

Section Meeting in ASIAHORCs Symposium

Among-taxon variability of relative contribution of environmental and spatial processes on rocky intertidal metacommunity structure



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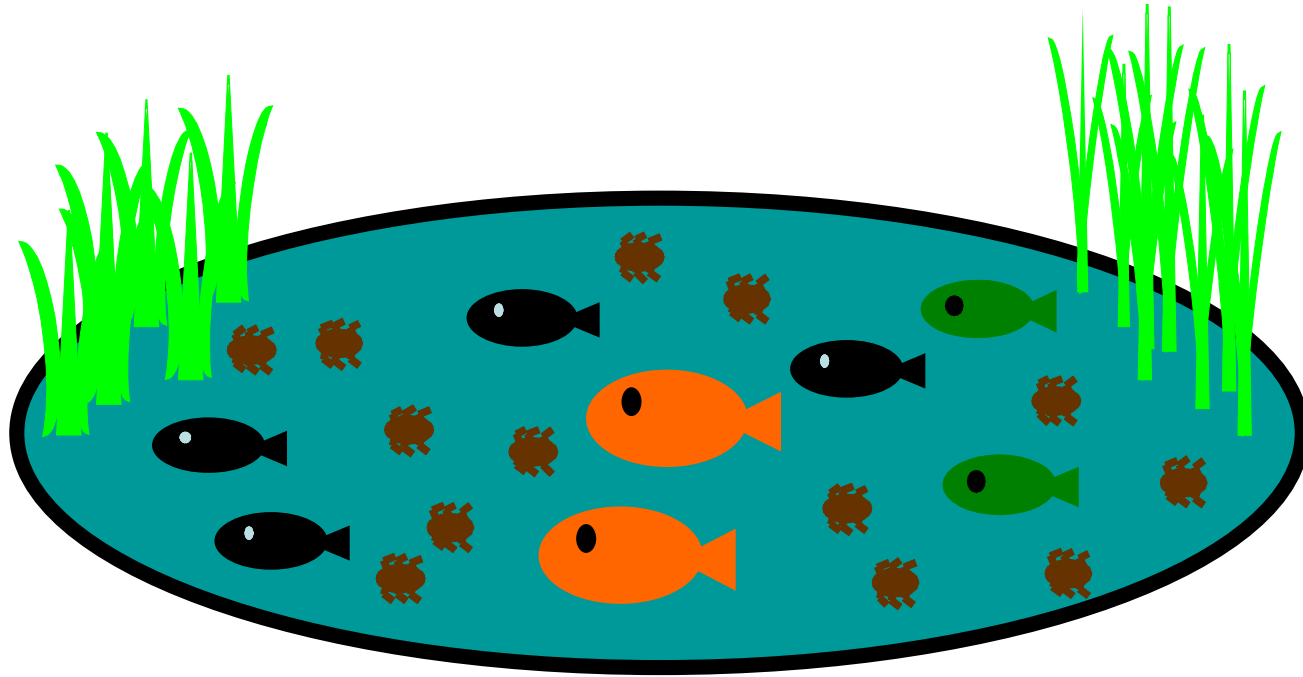
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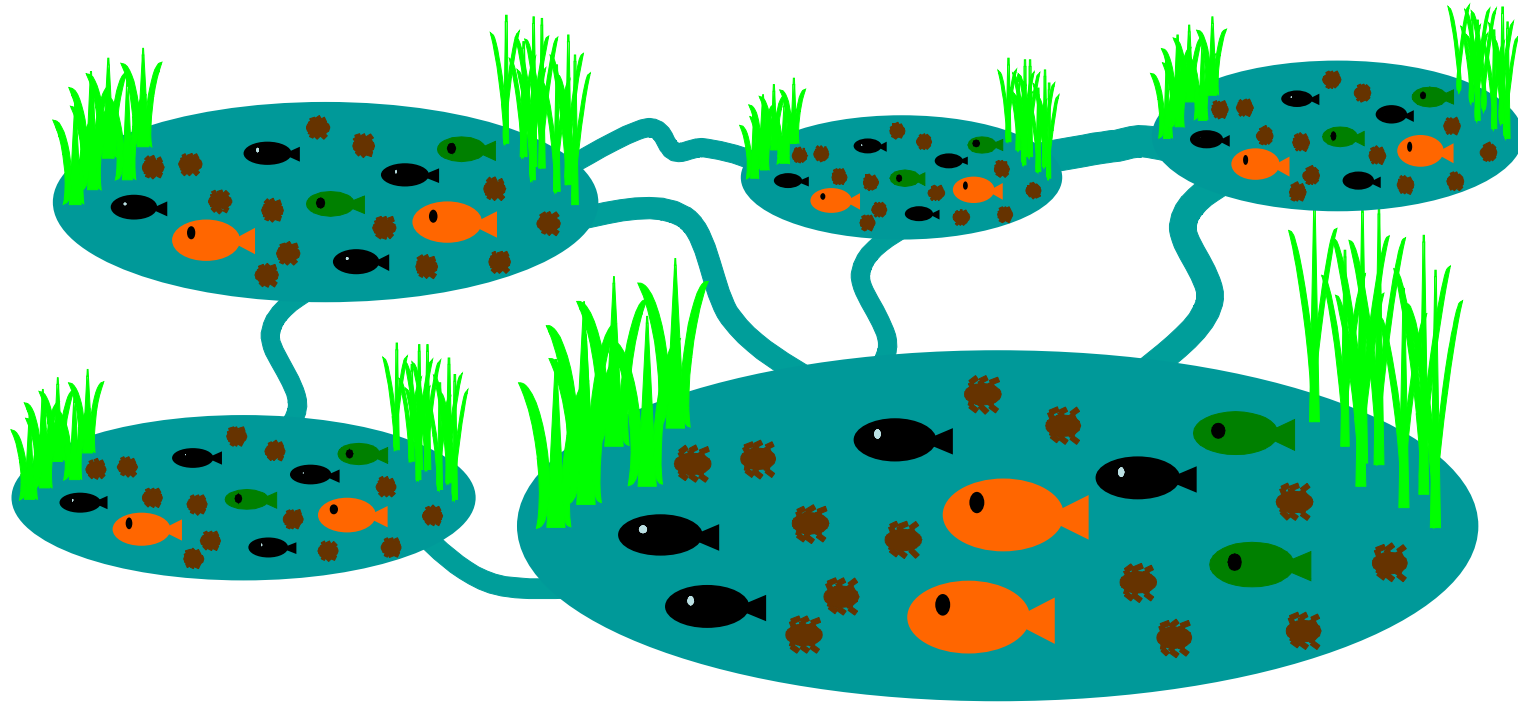
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Classical community ecology concept



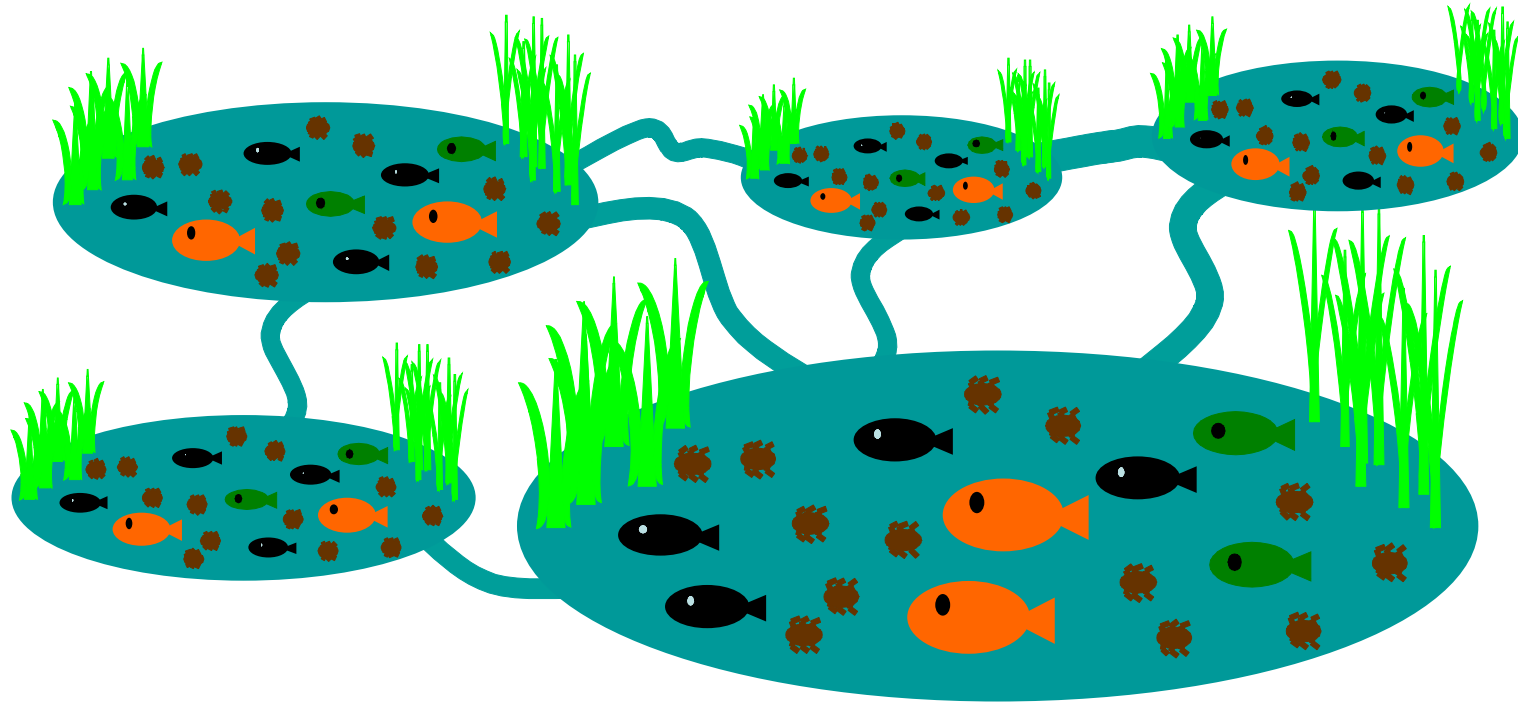
- “**Closed system**” which does not explicitly consider space
- Focus on a single spatial scale
e.g.) Lotka-Volterra model
Intermediate disturbance hypothesis

Natural community



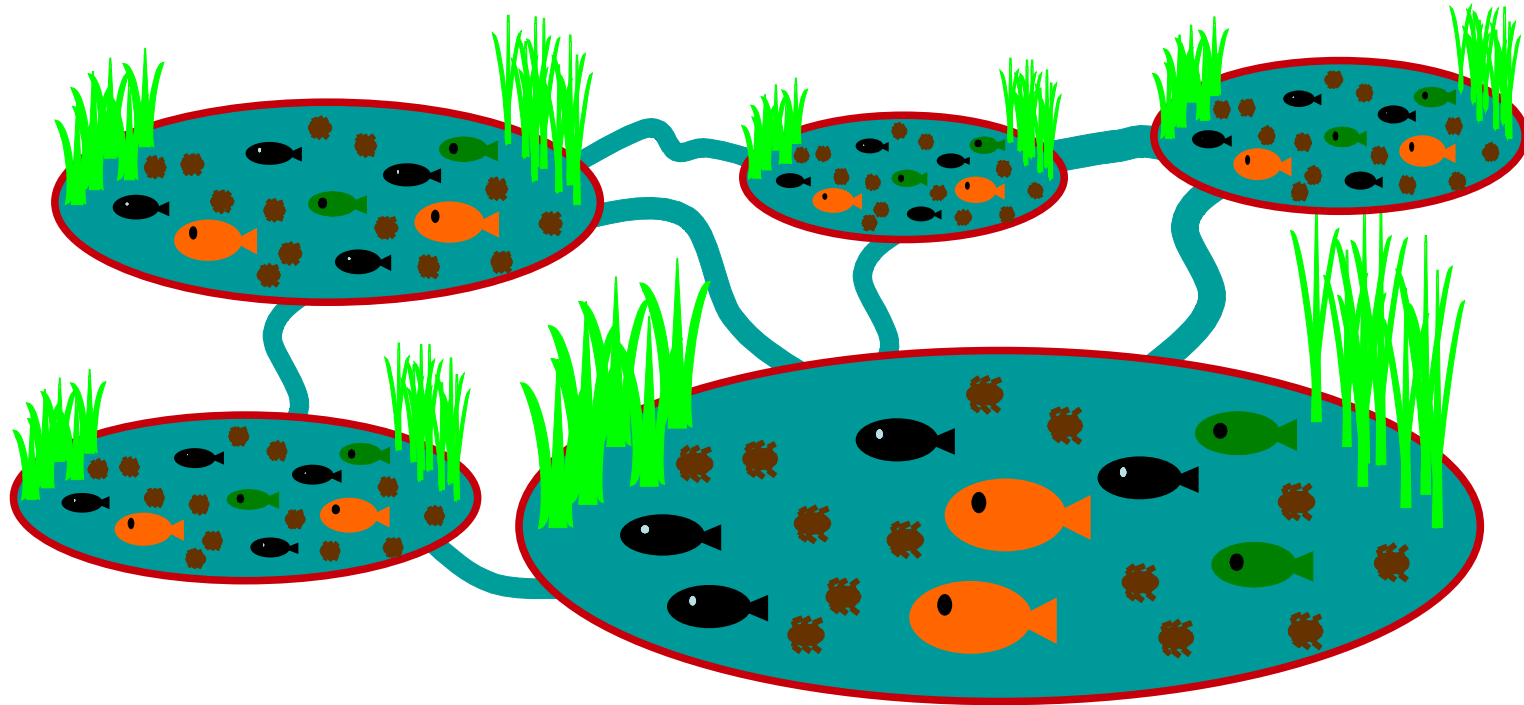
- “**Open system**” interacting organisms and materials
- Community structure is caused by processes operating at multiple spatial scales (single population ~ landscapes)
- Classical community theory cannot interpret natural system
- Need to the conceptual framework describing community dynamics with explicitly considering spatial structure

Metacommunity framework



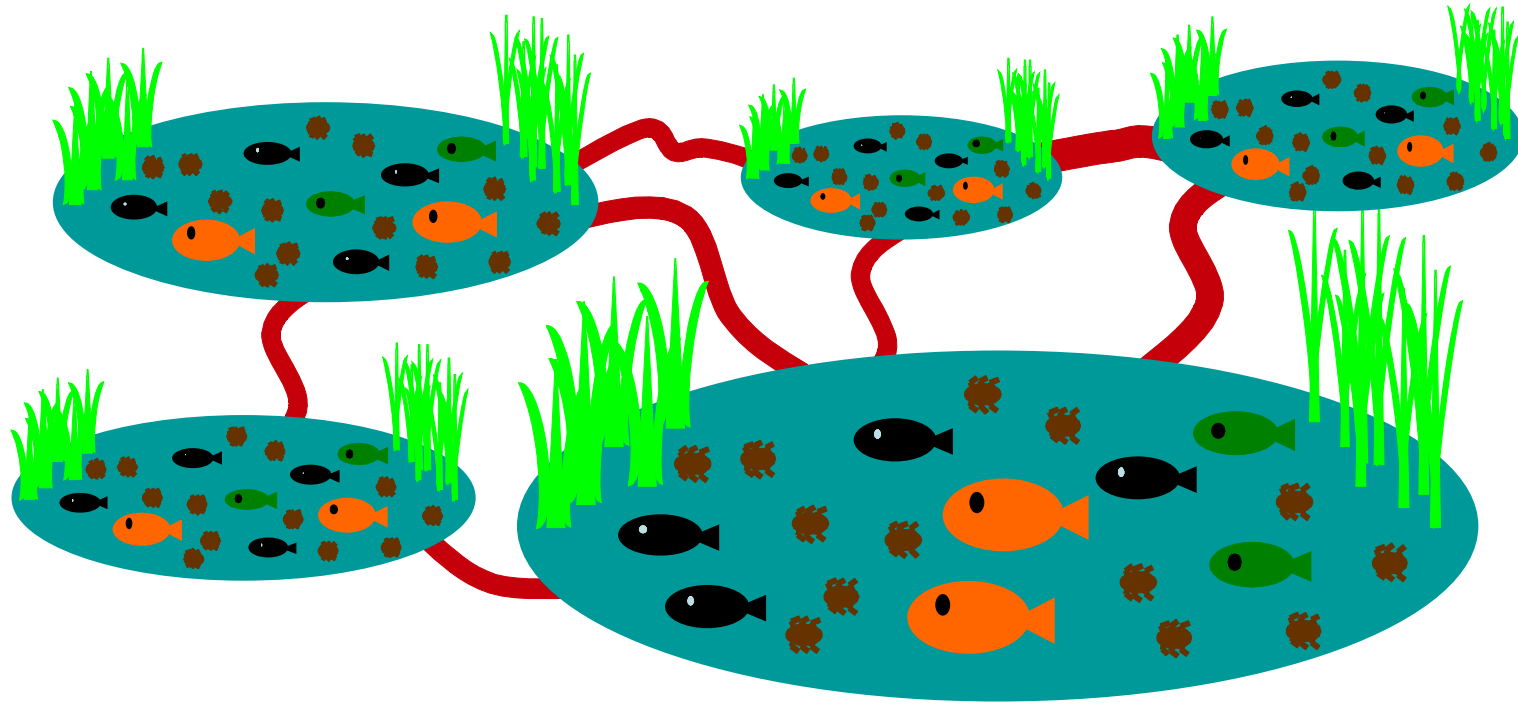
- Set of local communities linked by dispersal of multiple potentially interacting species (e.g., Leibold et al. 2004)
- Two factors influence the community dynamics
 - 1) Changing species interaction corresponding environmental heterogeneity among local communities
 - 2) Degree of dispersal among local communities(e.g., Holt and Hoopes 2005)

Metacommunity framework



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Which is more important, environment or space?

- The relative importance of two processes has been debated in previous studies focusing on the open system
 - The influence of environmental heterogeneity reflects environmental processes associated with species interaction
 - The influence of spatial structure of local communities reflects spatial processes related with dispersal
- Meta-analysis in Cottenie (2005)
 - Environmental processes tend to be more important
 - The relative importance varies depending on community characteristics, such as dispersal ability and habitat type
- Comparing datasets collected from different systems cannot distinguish between the influence of ecological characteristics of organisms and feature of the habitat

Objectives of this study

- Examine the relative contribution of environmental and spatial processes on community structure for three taxonomic groups with different ecological characteristics within the same ecosystem
- Test the prediction
“The portion of spatial processes explaining community structure is larger in taxonomic groups with lower dispersal ability than groups with greater dispersal ability”

Objectives of this study

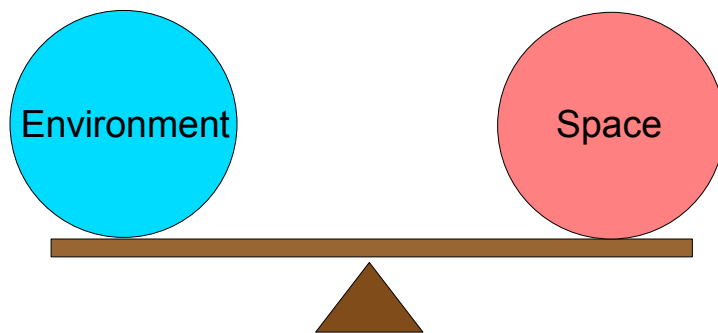
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Dispersal ability
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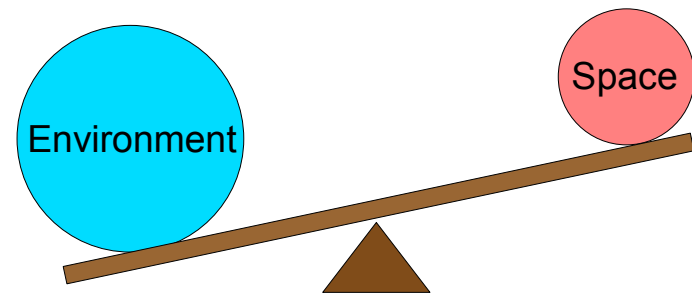
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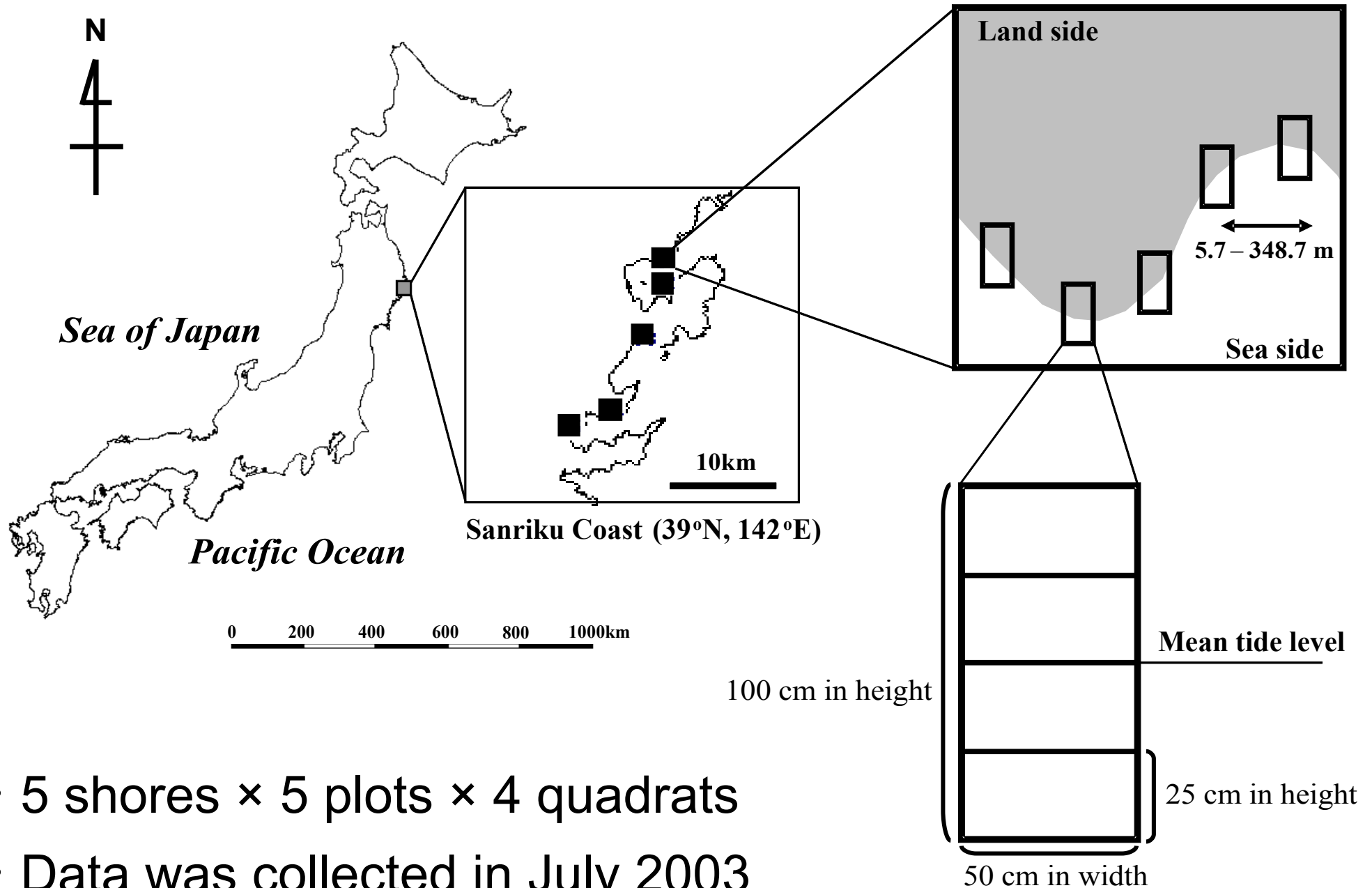


Lower dispersal groups



Greater dispersal groups

Study sites



- 5 shores × 5 plots × 4 quadrats
- Data was collected in July 2003

Data collection: biological data

- We surveyed the abundance of intertidal organisms
 - 23 Macro algal species: coverage
 - 20 sessile animal species: coverage
 - 19 mobile mollusc species: number of individuals



In this photo

Macro algae

Gloiopeltis furcata, *Gelidium divaricatum*,
Hildenbrandia rubra

Sessile animal

Crassostera gigas, *Septifer virgatus*,
Chthamalus, challenger

Mobile molluscs

Nucella lima, *Littorina sitkana*,
Lottia kogamogai

- Dispersal ability was estimated from dispersal period of propagule of algae and planctonic larvae of invertebrate
 - Macro algae: lower dispersal
 - Sessile animal and mobile molluscs: greater dispersal

Data collection: environmental and spatial factors

- We measured 18 environmental variables considered important in determining community structure

Shore scale

Chlorophyll a, Pheophytin, Water temperature

Plot scale

Nutrients (NO_3 , NO_2 , NH_4 , SiO_2 , PO_4), Disturbance frequency, Temperature of rock wall, Rate of sediment accumulation, Wave intensity, Direction of rock wall

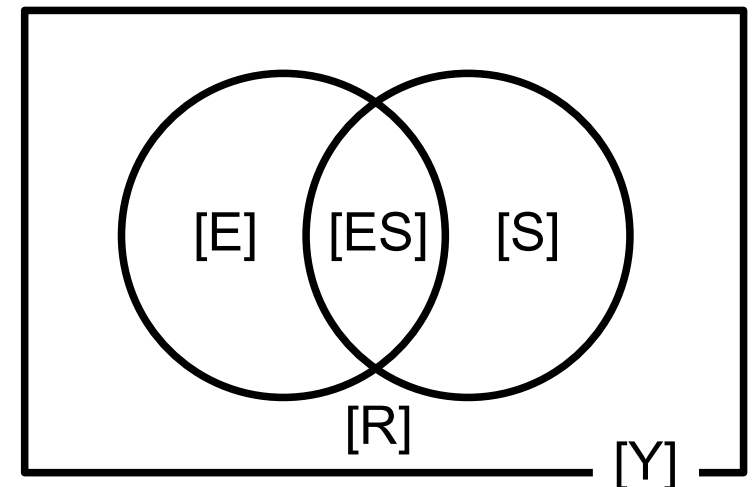
Quadrat scale

Predator density, herbivore density, Amount of food supply, Tide level, Rock surface rugosity

- Spatial coordinates of each plot was measured using GPS

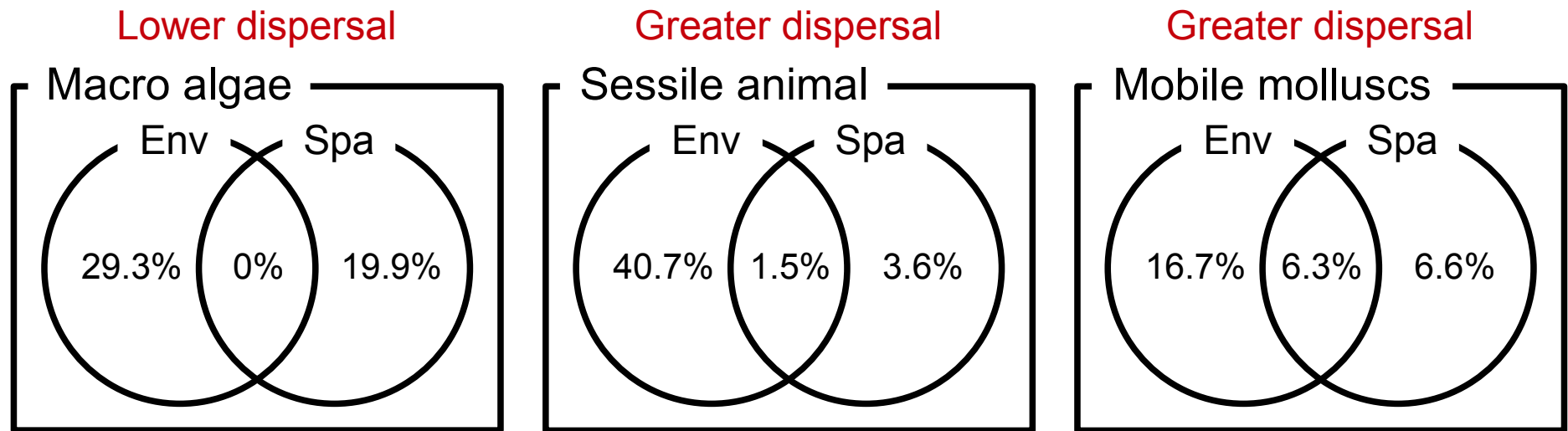
Statistical analysis: Variation Partitioning

- This can reveal the relative contribution of environment and space on variation of community structure
- Response variables [Y] is total variation of the community
- [Y] is decomposed into four fractions by using partial RDA with environmental and spatial explanatory variables
 - [E]: explained by environment
 - [S]: explained by space
 - [ES]: explained by correlation between environment and space
 - [R]: residual fraction



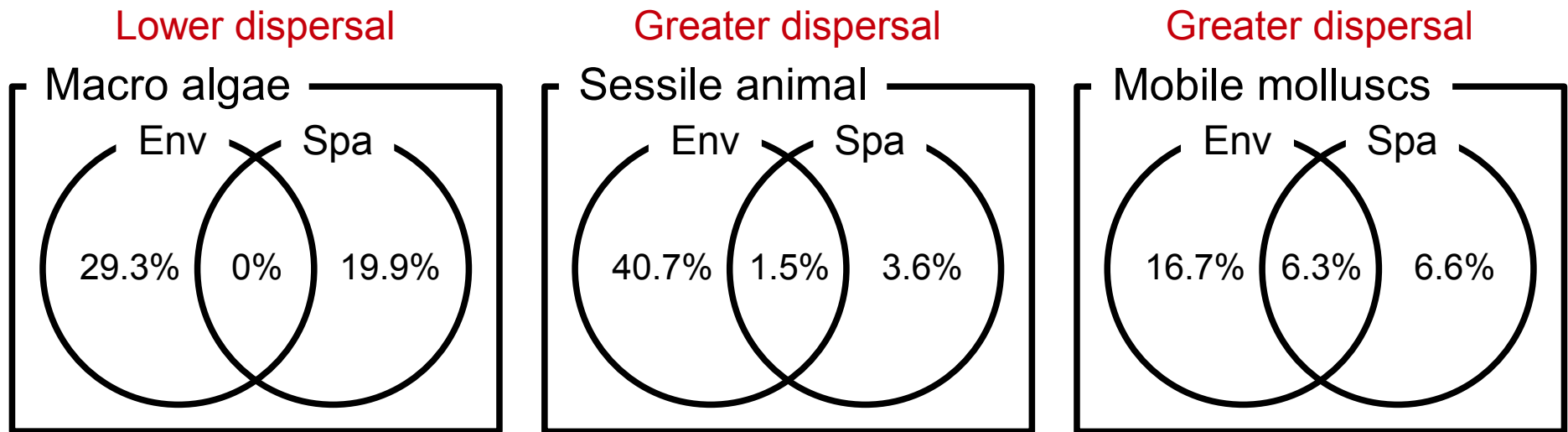
- This analysis was carried out in statistical software R with the package “vegan”

Result: explained variation of community structure



- Both environmental and spatial variables significantly explained the part of community structure
- Relative contribution of environmental variables was larger than spatial variables in all taxonomic groups
 - This result confirms findings of previous studies in rocky intertidal assemblages (e.g., Menge and Branch 2001)
 - Previous studies emphasize the influence of interaction and environmental filters on determining community structure

Result: explained variation of community structure



- Relative contribution of spatial variables in macro algae was greater than in sessile animal and mobile molluscs
 - This result supports our prediction
 - Even if taxonomic groups lived in the same ecosystem, the mechanisms determining community structure differ among taxonomic groups depending on ecological characteristics

Discussion

- Three mechanisms related to ecological characteristics may cause the differences in relative contribution of spatial processes among taxonomic groups
 - 1) Difference of dispersal distance between macro algae propagules and invertebrate larvae
 - 2) Ability of invertebrate larvae to select settlement substrate
 - 3) Life history of each organism: Invertebrate > Macro algae

Discussion

- Three mechanisms related to ecological characteristics may cause the differences in relative contribution of spatial processes among taxonomic groups
- 1) Difference of dispersal distance between macro algae propagules and invertebrate larvae
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 - Post settlement processes dependent on environmental conditions of each habitat will become more important

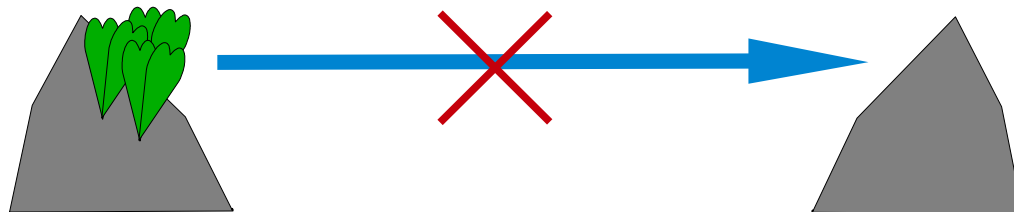


Discussion

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1) Difference of dispersal distance between macro algae propagules and invertebrate larvae

- Great dispersal ability of invertebrate larvae may allow to reach almost habitats
- Post settlement processes dependent on environmental conditions of each habitat will become more important
- Low dispersal ability of macro algae would be more restricted to reach suitable habitats, and the relative importance of spatial processes would be greater

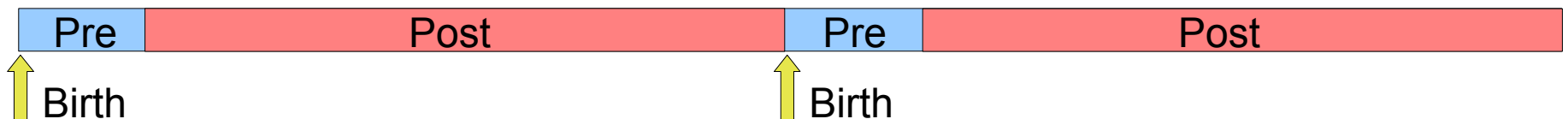


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3) Life history of each organism: Invertebrate > Macro algae

- Invertebrate with longer life span are exposed by post-recruitment processes for longer period
- The post-recruitment processes may be mainly caused by environmental factor

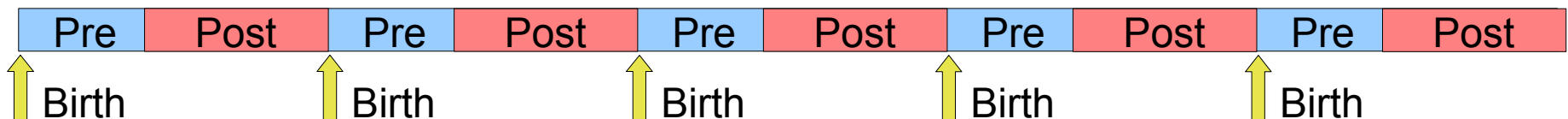


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3) Life history of each organism: Invertebrate > Macro algae

- Invertebrate with longer life span are exposed by post-recruitment processes for longer period
- The post-recruitment processes may be mainly caused by environmental factor
- Macro algae with shorter life span are enrage relative contribution of pre-recruitment processes
- The pre-recruitment processes would be mainly caused by spatial factors like as dispersal limitation



Conclusion

Relative contribution of spatial processes in macro algae was greater than in sessile animal and mobile molluscs



Even if some taxonomic groups live in the same ecosystem, mechanisms determining community structure may change depending on **ecological characteristics**, such as dispersal ability and life history

- Need detail information about ecological characteristics
- Combination of metacommunity framework and considering ecological characteristics may contribute to applied areas (e.g., environmental management and conservation)

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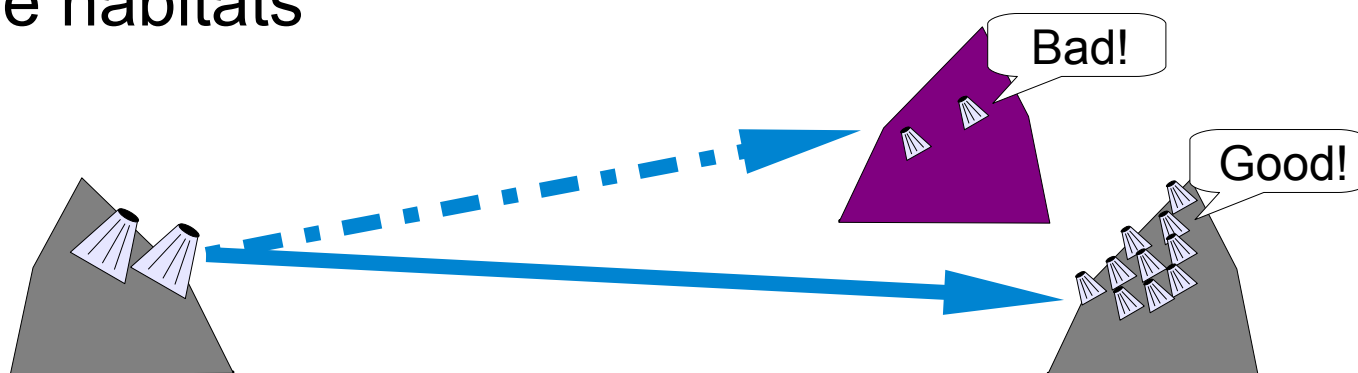
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Discussion

- Three mechanisms related to ecological characteristics may cause the differences in relative contribution of spatial processes among taxonomic groups

2) Ability of invertebrate larvae to select settlement substrate

- Larvae can selectively settle on suitable habitat guided by abiotic cues or the presence of conspecifics
(e.g., Tambutti et al. 1992; Jeffery 2000)
- Community structure of invertebrate would be explained more by environmental heterogeneity characterizing suitable habitats



Result and discussion 2

Variables	Macroalgae		Sessile animals		Mobile molluscs	
	%	<i>p</i>	%	<i>p</i>	%	<i>p</i>
<i>Shore scale</i>						
Pheophytin	<u>5</u>	<0.001	<u>4</u>	<0.001	<u>3</u>	<0.001
Water temperature	0.2	0.627	<u>2</u>	0.001	1	0.008
<i>Plot scale</i>						
NO ₂	1	0.031	1	0.061	1	0.100
NH ₄	1	0.049	1	0.012	1	0.148
PO ₄	1	0.020	0.4	0.240	1	0.174
SiO ₂	1	0.003	0.5	0.204	0.4	0.390
Disturbance	1	0.001	1	0.034	0.2	0.776
Rock temperature	1	0.023	1	0.012	1	0.084
Sediment	1	0.012	<u>2</u>	<0.001	1	0.136
Wave intensity	1	0.009	0.1	0.847	1	0.072
Direction	<u>2</u>	0.001	1	0.130	1	0.013
<i>Quadrat scale</i>						
Predator	0.5	0.126	<u>3</u>	<0.001	-	-
Herbivore	1	0.004	-	-	-	-
Macroalgae	-	-	<u>2</u>	<0.001	1	0.016
Sessile invertebrate	1	0.066	-	-	1	0.012
Tide level	1	0.011	<u>8</u>	<0.001	<u>2</u>	<0.001
Rugosity	0.4	0.128	1	0.089	0.4	0.268

* Chlorophyll a and NO₃ were excluded from the analysis because of their colinearity

- Each environmental variable explained a small portion of total variance of community structure
- Key environmental variables differ among taxon
 - Important niche axes may change among taxonomic groups depending on ecological characteristics