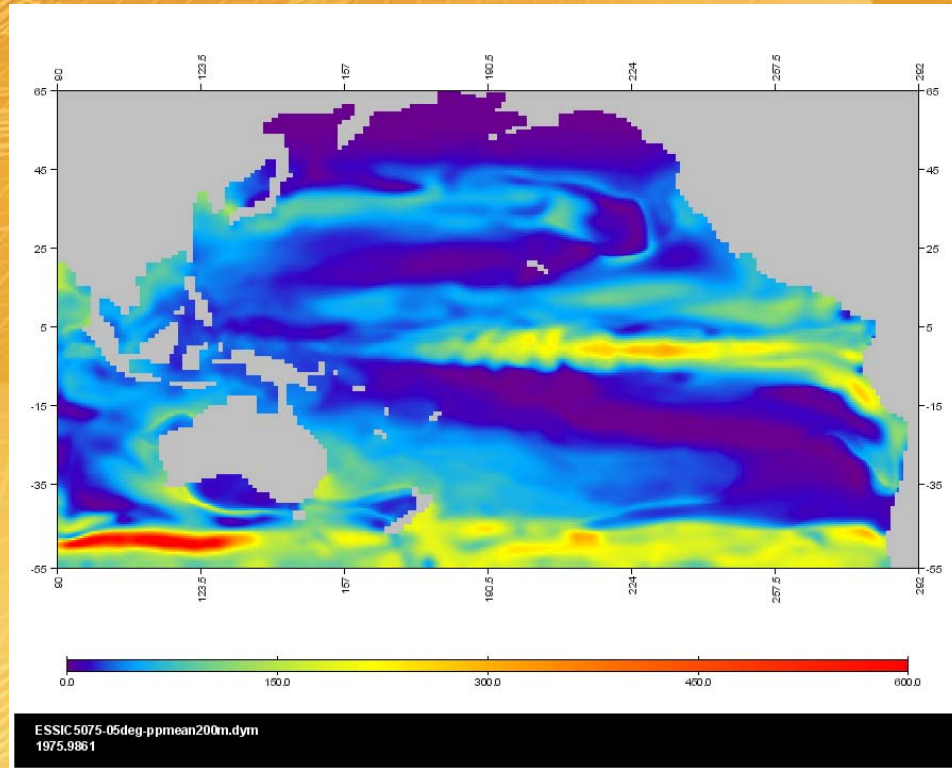
Secretariat of the Pacific Community

Noumea, New Caledonia

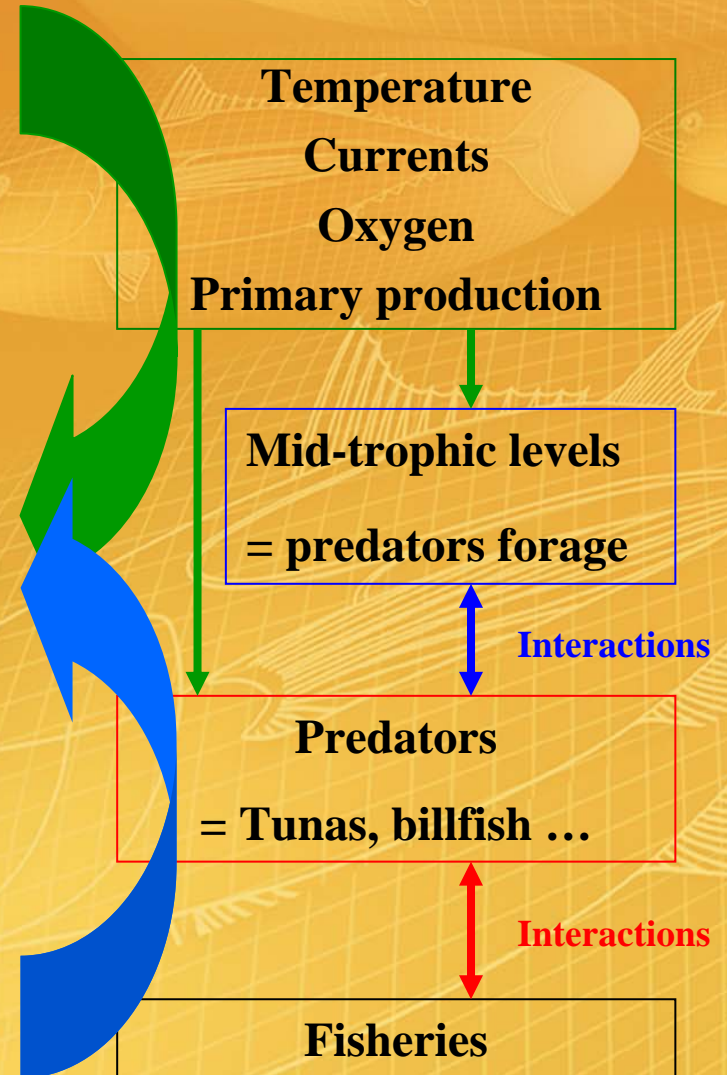


SEAPOODYM: Spatial model driven by physical and “simplified” food-web interactions

Climate/environment variability

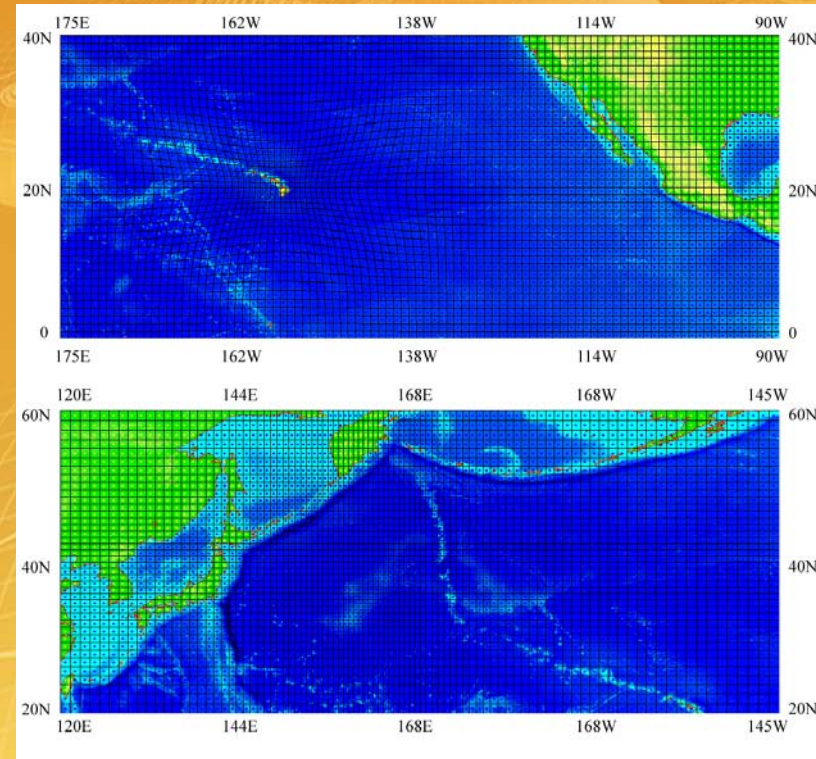


Fishing impact



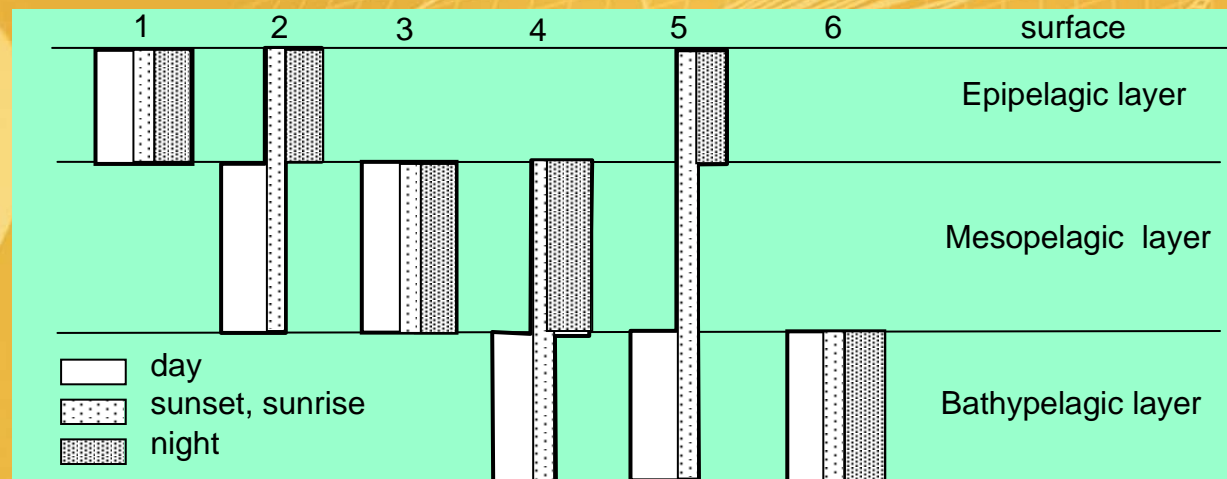
2004-05 achievements

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



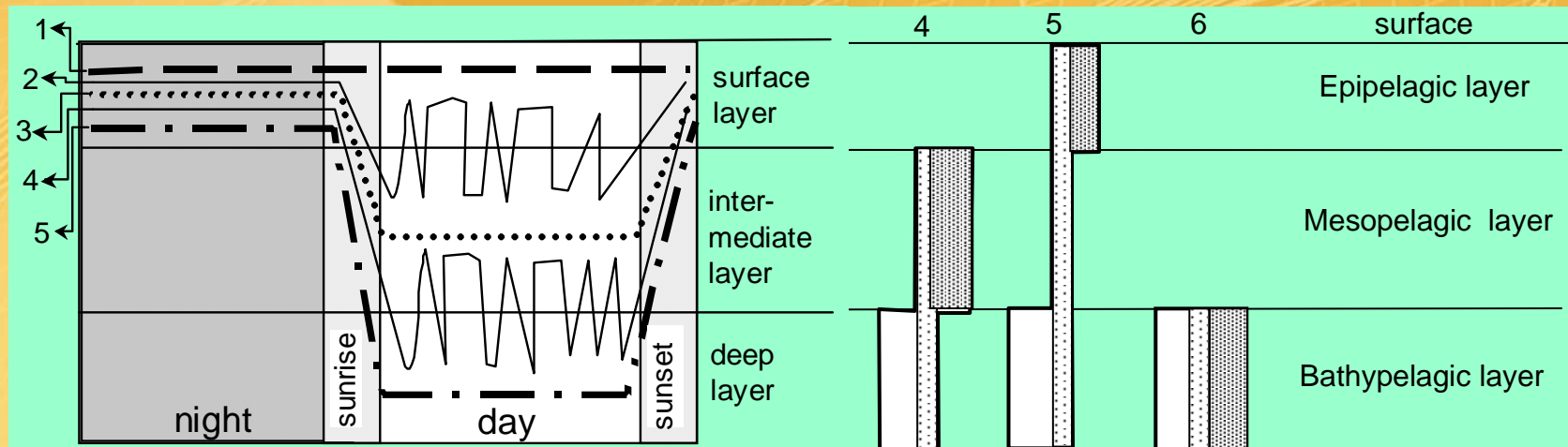
2004-05 achievements

- Model using a new numerical scheme for transport allowing to run the model with non-regular grid (ME-WP 2)
- Mid-trophic levels sub-model (6 components in 3 vertical layers)



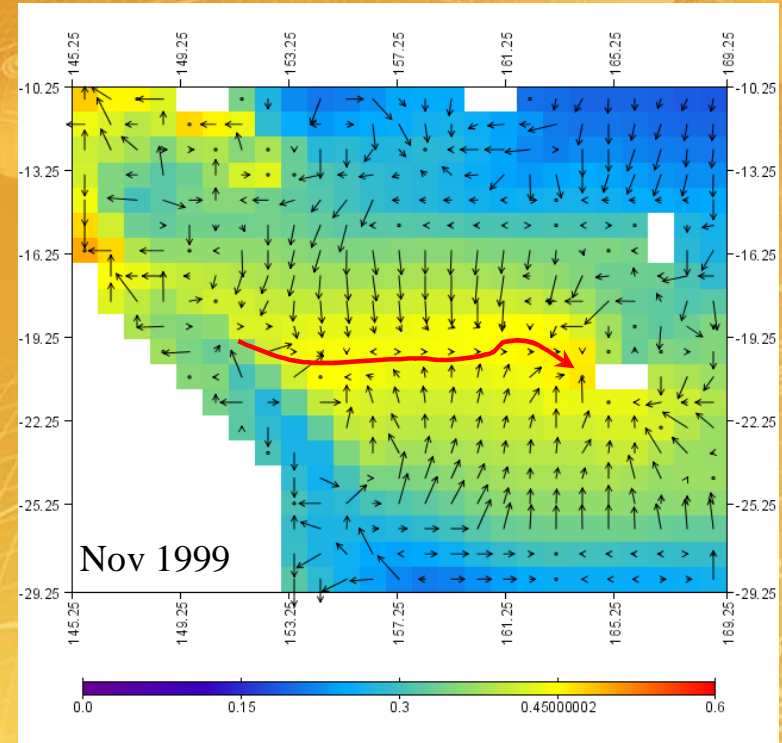
2004-05 achievements

- Model using a new numerical scheme for transport allowing to run the model with non-regular grid (ME-WP 2)
- Mid-trophic levels sub-model (6 components in 3 vertical layers)
- Coupling predator/forage revised



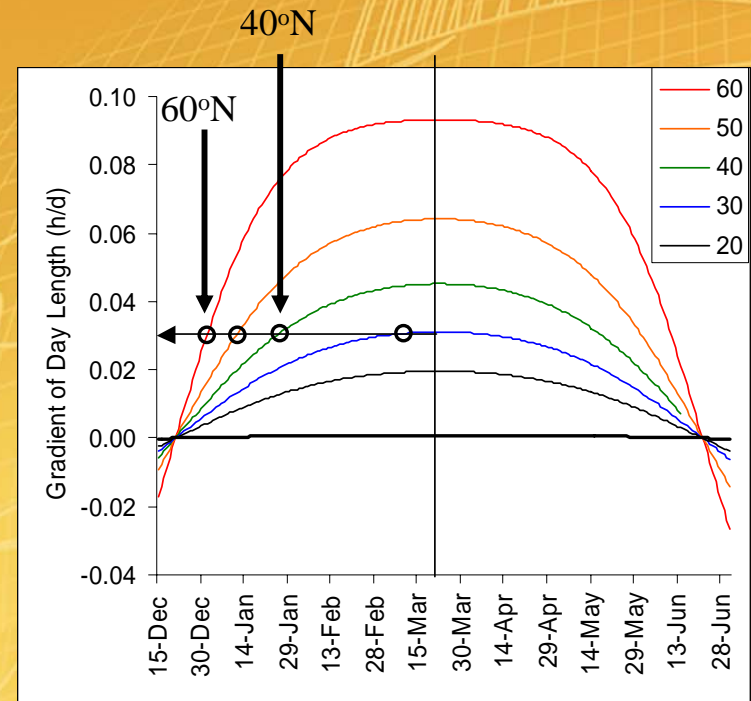
2004-05 achievements

- Model using a new numerical scheme for transport allowing to run the model with non-regular grid (ME-WP 2)
- Mid-trophic levels sub-model (6 components in 3 vertical layers)
- Coupling predator/forage revised
- Movement (advection-diffusion) linked to Maximum Sustainable Speed (MSS)



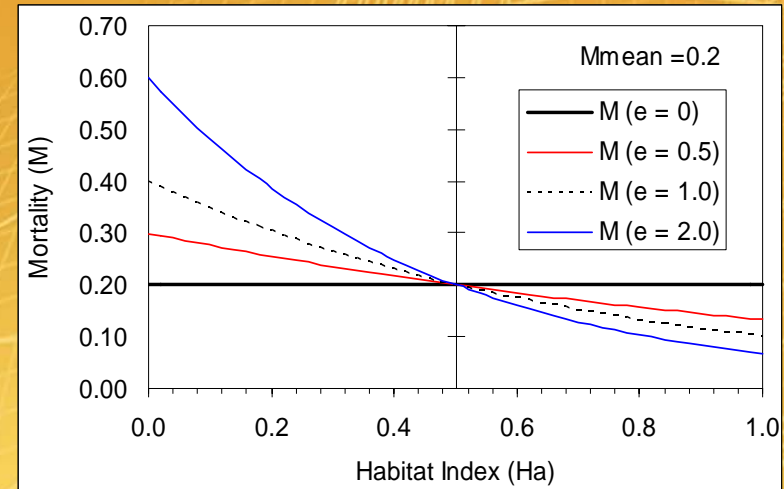
2004-05 achievements

- Model using a new numerical scheme for transport allowing to run the model with non-regular grid (ME-WP 2)
- Mid-trophic levels sub-model (6 components in 3 vertical layers)
- Coupling predator/forage revised
- Movement (advection-diffusion) linked to Maximum Sustainable Speed (MSS)
- Spawning seasonality



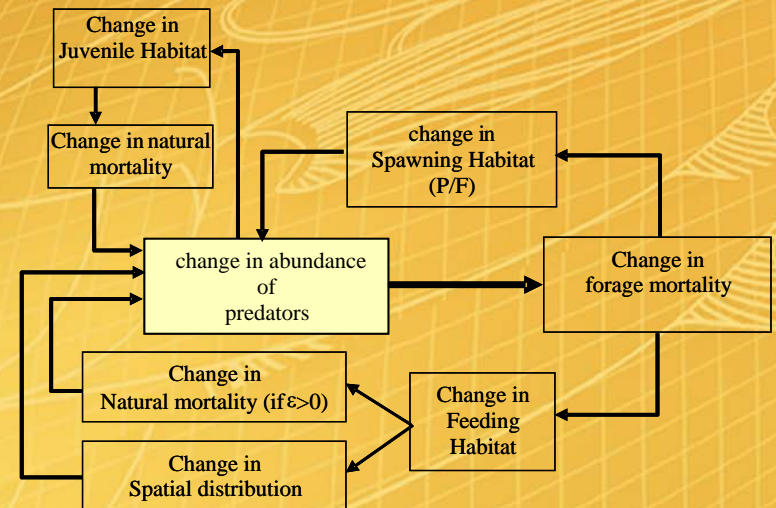
2004-05 achievements

- Model using a new numerical scheme for transport allowing to run the model with non-regular grid (ME-WP 2)
- Mid-trophic levels sub-model (6 components in 3 vertical layers)
- Coupling predator/forage revised
- Movement (advection-diffusion) linked to Maximum Sustainable Speed (MSS)
- Spawning seasonality
- Natural mortality varying in space and time in relation with habitats



2004-05 achievements

- Model using a new numerical scheme for transport allowing to run the model with non-regular grid (ME-WP 2)
- Mid-trophic levels sub-model (6 components in 3 vertical layers)
- Coupling predator/forage revised
- Movement (advection-diffusion) linked to Maximum Sustainable Speed (MSS)
- Spawning seasonality
- Natural mortality varying in space and time in relation with habitats
- Model is fully operational and can be used to run multi-species multi-fisheries simulations



2004-05 achievements

- Model using a new numerical scheme for transport allowing to run the model with non-regular grid (ME-WP 2)
- Mid-trophic levels sub-model (6 components in 3 vertical layers)
- Coupling predator/forage revised
- Movement (advection-diffusion) linked to Maximum Sustainable Speed (MSS)
- Spawning seasonality
- Natural mortality varying in space and time in relation with habitats
- 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


seapodym.tk - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites

Address <http://www.seapodym.tk/>

Pop-up blocked. To see this pop-up or additional options click here...

 [Login](#) [Signup](#)

A Spatial Ecosystem and Populations Dynamics Model

User not logged

[Home](#)

[News](#)

[License](#)

[Download](#)

[Publications](#)

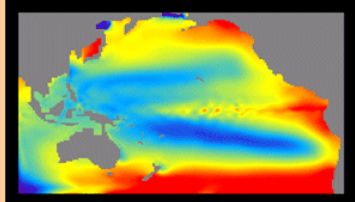
[Support](#)

[Forum](#)

[Contacts](#)

[Acknowledgments](#)

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...).

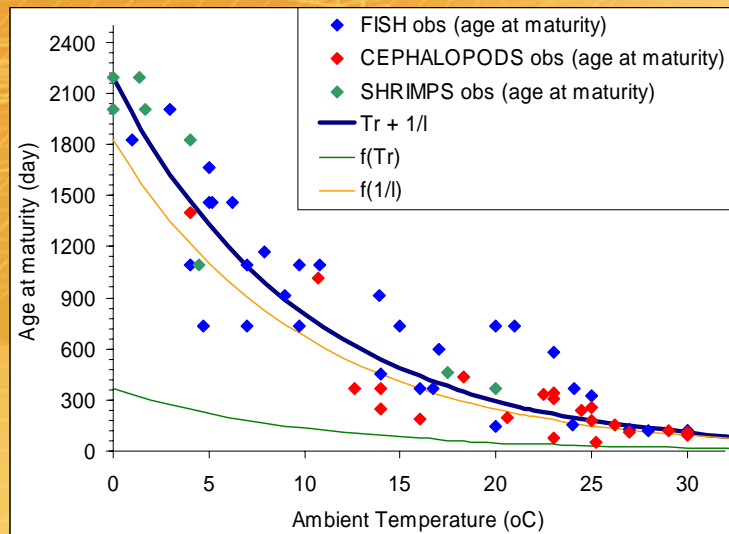
How to get Seapodym ?

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

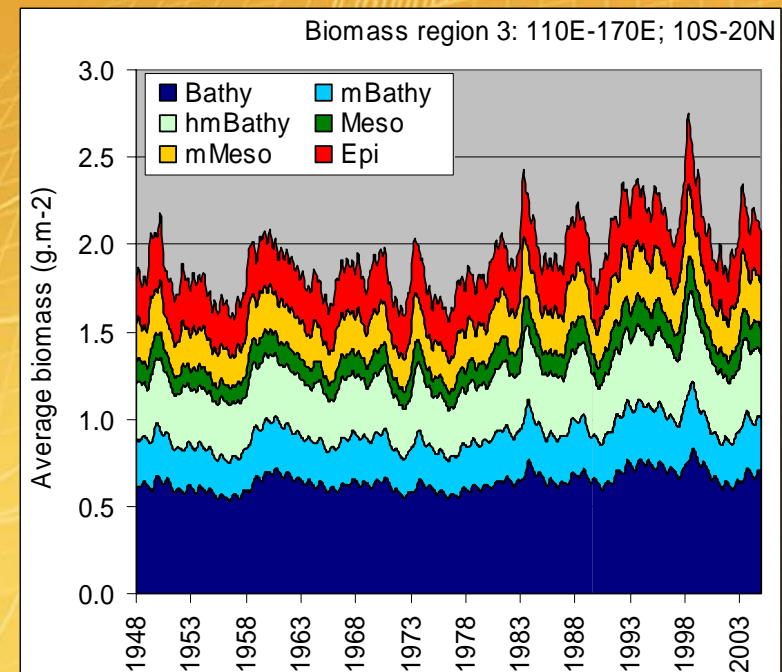
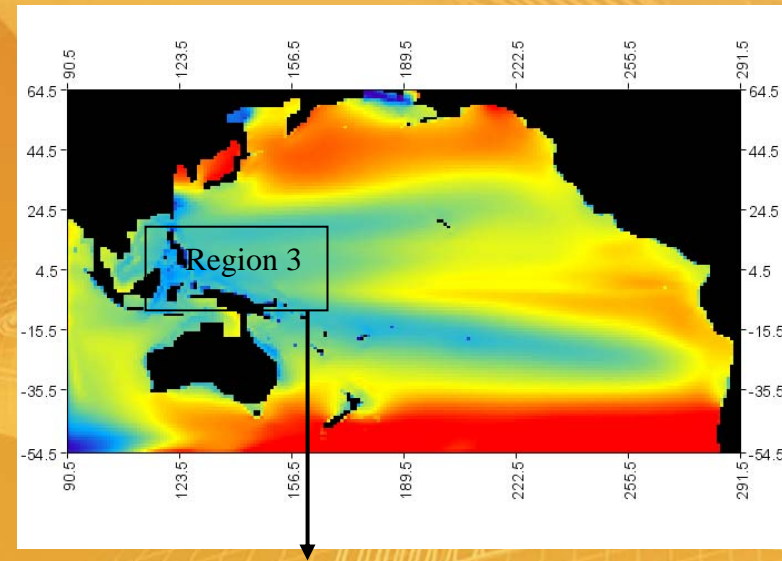
Running forage model alone:

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

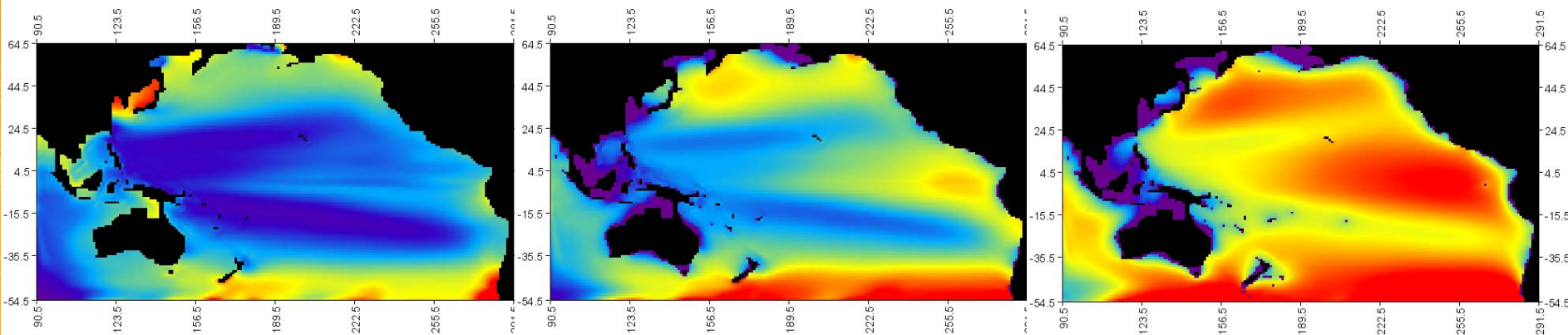


Results: mid-trophic levels

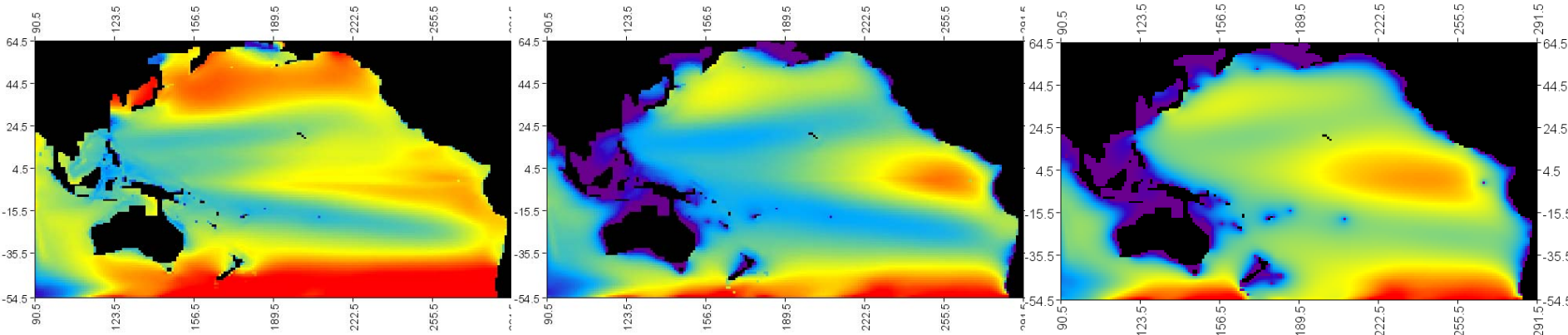
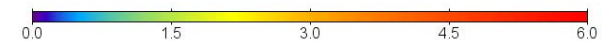
Epi-pelagic layer
(0-100m)

Meso-pelagic layer
(100-400m)

Bathy-pelagic layer
(400-1000m)

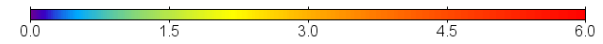


Day



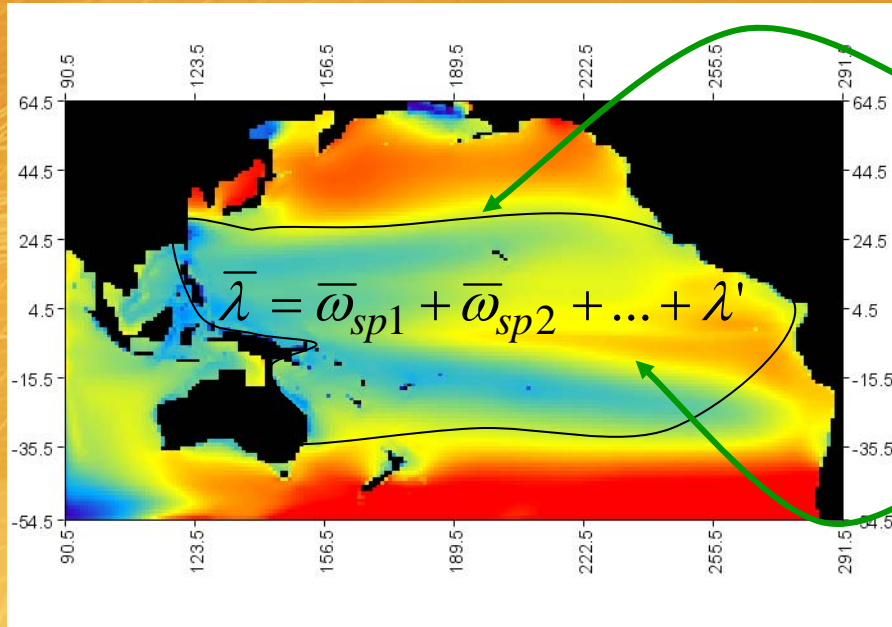
Night

Simulation outputs: Forage. 1948-2004, 10 days, 0.5 deg²



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 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

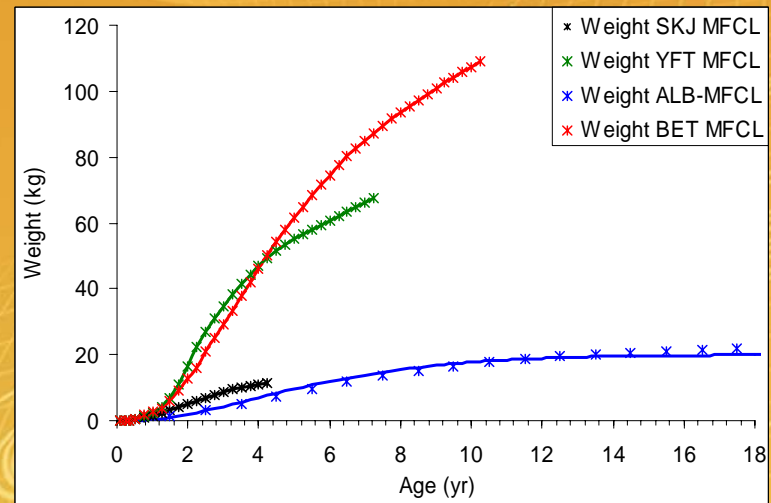
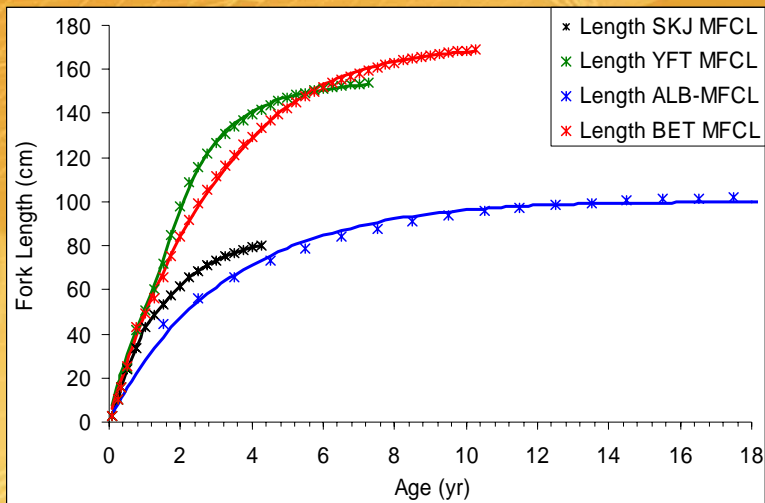
Outside specific predator area,
forage m = $\lambda(\text{temperature})$
Inside specific predator area
forage m = $\omega_{i,j} + \lambda'$

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 |



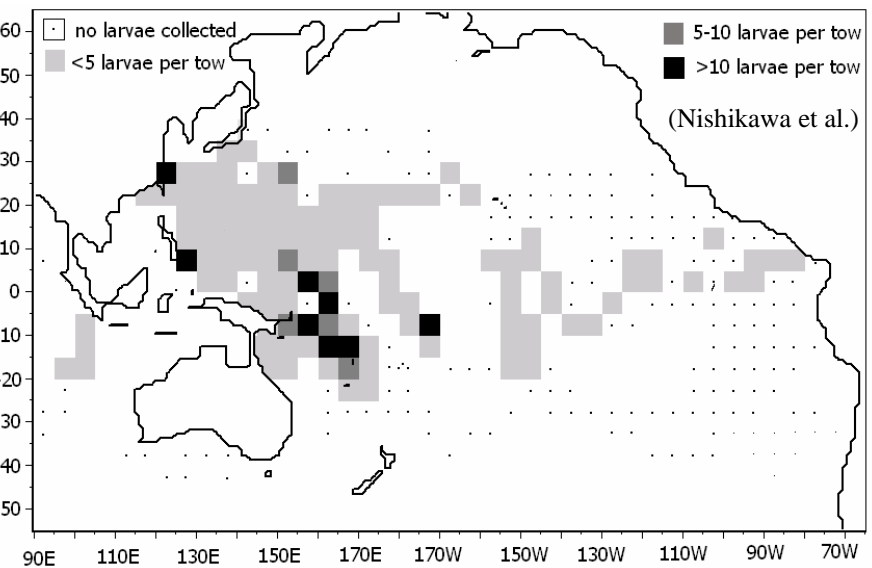
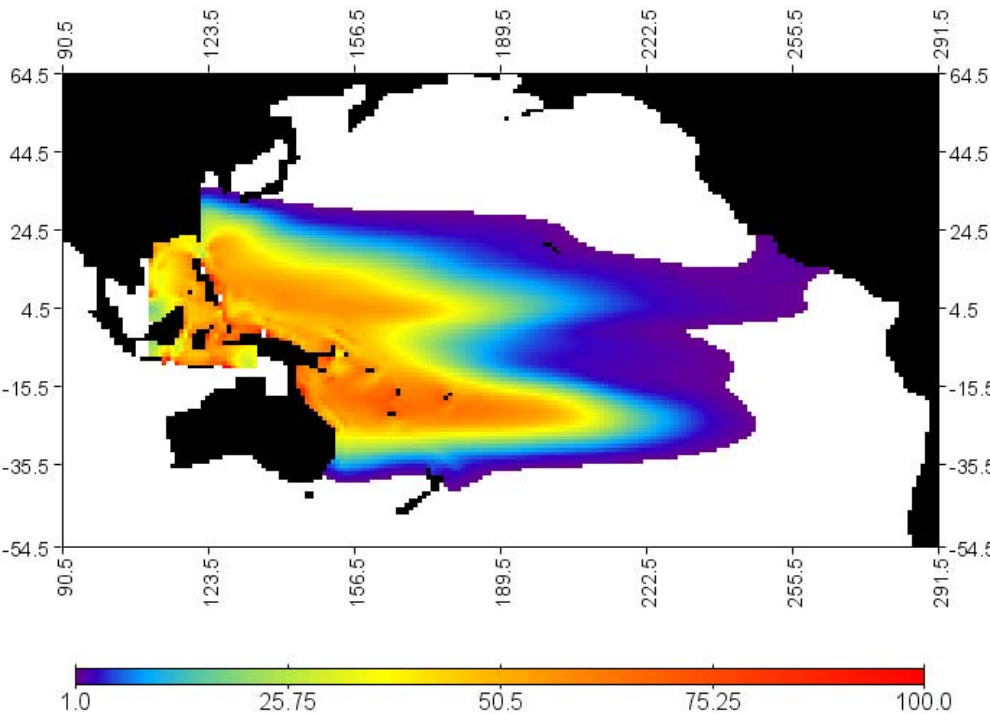
Length-at-age and weight-at-age coefficients estimated from MFCL analyses (crosses) and functions (curves) used to define the coefficient used in SEAPODYM simulations

Fisheries

| Category code | Description / source / resolution |
|----------------------|--|
| 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°N-25°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 |

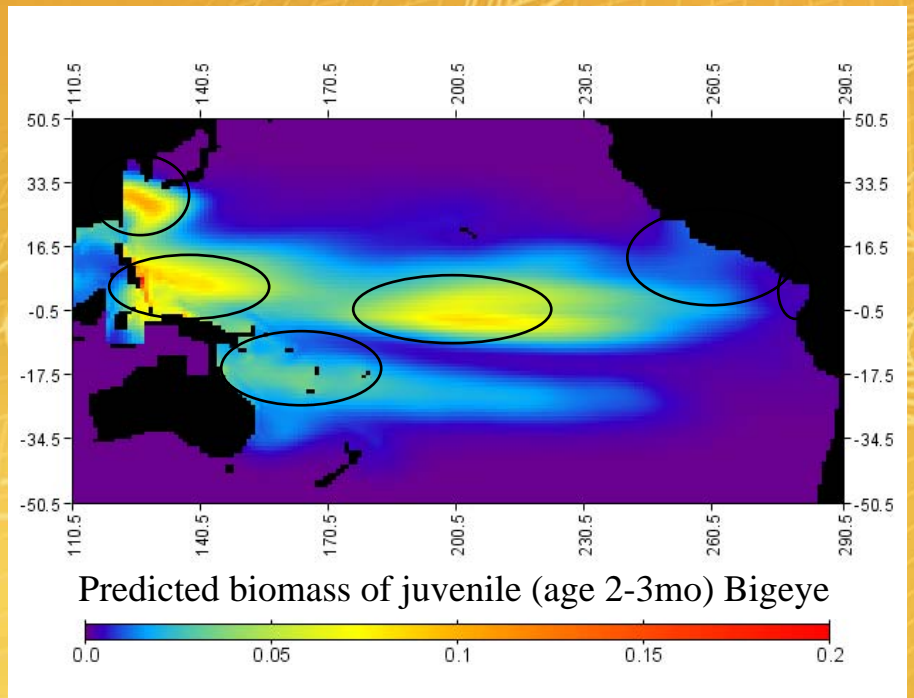
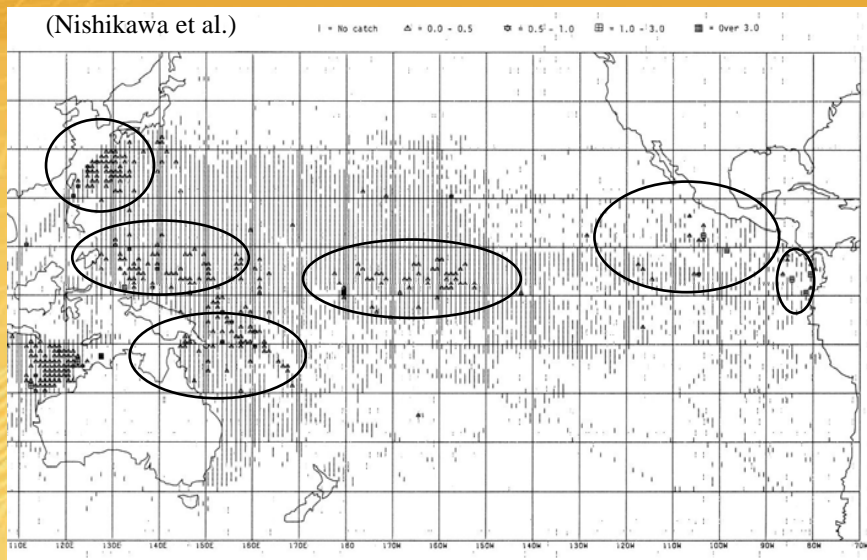
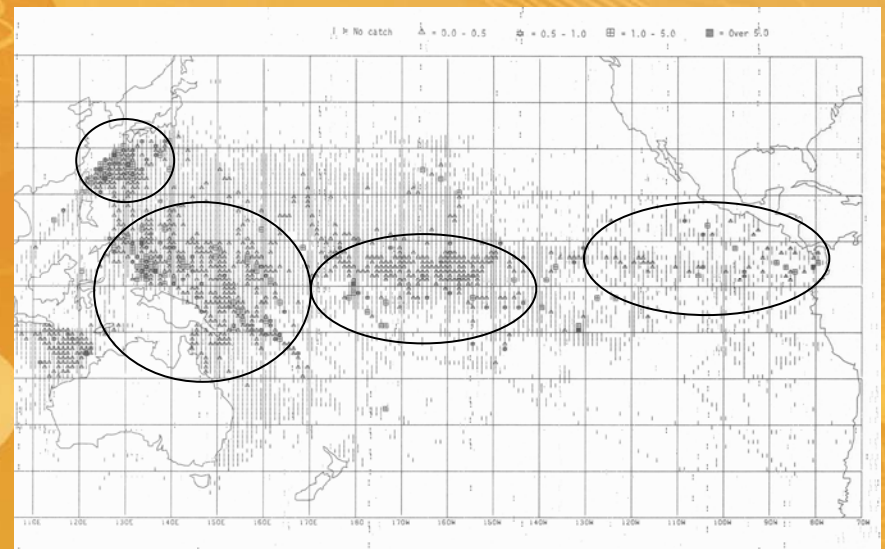
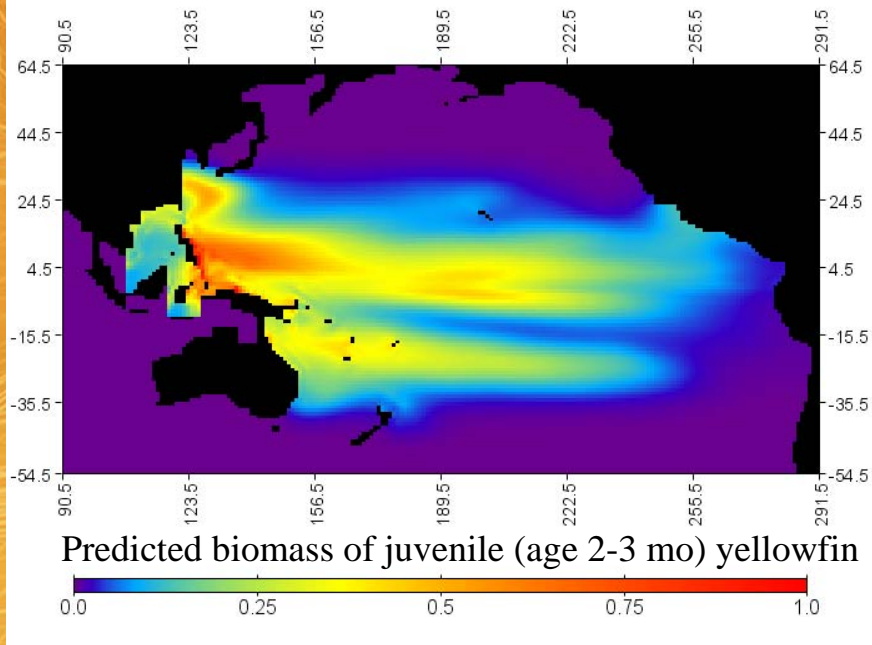
Spawning Habitat

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



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

Distribution of skipjack larvae (Nishikawa et al, 1985)

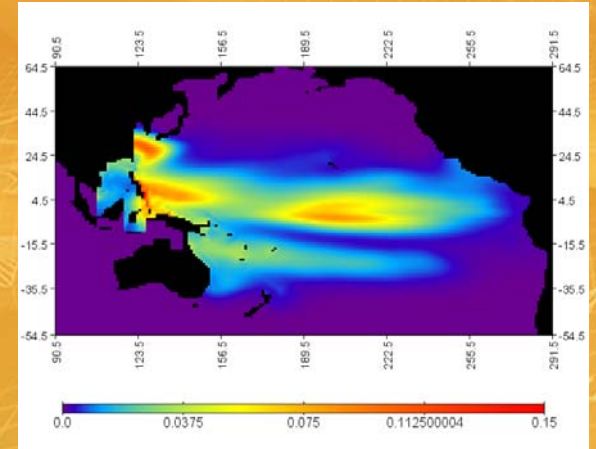
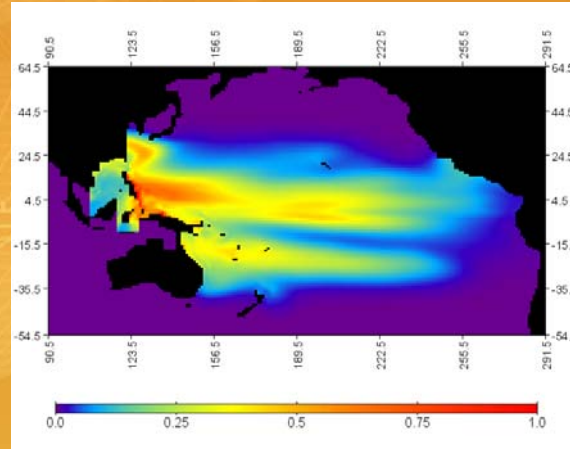
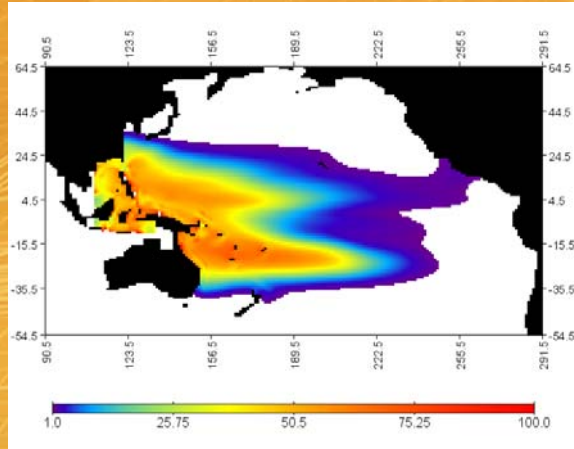


Skipjack

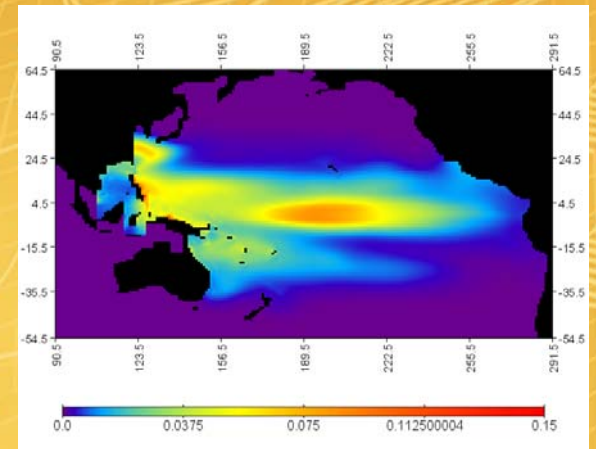
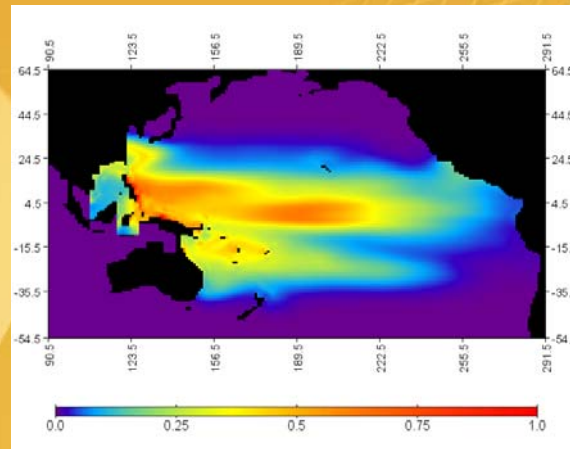
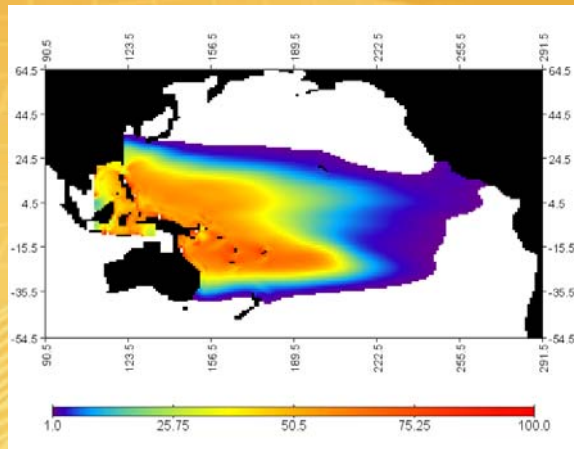
Yellowfin

Bigeye

1950-75



1976-98



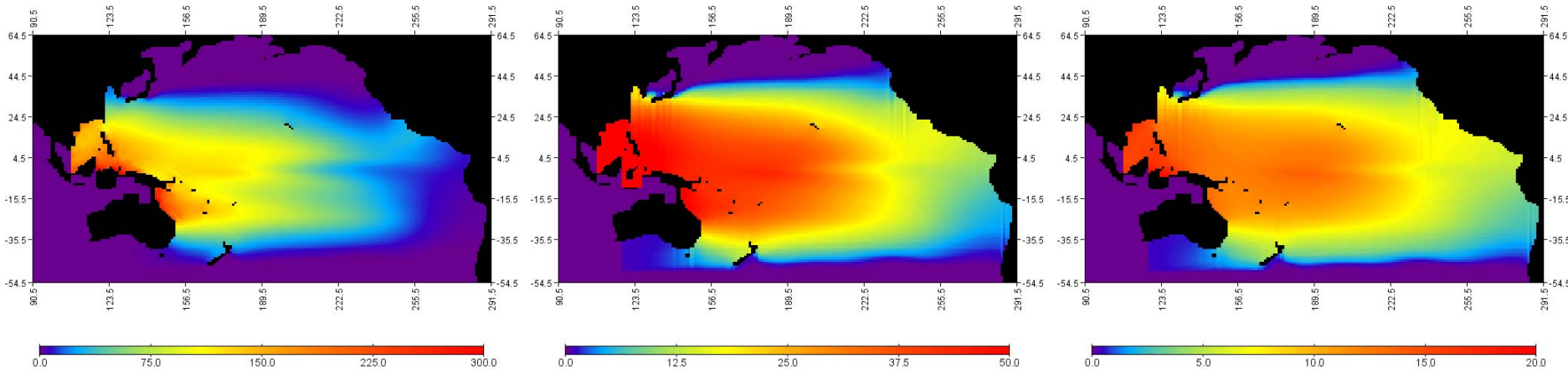
Average predicted distribution of juvenile (age 2-3 months) biomass during decadal period 1950-75 and 1976-98

Skipjack

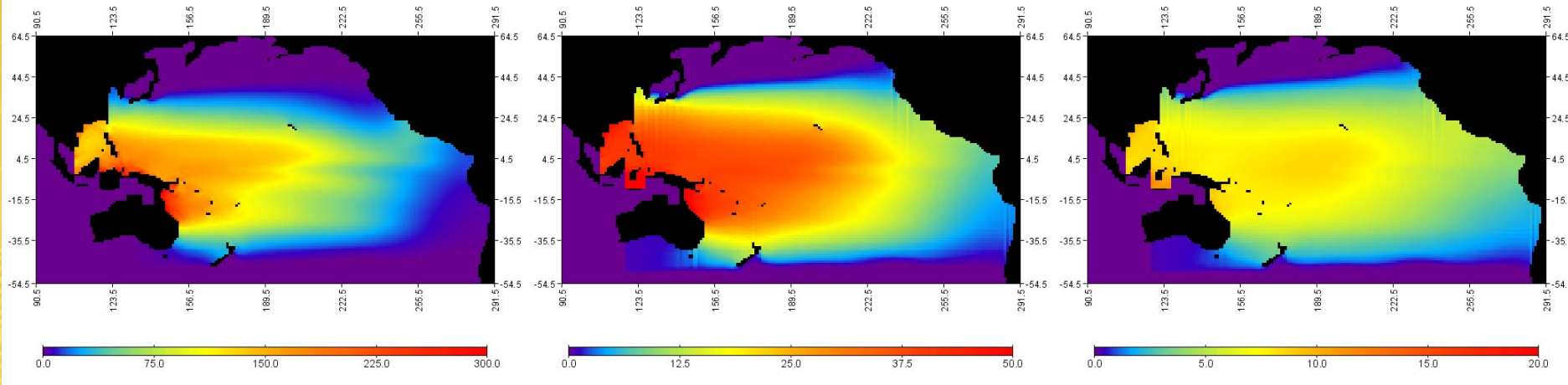
Yellowfin

Bigeye

1950-75

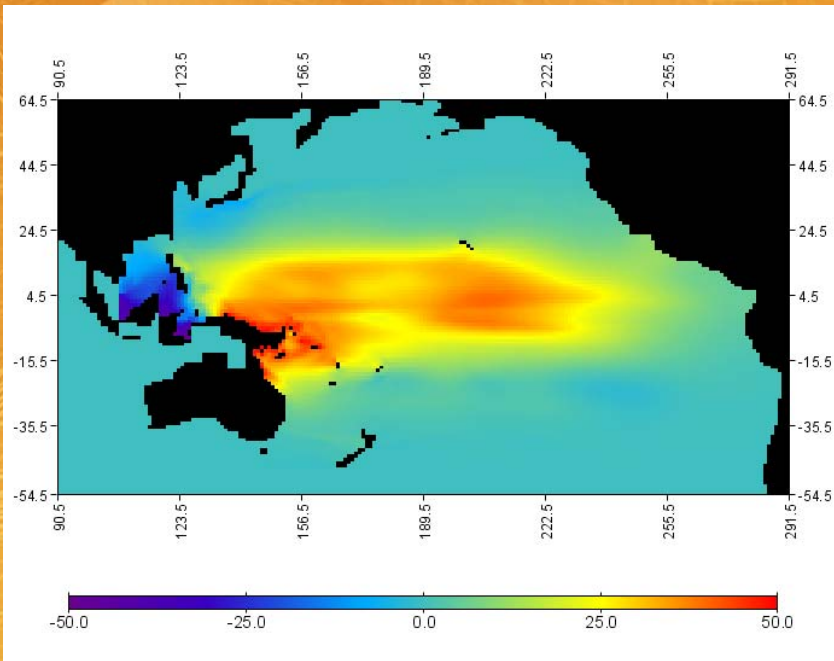


1976-98

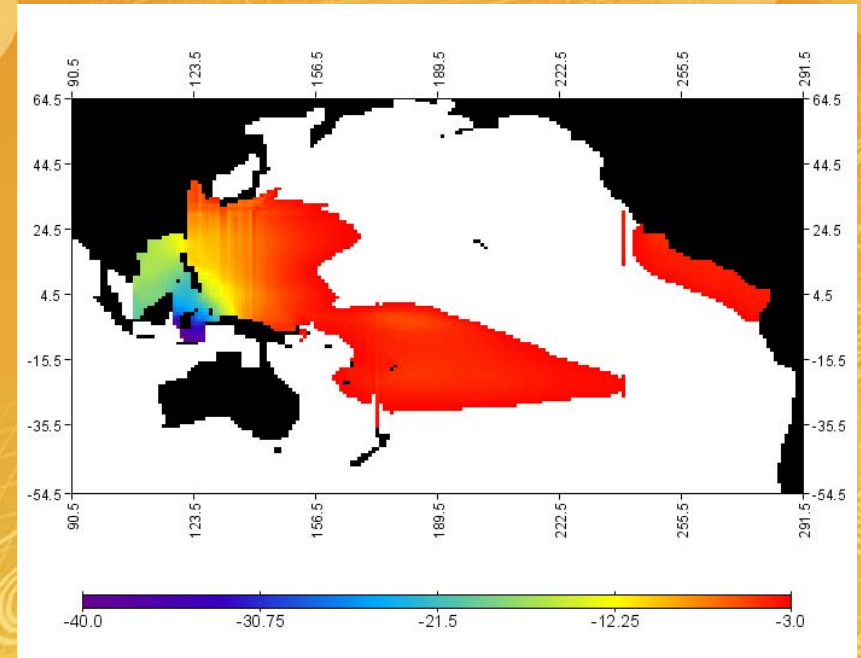


Average predicted distribution of **total biomass** during decadal period 1950-75 and 1976-98

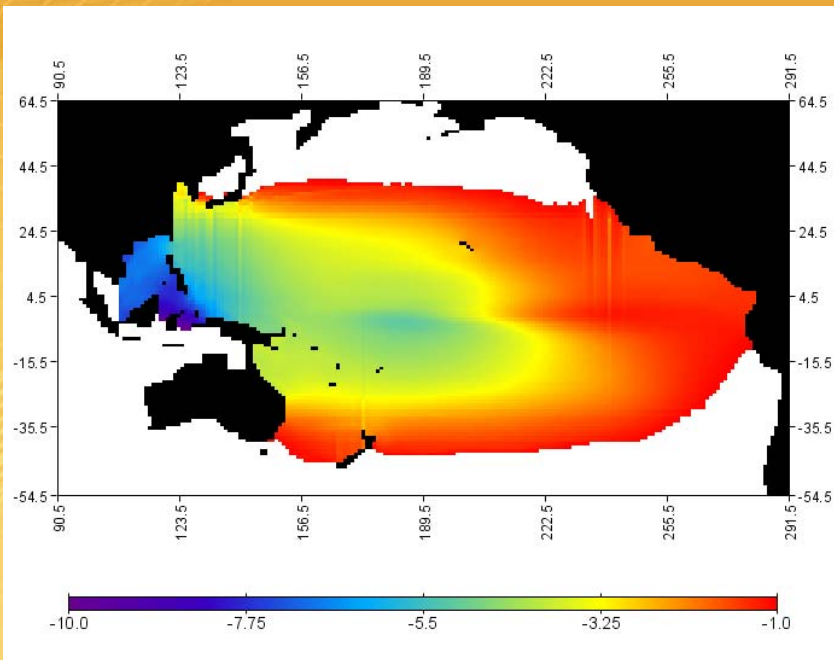
← Skipjack anomaly (1976-98) – (1950-75)



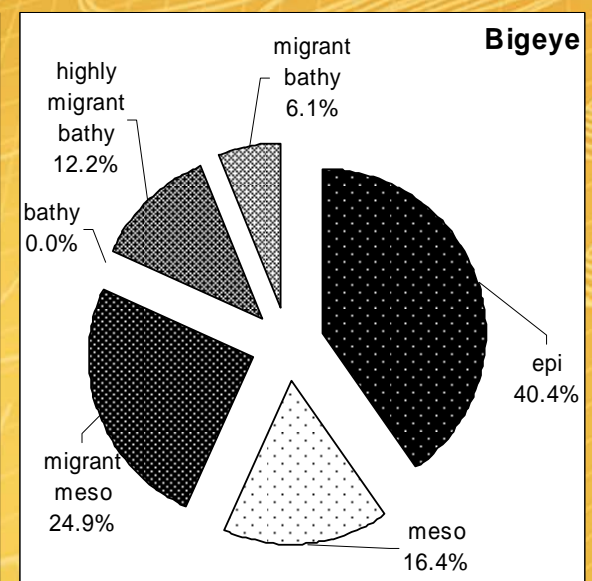
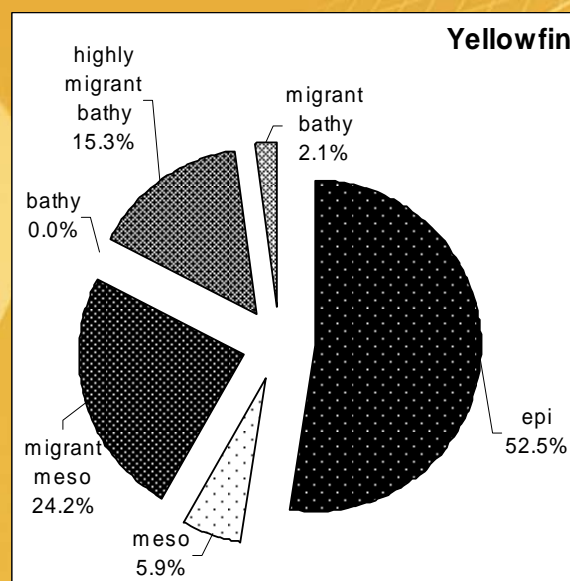
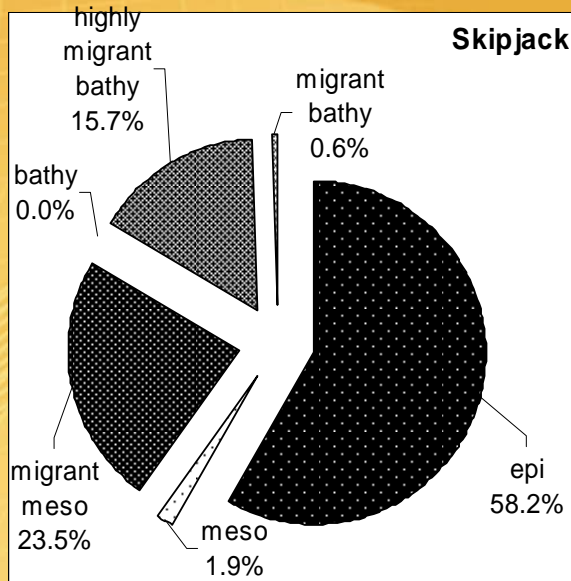
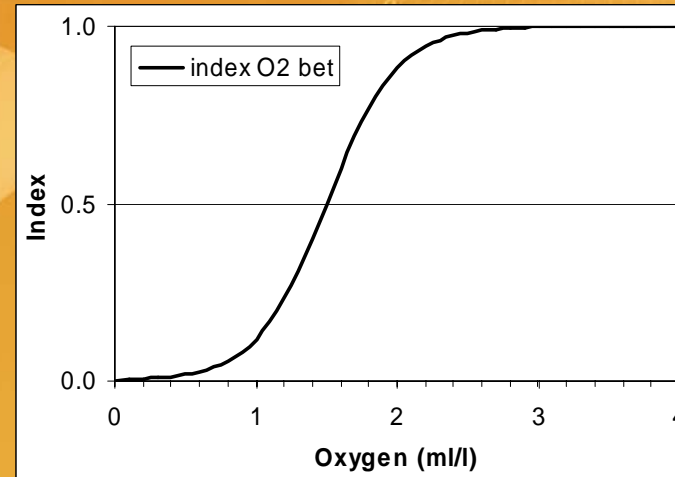
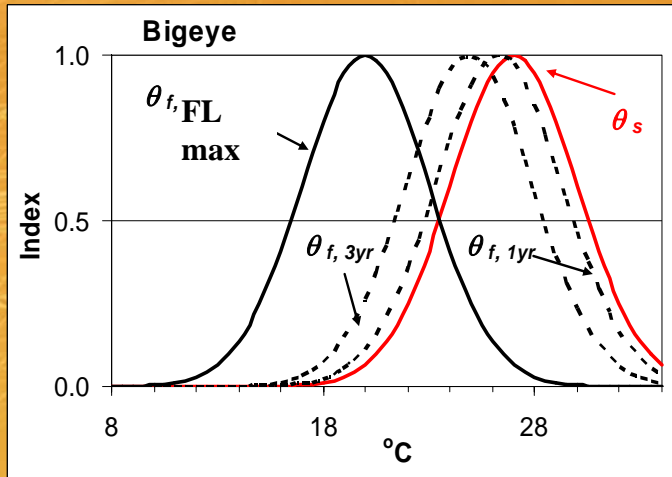
Yellowfin anomaly (1976-98) – (1950-75)



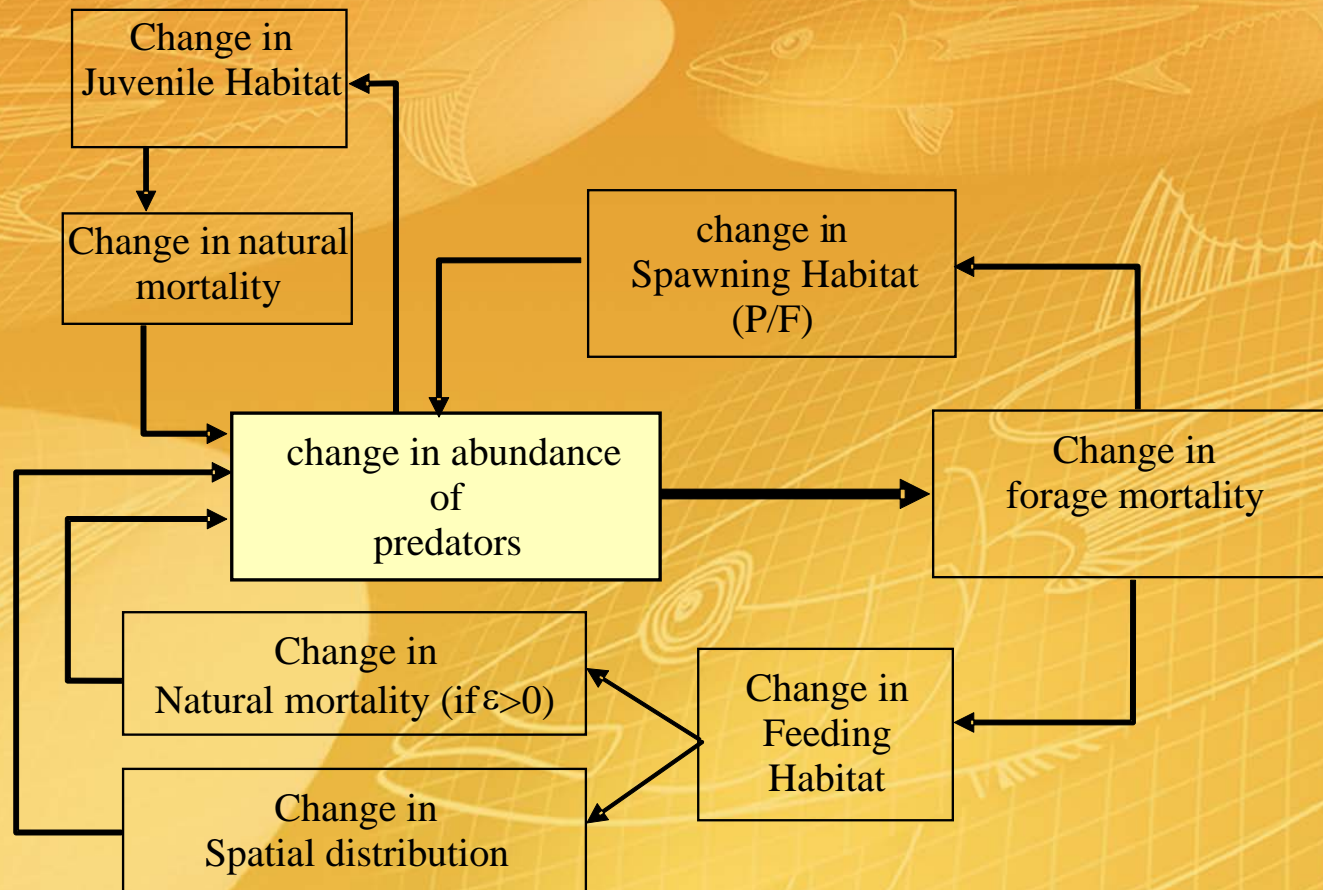
← Bigeye anomaly (1976-98) – (1950-75)



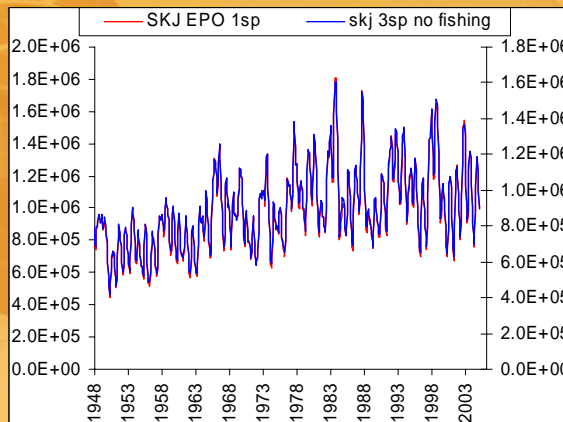
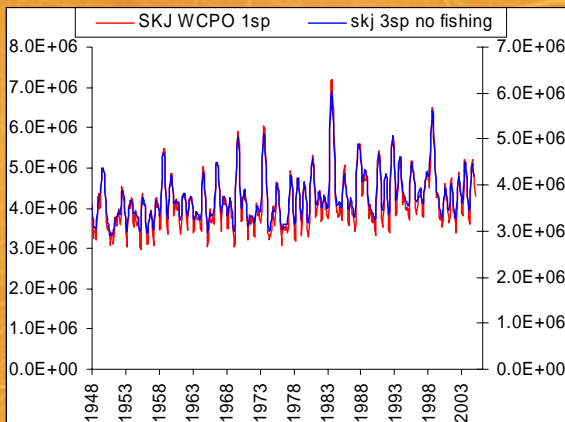
Average forage consumption by species (all age classes) based on accessibility to forage components



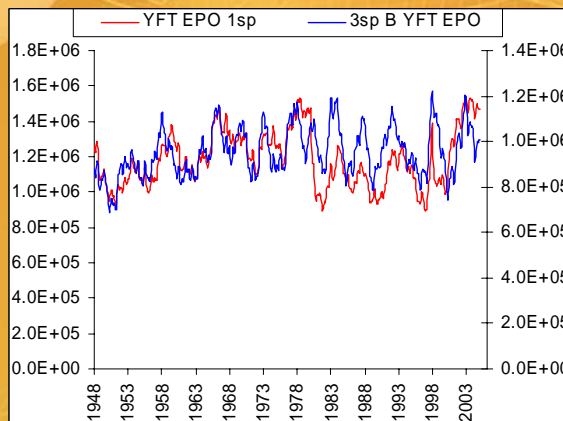
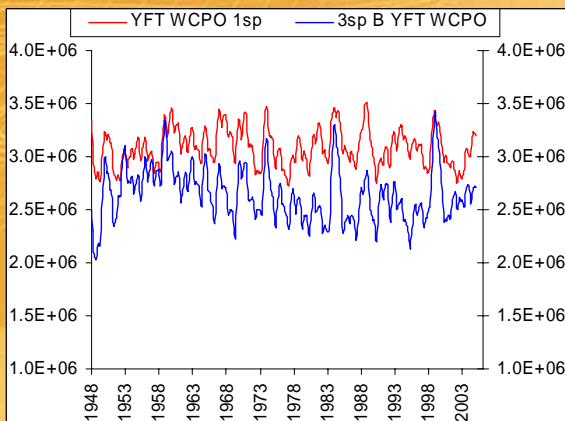
Running single vs multi-species simulations with SEAPODYM: What are the effect of interaction between top predator species like tuna?



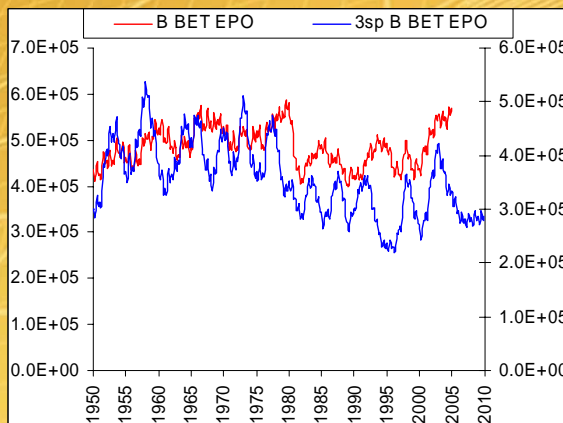
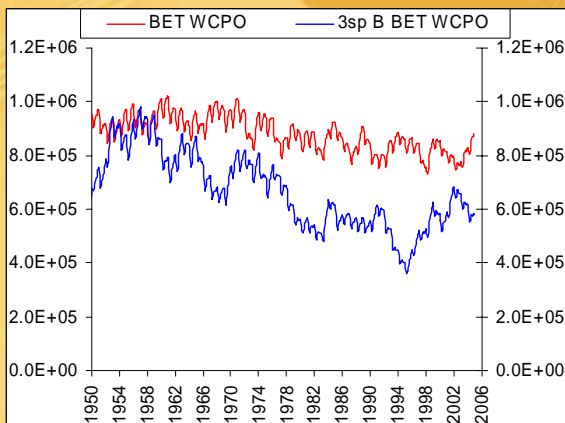
SKJ



YFT



BET

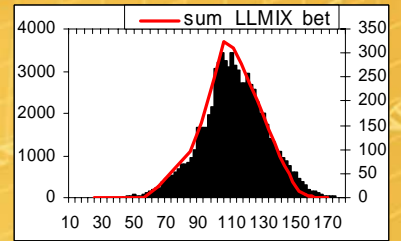
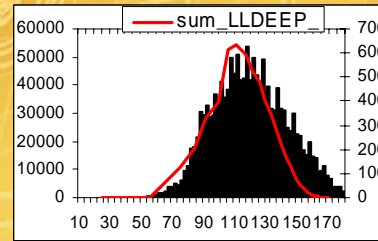
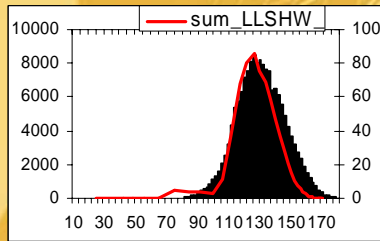
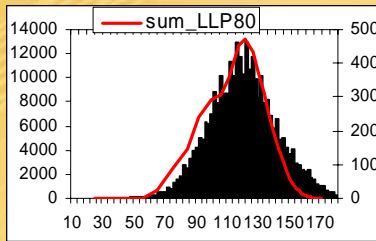
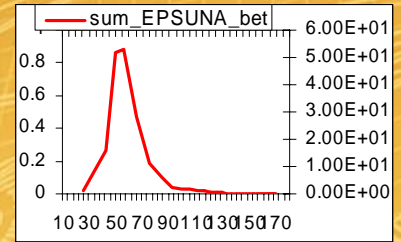
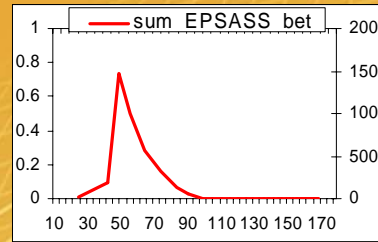
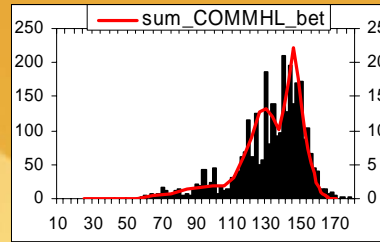
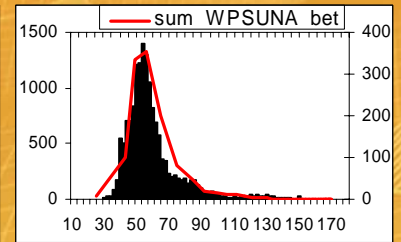
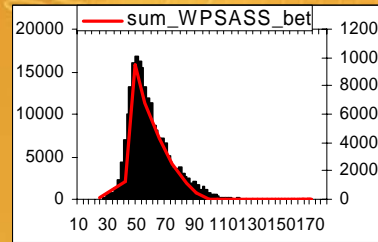
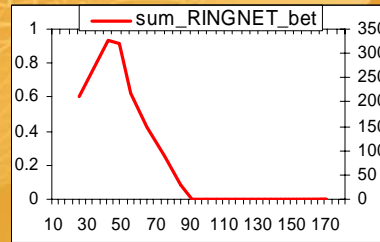
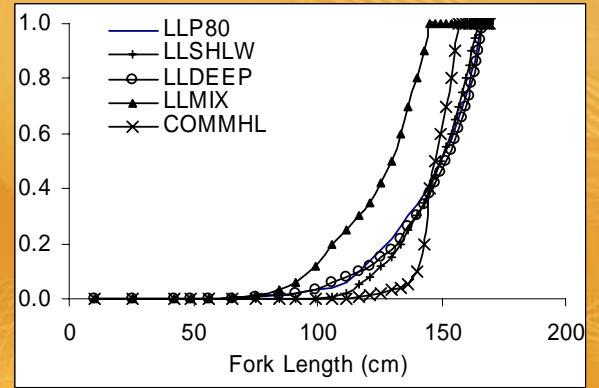
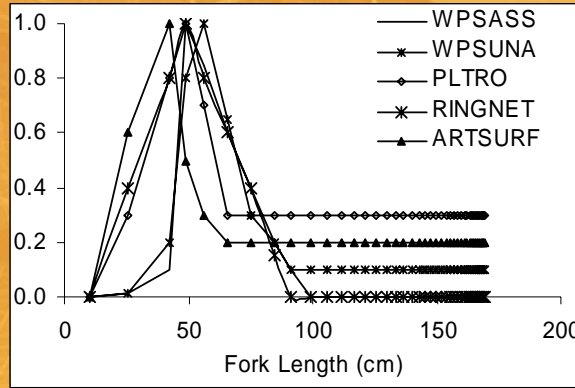


The background is a warm, golden-yellow color. It features several stylized, white line-art illustrations of fish, including what appears to be a large fish in the foreground and several smaller ones in the background. A faint, white grid pattern is overlaid on the entire background, creating a textured effect.

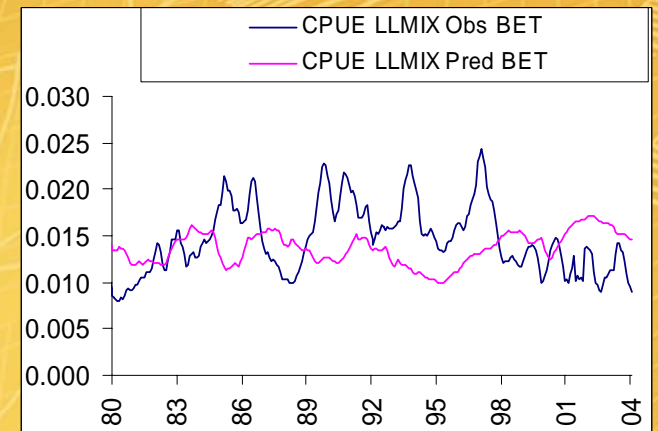
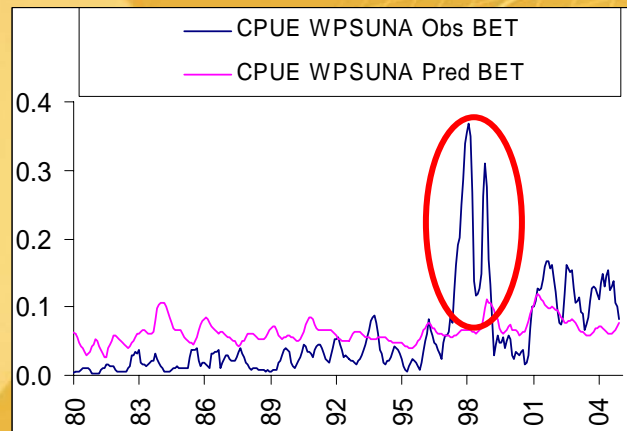
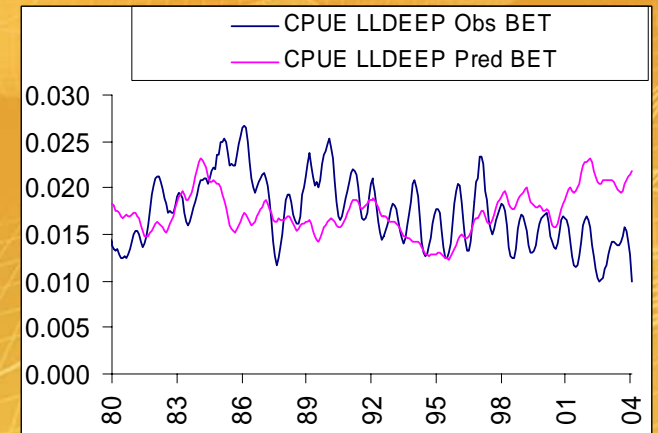
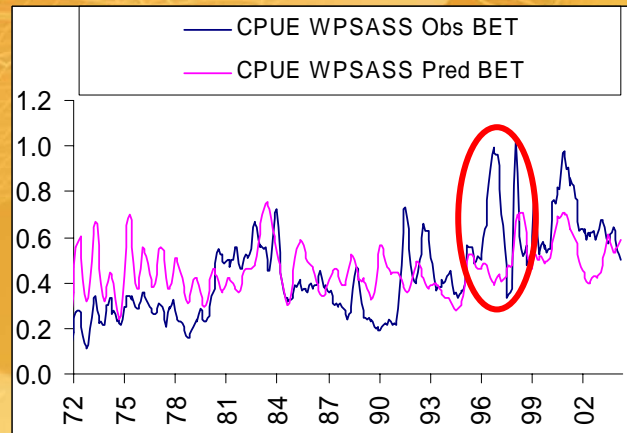
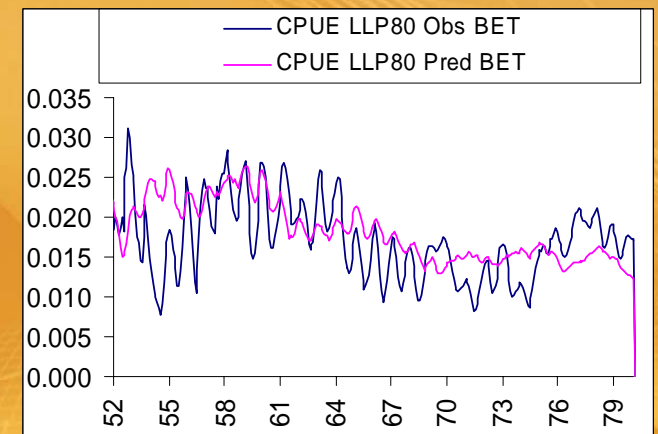
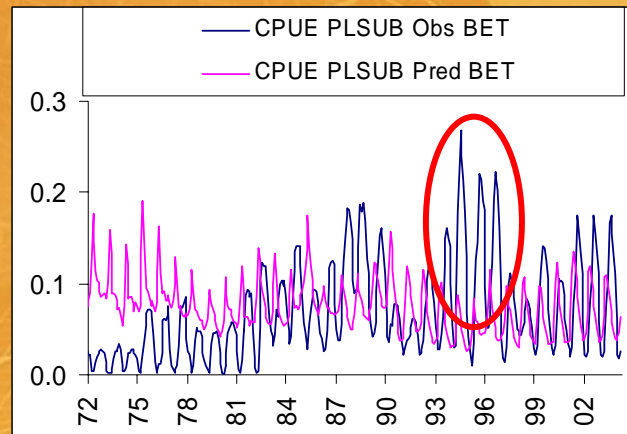
Some more results on bigeye...

Selectivity

bigeye



Predicted and observed CPUE



BET

Observed total catch (t)

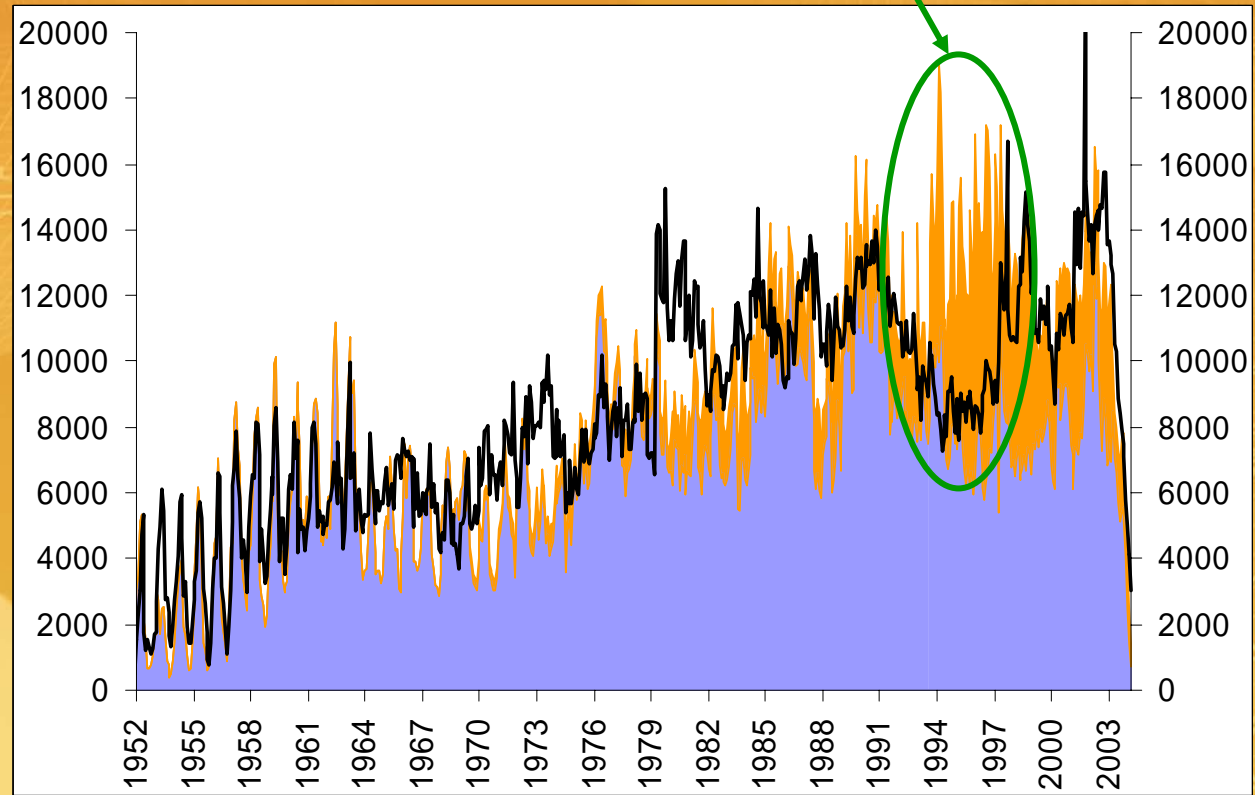
Blue = LL

Orange = Others (surf. Gears)

Predicted LL catch

Predicted total catch

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

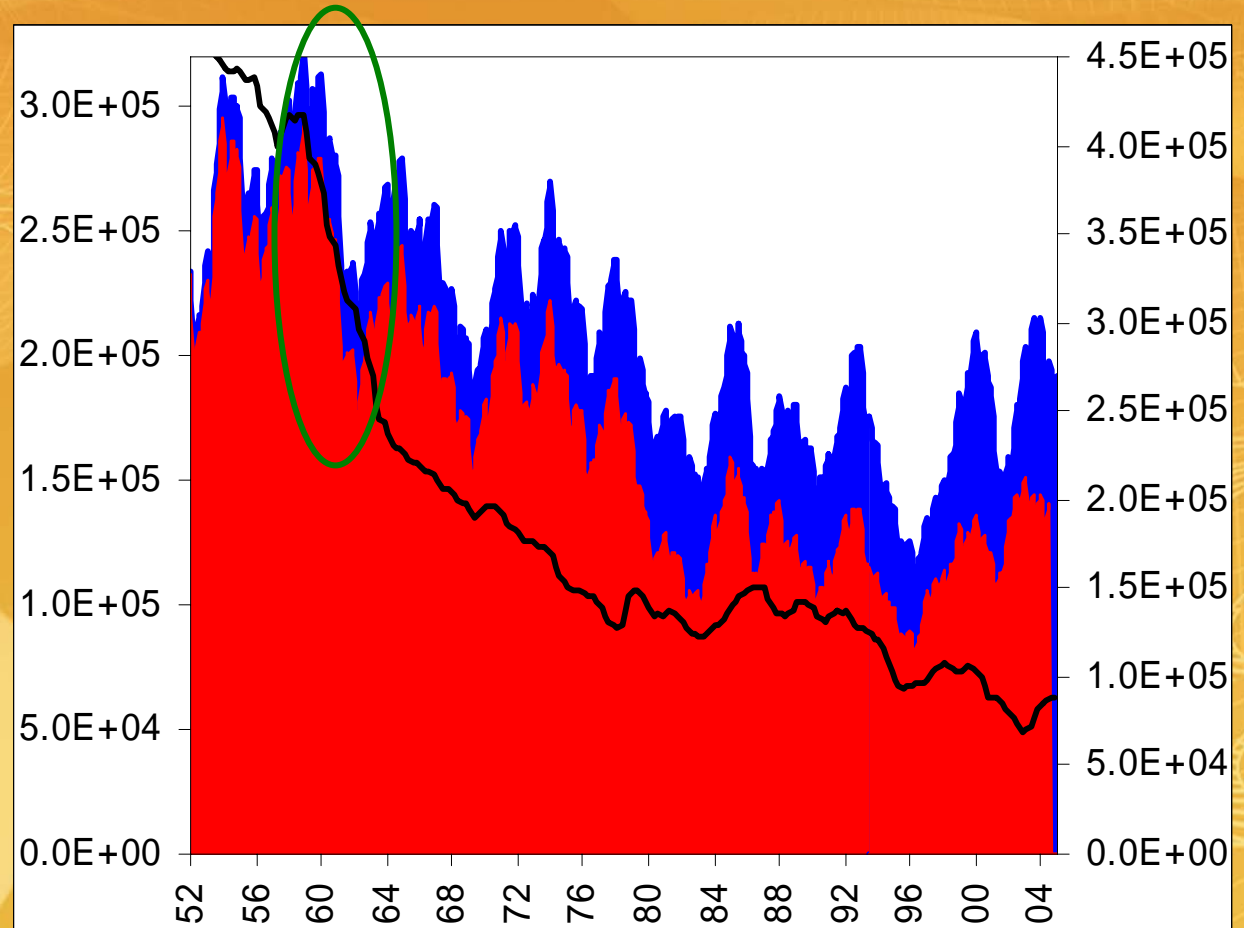


BET - WCPO

Adult total biomass

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

Black curve: MULTIFAN-CL estimate (with fishing)



Conclusions

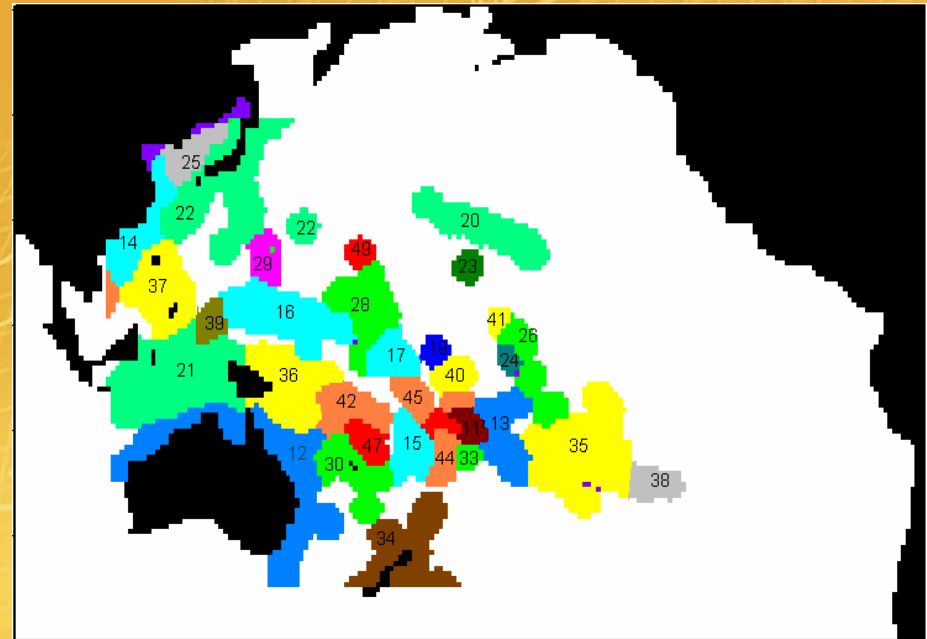
- In absence of an optimization function, a reasonable parameterization for 3 species (skj, yft and bet) and their fisheries was obtained.
- The model capture important changes in the population dynamics that explain a large part of time space variability in the catch and CPUE.
- Multi-species simulations 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

Perspectives

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

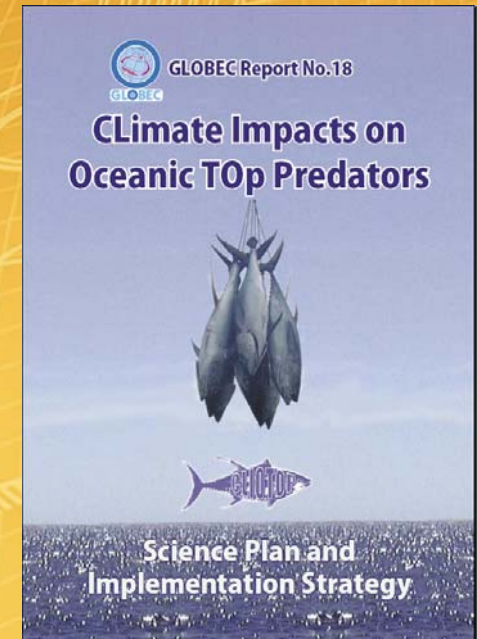
Perspectives

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



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)

