The pelagic and benthic coupled biogeochemical cycle model study for Mikawa Bay estuary

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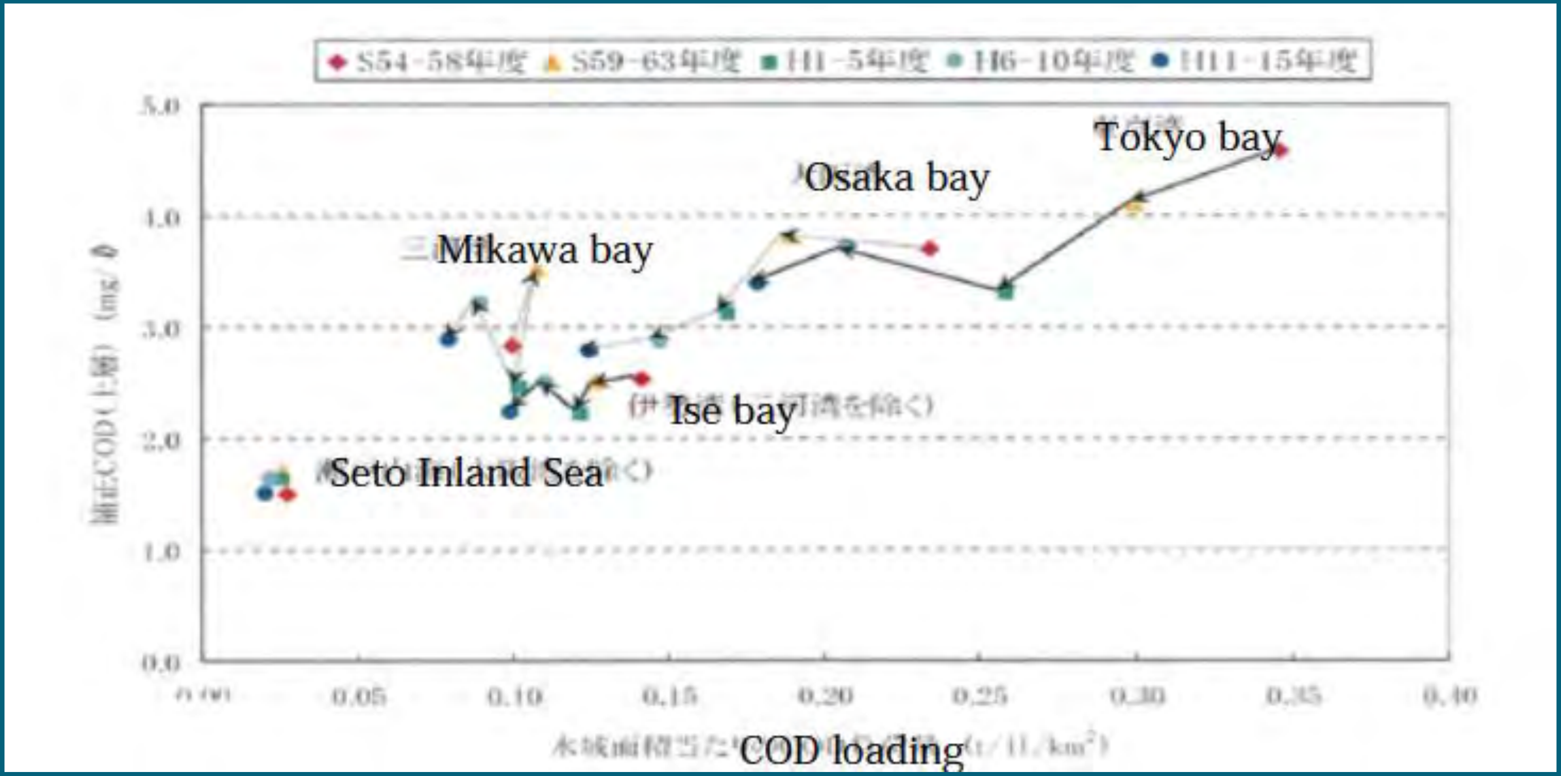
What happened in the environment after TPLC has been applied



As a whole , this policy is not successful except Tokyo Bay during 1980s.

For an aquatic environment, we have environmental standard such as COD, T-N and T-P.

To check an environmental health, the government has thought only environmental standard , that is , if the environment meet the standard , the area is judged to be in healthy condition.

DO in the bottom water is not included in the environmental standard, , which is the most important indicator from ecological point of view.

When TPLC was applied to a bay, an ecological model was run to examine if it is effective or not. But in general, model only considered primary producer (phytoplankton). Thus the model predicts that, if TPLC is applied to some estuary, the primary production decreases(COD decrease). In fact, this was not always true.

To judge an environmental health, we required a new idea incorporating ecological view points

【Efforts in Japan】

- Ship and Ocean Foundation had a committee to develop the method how we can examine the environmental health in the semi-enclosed sea in Japan (chaired by Prof. H.Nakata)
- We employed two criteria for check the health of the sea. These are

Stability of an ecosystem

species

・based on fish catches data etc.

habitat

・tidal flat area etc.

habitat environment

・appearance ratio of hypoxia etc.

Smoothness of a materials cycle

primary production

・red tide frequency

loading * flushing time

・Cx=loading per unit volume * flushing time ,x means COD,T-N or T-P

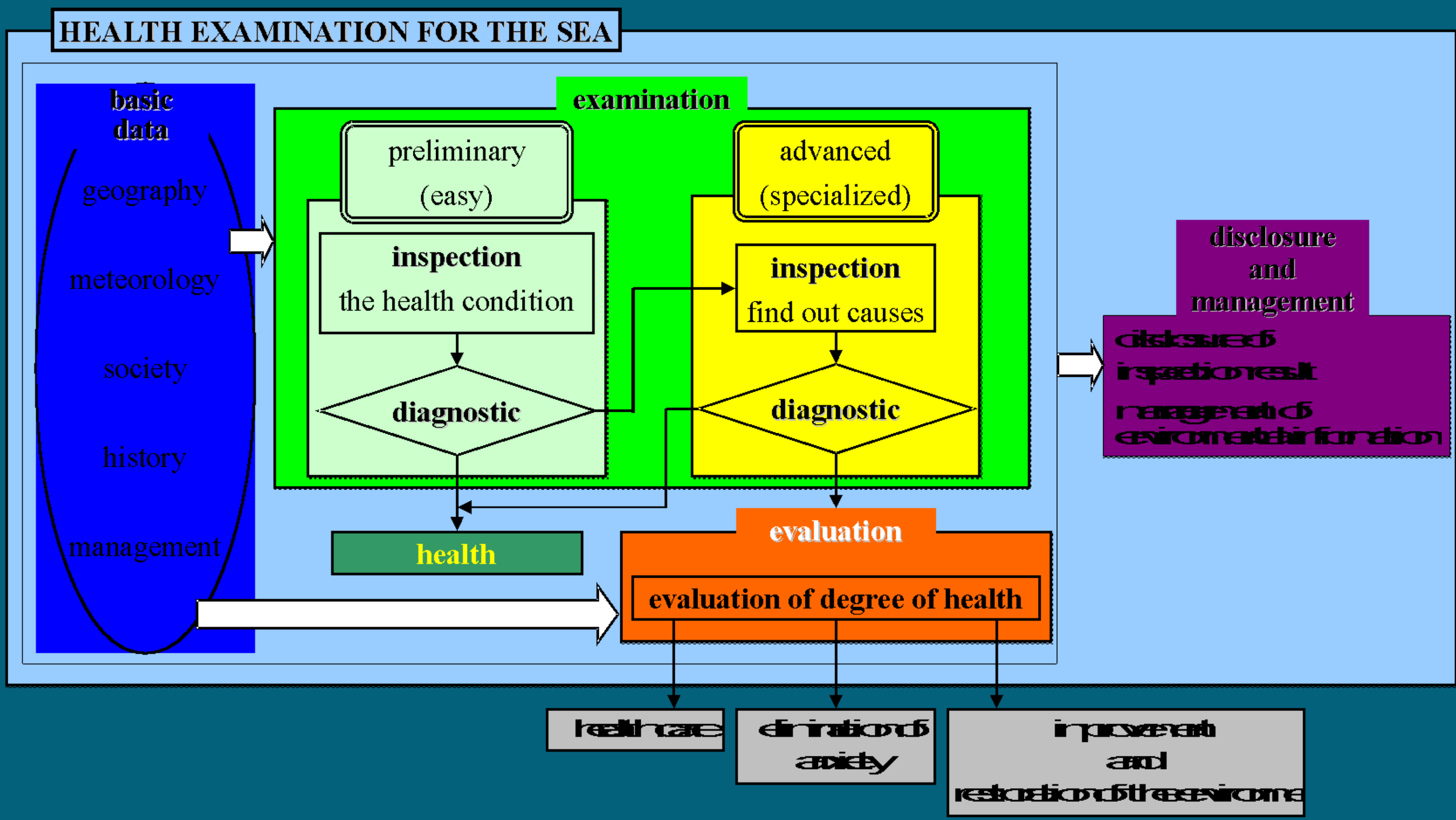
sediment/decomposition

・maximum sulfide concentration
・minimum DO concentration in bottom layer etc.

removal process by fishing

・fish catches of demersal fish etc.

Health diagnosis for the coastal environment



Format of the medical chart

	視点	検査項目	検査基準			検査結果	診断	
			良好(A)	要注意(B)	悪化(C)			
【生態系の安定性】を示す項目	生物組成	最優占分類群の漁獲量比:F(最近3年間の平均/過去の平均)	0.8＜F＜1.2 かつ 最近3年間増加もしくは横這い傾向	0.8＜F＜1.2 かつ 最近3年間減少傾向	0.8≧F または 1.2≦F	F=( )	A B C	
		海岸生物の出現状況比:L(代表種の確認種類数/代表種	0.7≦L	0.4＜L＜0.7	0.4≧ L	L=( )	A B C	
	生息空間	干潟・藻場面積比:K,S(K=最新の干潟面積/過去の干潟面積、S=最新の藻場面積/過去の藻場面積)	0.8＜K かつ 0.8＜S	0.8<K、0.8≧S または 0.8≧K、0.8＜S	0.8≧K かつ 0.8≧S	K=( ) S=( )	A B C	
		最新の人工海岸の割合:M(%)	20≧M	20＜M＜50	50≦M	M=( )	A B C	
	生息環境	有害物質分析値の比:P(過去の最大値/環境基準値)	P＜0.8	0.8≦P＜1	1≦P	P=( )	A B C	
		貧酸素水の出現比:G(貧酸素水確認地点数/全調査地点数)	G＜0.5 かつ 最近3年間減少もしくは横這い傾向	G＜0.5 かつ 最近3年間増加傾向	0.5≦G	G=( )	A B C	
【物質循環の円滑さ】を示す項目	基礎生産	透明度の差:D(cm)(過去20年間の平均−最近3年間の平	D＜20 かつ 最近3年間横這い傾向	D＜20 かつ 最近3年間増加もしくは減少傾向	20≦D	D=( )	A B C	
		赤潮の発生日数比:R(赤潮の発生年数/全調査年数)	R=0	0＜R＜1	R=1	R=( )	A B C	
	負荷・海水交換	負荷滞留濃度:Cx(淡水滞留時間×単位体積当たりの負荷量(x=cod、n、p))	Ccod＜0.2 かつ Cn＜0.2 かつ Cp＜0.02	良好(A)、悪化(C)の検査基準以外の場合	Ccod≧0.2 かつ Cn≧0.2 かつ Cp≧0.02	Ccod=( ) Cn=( ) Cp=( )	A B C	
		潮位振幅変化量:T(m)(過去30年間の朔望平均満潮位と干潮位の差の線形回帰より求めた傾き(G)×30(年))	T＜0.05 かつ 最近3年間減少傾向にない	T＜0.05 かつ 最近3年間減少傾向	T≧0.05	T=( )	A B C	
	堆積・分解	底質環境(硫化物の最大値:SD(mg/g))	SD＜0.2	0.2≦SD＜1	1≦SD	SD=( )	A B C	
		底層の最低溶存酸素濃度:N(mg/L)	4.2≦N	0.5≦N＜4.2	0.5>N	N=( )	A B C	
	除去	底生魚介類の漁獲量比:FB(最近3年間の平均/過去の平均)	0.8＜FB＜1.2 かつ 最近3年間増加もしくは横這い傾向	0.8＜FB＜1.2 かつ 最近3年間減少傾向	0.8≧FB または 1.2≦FB	FB=( )	A B C	

Inspection criteria

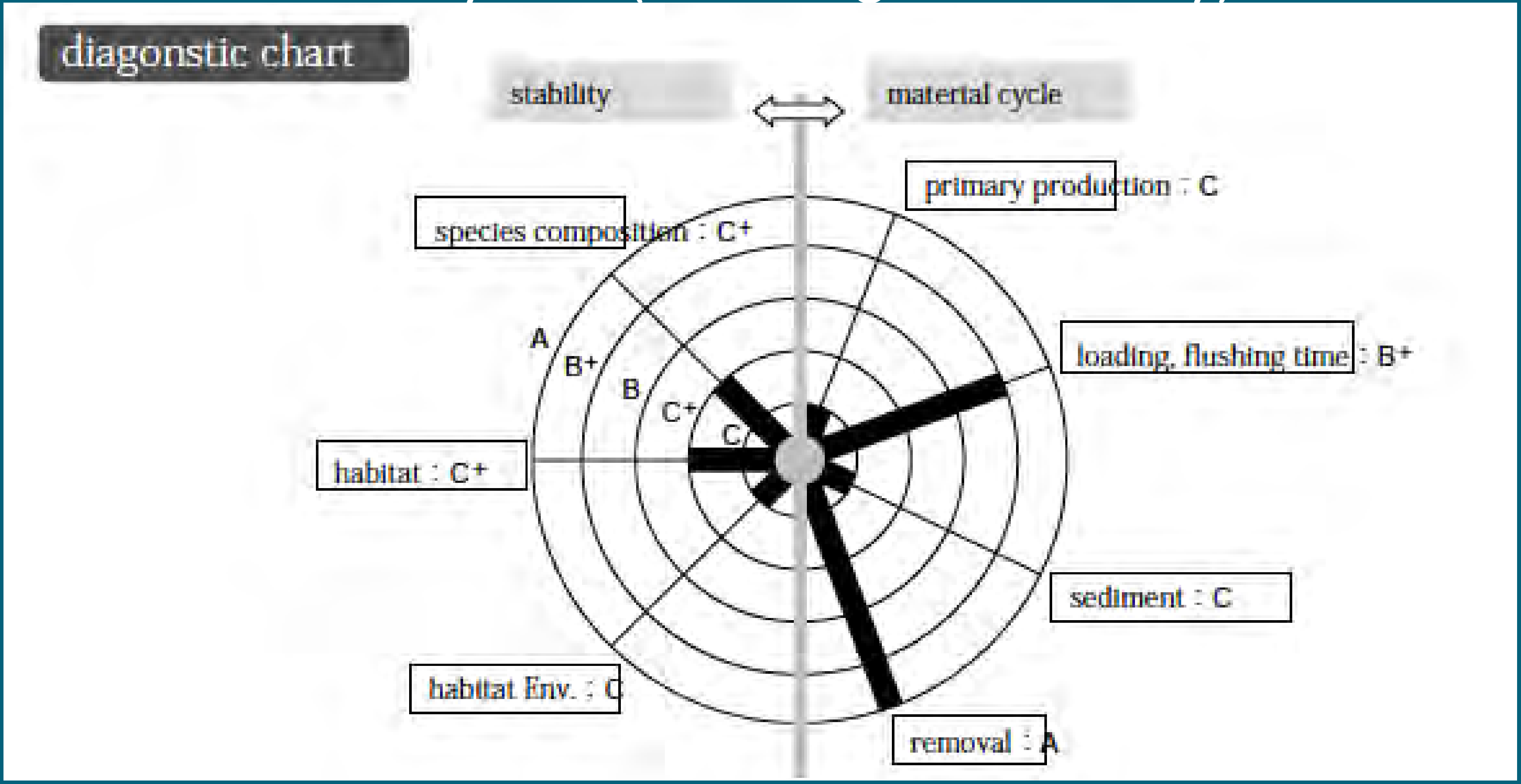
- The item indicating an ecological stability
- species composition (based on fish catches data);the ratio of dominant species   ;F= the last 3 years average /average)
- habitat (tidal flat , K=the recent area of tidal flat/ the past average)
- habitat environment (appearance ratio of hypoxia; G= the number of stations hypoxic condition/ total sampling stations)

The item indicating the smoothness of material cycle

- primary production (red tide frequency ; the difference of transparency; D(cm)= the last 20 years - the past 3 years if D> 20cm , rank C)
- Cx=loading per unit volume * flushing time , x means COD,T-N or T-P
- sediment/decomposition maximum sulfide concentration SD(mg/g) rank C SD>1 or minimum DO concentration in bottom layer N(mg/L) rank C N<0.5 mg/L
- removal process by fishing fish catches of demersal fish FB= the past 3 years average / the past average

- Based on this idea, we did the health check for 71 coastal bay estuaries in Japan. Health condition in each area is summarized as diagnostic chart .
- This is the case of Ise Bay.

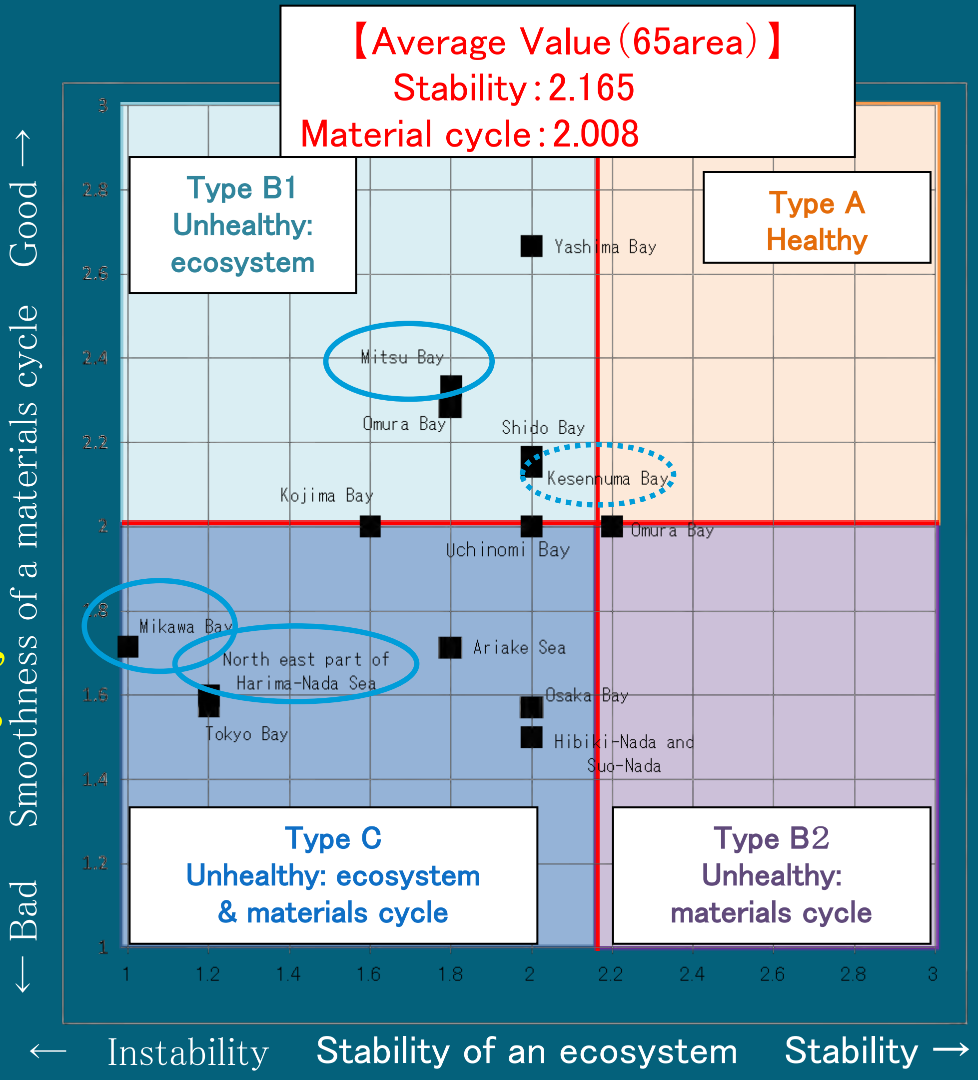
Ise Bay Case(including Mikawa bay)



- Based on this health check method、Ministry of Environment supports to develop the action plan of restoring the smoothness of material cycle in a coastal bay estuaries

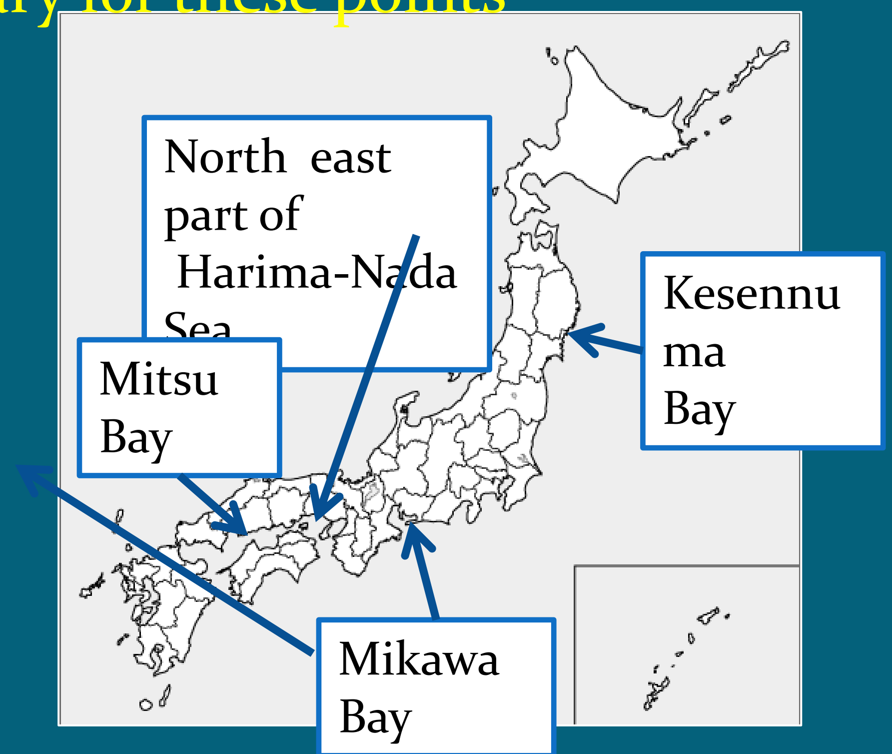
- the 10 candidate areas were classified using the results of "Health examination for the sea".

- Observations and simulations were examined for selected model areas (Kesennuma Bay, Mikawa Bay, North east part of Harima-Nada Sea and Mitsu Bay), which had different characteristics



Mikawa Bay is the typical case that the landfill reduce the habitat for bivalve on the tidal flat and shallows ,resulting in the developing of hypoxic water mass.

As shown in primary diagnostic chart, Mikawa bay is representative one that habitat environment, sediment and primary production are in C-rank, which means that advanced examination is necessary for these points



- We developed a pelagic and benthic coupled ecosystem model to understand what happens in the biogeochemical cycle of the coastal system with the present topography and without land reclamation (topography in 1960) in Mikawa Bay.

Basic assumption

- Pollutant loading is not a main reason for unhealthy environment.
- Landfill is a main reason because loss of habitat for suspension feeder weaken a material flow from primary producer to consumer.

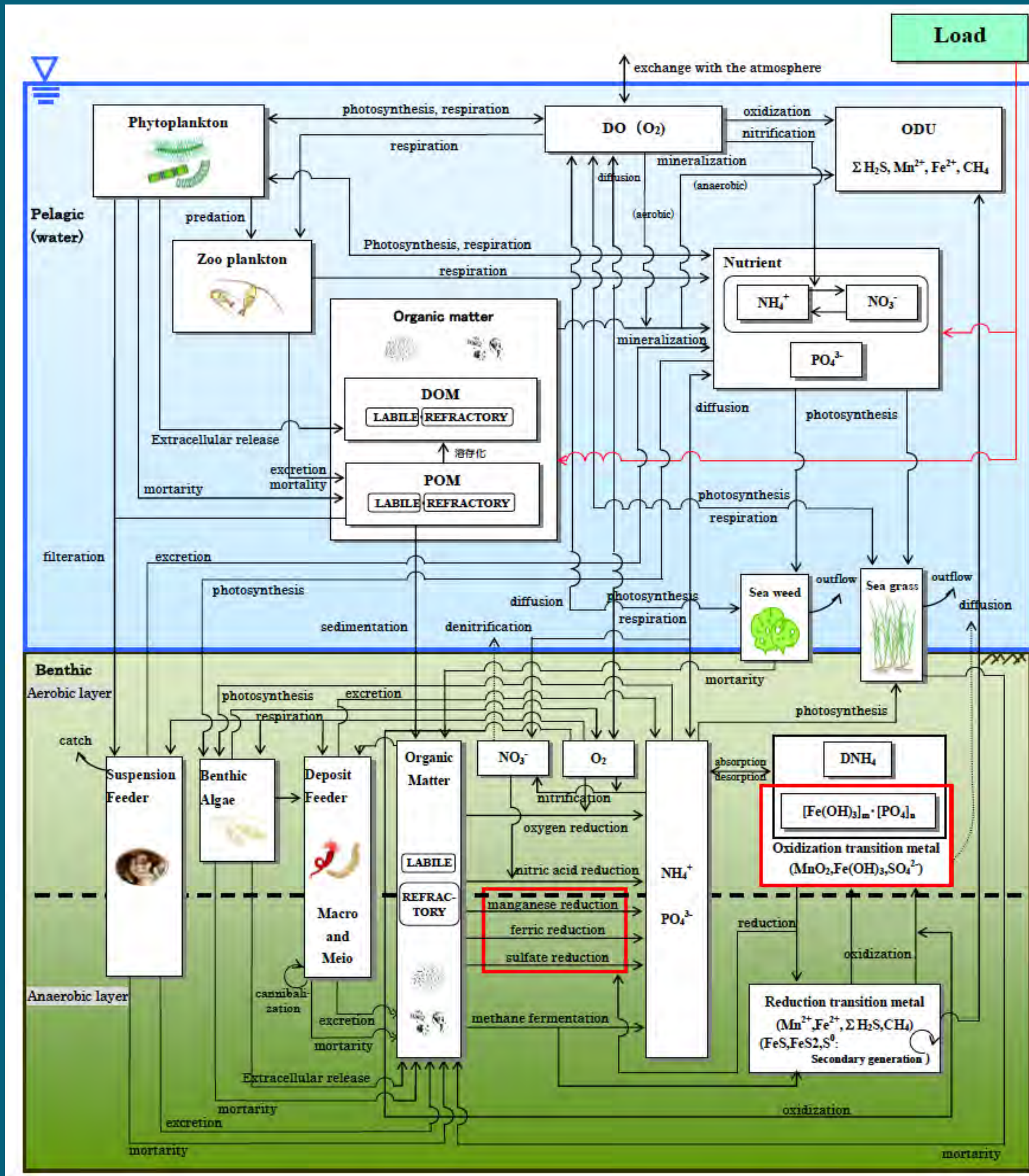
- The pelagic – benthic ecosystem coupling model is necessary to analyze these processes.

Pelagic system

- Phytoplankton(3 size)
- Zooplankton(3 size)
- POM・DOM(Labile, Refractory)
- Nutrients
- DO, ODU

Benthic system

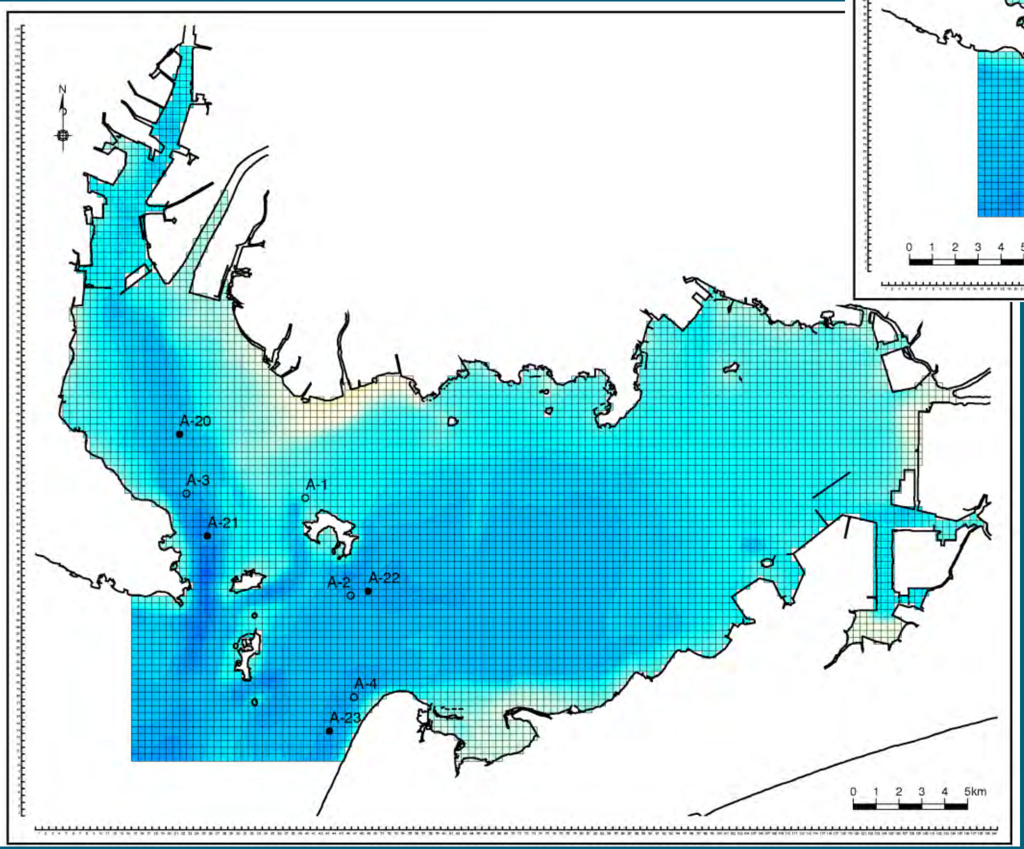
- Suspension Feeder
- Deposit Feeder
- Meio fauna
- Benthic Algae
- Sea weed, Sea grass
- POM・DOM(Labile, Refractory)
- Nutrients
- DO, ODU
- Transition metal elements (Mn・Fe・S・CH4)

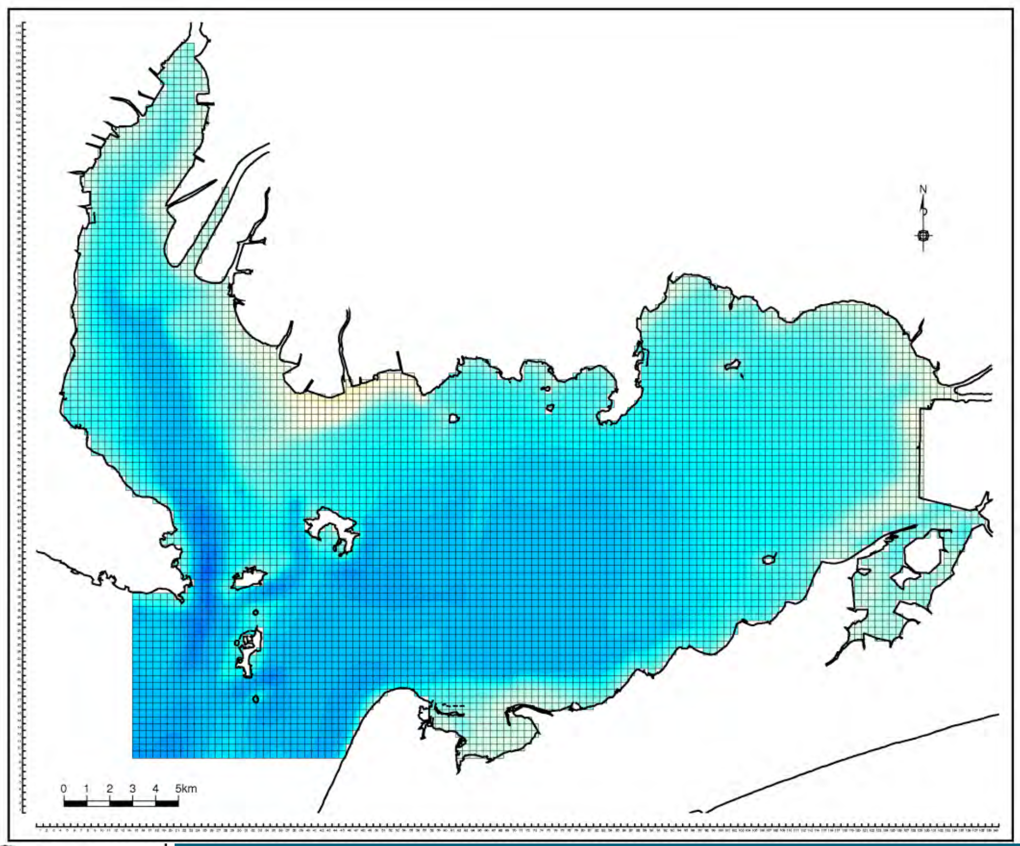


Computation condition

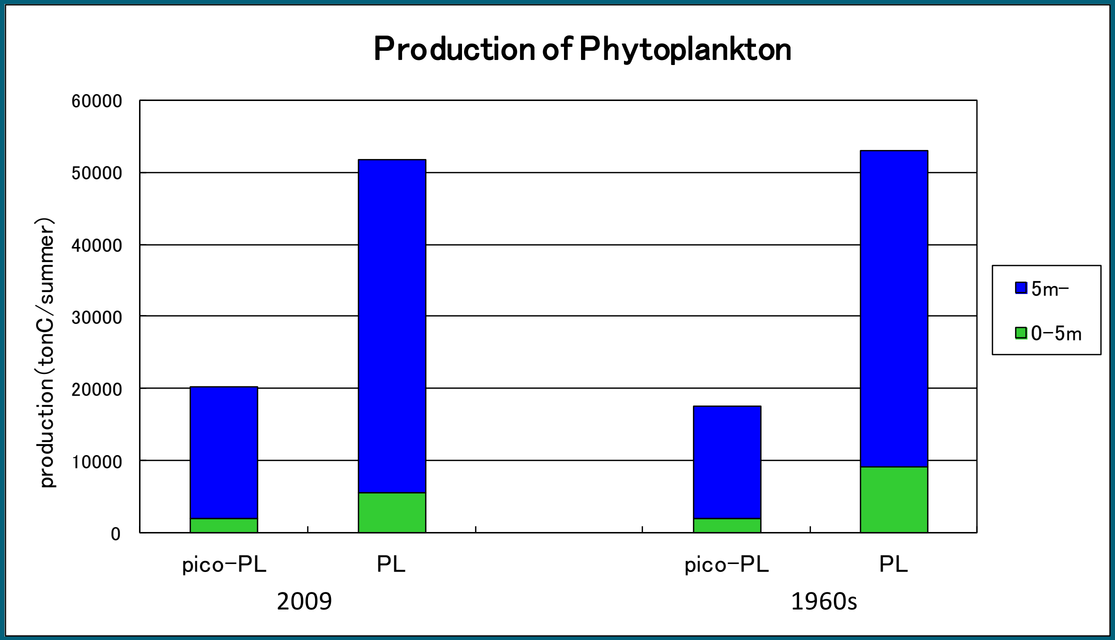
- reference case ; the observed boundary condition, estimated loading , and topography in 2009 are used
- the observed boundary condition, estimated loading are same as in 2009. Topography is assumed to be the one in 1960s (without landfill)
- Compare the flux between two simulations

The present geographical feature





Geographical feature of the 1960s

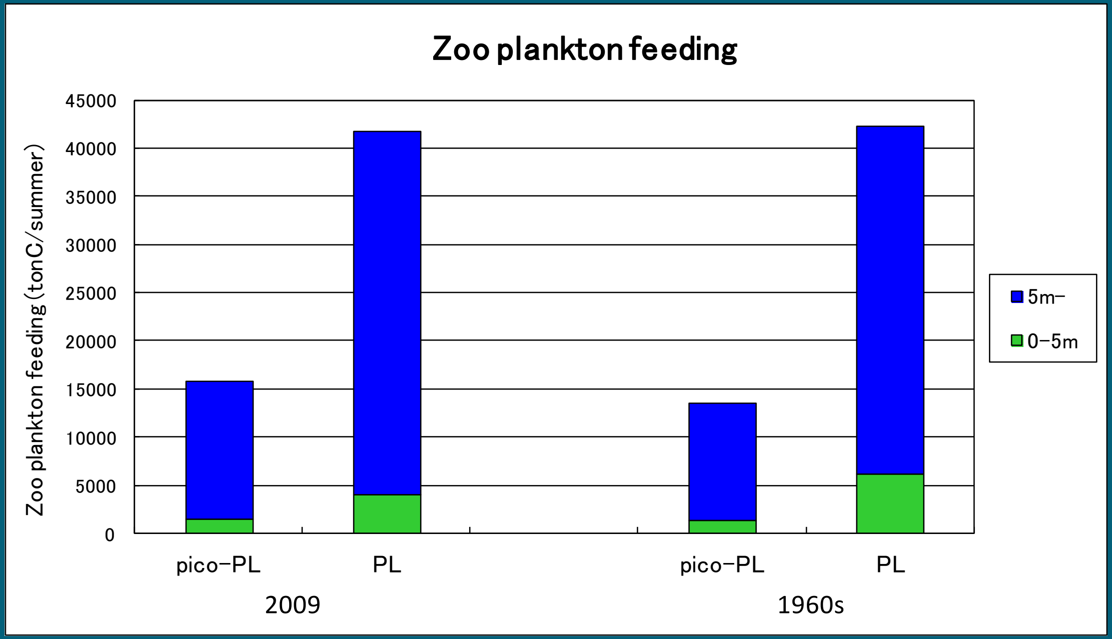


Production

2009→1960s

Pico-plankton

Nano and micro plankton



Zoo plankton feeding

2009→1960s

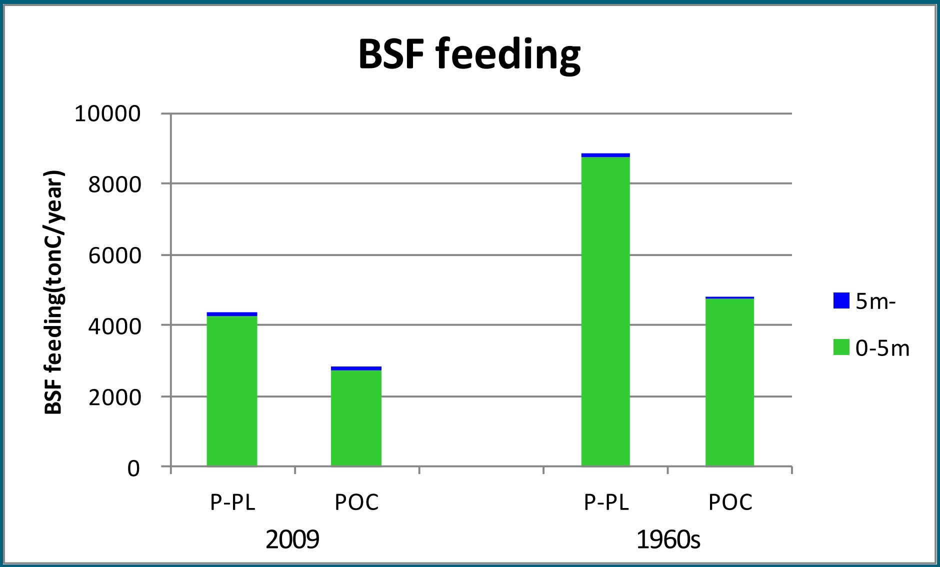
Pico-plankton

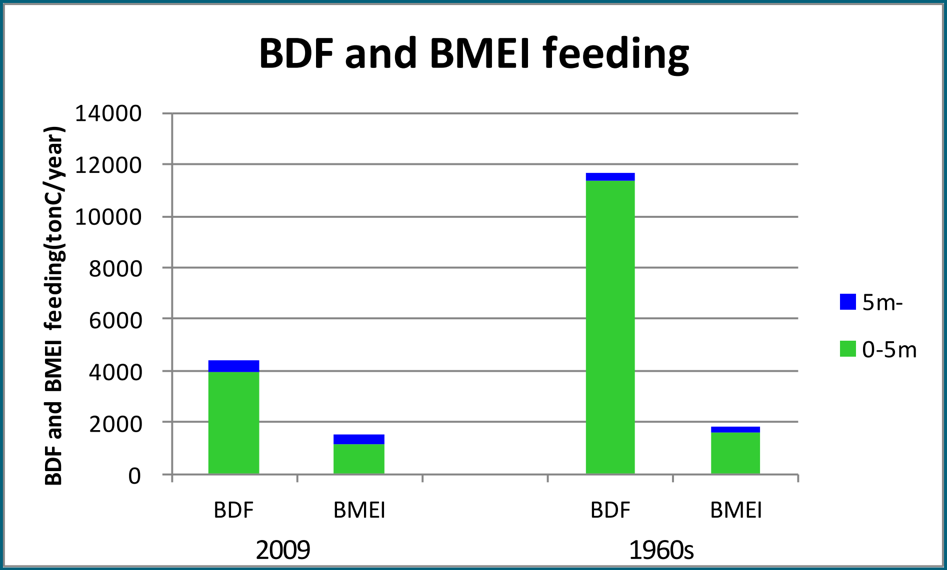
Nano and micro plankton

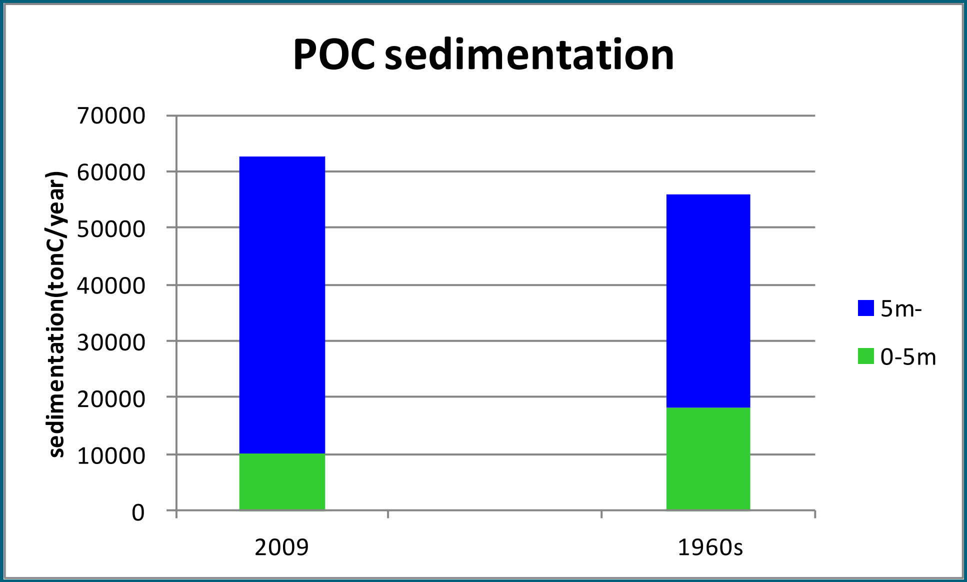
Microbial-food web

↓

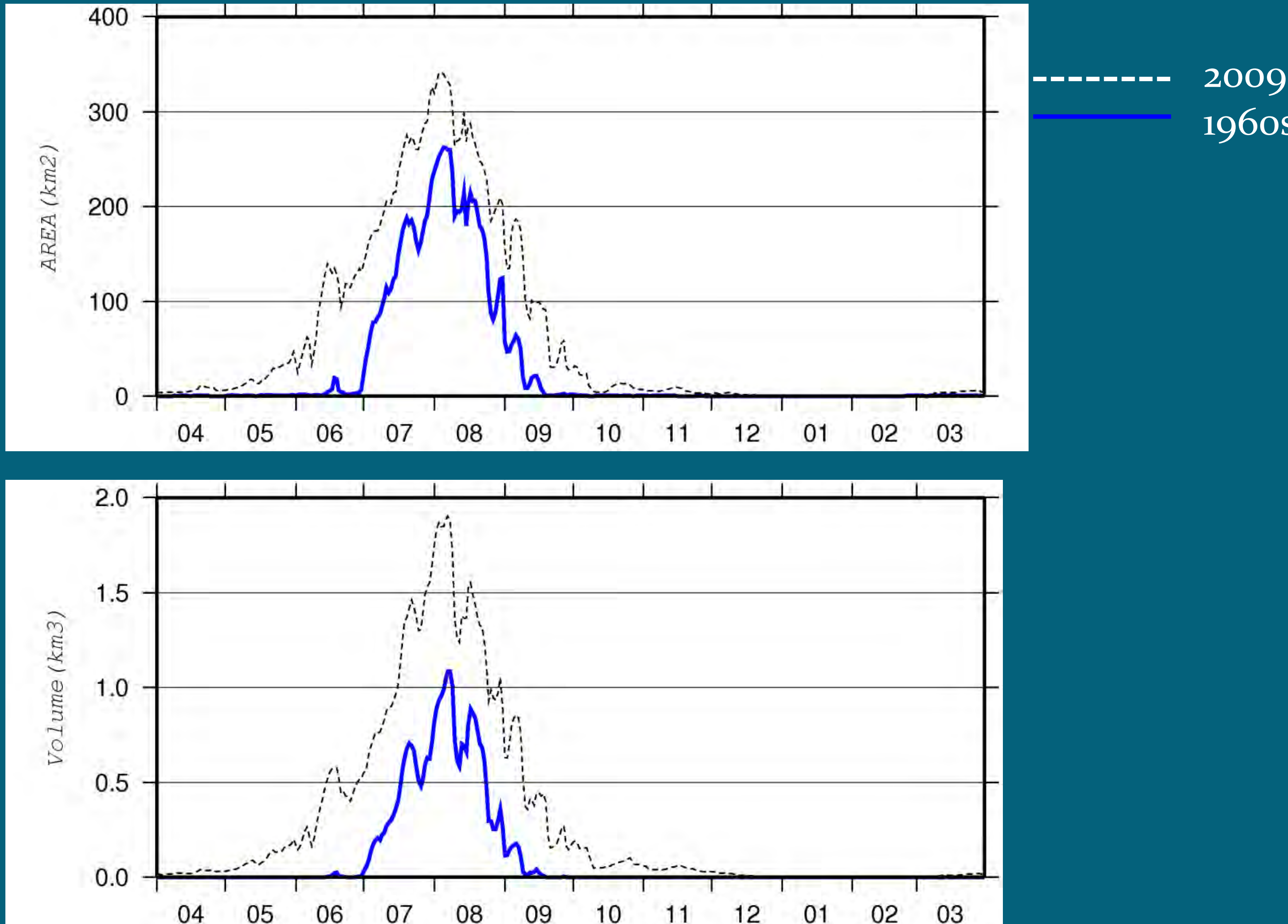
Classical food web



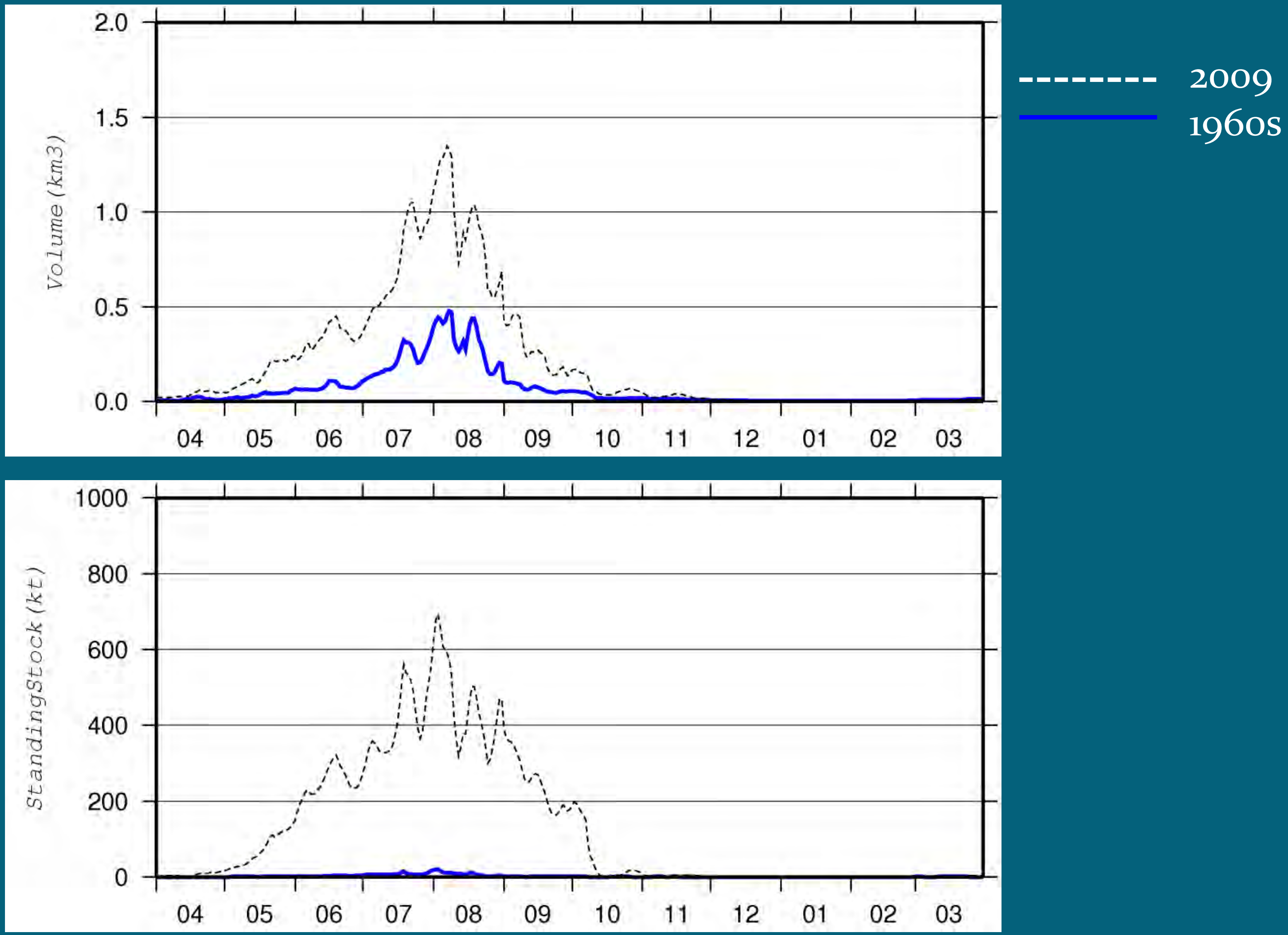




2009→1960s
Benthos feeding
sedimentation



Area and Volume of Hypoxia water mass in Mikawa Bay



Volume and Standing stock of ODU in Mikawa Bay

Conclusion

- In 1960s, lower Pico-plankton production and hiher Nano and micro plankton than in 2009
- Zooplankton graze more nano and micro plankton in 1960s than in 2009.
- Coupling between pelagic and benthic system in shallow region are richer in 1960s than in 2009.
- POC flux to the sea bottom in 2009 is more than in 1060s resulting in more hypoxic environment in 2009.
- The model suggests top down control is more effective than TPLC to restore Mikawa bay environmental health.

- The prescription to Mikawa Bay is not TPLC, but to create the tidal flat and shallow area to restore the material cycle.