# Ecosystem Simulations by an End-to-end Model Coupling MEC Ocean Model and EwE Model

# （MEC Ocean Model と EwE Model を結合した End-to-End モデルによる生態系シミュレーション）

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It is currently recognized that many fisheries are being affected by fishing and climatic and human-induced ecosystem changes such as global warming. To cope with the changes in productivity of regional ecosystems, control over fleet capacity and development of operational management procedures may be critical to the long-term sustainability of fisheries in the region. Establishment of a new convention on the management of international fisheries in northeast Asia has been recommended. Implementation of an ecosystem approach to fisheries or ecosystem-based management has recently started, focusing on: (i) minimizing fishing and other human-induced impacts; (ii) rebuilding depleted fisheries stocks; and (iii) adapting to climate changes and natural disasters. In particular, widespread impacts in the marine environment of land runoff.

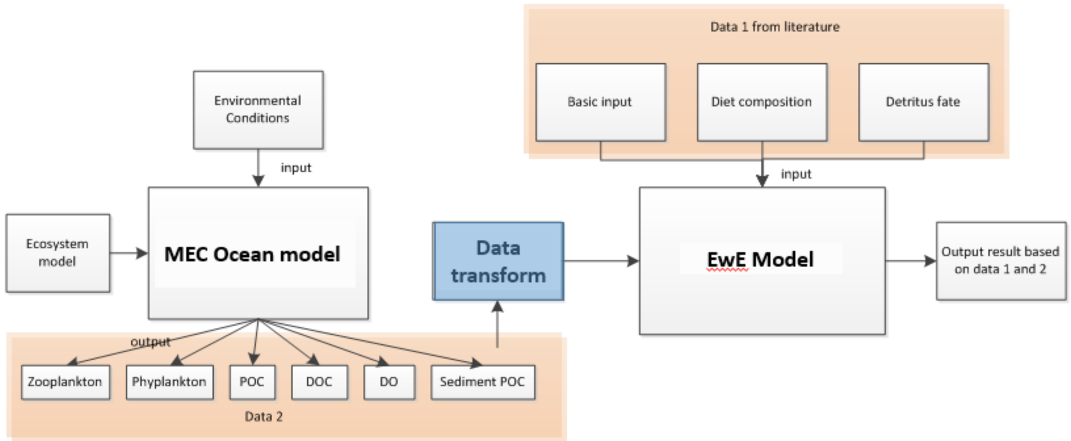



Figure 1 Combination of MEC model and EwE model

The purpose of this study is to provide a holistic framework which can combine the effect of fishing and environmental factor change and reveal the relationship between LTL and HTL ecosystems. Furthermore, we can evaluate what kind of roles that these factors played during the degeneration of ecosystem. Here we employed two models MEC model and EwE model. MEC model embedded with LTL-model was used to simulate the temporary and spatial distribution of plankton, nutrient and detritus under different external variables such like nutrient load and reclamation. EwE model was employed to calculate the relationship of LTL and HTL based on the biomass flow and prey-predation.

Then by combining these two models, an integrated end-to-end model was developed and applied into two different cases: East China Sea and Tokyo Bay according to different scales.

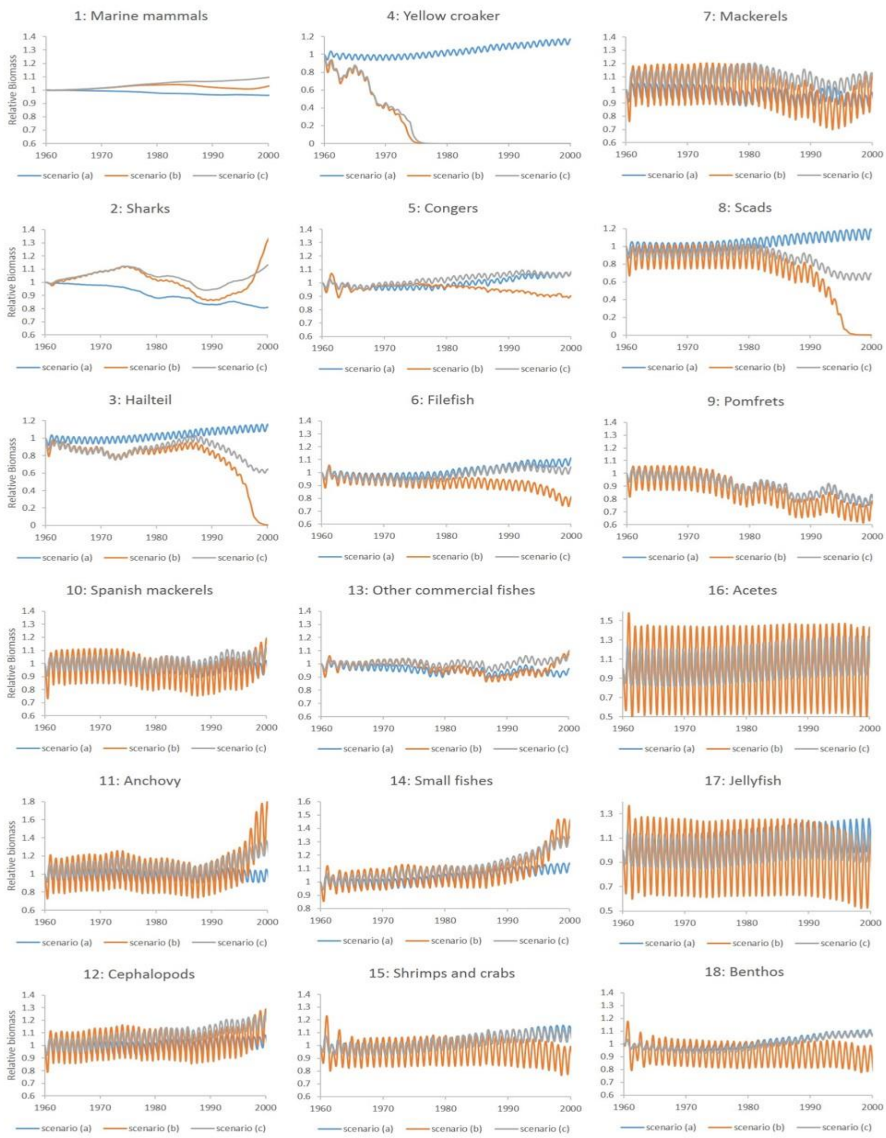
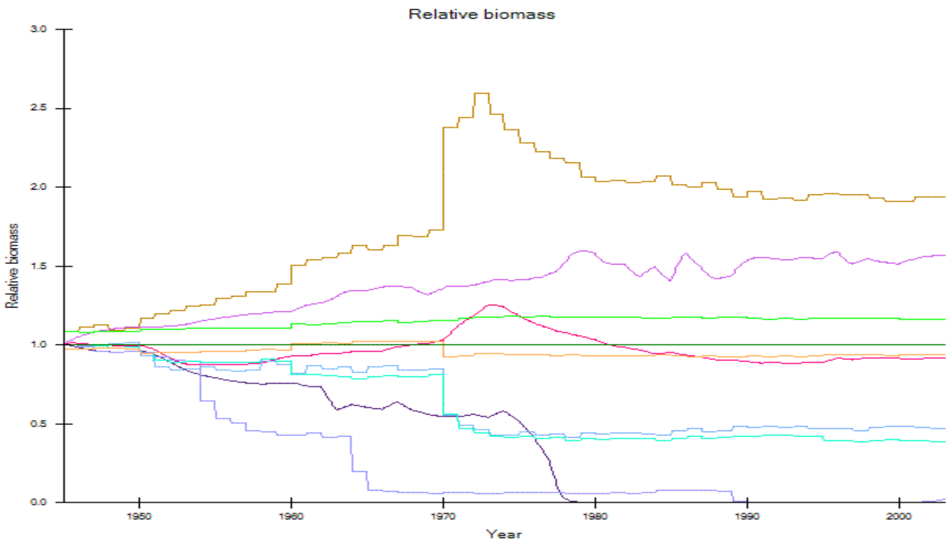
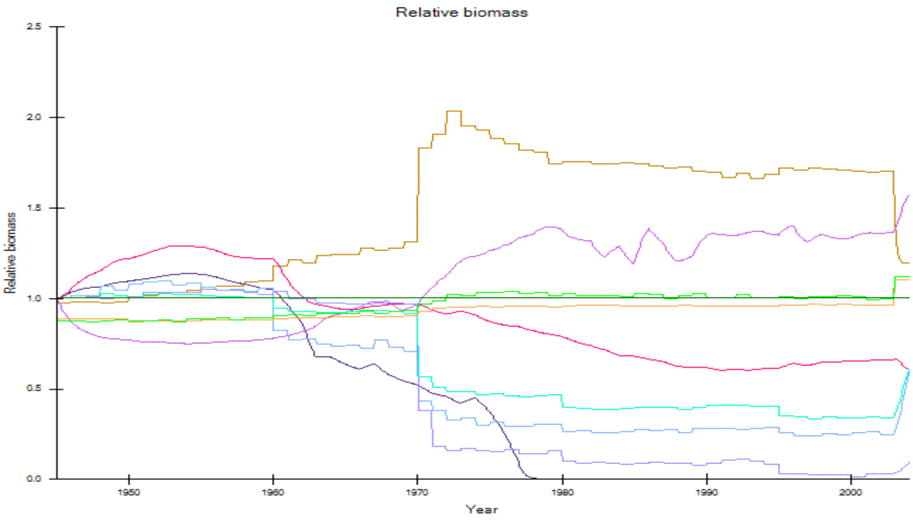



Figure 2 Simulation result of Relative Biomass change of high trophic level species under different scenarios.

In the East China Sea case, by using this integrated model, we analyzed the impact of nutrient fluxes change from Yangtze River and fishing influence on the ecosystem of ECS. MEC model embedded with LTL-model was used to calculate the temporary and spatial distribution of plankton, nutrient and detritus under the condition of Yangtze nutrient fluxes in 1960, 70, 80, 90, and 2000. On the basis of this, we transfer the temporal varying 3D data obtained by MEC model to spatially and temporally integrated data, and fit out the long-time fluctuation of low-tropic level ecosystem during 40 years. EwE model was used to simulate the marine ecosystem dynamics through taking the fluctuation of low-trophic level variables and fishing data as the forcing functions. The results show that the main fish production decrease significantly, average trophic level recession and small fish take the main position of ecosystem. But the increase of nutrition input have a certain influence for the ecosystem to slow the decline tendency. The seasonal variation shows that peak value of most pieces occurs in summer and autumn because of the zooplankton boom. In this case, we only take the river flux in consideration as the environmental factor but it is possible to involve more factors such as climate change. It is hard to involve other environmental factor especially DO effect on ecosystem because the scale is too large so that the average DO change in the bottom is hard to identify. But in small scale area especially for the bay, this area will be very sensitive to DO change and the simulation result could be more precious. That is why we applied this model into Tokyo Bay for one more time.

In this application of Tokyo Bay, we included another important fact hypoxia into discussion which we can't include in the East China Sea case. The result showed that the hypoxia had different degree of influence on the different part of Tokyo bay based on different hypoxia degree. By combining MEC model and EwE model, to evaluate multiple impacts including the environmental factor change and fishery on the ecosystem of three parts in Tokyo bay. Inside part ecosystem dominated by hypoxia; mid part ecosystem affected by hypoxia and overfishing; out part ecosystem affected by overfishing. River influx can increase primary production but also bring the hypoxia. Both will affect ecosystem in different situations. Hypoxia will not affect the HTL directly but the consequence loss of benthos and demersal have adverse impact on big fish. By now, by using this integrated model, we could engage DO, nutrient load, and fishing into one single framework, and discuss the ecosystem change under different scenarios affected by these factors.





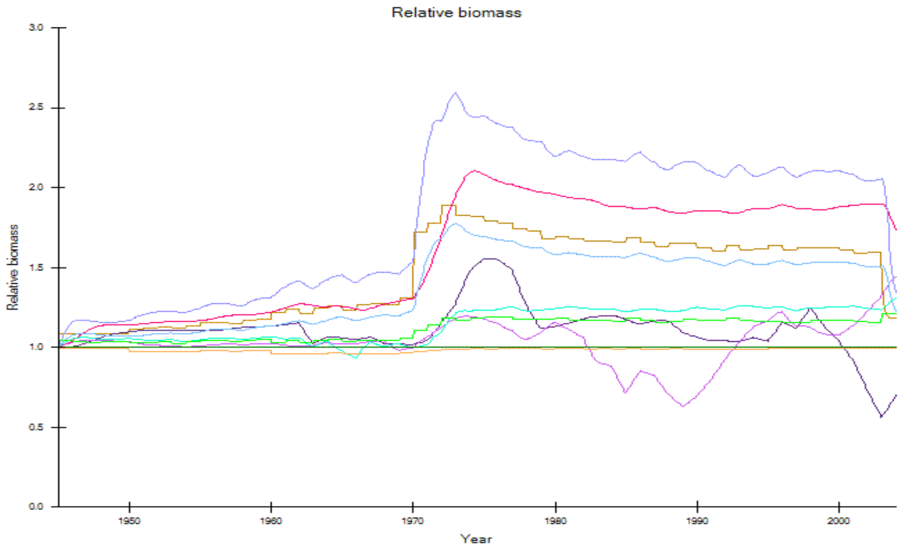




Figure 3 the relative biomass change of ecosystem in the three parts of Tokyo Bay. Inner part (up), mid part (mid), out part (down).

However for ecosystem simulation, there is a key issues here which will block the development of modelling is lack of enough data. So in this research, a lot of research was based on different assumption that was close to actual situation. This still reveal many interesting result and information for future research. For example, in this research, the LTL ecosystem was simplified as one-phytoplankton-one-zooplankton system. In actually, it could be more complicated. In addition, Si which is very important nutrient in the growth of plankton was ignored in our simulation. This element will be affected by nutrient load from land greatly. In a word, there are a lot of work remaining unfinished and needed more improving.

In conclusion, the integrated model provides a prospect that we can study the entire ecosystem from the prospective of both environmental and fishery factors, extending from lower to higher ecosystem, to achieve a top-down and bottom-up management.