Trophic flows in the marine ecosystem of an artificial reef zone in the Yellow Sea China

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Outline

- Background information and rationale
- Developing the Lidao artificial reef Ecopath model
- Results from the Ecopath model
- Ecosim-alternative fishing management strategy and effects of aquaculture activities
- Summary

Background introduction

- Artificial reefs, demonstrated as an effective fishery management tool, have been widely used to restore fishery resources and improve the aquatic environment.

- From 2001, massive artificial reef construction was implemented along the coast of China.
- By the end of October 2013, in Shandong Province alone, 100-million m^3 various types of artificial reefs, covering $150km^2$, had been deployed at 170 sites along the coast of Shandong Peninsula.

Rationale

- Ecological efforts of artificial reef construction: comparison of reef organism community structure between the temporal or spatial scale.

- However, the reports concerning system structure and function of artificial reefs were relatively limited

- An ecopath model was developed for a typical artificial reef zone in the northern coast of the Yellow Sea to explore how artificial reefs may have influenced the productivity and trophic dynamics of the system

- The possible effect of related fishing and aquaculture activities on the biomass of the major groups in the system was also evaluated

Ecopath & Ecosim core equations:

1) Mass-balance (within groups):

$$B_i \cdot (P/B)_i = Y_i + \sum_{j=1}^{n} B_j \cdot (Q/B)_j \cdot DC_{ji} + E_i + BA_i + B_i (P/B)_i \cdot (1 - EE_i)$$

Production = Yield + Predation + Biomass Acc. + Migration

2) Conservation of energy (between groups):

$$B \cdot (Q/B) = B \cdot (P/B) + (1 - GS) \cdot Q - (1 - TM) \cdot P + B \cdot (Q/B) \cdot GS$$

Consumption = Production + Respiration+ Unassimilated food

3) Biomass dynamics:

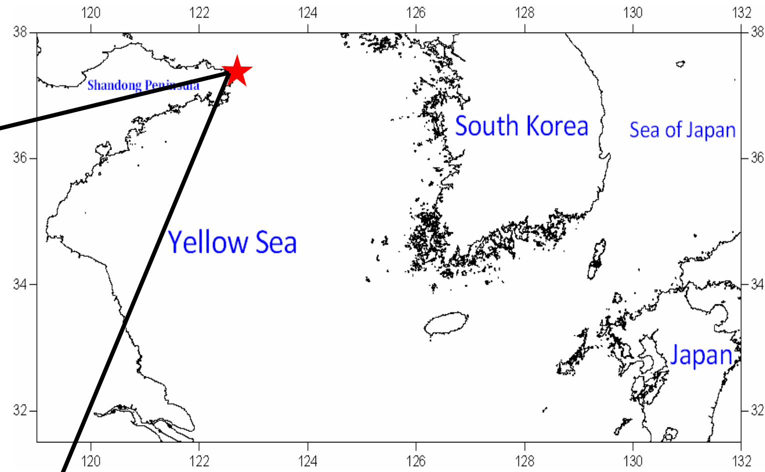
$$\frac{dB_i}{dt} = g_i \sum_j C_{ji} - \sum_j C_{ji} + I_i - (M_i + F_i + e_i) B_i$$

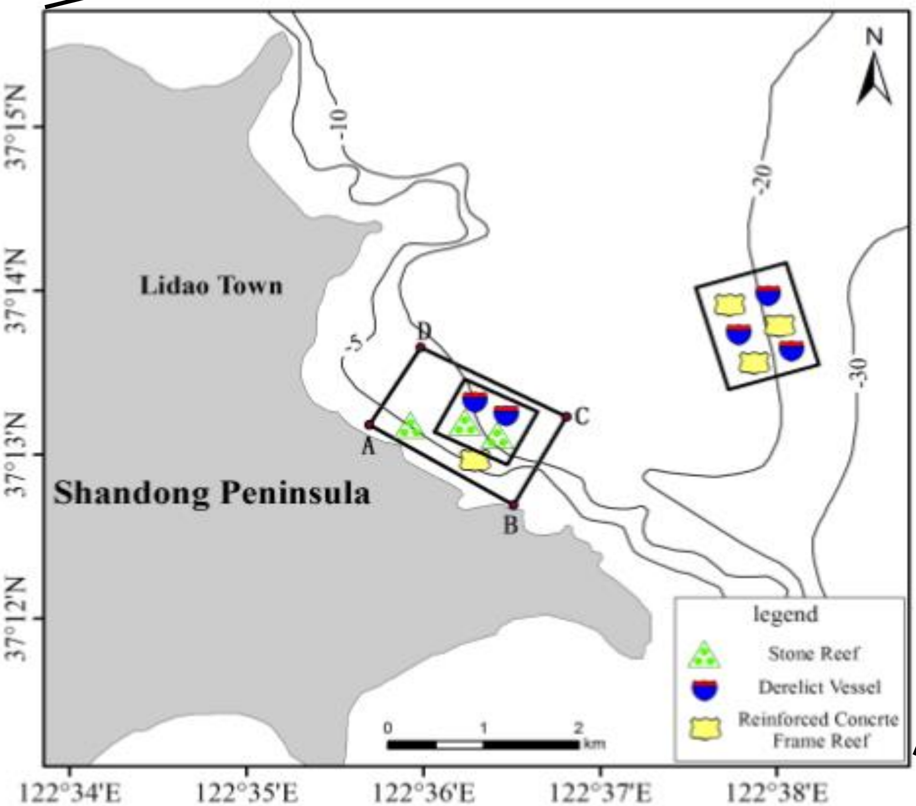
D Biomass = Growth + Immigration – Predation - Mortality

Modelled area

Simulated period

2009—2012





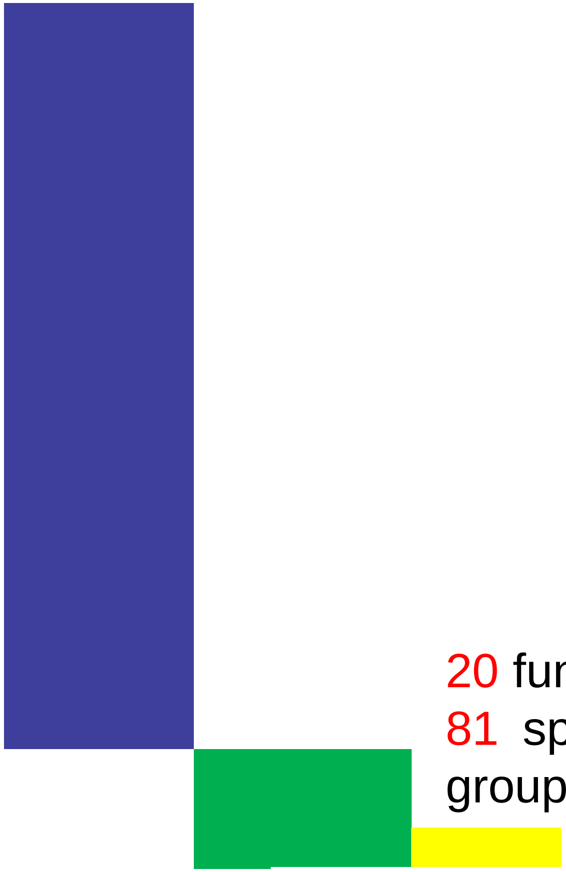
Boundaries of the model:

Denoted by squares ABCD

Total area = 1.49 km^2

Functional groups

1	Type I fishes
2	Type II fishes
3	Type III fishes
4	*Sebastes schlegelii*
5	*Hexagrammos otakii*
6	*Hexagrammous agrammus*
7	Small demersal fishes
8	Small pelagic fishes
9	*Apostichopus japonicus*
10	*Haliotis discus hannai*
11	Crustaceans
12	Cephalopods
13	Molluscs
14	Echinoderms
15	Other benthos
16	Zooplankton
17	Heterotrophic bacteria
18	Benthic algae and seagrass
19	Phytoplankton
20	Detritus



- Special interest= 5
- Fish = 5
- Benthos = 4
- Cephalopods
- Zooplankton
- Primary producer=2
- Heterotrophic bacteria
- Detritus

20 functional groups, representing a total of 81 species and 11 aggregated taxonomic groups

Sebastes schlegelii

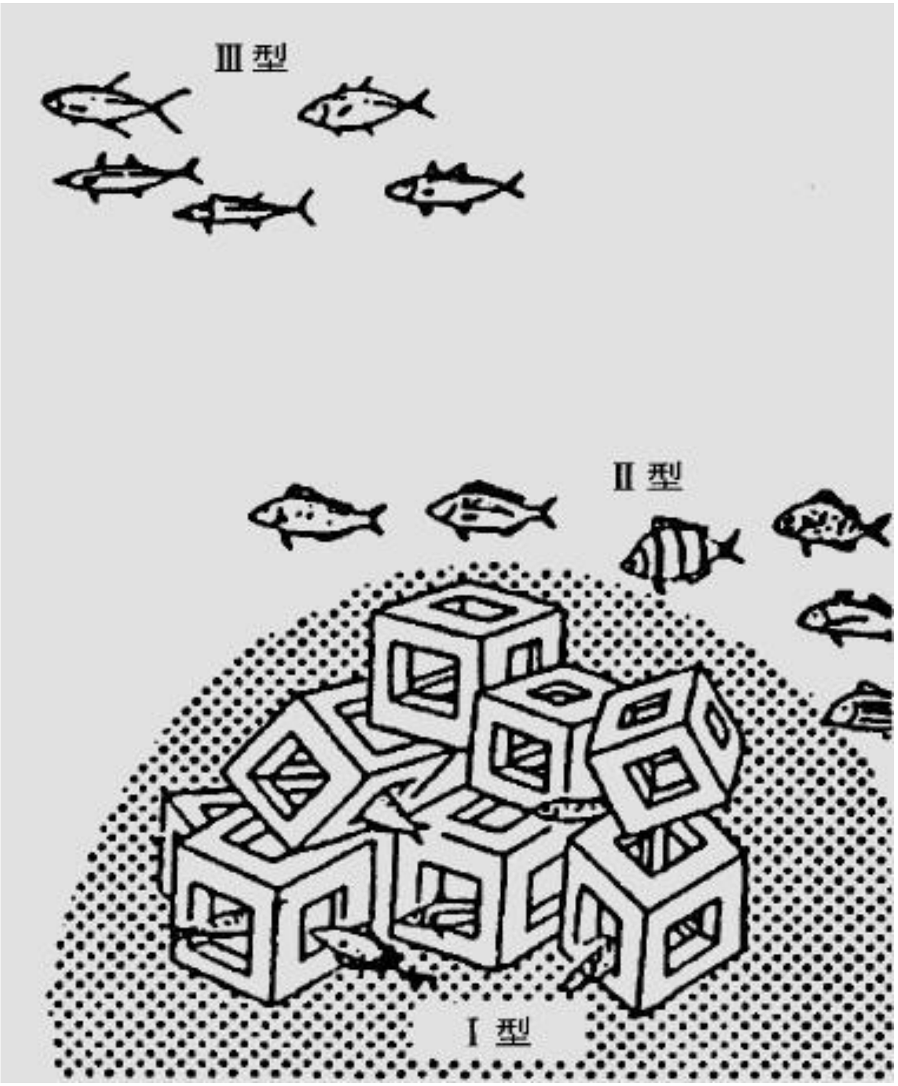
H. agrammus

Hexagrammos otakii

Apostichopus japonicus

Haliotis discus hannai

The Relationship between fishes and artificial reef



Ⅰ style fishes :

False kelpfish(*Sebastiscus marmoratus)*

Blackhead seabream *(Sparus macrocephalus)*

Whitespotted conger(*Conger myriaster)*

Elongate eel-pout *(Enchelyopus elongatus)* ,etc.

Ⅱ style fishes：

Stone flounder *(Kareius bicoloratus)*

Japanese flounder(*Paralichthys olivaceus)*

Ocellate spot skate *(Raja porosa),*etc

Ⅲ style fishes：

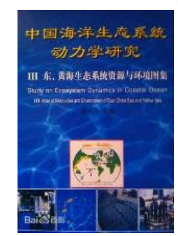
Japanese Spanish mackerel *(Scomberomorus niphonius)*

Chub mackerel *(Scomber japonicus)*

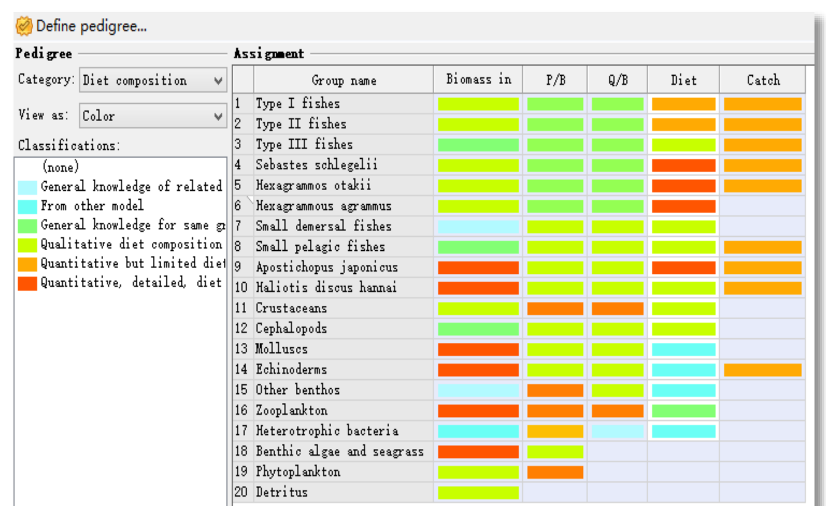
Data sources and model establishment

- -*in situ* sampling
- -Mini remotely operated video (ROV) census
- -Published information(2005-2012)
- -Fishbase (www.fishbase.net)
- -Using Ecopath estimate
- -Landing data for the three fleets(fence trap, long fishing trap and diving fishing) were mainly taken from Gaolv Fishery company ‘s statistics.
- -Pedigree index of the model = 0.57(80 input series)

FishBase



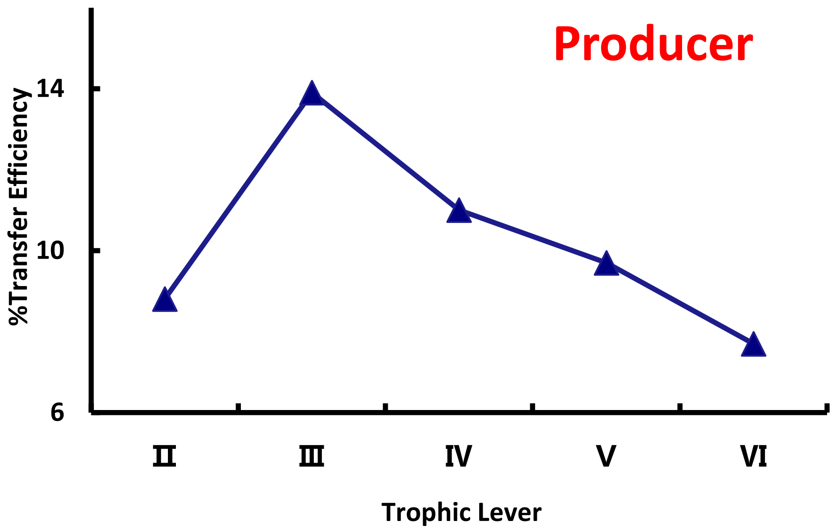
SEA AROUND US PROJECT

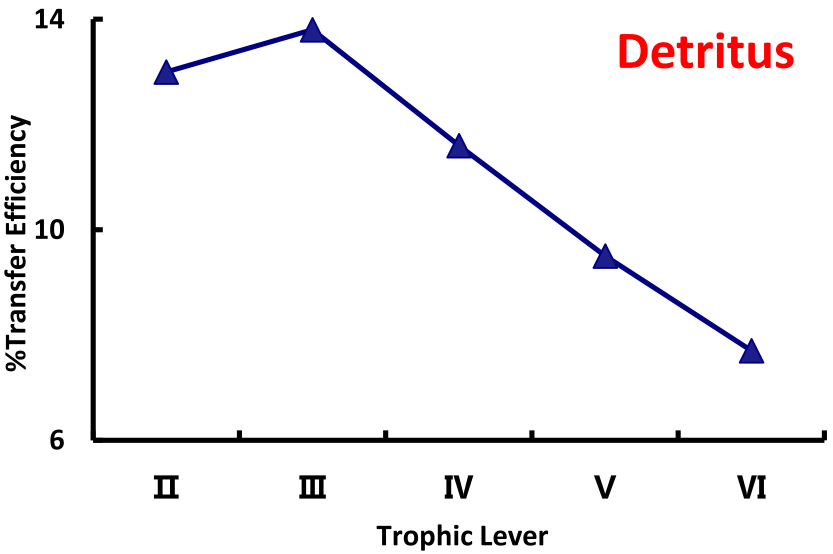


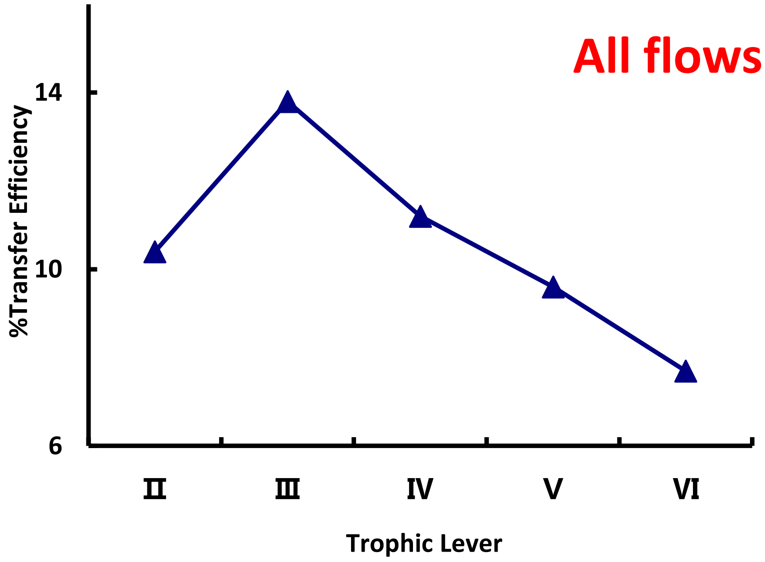
Results from the Ecopath model

1. Trophic levels of the ecosystem range from 1.0 to 4.1 (Type III fishes)
2. The system biomass is mainly contributed by benthic components, and the system is dominated by lower trophic groups (14 of 20 groups <TL 3.5)
3. Trophic level of the catch is low(2.09, sea cucumber and abalone dominant)
4. Lidao artificial reef zone is a relative low maturity and stability, remaining at a developing stage(TPP/TR =1.844,FCI=5.46% and FML=2.671)

Model's performance: Transfer Efficiency





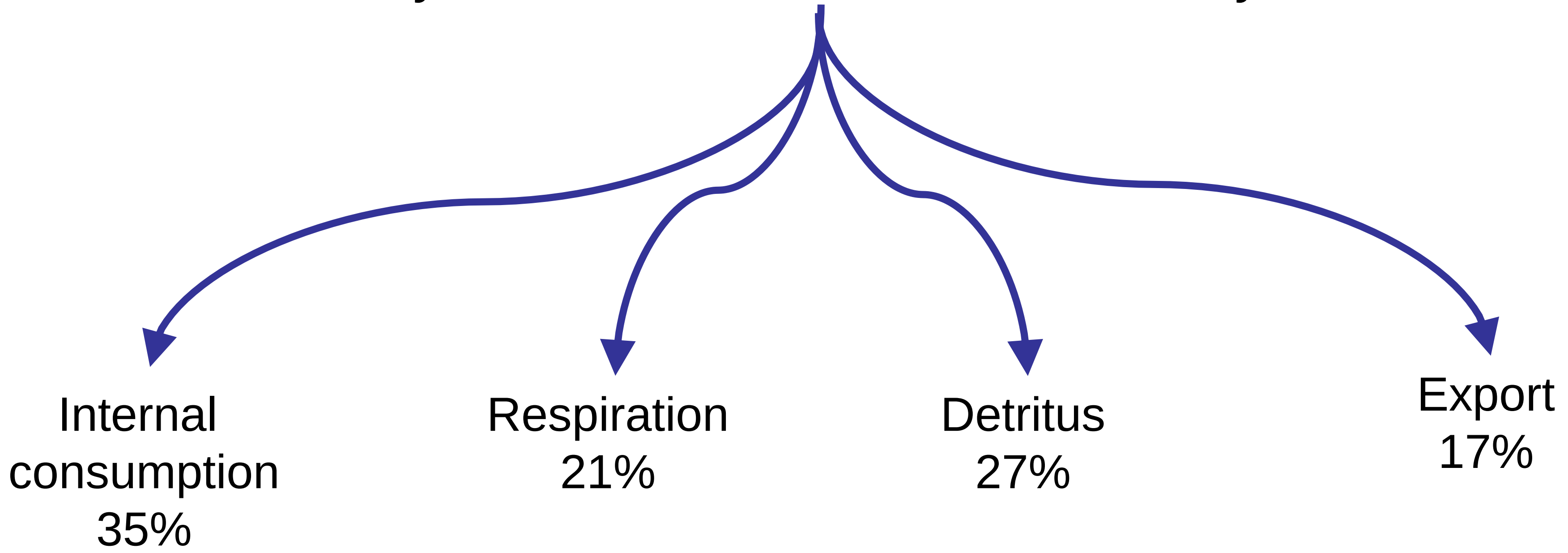


- Proportion of total flow originating from detritus: 0.41
- Transfer Efficiencies
  - From primary producers: 11.1%
  - From detritus: 12.7%
  - Total: 11.7%

Trophic structure of the ecosystem

Energy flow in Lidao artificial reef zone

Total system flow was 11104 tons km^{-2} $year^{-1}$



Ecosim—Fishery management strategy

Scenario 1，Fishing effort was decreased to 0

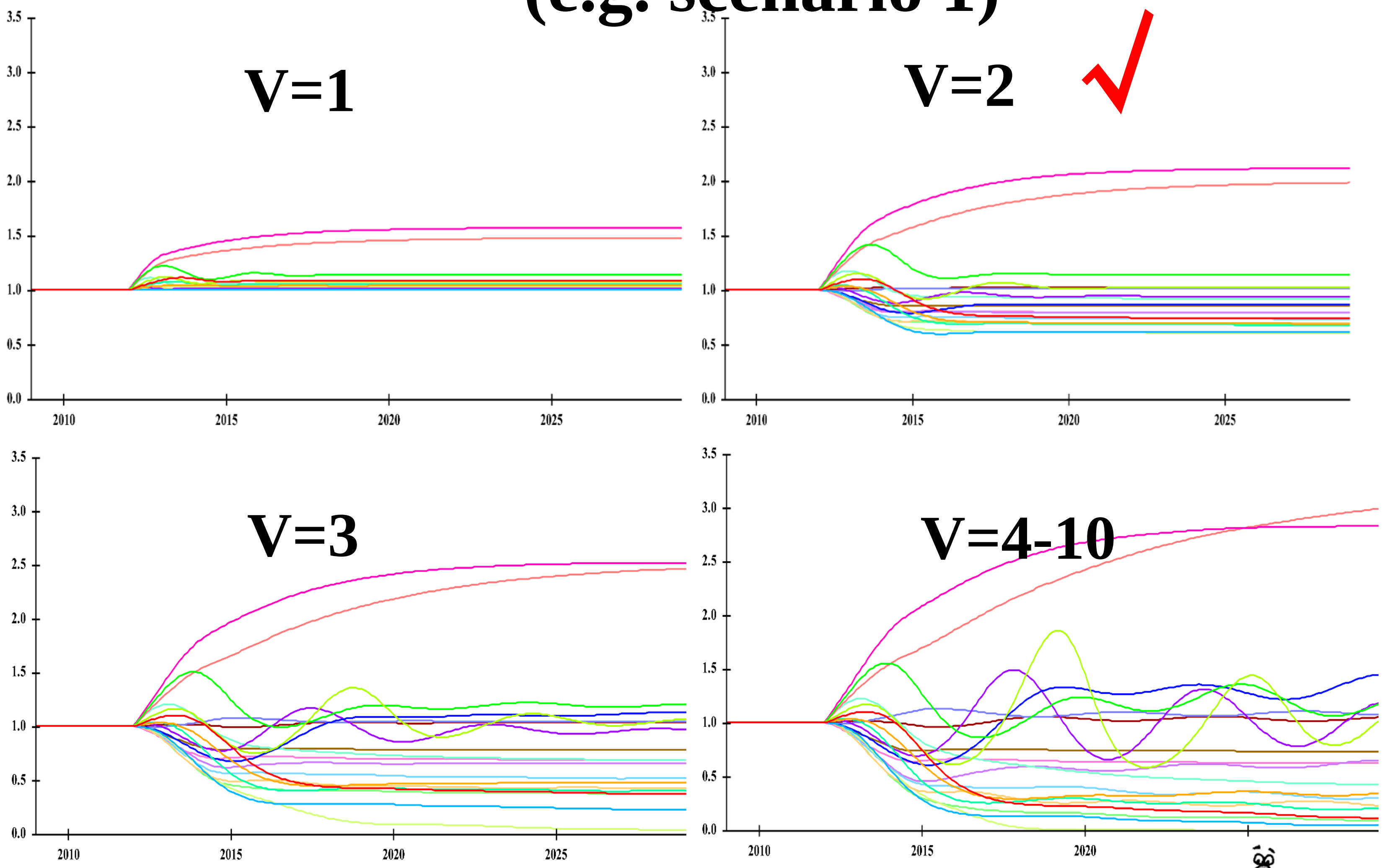
Keep the initial state

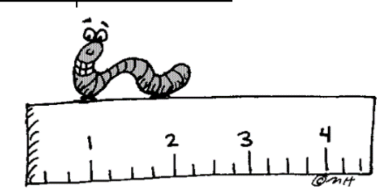
2029 **2012** **2009**

Scenario 2，Fishing effort was decreased to current 50% level

Vulnerability exploration （V）

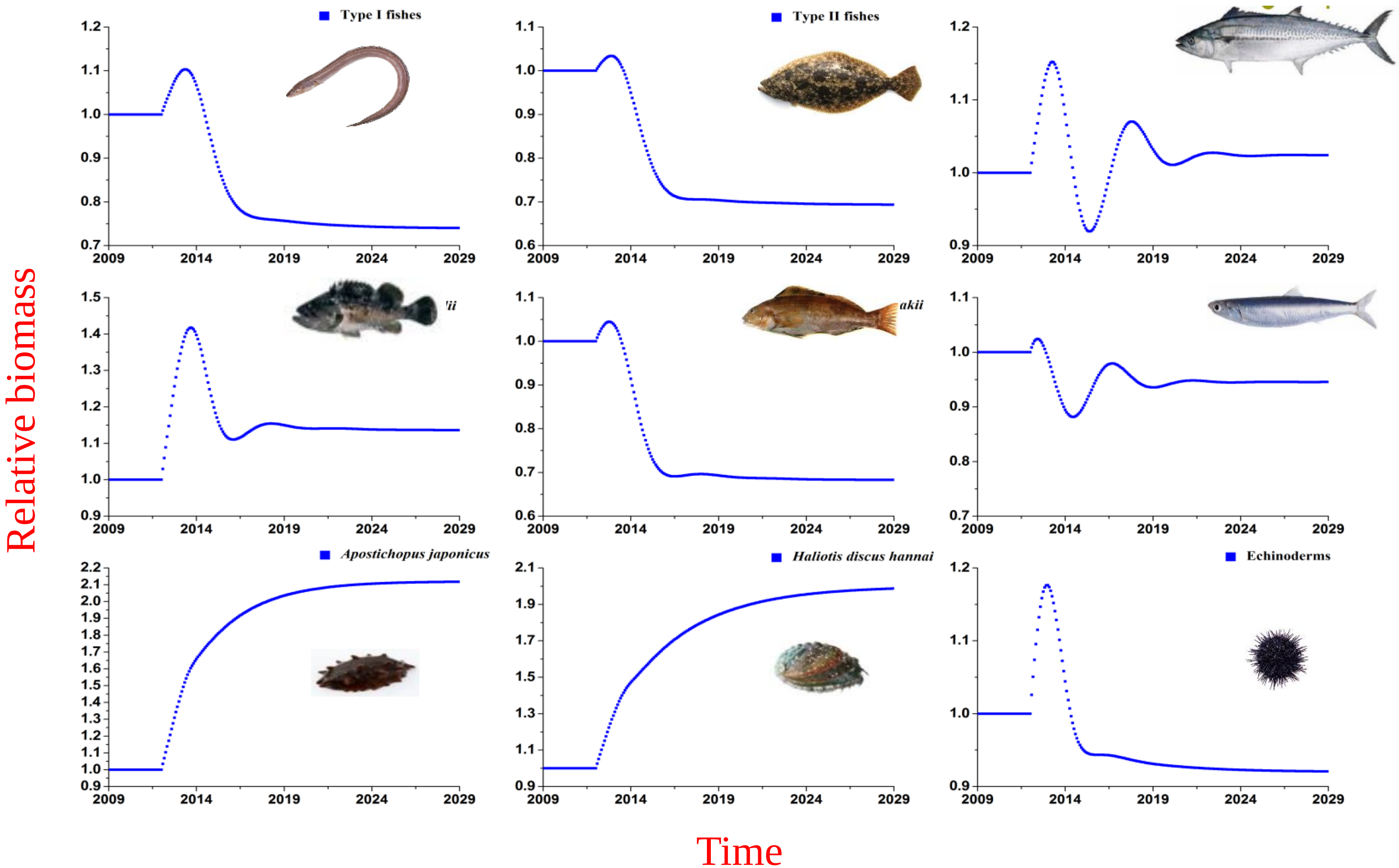
(e.g. scenario 1)





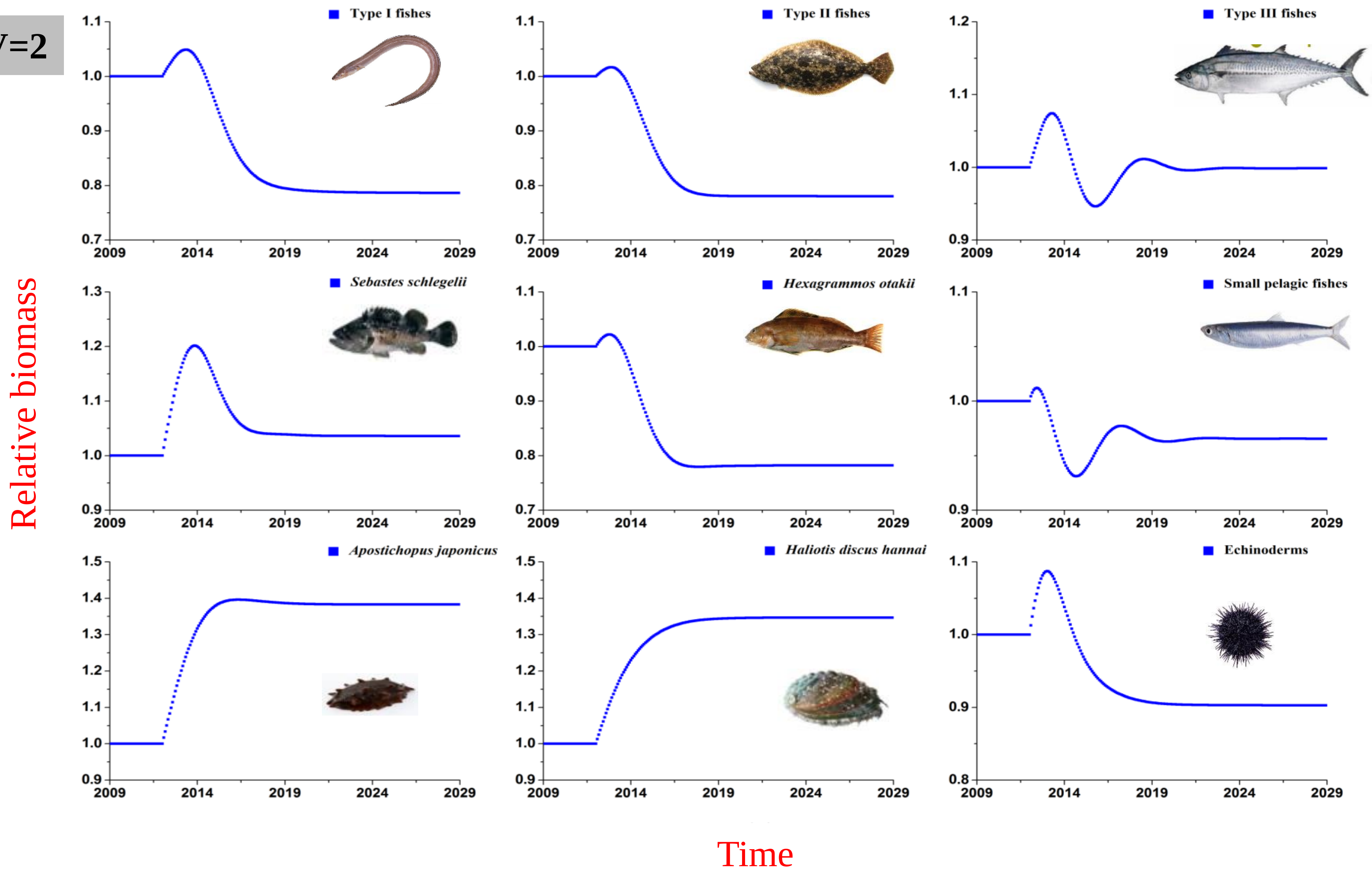
The predicted result of scenario 1

V=2

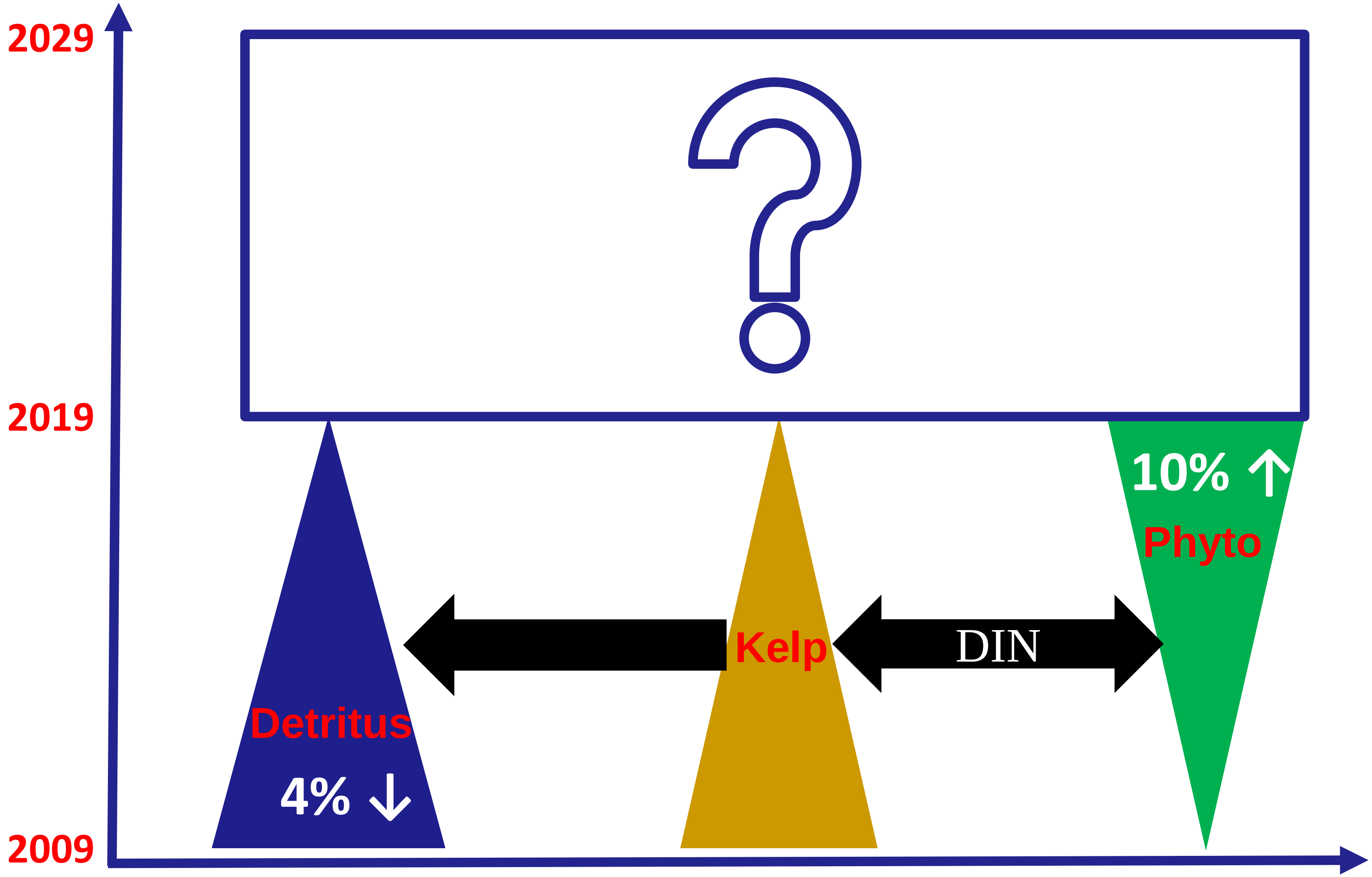


The predicted result of scenario 2

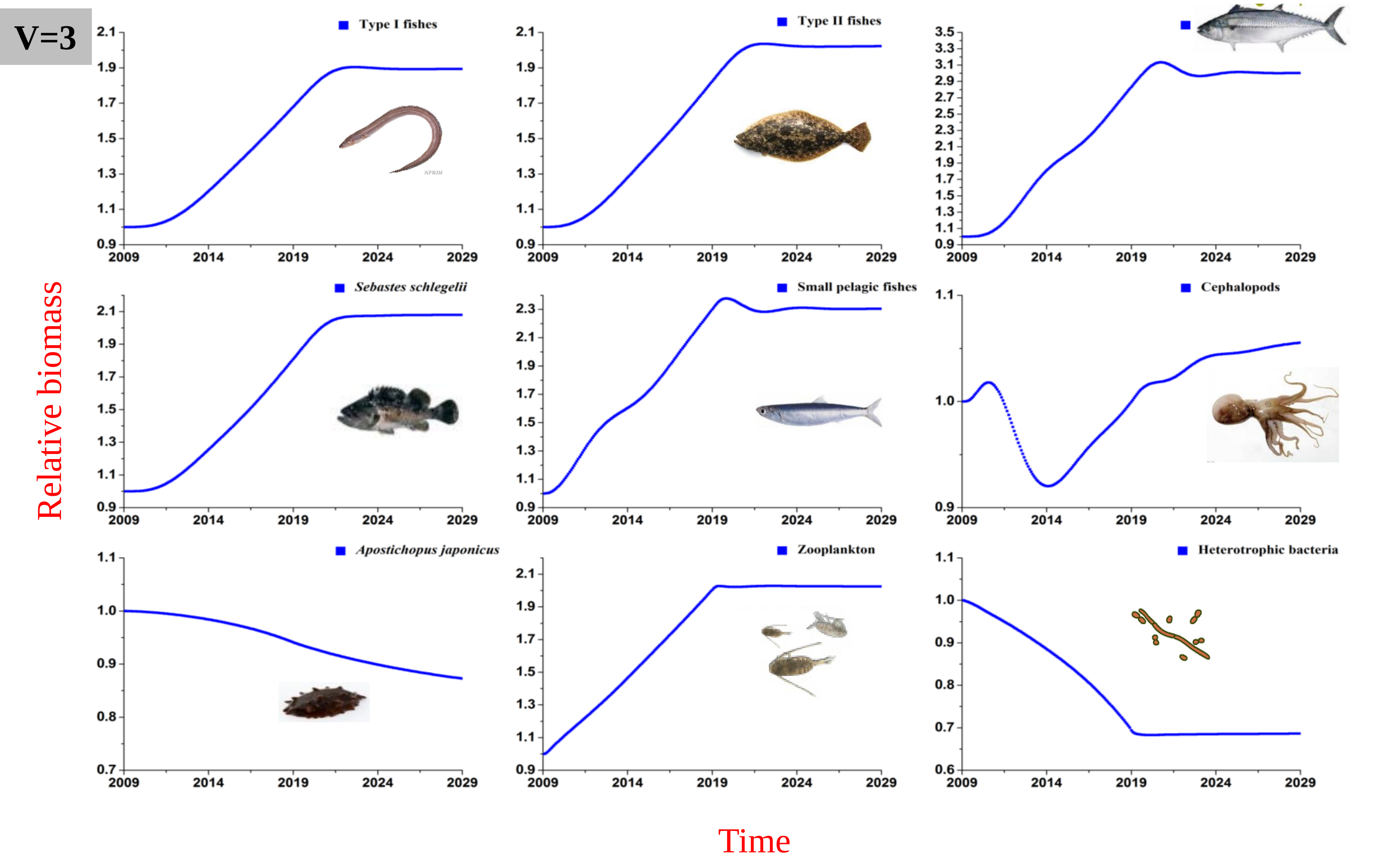
V=2



Scenario 3-simulating the effect of removing kelp farm

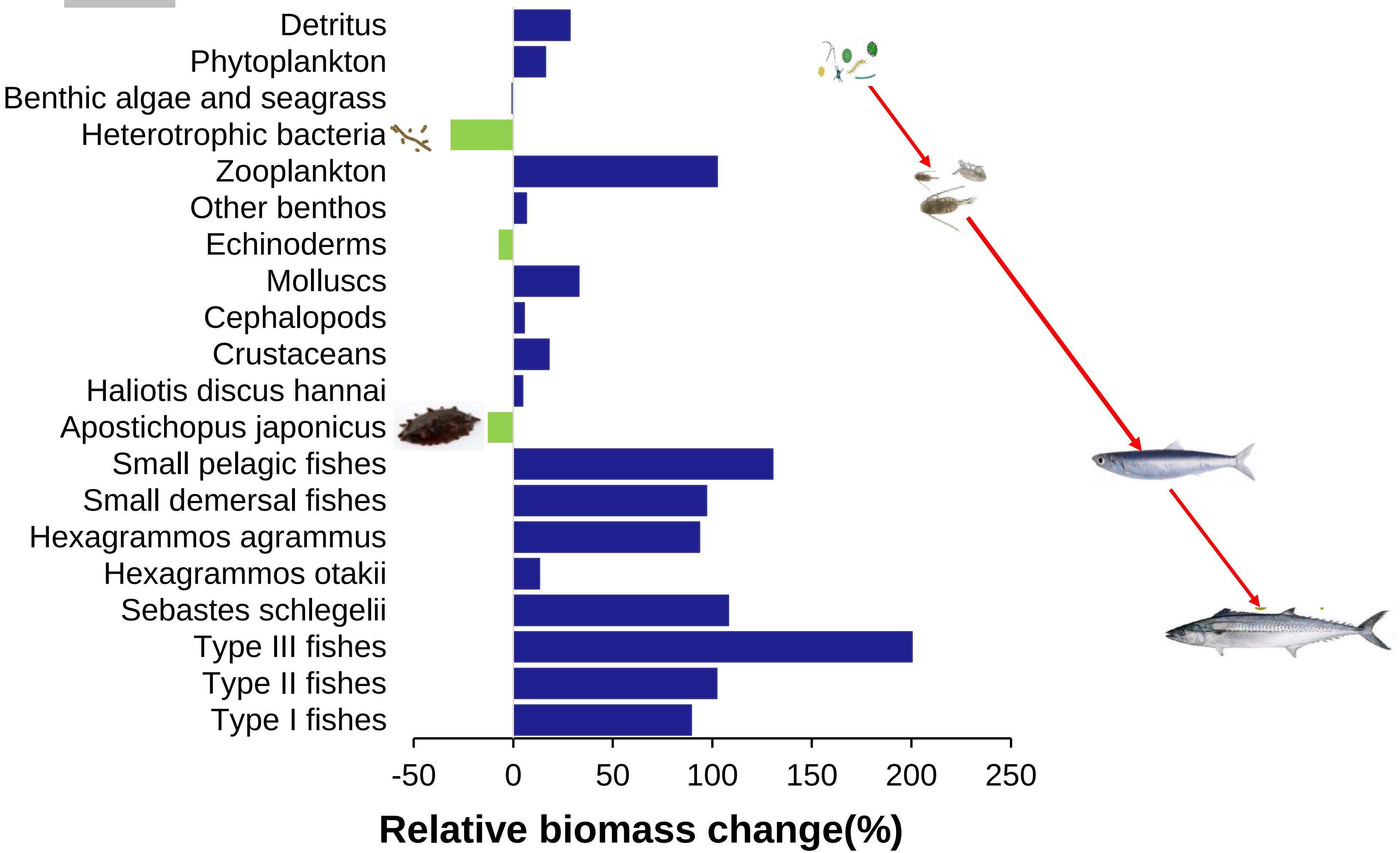


The predicted result of scenario 3



The predicted result of scenario 3

V=3



Summary

- Ecopath with Ecosim was first employed to characterize the trophic flow of a system representative of the coastal nearshore reef systems of northern China where aquaculture and fishing activities are intense.
- The system is dominated by benthic production and that the catches are low in the food web due to the focus on the very high value sea cucumber and abalone species.
- The system had a relative low maturity and stability, remaining at a developing stage.
- The kelp culture is likely to provide a significant subsidy to the benthic detritus and contribute to the low importance of water column production and grazing in the system.

Thank you

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