



Title	Investigating the linkage between biodiversity and ecosystem functions in coastal areas
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# Investigating the linkage between biodiversity and ecosystem functions in coastal areas

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# Adaptive management of biodiversity and functions of coastal ecosystems

Q: Where to conserve?

A1: A site with highest biodiversity  
(for conservationists)

A2: A site with highest productivity  
(for fishermen)

**Are the answers the same?**

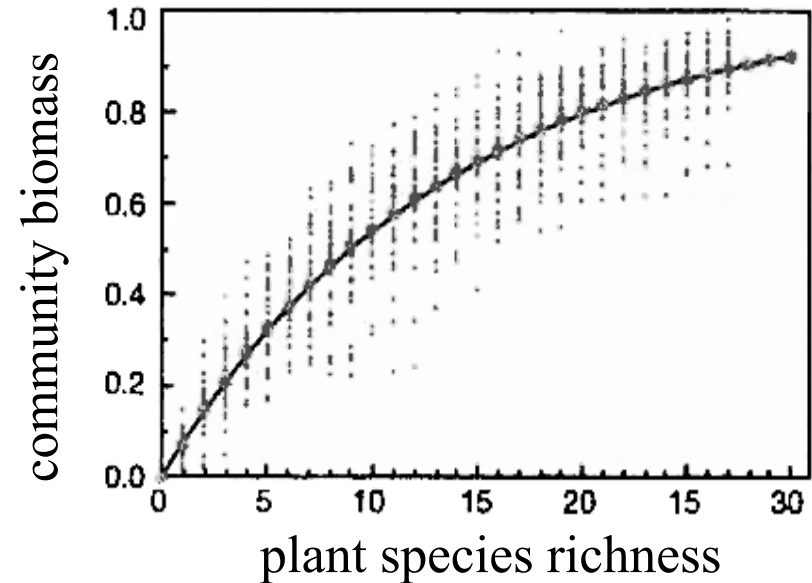




# Biodiversity enhances ecosystem functions

## BD-EF relationship

Positive link between biodiversity and ecosystem functions revealed by manipulative experiments



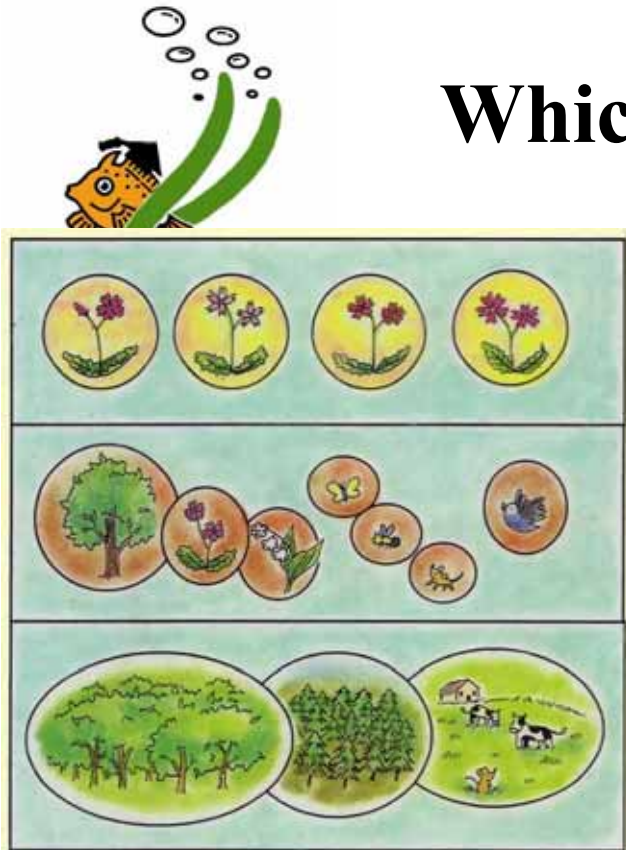
Tillman (2000)

## Questions and problems

1. Which measures of biodiversity should be used?
2. Does the rule hold at larger spatial scales?

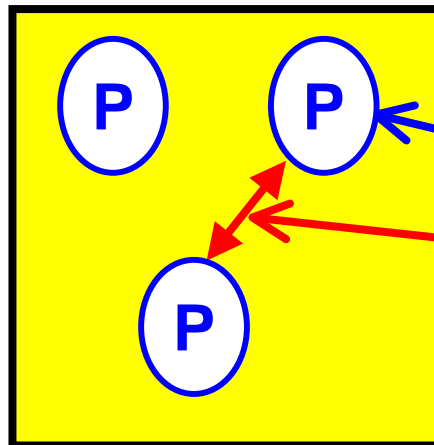
**Fewer research has been done in marine ecosystems.**

# Which measure of biodiversity ?



## 1. Definition at different biological levels

- Genetic diversity at population level
- Species diversity at community level
- Landscape diversity at ecosystem level

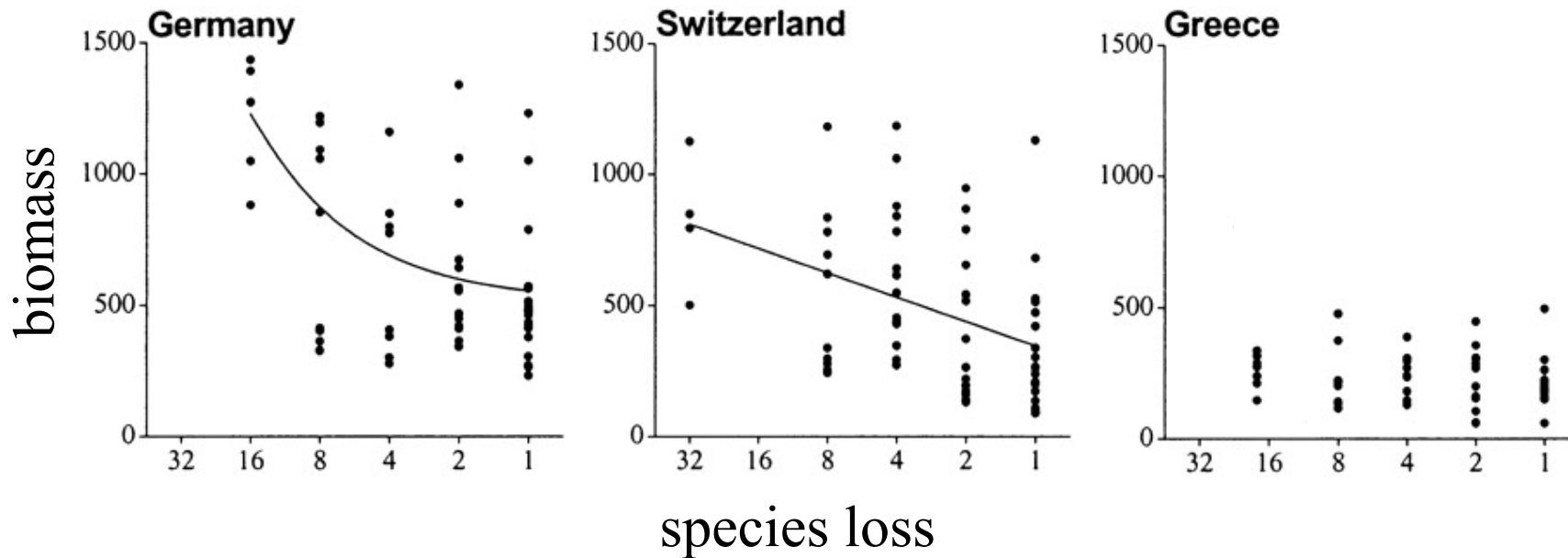


## 2. Spatial scale of biodiversity

- $\alpha$  diversity: diversity within a patch
- $\beta$  diversity: difference between patches
- $\gamma$  diversity: diversity of whole area



# BD-EF relationship changes among regions



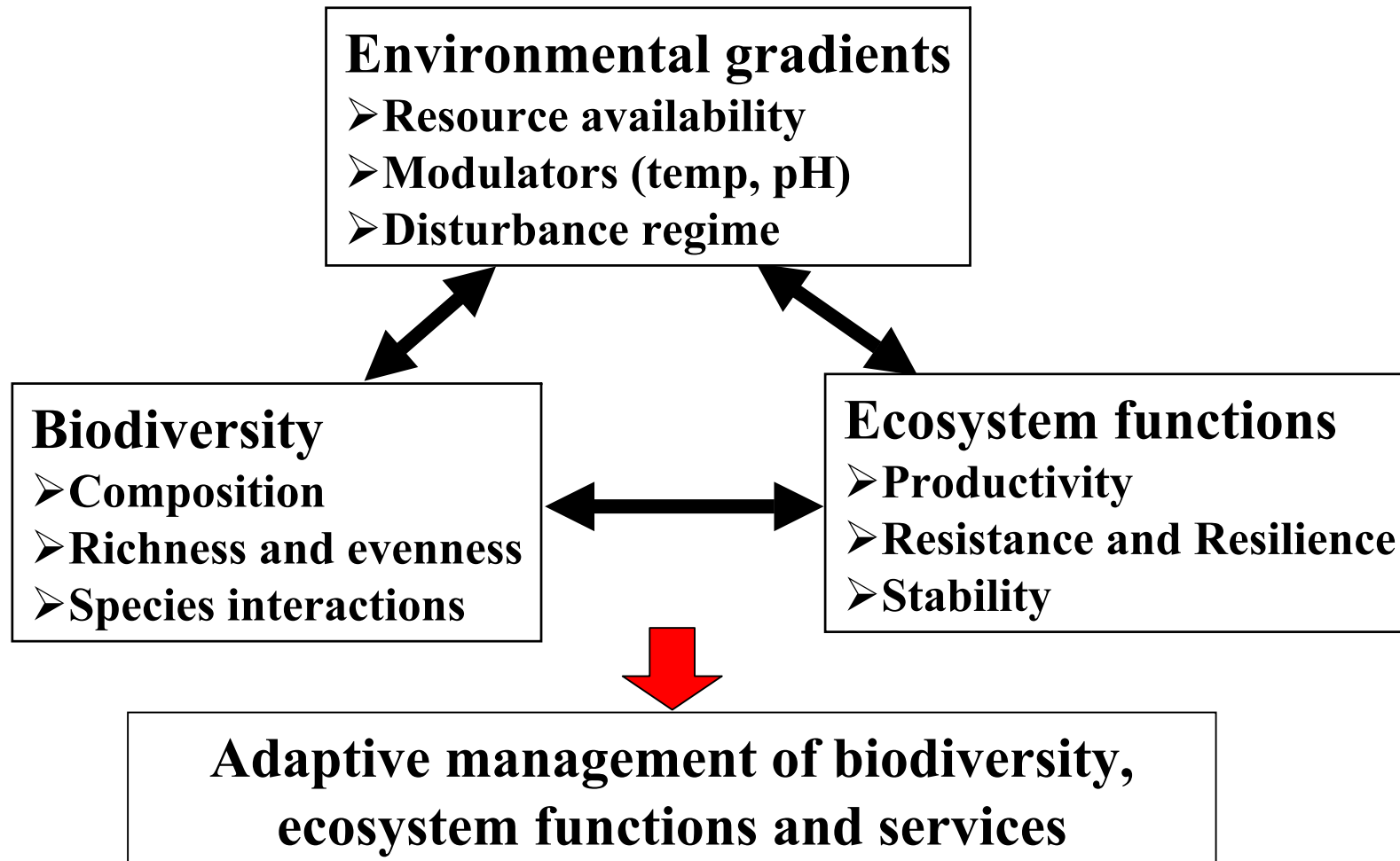
Hector et al (1999)

Environmental factors interfere with BD-EF relationship at broad spatial scales.



# Purpose of the present study

Investigating possible relationships among environmental factors, biodiversity and ecosystem functions in coastal habitats





## **Case studies at two different habitats**



**Seagrass beds in  
Tokyo Bay**



**Rocky intertidal community  
along the Pacific coast of Japan**





## What is seagrass bed?



- A unit of coastal landscape consisting of seagrasses, i.e., “flowering plants living in the sea” (Do not confuse with seaweeds!)
- Known as most productive habitats in the world (annual productivity exceeding tropical rain forest)
- Harbor diverse plant and animals species, forming “hot spot” of biodiversity in marine ecosystems

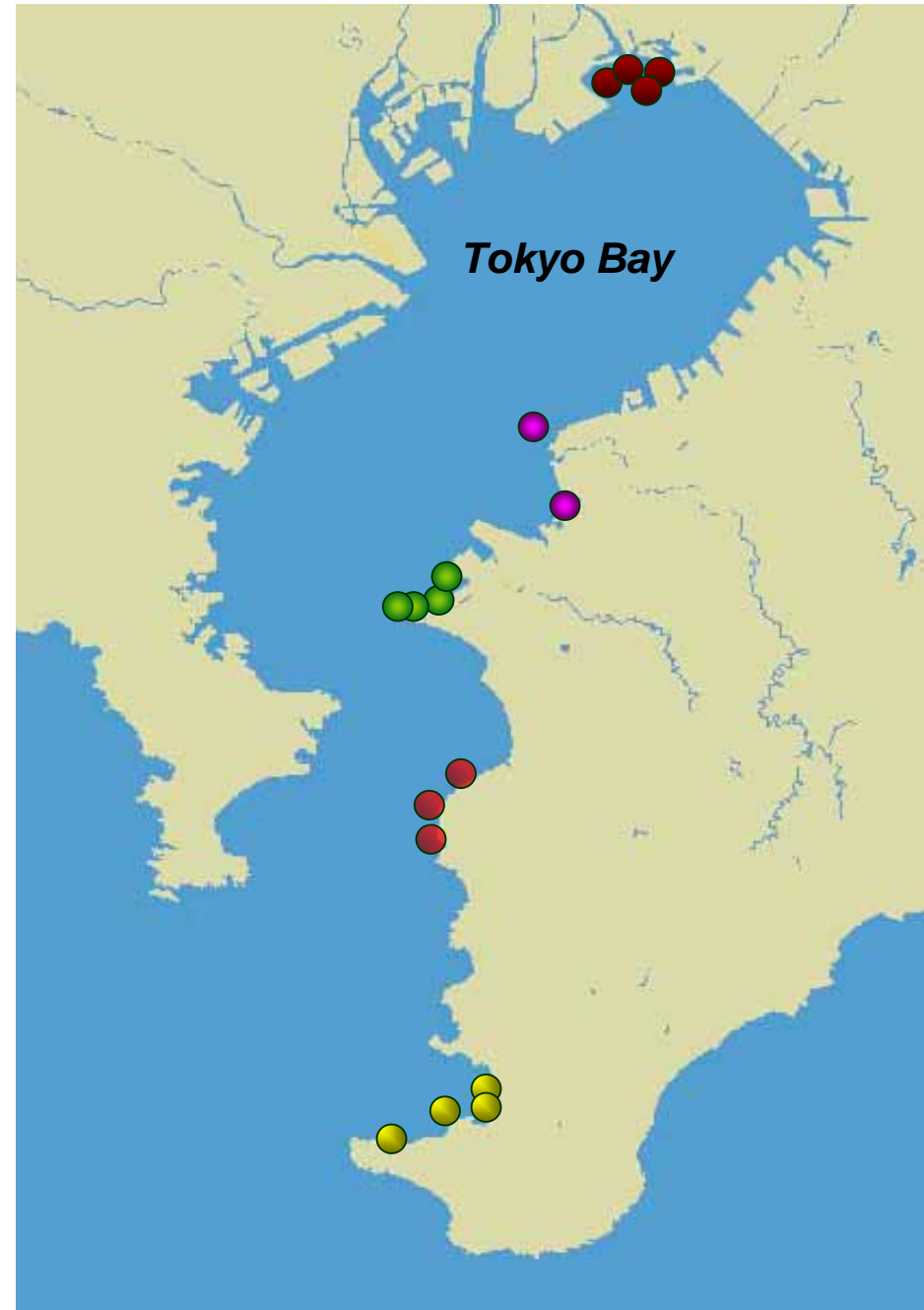


## Study sites

17 stations in 5 areas established in a nested design (although not perfectly designed)



**Seagrass bed in Futtsu**

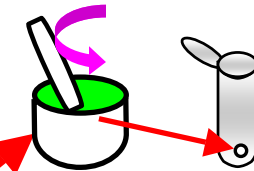
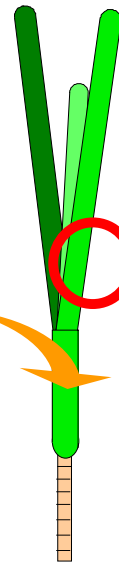




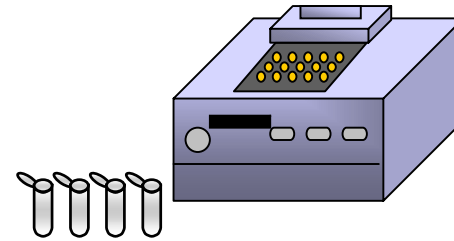
# Analysis of genetic diversity of eelgrass using microsatellite DNA



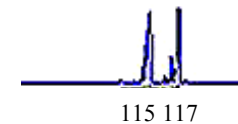
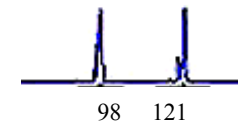
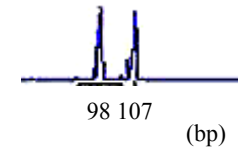
Collection of eelgrass



DNA extraction by CTAB method



PCR amplification



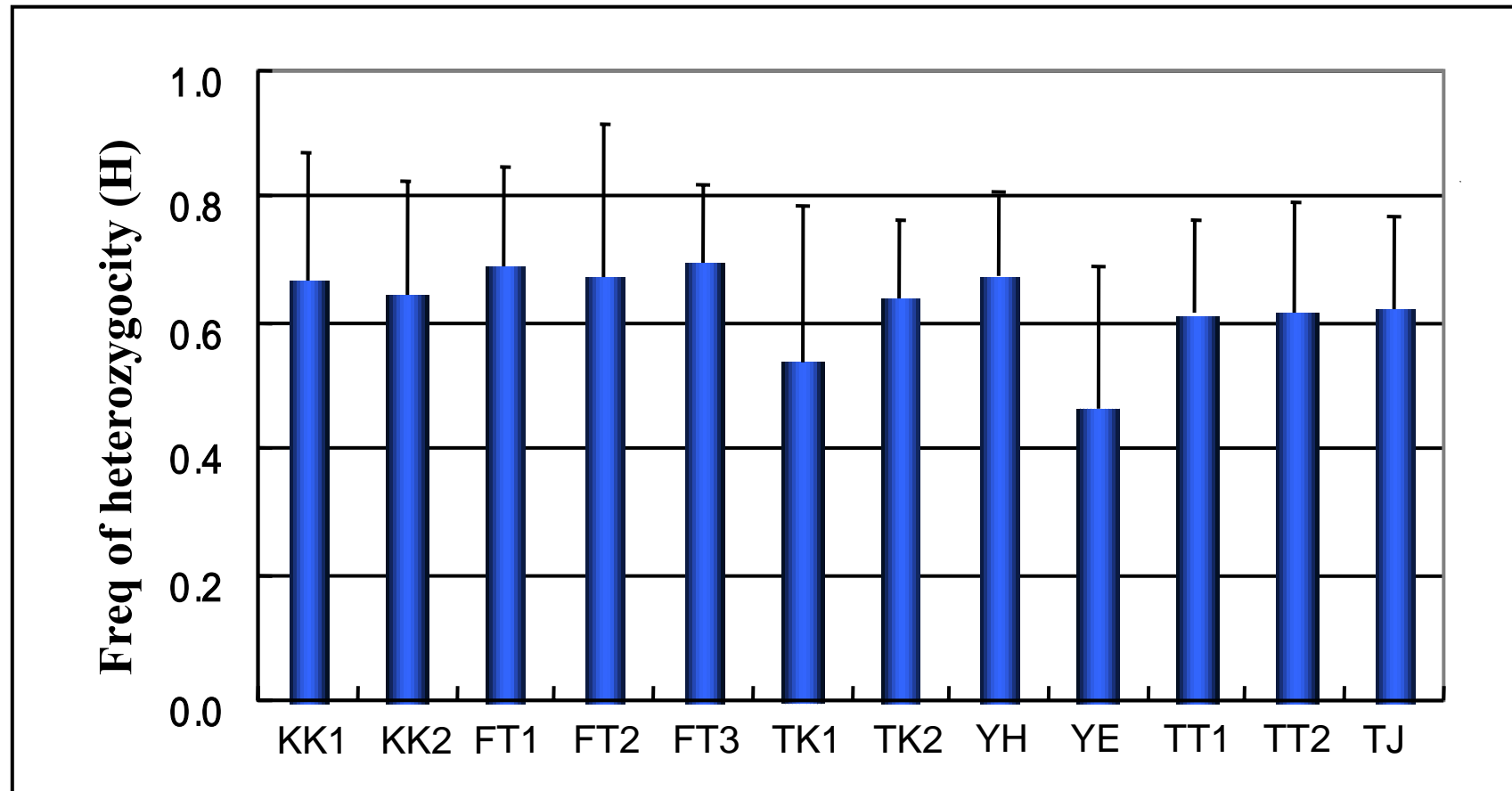
Electrophoresis

Determination of genotypes

Calculation of genetic diversity

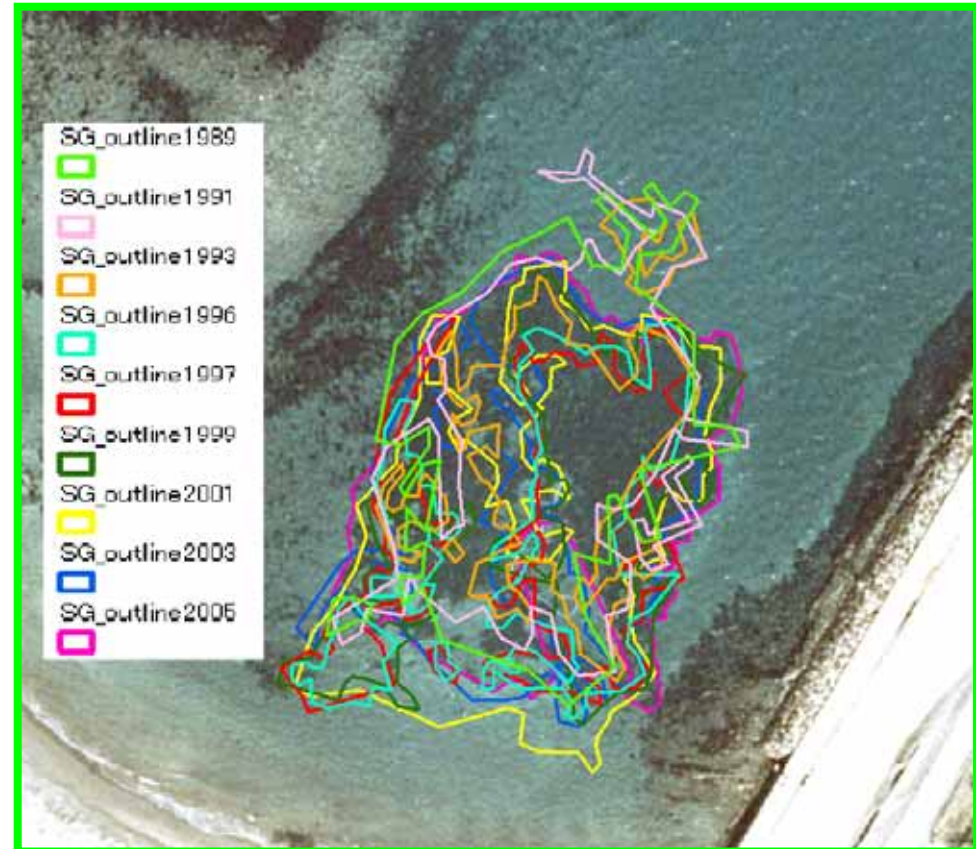


# Analysis of genetic diversity of eelgrass using microsatellite DNA



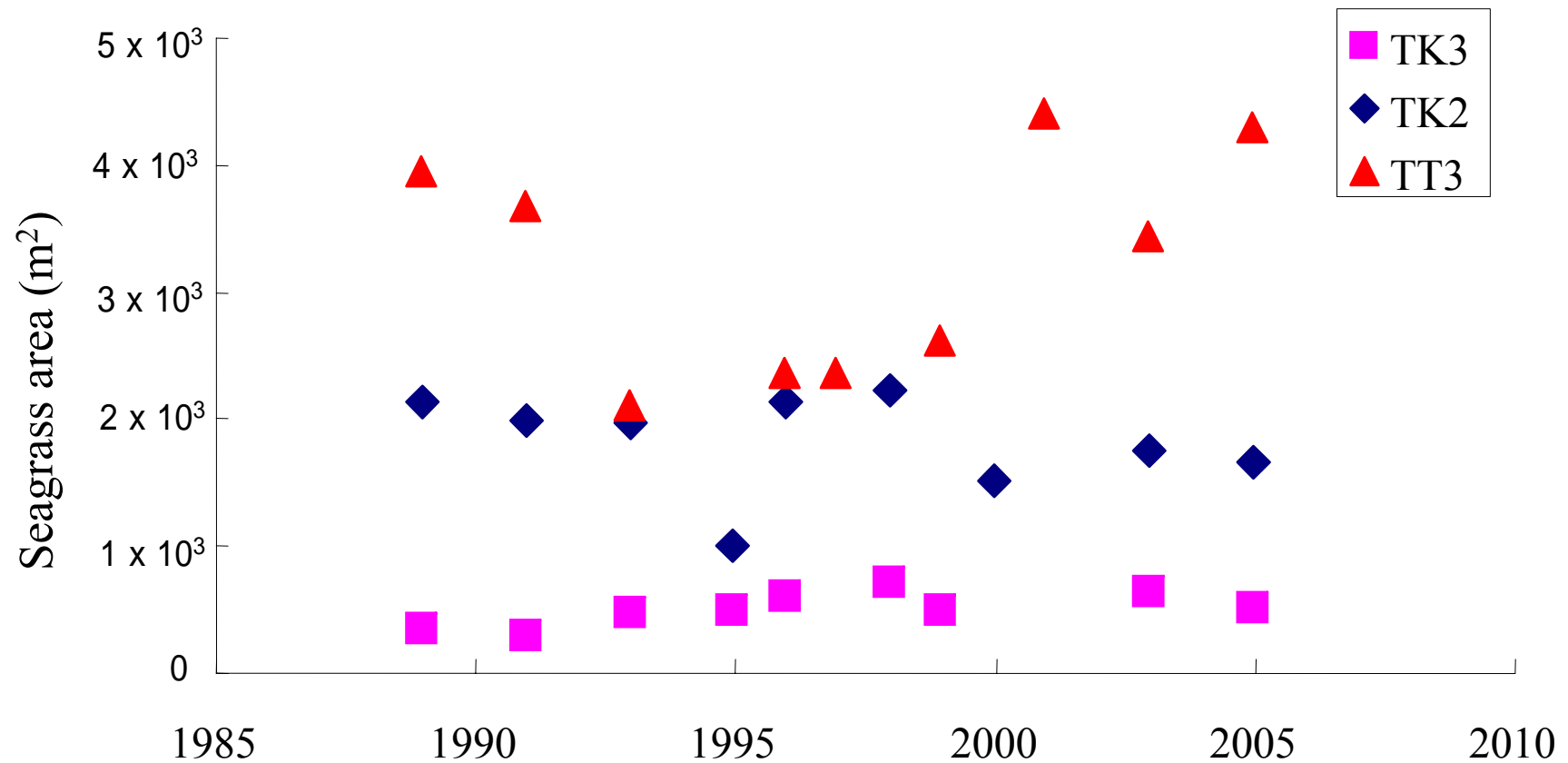


# Remote sensing analysis on long-term changes in seagrass beds



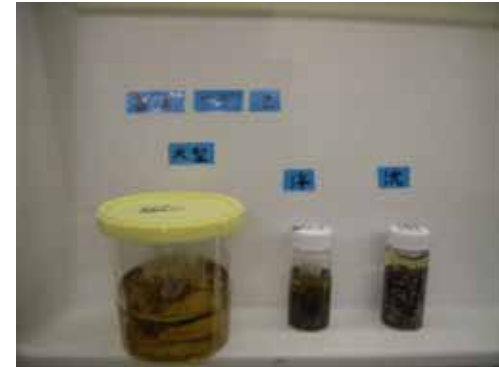


# Remote sensing analysis on long-term changes in seagrass beds



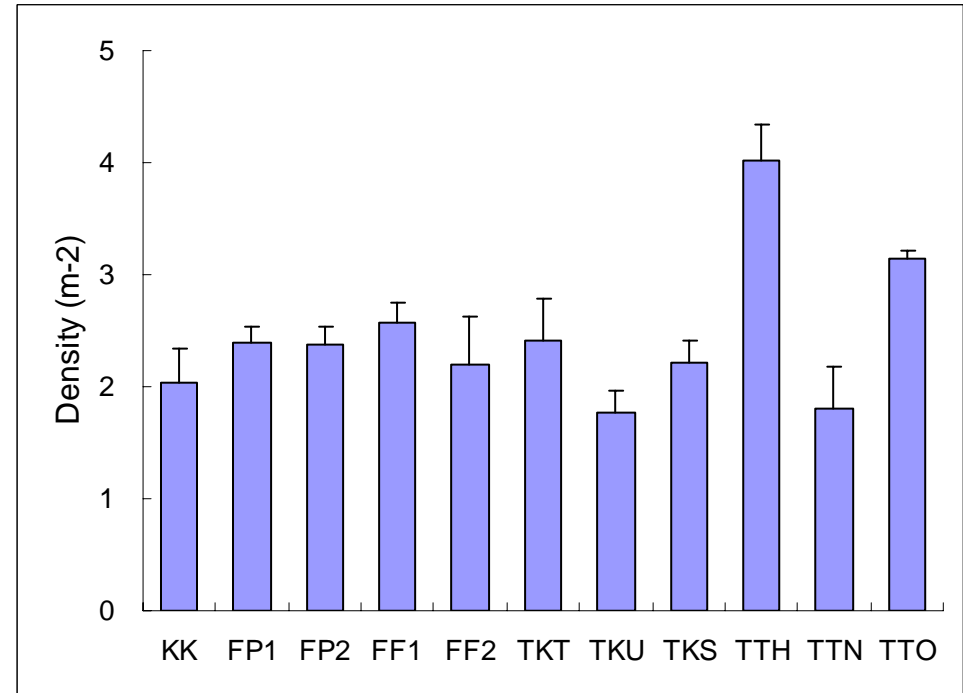
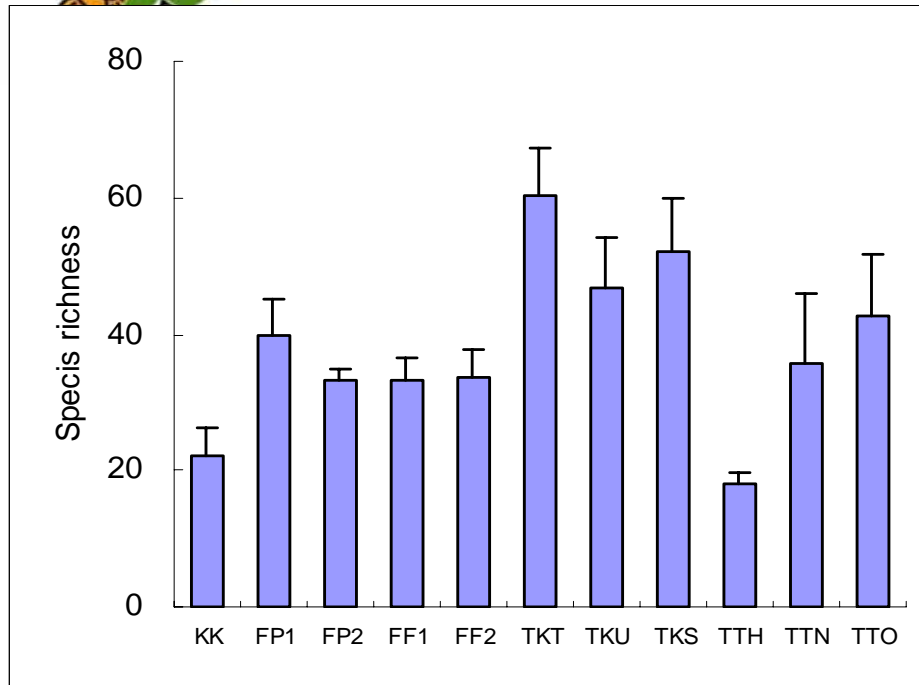


# Analyses on animal community





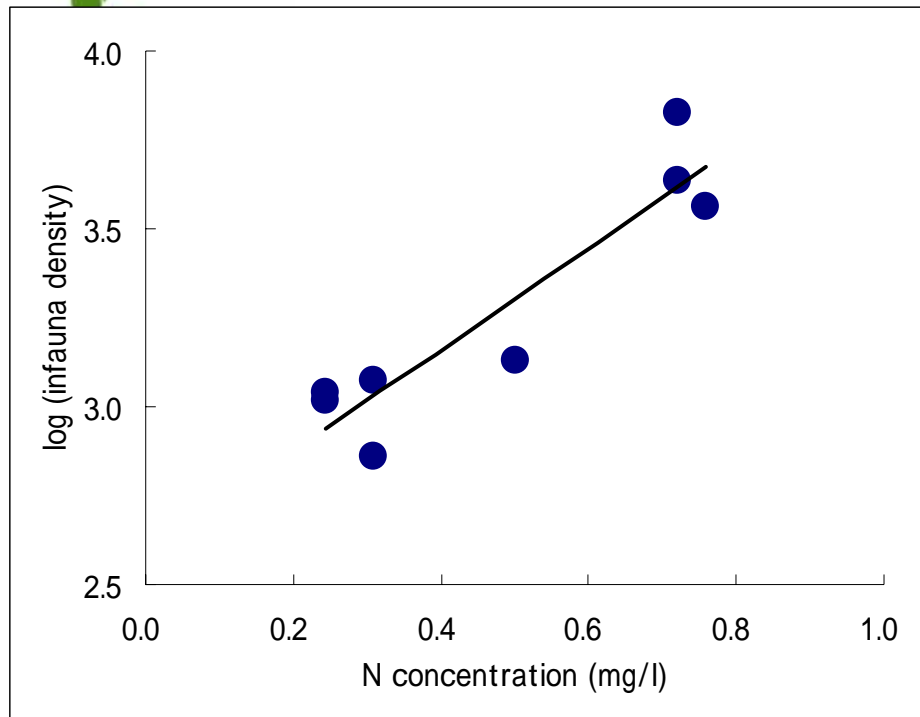
# Analyses on animal community



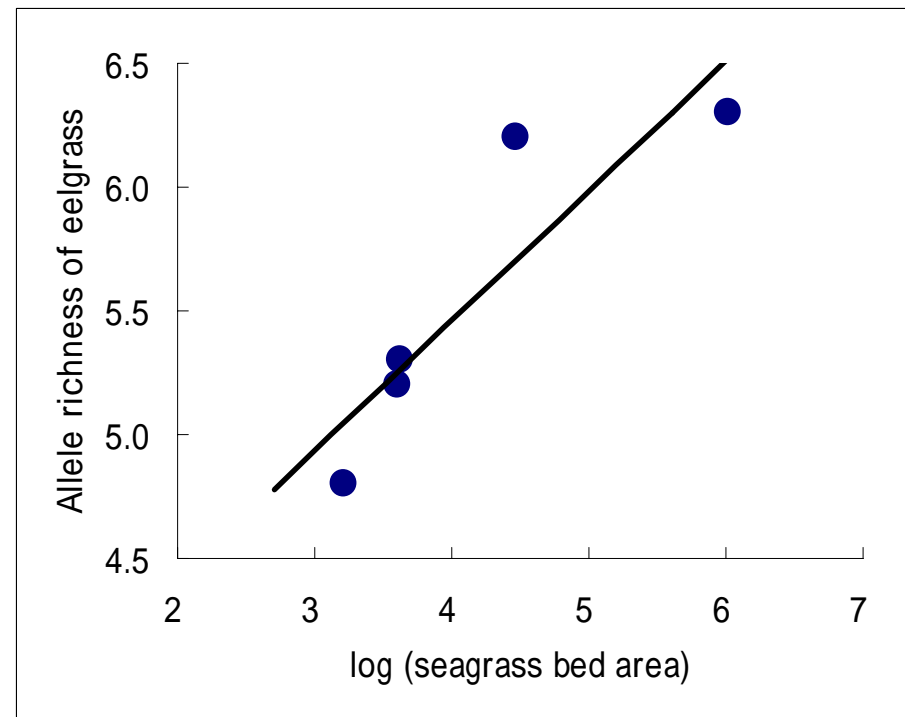




# Relationships among environmental factors, biodiversity and ecosystem functions



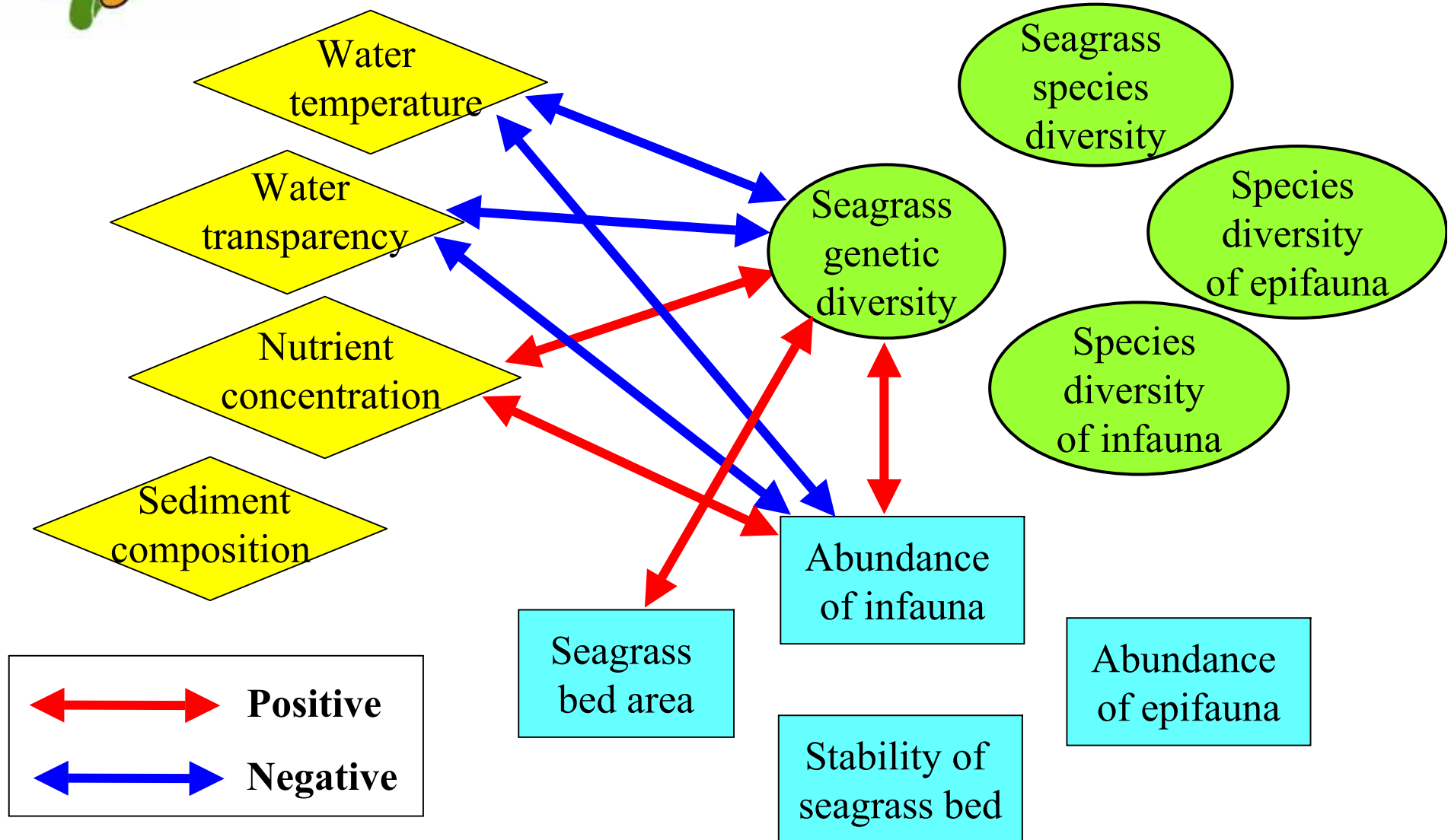
Positive correlation between nutrient concentration and density of benthic animals  
( $r=0.921$ ,  $p=0.001$ )



Positive correlation between seagrass bed area and genetic diversity of eelgrass  
( $r=0.892$ ,  $p=0.042$ )



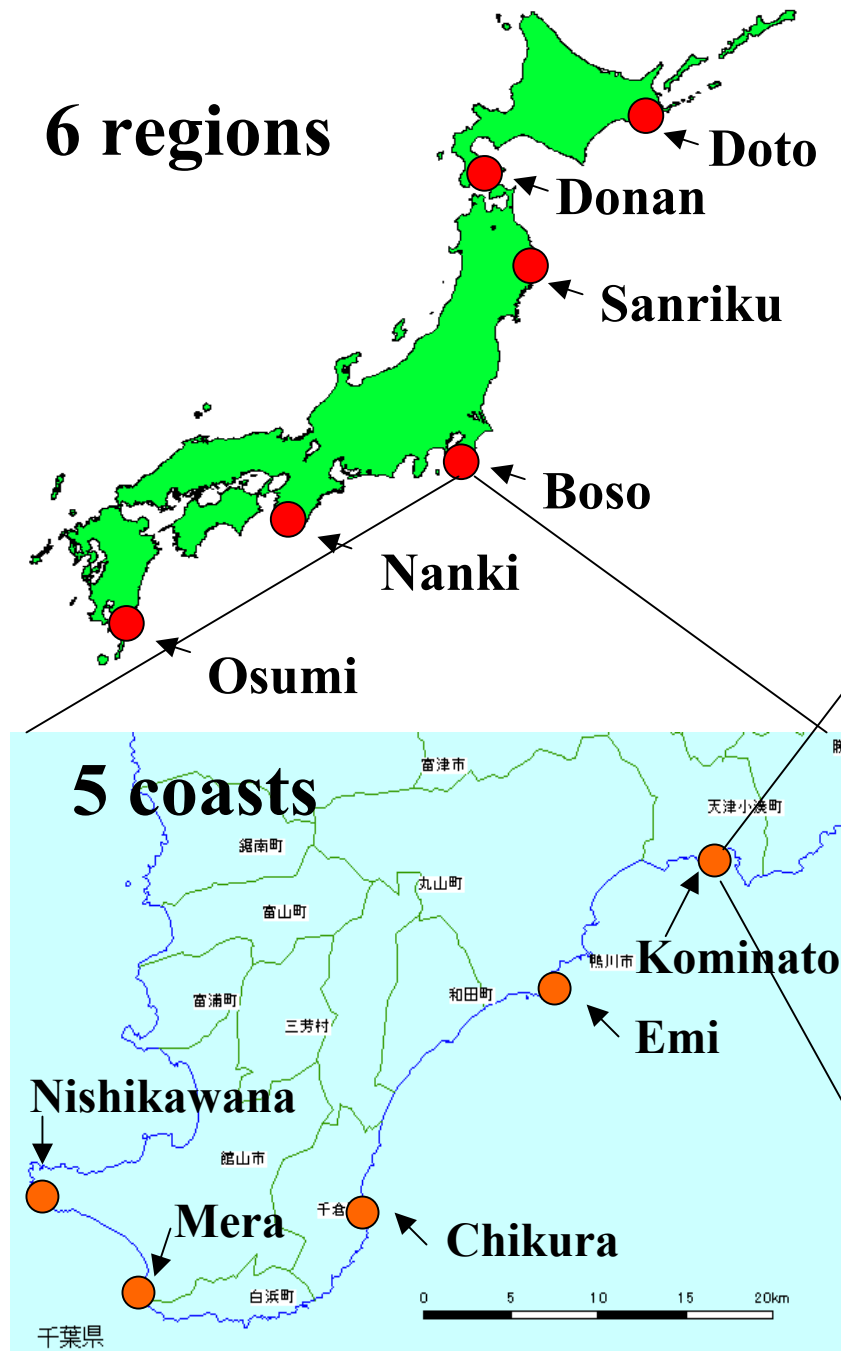
# Relationships among environmental factors, biodiversity and ecosystem functions



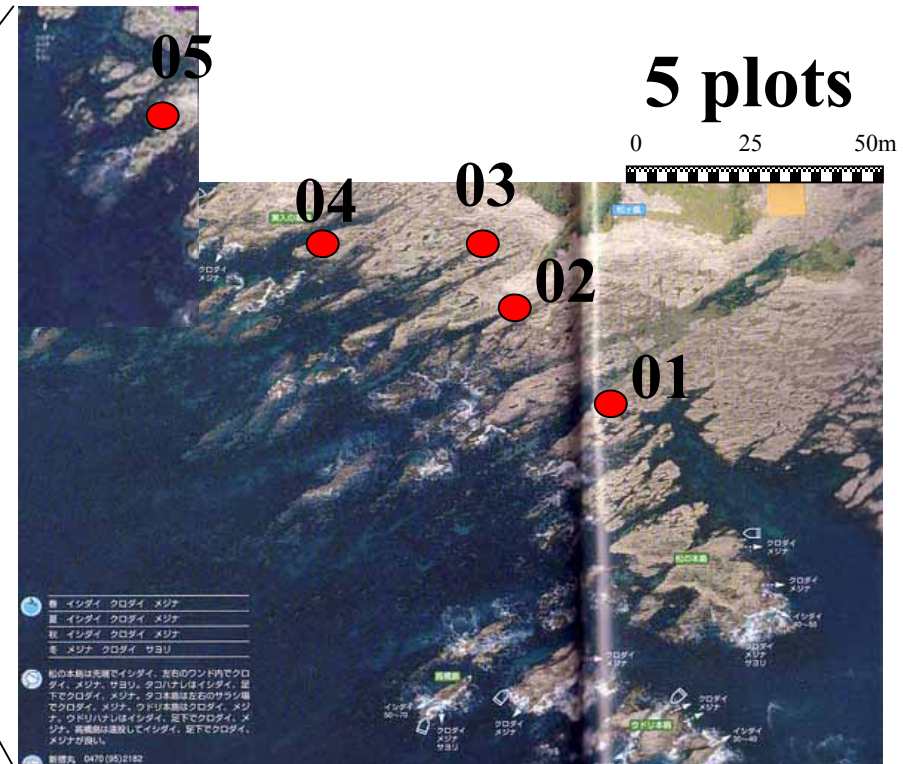
# What is rocky intertidal community?

- **Community on marine hard bottom which is exposed to severe stress when emerged at low tide**
- **Strong environmental gradient creates characteristic zonation pattern of organisms.**
- **Species interactions were strongly influenced by competition over space.**
- **Known as ideal system for experimental studies on population and community ecology (such as classic studies by Joseph Connell and Robert T. Paine)**

# Hierarchical census along the Pacific coast of Japan

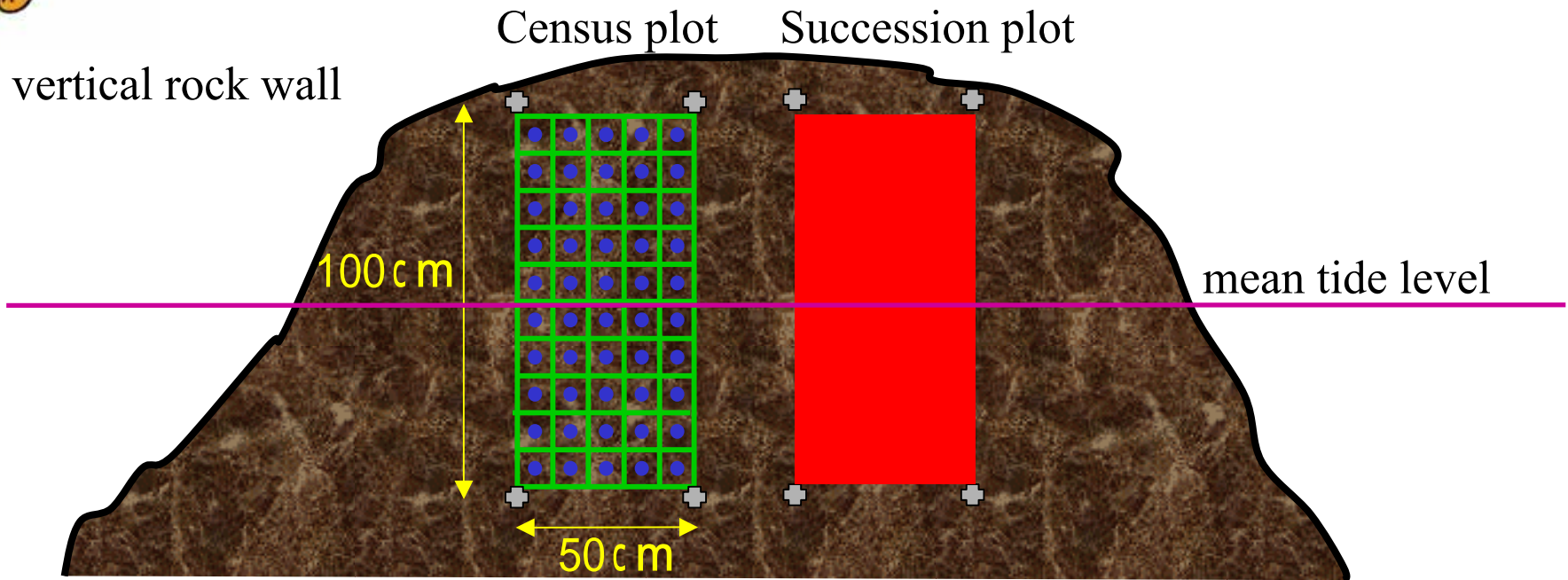


6 regions \* 5 coasts \* 5 plots  
=150 plots





# Field census



Simultaneous monitoring at all sites since 2002

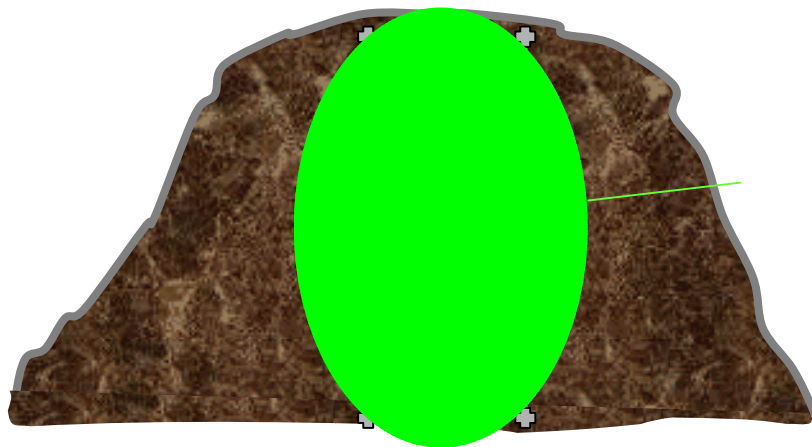
- Monitoring of environment (temperature, nutrient, chlorophyll *a* concentration, wave exposure, geology and geography of rocks)
- Measurement of BD and EF (see next page)



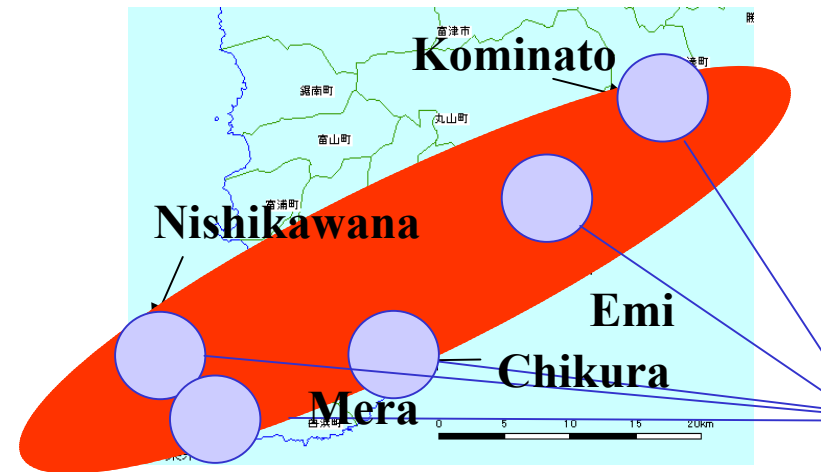
# Biodiversity at different spatial scales

Species richness of sessile organisms appeared at census plots between 2002 and 2005

- 1 : plot species richness
- 2 : coastal species richness
- : regional species richness



1



2



# Ecosystem functions

## 1: Coverage

- indicator of biomass and productivity  
(average between 2002 and 2005)

## 2: Temporal variation in coverage

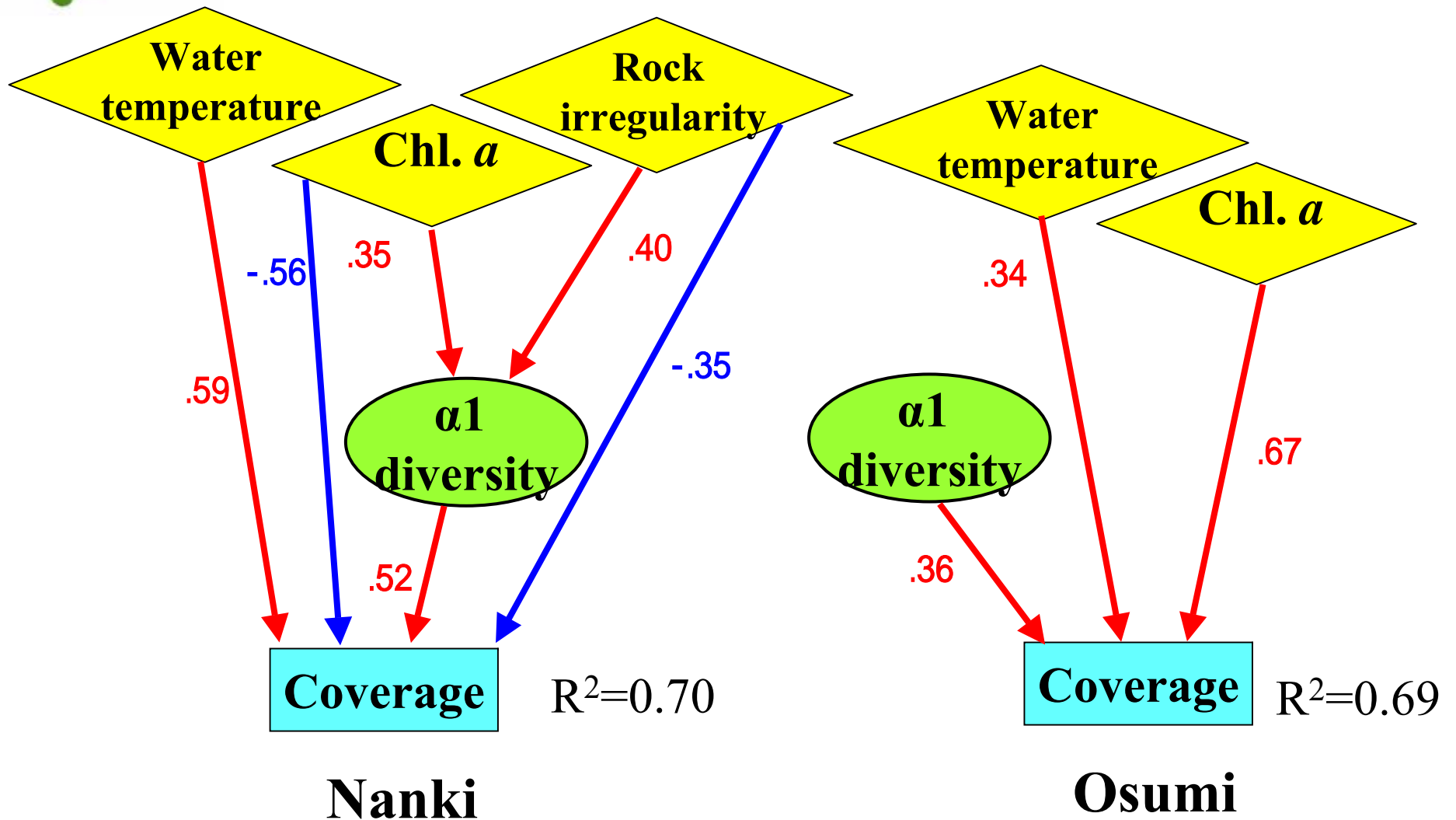
- indicator of stability  
(C.V. of coverage between 2002 and 2005)

## 3: Recovery speed from disturbance

- indicator of resilience  
(coverage of the succession plot in 2004, i.e.,  
one year after the removal of organisms)



# Results of path analysis







## BD-EF relationship at different scales

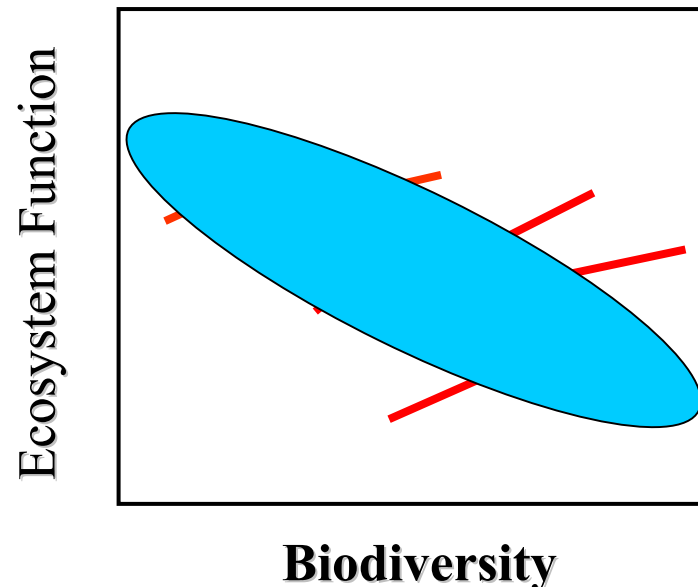
EF	Coverage			Stability			Resilience		
	$\alpha 1$	$\alpha 2$	$\gamma$	$\alpha 1$	$\alpha 2$	$\gamma$	$\alpha 1$	$\alpha 2$	$\gamma$
All	0	-	-	0	0	0	0	-	-
Doto	0	0	/	0	+	/	0	0	/
Donan	0	0	/	0	+	/	+	0	/
Sanriku	0	0	/	0	0	/	0	+	/
Boso	0	0	/	0	0	/	0	0	/
Nanki	+	+	/	-	0	/	+	+	/
Osumi	+	0	/	0	0	/	+	0	/



## Discussion from the rocky shore study

Plot diversity ( $\alpha_1$ ) affects ecosystem functions more frequently than coastal diversity ( $\alpha_2$ ).

Effects of BD on EF were negative by analysis using data from all regions, but positive for each region.





## Conclusion

- Biodiversity measured at different spatial and biological levels is related to functions of coastal ecosystem.
- The observed BD-EF relationship varied among regions and among measures of biodiversity, suggesting importance of considering spatial scale of observation and the effects of environmental gradient.
- Combined approaches using long-term monitoring data and experimental approaches are promising to elucidate **causal mechanisms** for the observed relationships, which is necessary for planning adaptive management strategy for conservation of coastal ecosystem.

# Acknowledgements



Seagrass team: T. Yamakita, K. Yamada, N. Whanpetch, M. Hori, Y. Tanaka, N. Tanaka, M. Ishii, A. Kondoh,

Rocky intertidal team : T. Noda, T. Yamamoto, M. Hori, T. Okuda, M. Tsujino, T. Hagino, N. Ito, T. Maruyama