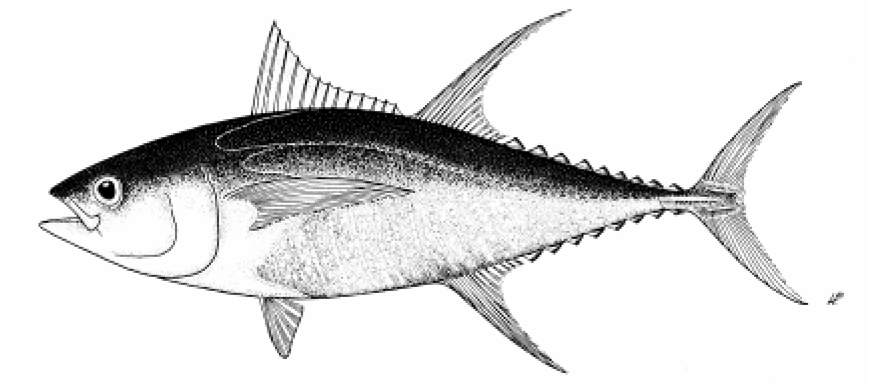
WCPFC–SC1 **ME WP–1**

Western and Central Pacific Fisheries Commission

1st Meeting of the Scientific Committee of the Western and Central Pacific Fisheries Commission
WCPFC–SC1
Noumea, New Caledonia
8–19 August 2005

First application of SEAPODYM to Pacific bigeye tuna



Patrick Lehodey

Oceanic Fisheries Programme
Secretariat of the Pacific Community
Noumea, New Caledonia

July 2005

Introduction

This document provides complementary information on the bigeye SEAPODYM application presented in Lehodey (2005a) to support the discussion during the Methodology Working group of the first scientific meeting of the Western and Central Pacific Fisheries Commission (WCPFC). Details on the model itself can be found in the reference manual (Lehodey 2005b).

Parameterization

Population structure, age, growth

Bigeye population is described with 3 monthly age classes (larvae and juveniles) and 40 quarterly age classes. Number of age classes, length-at-age and weight-at-age coefficients are identical to those defined or estimated for/by MULTIFAN-CL (Hampton et al., 2005). Age at maturity is set to 2.5 years and recruitment occurs during the 3rd quarter.

Mortality

Parameterization of the natural mortality functions result in mortality-at-age coefficients close to those estimated by MULTIFAN-CL (Lehodey 2005a). The parameter ε was set to 0.5 allowing the natural mortality to slightly vary in relation with the habitat (Fig. 1). The fishing mortality is proportional to the fishing effort, the catchability coefficient of the fishery and the selectivity coefficient for the gear and age (size) considered.

Habitats

Parameters of spawning and feeding habitat were defined in relation with the other species to obtain a coherent set of parameters (Lehodey 2005a). However, sensitive analyses need to be conducted for these parameters as well as for the threshold value (set to $\geq$0.03h per day) used for triggering the spawning migration.

Results

Larvae/juvenile distribution

Knowledge on the distribution of larvae of bigeye is sparse and comes from sampling cruises carried by Japanese scientists mainly during the 1960's and 1970's (Nishikawa et al. 1985). Comparison of predicted distribution of biomass of age 2 and 3 months fish with these observations (Figure 2) is encouraging as the main spawning grounds predicted by the model correspond well with those identified from the sampling cruises. There are seasonal changes in the predicted distribution (Figure 3) with peaks in the western equatorial region in the first quarter, in the EPO in the second quarter, in the central equatorial Pacific in the third quarter and finally in the East China sea and Coral Sea in the fourth quarter. Interannual (ENSO) and decadal changes were also predicted (Lehodey 2005a) with increases during El Niño events and higher productivity regime in the 1975-98 period.

Recruitment and biomass time series by region

Time series of recruitment and total biomass are compared with estimates from statistical models MULTIFAN-CL (Hampton et al. 2005) and A-SCALA (Maunder and Harley 2003) in the regions defined for these assessment analyses, i.e. 6 regions for the WCPO and one (east of 150^{o}W) for the EPO. Recruitment series have a high frequency variability and correlation coefficients are usually low, with the exception of region 1 (Table 2). Convergence between series is much better for total biomass with substantial increase in correlation coefficients for all regions. Decline of biomass is observed in the 1950's and early 60's in region 1, 3 and 5 as for statistical series but not in regions 2, 4 and 6. Peaks of biomass following strong El Niño events of 1982-83 and 1997-98 are the most visible in region 1, 3, 5 and 6. With the present parameterization, the SEAPODYM simulation predicted a much lower biomass in the EPO than estimated with A-SCALA. The level of biomass in this region is likely sensitive to the parameterization of the temperature function for the feeding habitat. It will be necessary to carry out a sensitive analysis for the parameter θ_a. Also, Oxygen fields used here are only quarterly climatologies that can lead to some bias particularly during El Niño events.

Conclusion

These first results are presented to support the discussion on the future tasks that should be considered with the use and evolution of SEAPODYM. While the development of an optimization function that will greatly facilitate the future parameterization, it is already possible to test different scenarios with time and space changes in the fishing effort distribution of the fisheries. Multi-species simulations have been tested but still require changes in the parameterisation from the one presented here and in Lehodey (2005a), due to the interactions between species (Figure 7). Starting from the same single-species parameterization (but changing R_s fro yellowfin and bigeye), the first obvious changes from the multi-species simulation is an increased biomass of skipjack in the EPO and reduced amplitude of fluctuations in yellowfin and bigeye.

References

Hampton J., Kleiber P., Langley A., Takeuchi Y., Ichinokawa M., Maunder M., 2005b. Stock assessment of bigeye tuna in the western and central Pacific Ocean, with comparisons to a Pacific-wide assessment. First meeting of the Scientific Committee of the Western and Central Pacific Fisheries Commission WCPFC-SC1, Noumea, New Caledonia, 8-19 August 2005. **SA WP–2**.

Lehodey P., 2005a. Reference manual for the Spatial Ecosystem And Populations Dynamics Model SEAPODYM. First meeting of the Scientific Committee of the Western and Central Pacific Fisheries Commission WCPFC-SC1, Noumea, New Caledonia, 8-19 August 2005. **ME IP–1**

Lehodey P., 2005b. Application of SEAPODYM to the Pacific Pelagic Ecosystem. Recent results and perspectives. First meeting of the Scientific Committee of the Western and Central Pacific Fisheries Commission WCPFC-SC1, Noumea, New Caledonia, 8-19 August 2005. **EB-WP-8**

Maunder M. and Harley S., 2003. Status of bigeye tuna in the eastern Pacific Ocean in 2001 and outlook for 2002. Inter-American Tropical Tuna Commission (IATTC), La Jolla, CA. 15th meeting of the Standing Committee on Tuna and Billfish, Honolulu, Hawaii, USA, 22-27 July 2002, *Working Paper:* B**ET-2**.

Nishikawa Y., Honma M., Ueyenagi S., Kikawa S., 1985. Average distribution of larvae of oceanic species of scombrid fishes, 1951-81. Contribution of the Far Seas Fisheries Research Laboratory, Fishery Agency of Japan **236**: 1-99.

Table 1. Main parameters used in SEAPODYM application (Lehodey 2005a).

Parameter	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
Mpmax (qtr^{-1})	0.9	0.5	0.25
Mp_exp	0.17	0.17	0.17
Msmax (qtr^{-1})	0.46	0.23	0.12
Ms_slope	-0.5	-0.5	-0.5
Ms_half (qtr)	10	11	12
ε	1.5	1	0.5
θ_s	29	28	27
σ_s	3	3	3
Seasonality	1	1	1
α	2	3	4
R_s	5500	900	800
θ_a	25	23	20
σ_a	3	3	3
$O_{1/2}$	2.5	2	1.5
O_{slope}	-4	-4	-4
MSS	1	1	1

Table 2. Correlations between time series of recruitment and total biomass predicted from SEAPODYM and statistical models MULTIFAN-CL (regions 1 to 6) and A-SCALA (EPO).

	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	EPO
R	0.44	-0.18	-0.06	0.03	0.02	0.13	-0.17
B	0.55	0.05	0.32	0.25	0.24	0.31	0.12

Table 3. Percentage of increase in the CPUE of remaining fisheries when removing the purse seine fisheries

PLSUB	7.4
PLTRO	8.9
RINGNET	17.2
ARTSURF	12.0
COMMHL	11.5
LLP80	0.3
LLSHW	13.6
LLDEEP	13.9
LLMIX	13.8

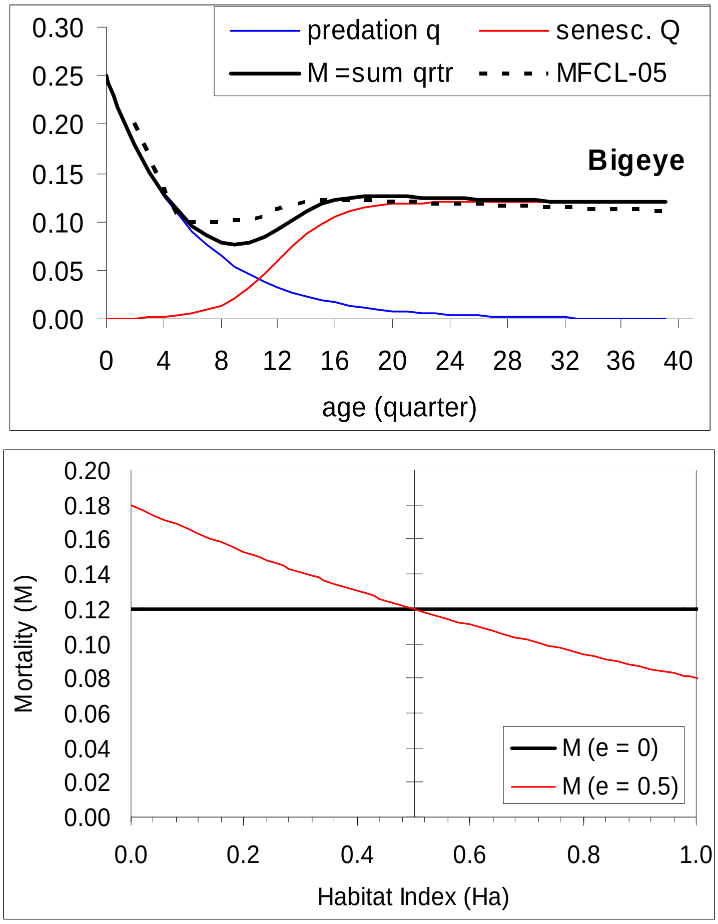


Figure 1. Natural mortality of bigeye in SEAPODYM, compared to MFCL estimates (top), and change in natural mortality coefficient-at-age in relation with the habitat illustrated with a value of $M=0.12$ and $\varepsilon = 0.5$

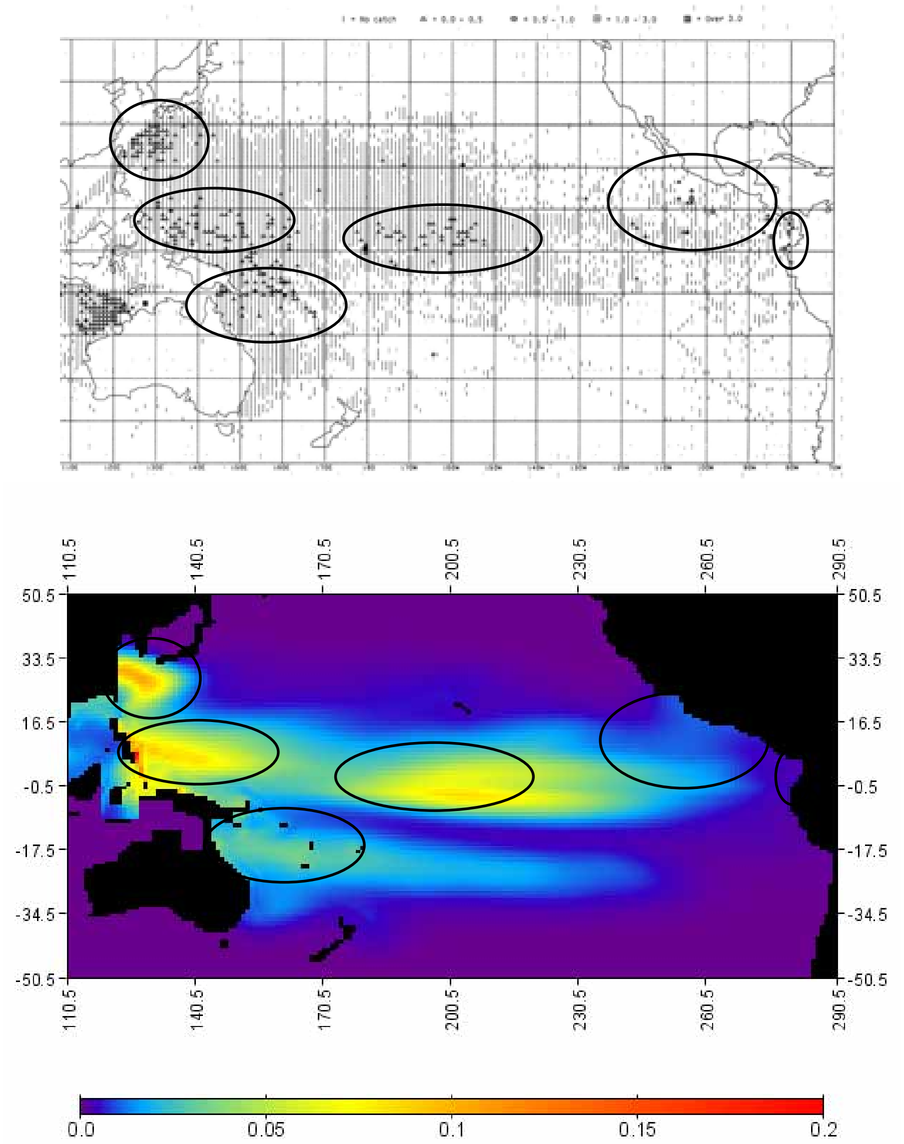


Figure 2. Comparison of observed bigeye larvae distribution (Nishikawa et al. 1985) in the Pacific Ocean with predicted average distribution for the period 1950-75 of "juvenile" age classes (2 and 3 months old).

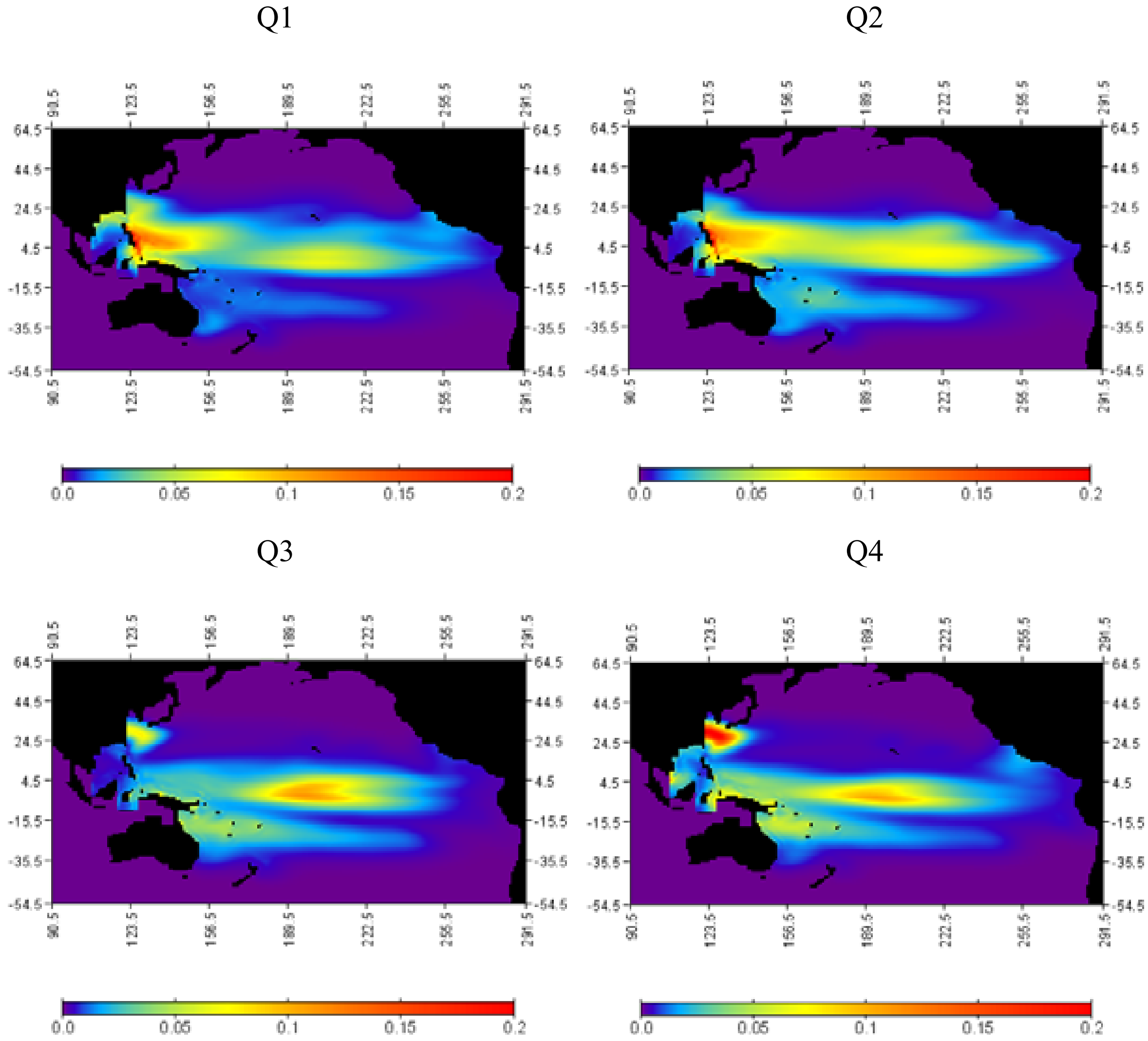


Figure 3. Predicted quarterly average distribution of bigeye “juvenile” biomass (age classes 2 and 3 months).

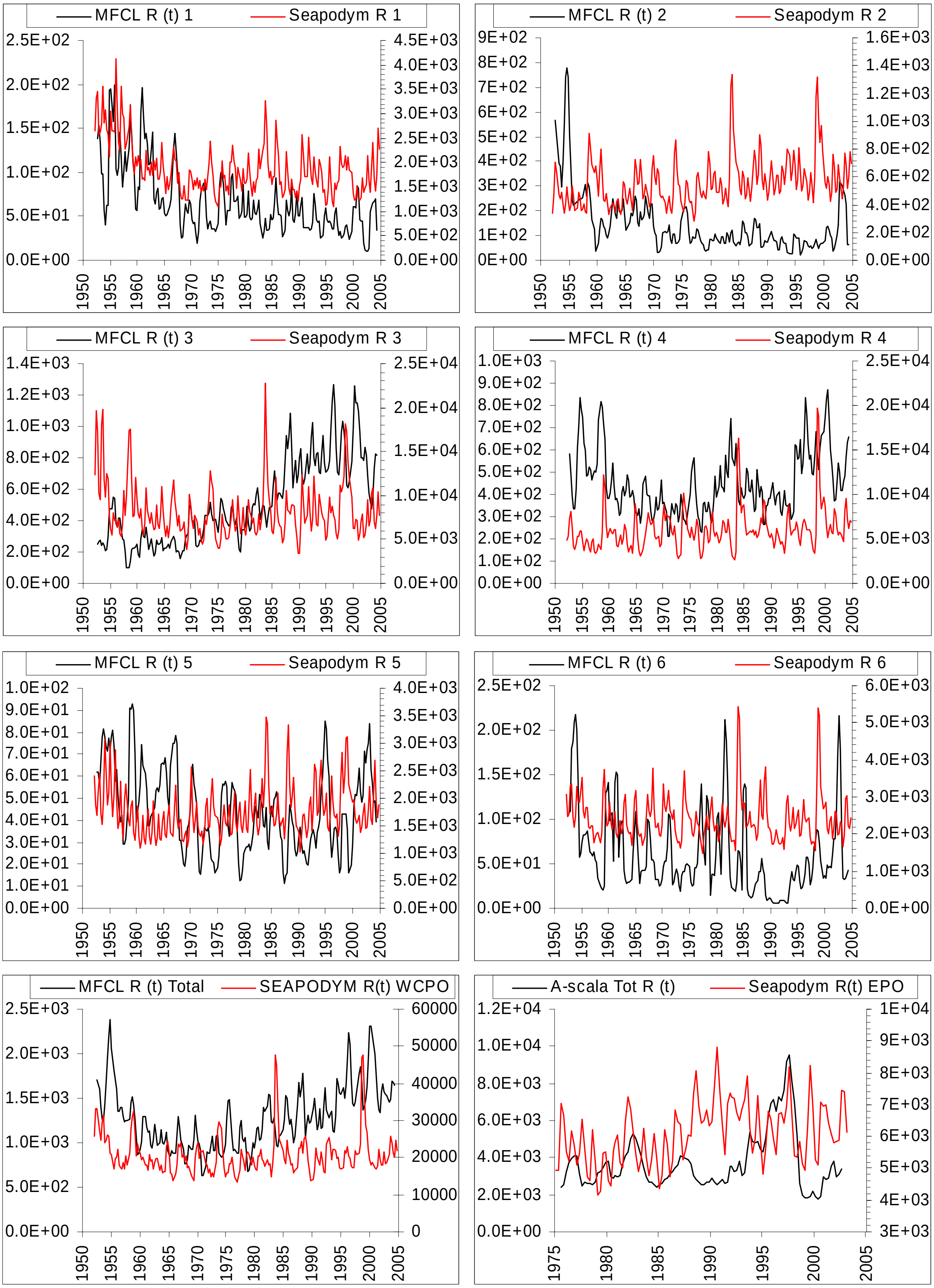


Figure 4. Recruitment time series by regions from MULTIFAN CL (region 1 to 6) or A-SCALA (region 7+8) compared to SEAPODYM predictions.

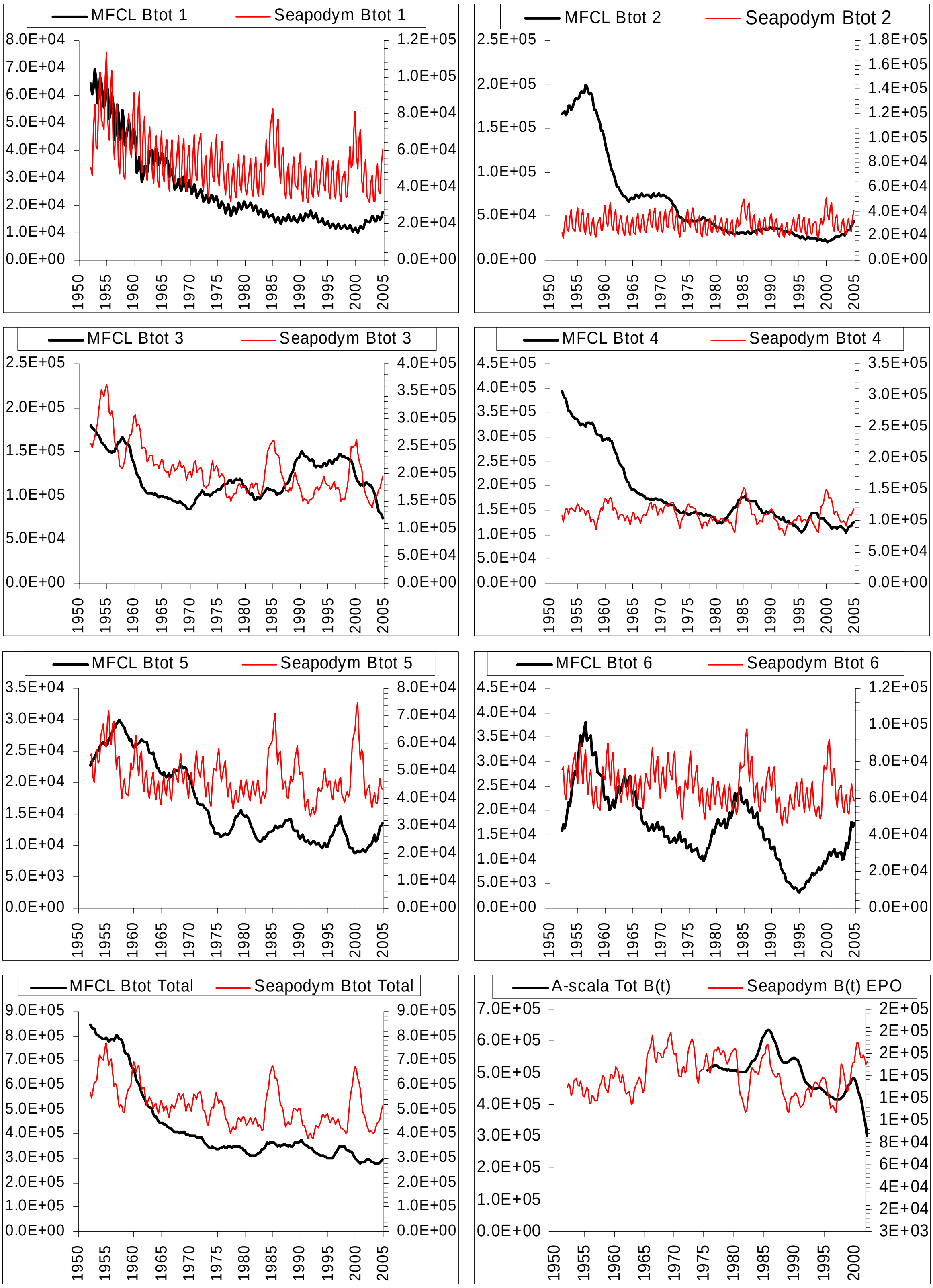


Figure 5. Biomass time series by regions from MULTIFAN CL (region 1 to 6) or A-SCALA (region 7+8) compared to SEAPODYM predictions (red curves)

.

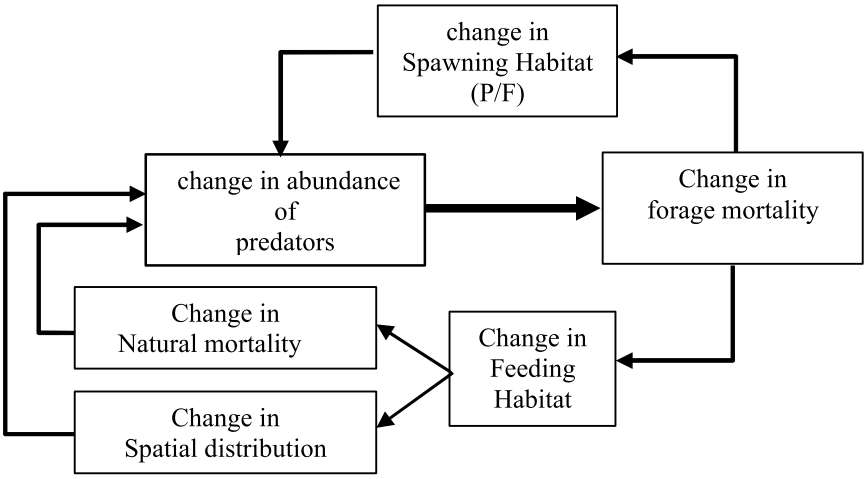


Figure 7. Mechanisms of feedbacks in the model potentially leading to differences between single and multi-species simulations.