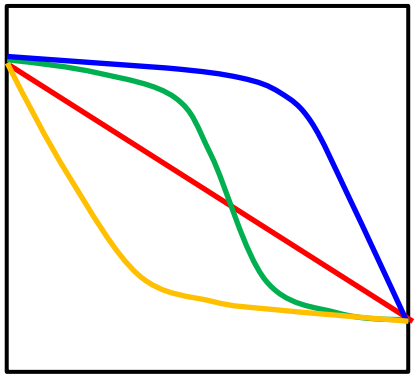
Functional diversity and functional redundancy of faunal community in seagrass ecosystem of northern Japan



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Today's Contents

Two Conceptual Question

1. How measure "functional strength" ?

2. What are "ecological functions" ?

of faunal community in seagrass ecosystem

Macrofaunal Community in seagrass meadow

- Dominant taxonomic group in seagrass meadow
- High diversity in seagrass meadow (Hotspot in coastal area)
(e.g., Kikuchi,1974; Orth et al. 1984; Yamada et al. 2007a)
- High abundance and productively in seagrass meadow
(e.g., Jernakoff et al. 1996; Edgar and Barrett 2002; Duffy 2006; Yamada et al. 2007b).
- Fish prey as primary consumer (nursery and feeding round for fishes)
(e.g., Edgar and Aoki 1993; Horinouchi 2007; Hori et al. 2009; Yamada et al. 2010)

Measurement of **functional role** of macrofaunal community in seagrass ecosystem is required to manage and conserve coastal ecosystem for harmonious coexistence of nature and humans.
(e.g., Hemminga and Duarte 2000; Larkum et al. 2006)

Measurement of functioning (functional role) of a community

Changing species richness may alter and modify role of the community, that leads to Ecosystem Functioning (ecosystem service) (Tilman 2000; Duffy et al. 2001; Solan et al. 2004).

Species richness

↓

Functional strength of a community

↓

Ecosystem functioning
(Ecosystem service)

Measurement of functioning (functional role) of a community

In marine macrofaunal community, functional diversity has traditionally been addressed by describing the taxonomic composition of assemblage.
A pattern in taxonomic richness and/or composition is relevant to presumed functional roles (Bremmer et al. 2003; Duffy et al. 2001).

Species and/or taxonomic richness (composition)

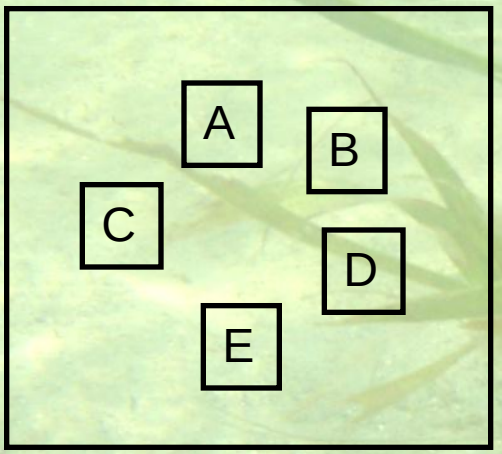
Functional strength of a community

Ecosystem functioning
(Ecosystem service)

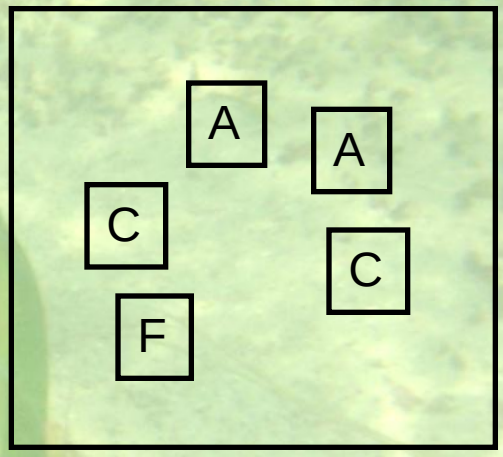
Species richness can be represented as functional strength (diversity)?

Measurement of functioning (functional role) of a community

Community A: 5 species



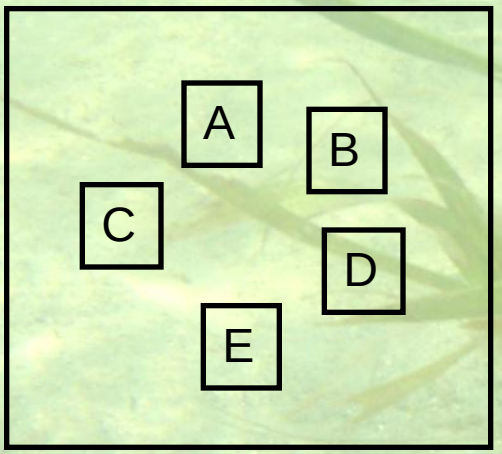
Community B: 3 species



Which community is higher functional diversity?

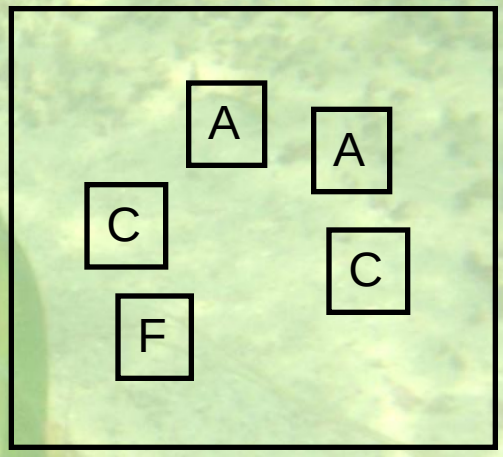
Measurement of functioning (functional role) of a community

Community A: 5 species



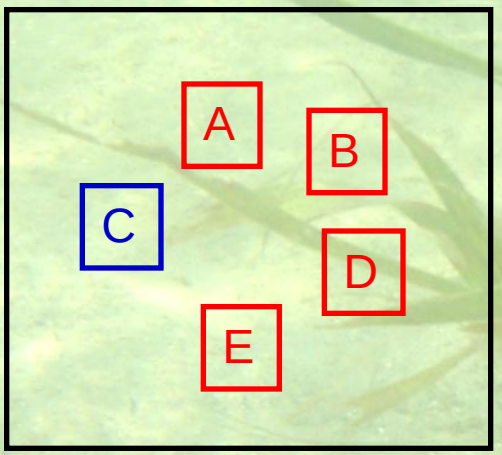
Species richness

Community B: 3 species



Measurement of functioning (functional role) of a community

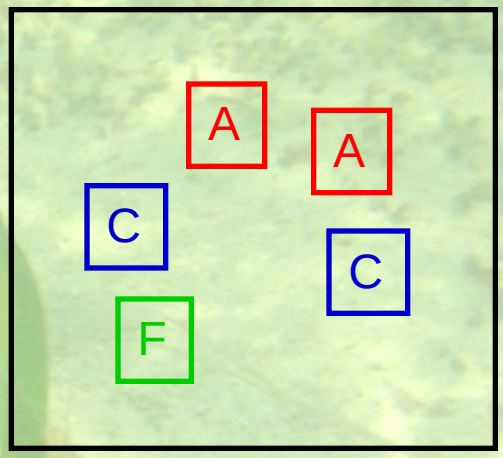
Community A: 5 species



Differences of color indicate different functional role

→2 functional roles

Community B: 3 species

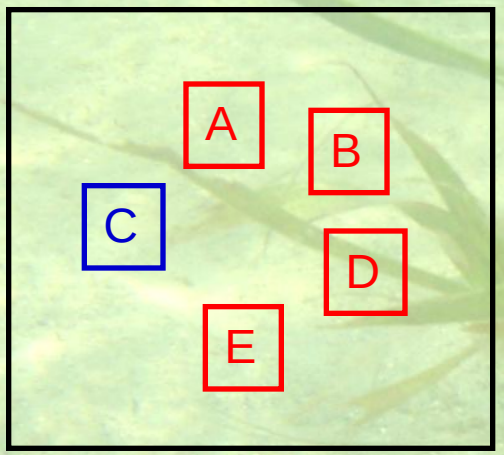


Differences of color indicate different functional role

→3 functional roles

Measurement of functioning (functional role) of a community

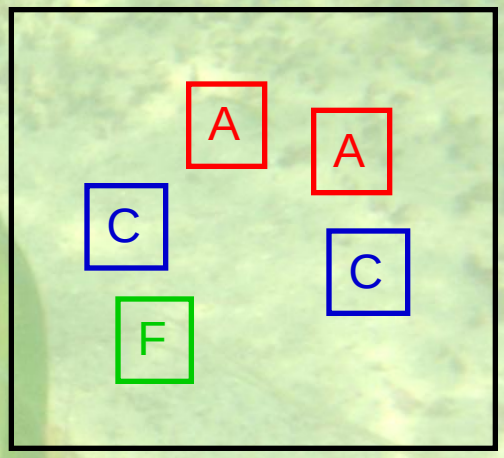
Community A: 5 species



Differences of color indicate different functional role
→2 functional roles

Functional richness

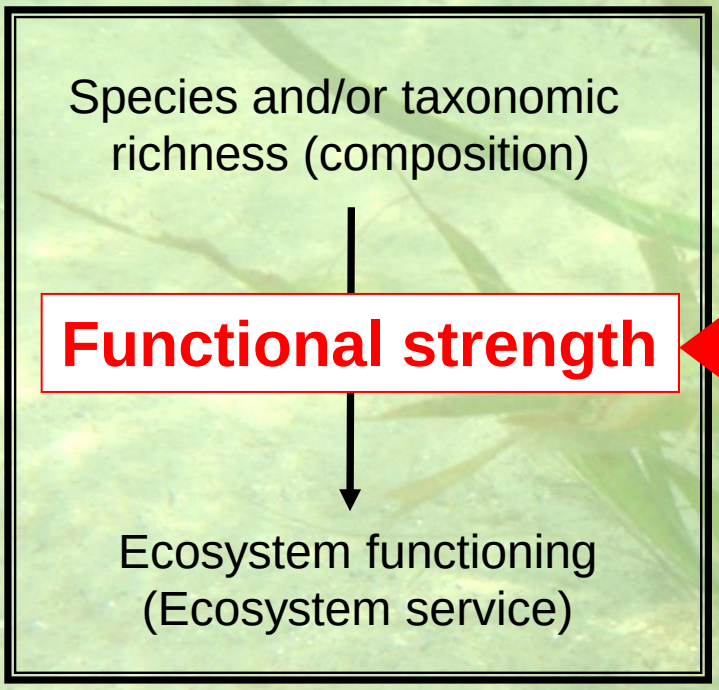
Community B: 3 species



Differences of color indicate different functional role
→3 functional roles

Species richness is not always represented as functional diversity! (e.g., Hooper et al. 2005; Yamada et al. 2011)

Measurement of functioning (functional role) of a community



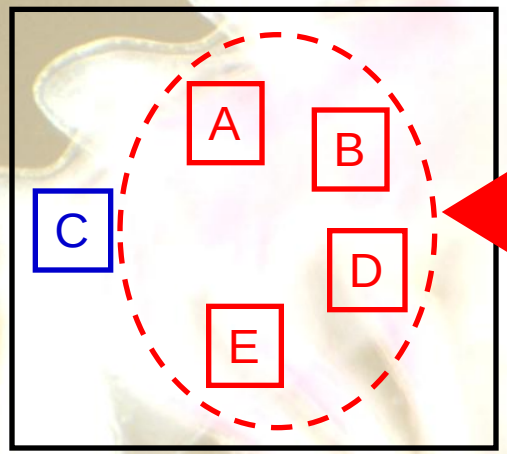
Index for measuring functional strength of a community are needed to predict Ecosystem functioning!

Conceptual question of this study (1)

1. **How measure "functional strength" ?**

Measurement of functioning (functional role) of a community

Community A: 5 species



Different species but same function
(compensational role in a community)

REDUNDANT group

Functional group !

Conceptual question of this study (1)

1. **How measure "functional strength" ?**

How measure “functional strength” ?

Three “functional groups” of macrofaunal community in seagrass meadows (Yamada et al. 2007b, 2010)

- ***Seagrass-associated* group (*SA* group)**

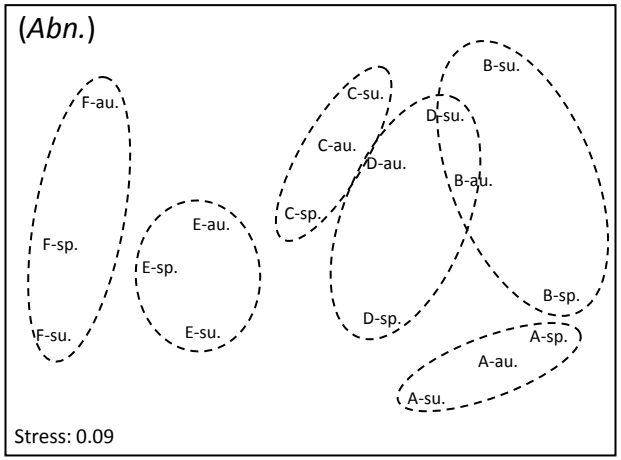
- ***Drift-faunal* group (*DF* group)**

- ***Epi- and infaunal* group (*EI* group)**

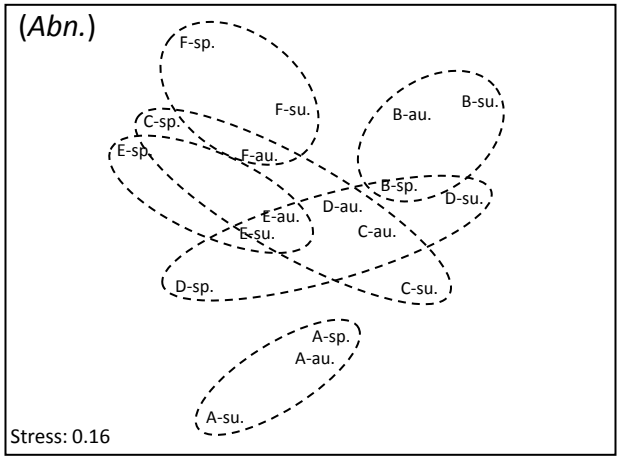
I have evaluated variations of “functional groups” in macrofaunal assemblage of seagrass ecosystem

Focusing on “functional group” of macrofaunal community

Drift-faunal group (*DF*)



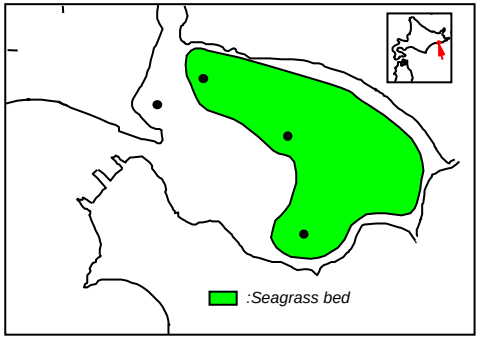
Seagrass-associated group (*SA*)



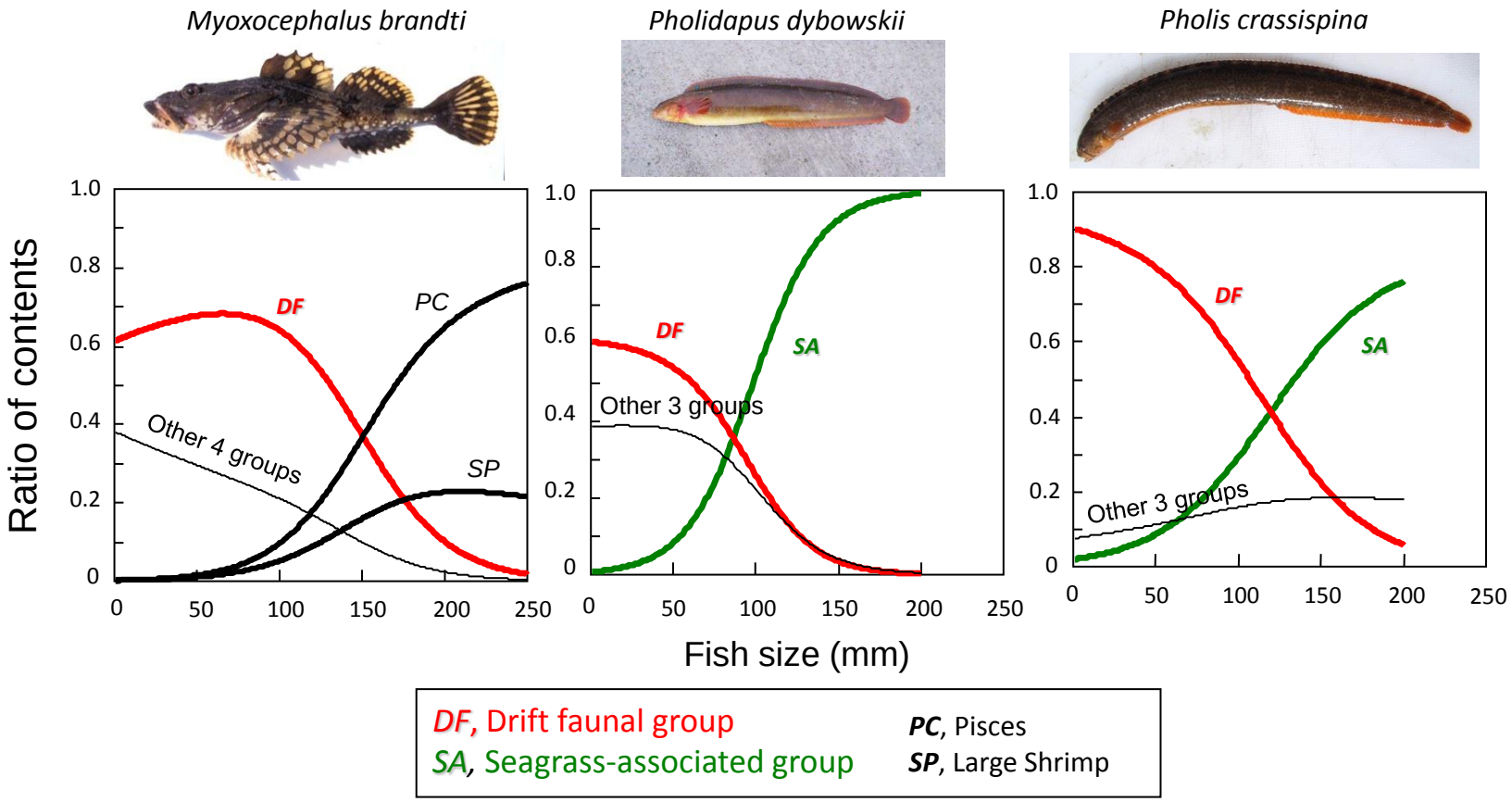
Salinity gradient

- Response to **environments factor (salinity)** is different among functional groups

(Yamada et al. 2007b)

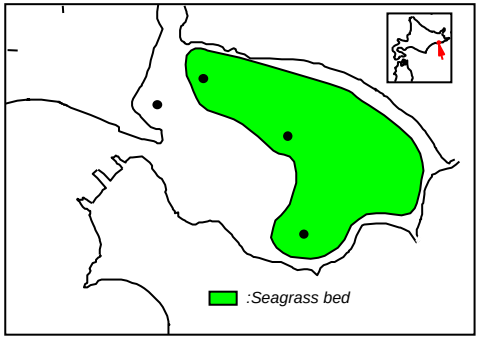


Focusing on “functional group” of macrofaunal community



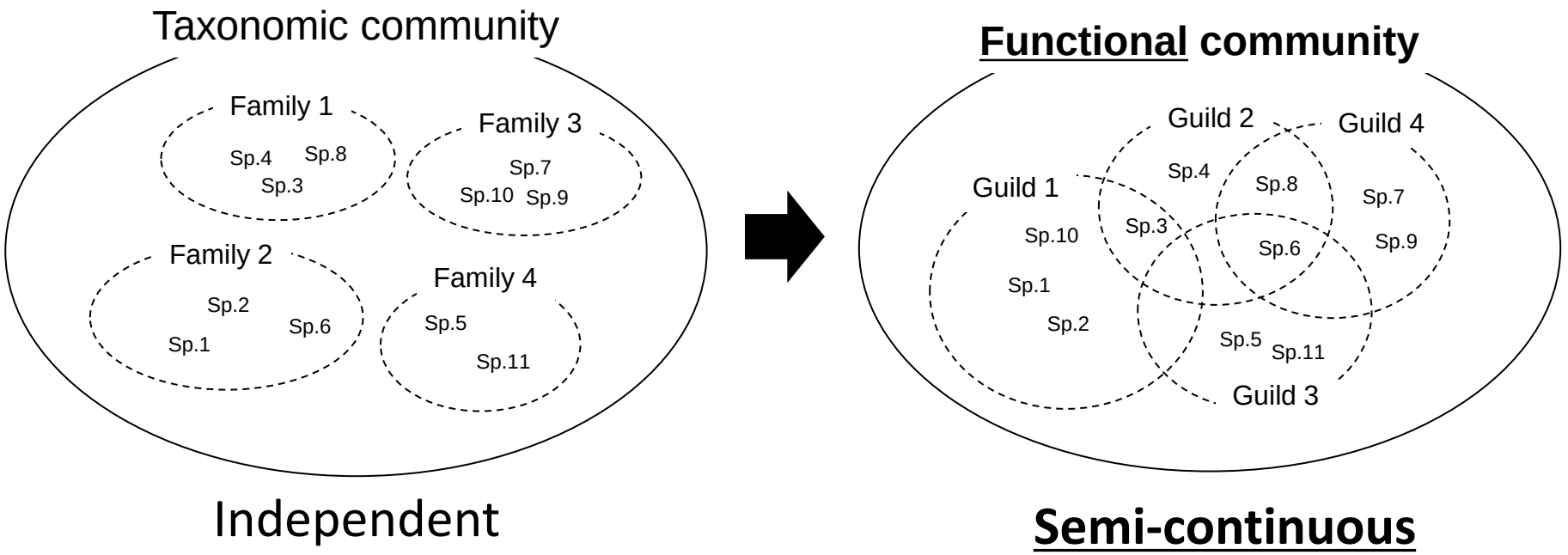
- Response to **food web structure** is different among functional groups

(Yamada et al. 2010)

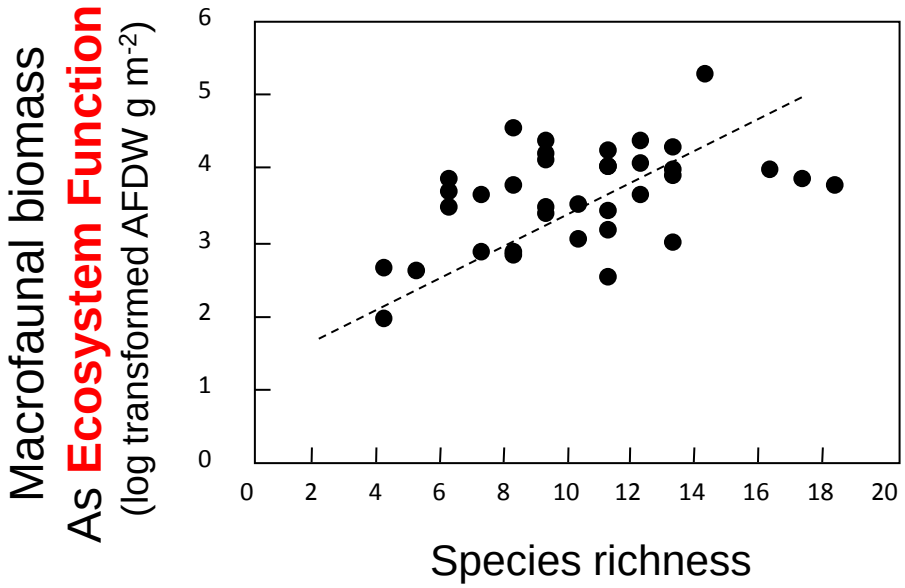


Focusing on “functional group” of macrofaunal community

The process of macrofaunal assemble in seagrass ecosystem (**Assembly rule**) based on the “Ecosystem Functioning” can be detected by evaluation of community structure using functional group…..

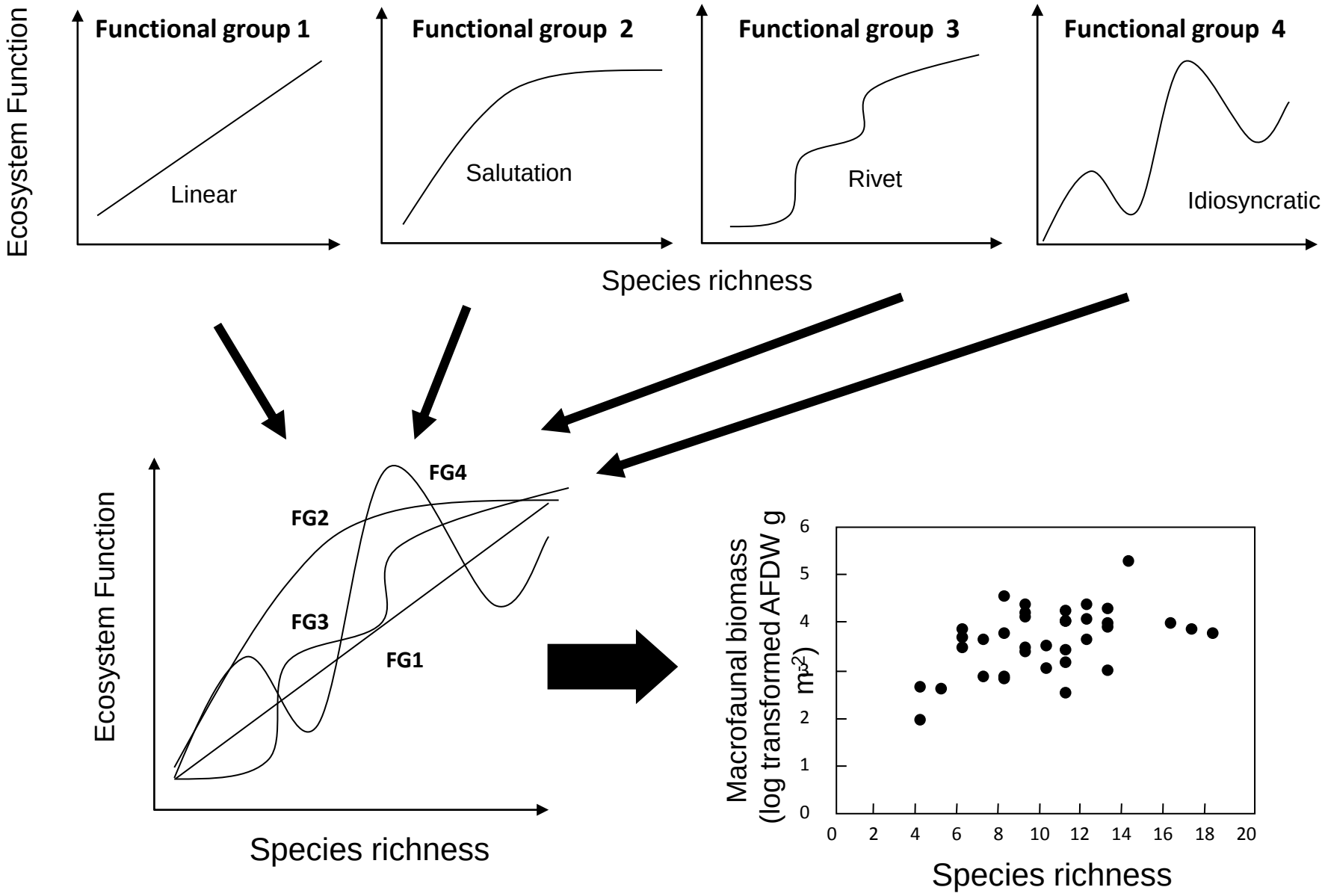


Concept of “functional group” of my studies in relation of BD-EF

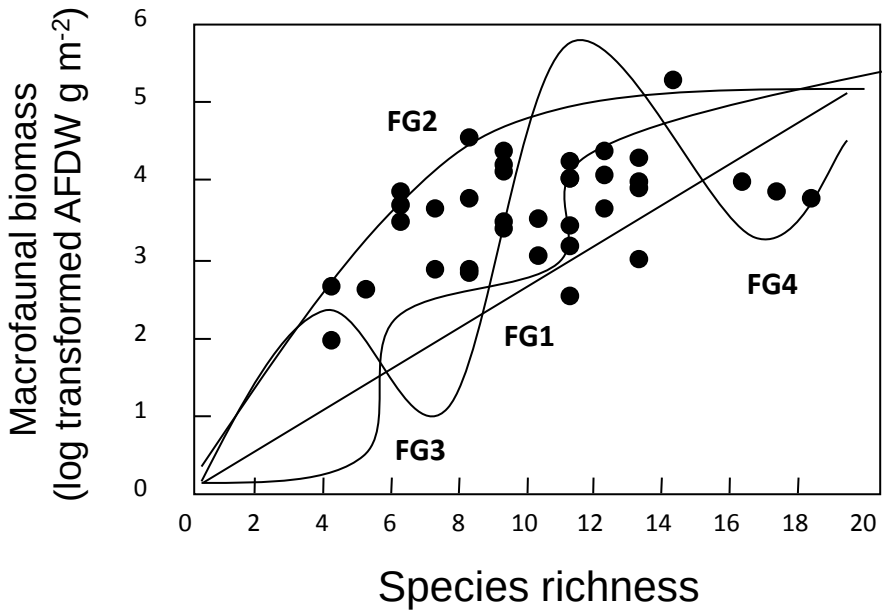


……..Liner?

Focusing on “functional group” of macrofaunal community



Focusing on “functional group” of macrofaunal community



The relationship between species richness and quantitative Ecosystem function (e.g., biomass) is actually a collection of relationships of functional groups (FDs)

Conceptual question of this study (2)

What are the ecological functions of macrofaunal community in seagrass ecosystem?

Is it

Quantitative? (e.g., biomass and production)

Qqualitative? (e.g., ????)

Ecological traits of macrofaunal species

- Potentiality multiple function (niche overlap: Yamada & Kumagai 2012)
- Direct development (most species)
- High migration (i.e., dispersal) ability

(some species is semi-sessile and/or dwelling)

Emergent functions of the macrofaunal community seem attributable to flexible functional changes among species, and even among individuals

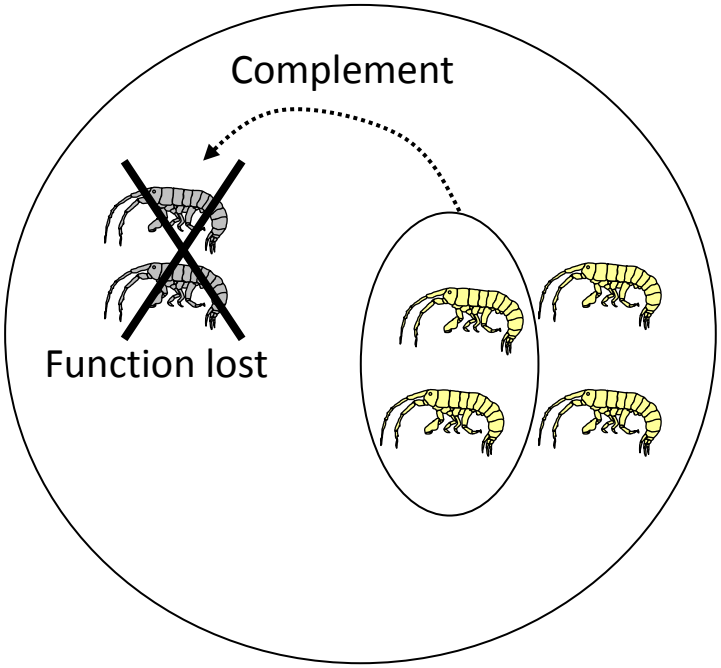
["Flexible functional changes" is actually *FUNCTIONS*……..?]

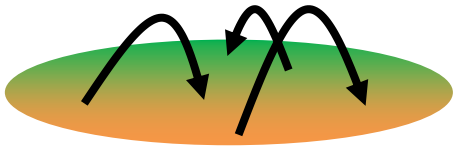
- In an community, even if a function is lost (i.e., species extinction), it may be complemented promptly

→Furthermore, I suggest that the process of functional complementarity may be different among spatial scale because of seagrass patch dynamics

For example……

1. Small (local) scale

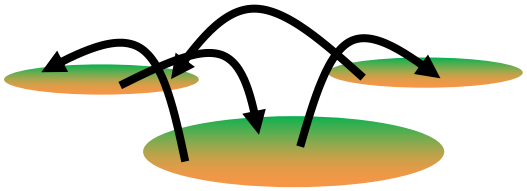


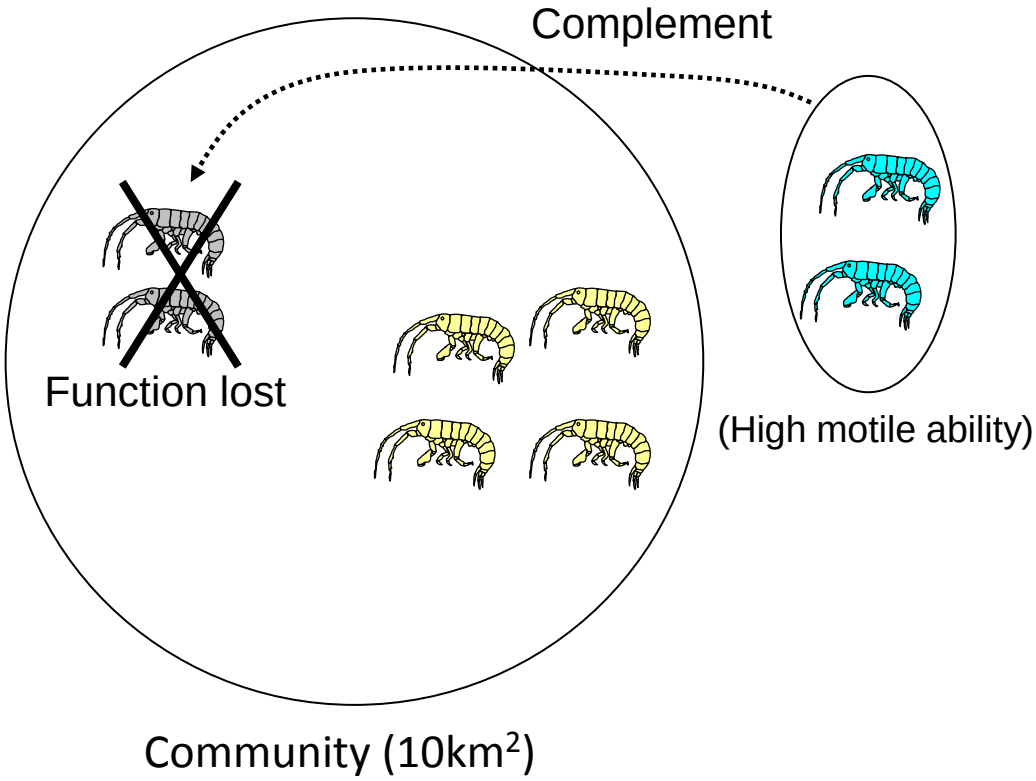


Intrinsic complementarity

Petchey et al. (2006), Sasaki et al. (2009), Yamada et al. (2011)

2. Large (regional) scale





Extrinsic complementarity

(*sensu* meta-community)

Petchey et al. (2006), Sasaki et al. (2009), Yamada et al. (2011)

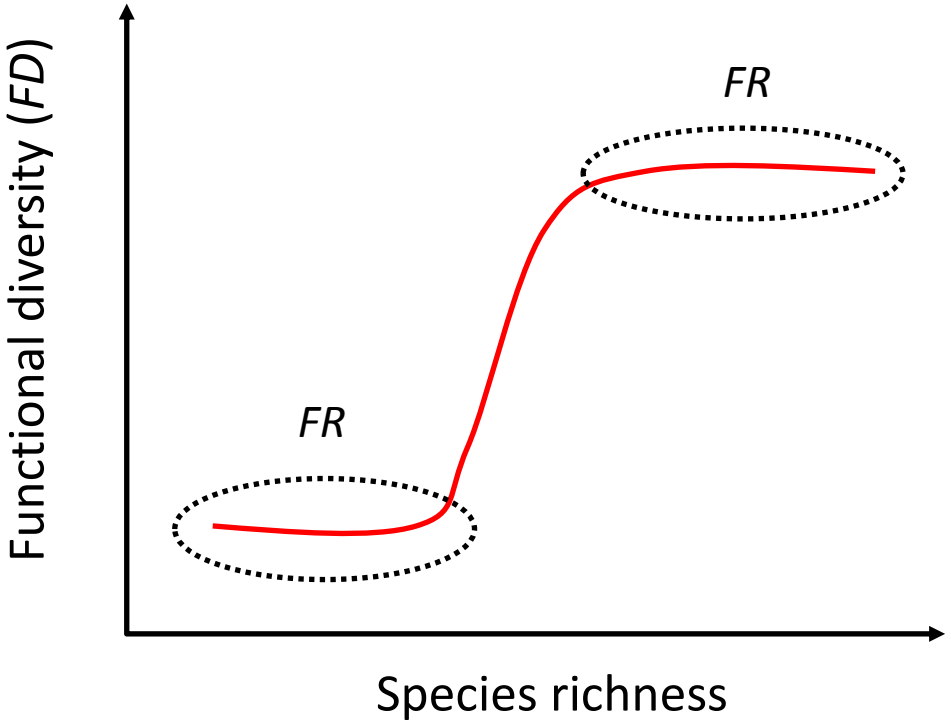
["Flexible functional changes" is actually *FUNCTIONS*……..?]

- In an community, even if a function is lost (i.e., species extinction), it may be complemented promptly

That is one of the *Ecological Functions* of macrofaunal community in seagrass ecosystems!

(Functional Redunduncy)

***Functional Redundancy* (*FR*)** could be detected from threshold relationship between
Species richness (*SP*) and *Functional diversity* (*FD*)



Petchey et al. (2006), Sasaki et al. (2009), Yamada et al. (2011)

Estimation of *Functional diversity* (*FD*)

Measurement of functional diversity from semi-continious functional community

$$d_{ij} = \sqrt{\sum_{k=1}^{h} (q_{ik} - q_{jk})^2}$$

$$FD = \sum_{i=1}^{N} \sum_{j=1}^{N} d_{ij} P_i P_j$$

- Functional traits:
32 categories in 4 traits

- Based on dissimilarity (Euclidean distance) among species

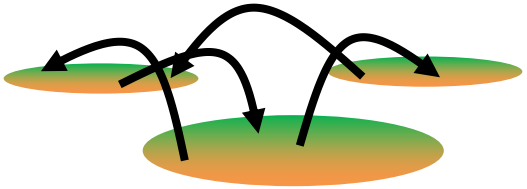
Table 1. Macro-crustacean functional traits and their categories used in the analysis. Almost species belong to more than one trait category (multiple membership).

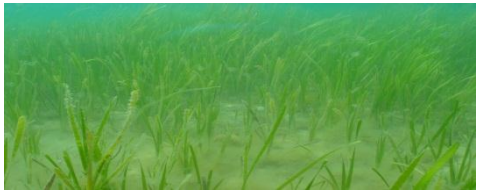
Macro-crustacean functional trait	Trait categories
1.Occurrence	Abyssal; Marine ;Brackish; Fresh water; Terrestrial and littoral
2. Life type	Bbrore; Commensal; Epi-infauna; Epifauna; Infauna; Interstitia; Pelagic; Phreatic; Periphytic; Substrata (e.g., Rock); Streams; Terrestrial; Swarm; Nest builder; Live in the shell of gastropoda; Tube
3. Feeding type	Detrivore; Predator; Planktivore; Scavenger; Suspension feeder; Grass grazer; Algae (seaweed) grazer;
4. Size	Large (adult >30mm); Middle (adult 10-30mm); Small (adult <10mm)

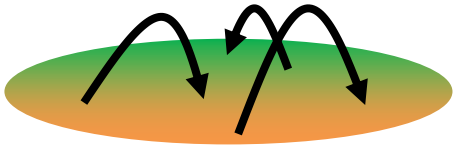
Sasaki et al. (2009), Schleuter et al. (2010), Yamada et al. (2011)

[Scope]

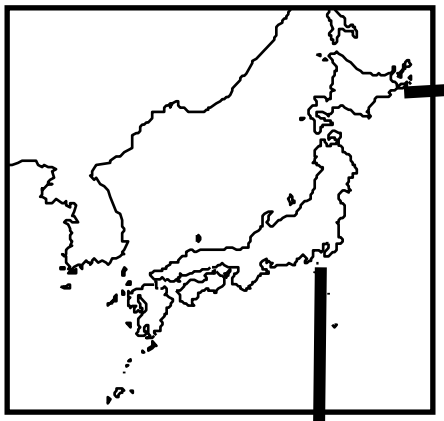
Detection of *Functional Redundancy* (*FR*) of macrofaunal community in seagrass ecosystem, at different scale-phases

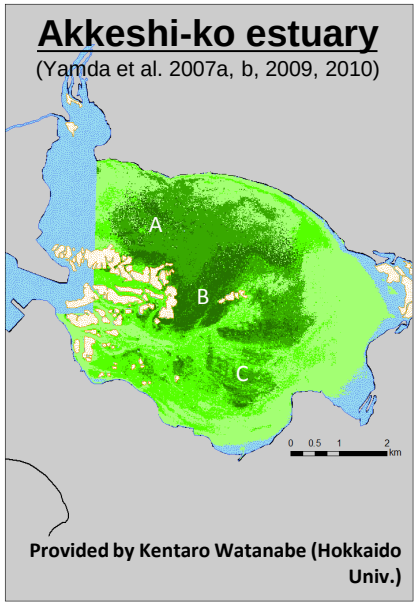


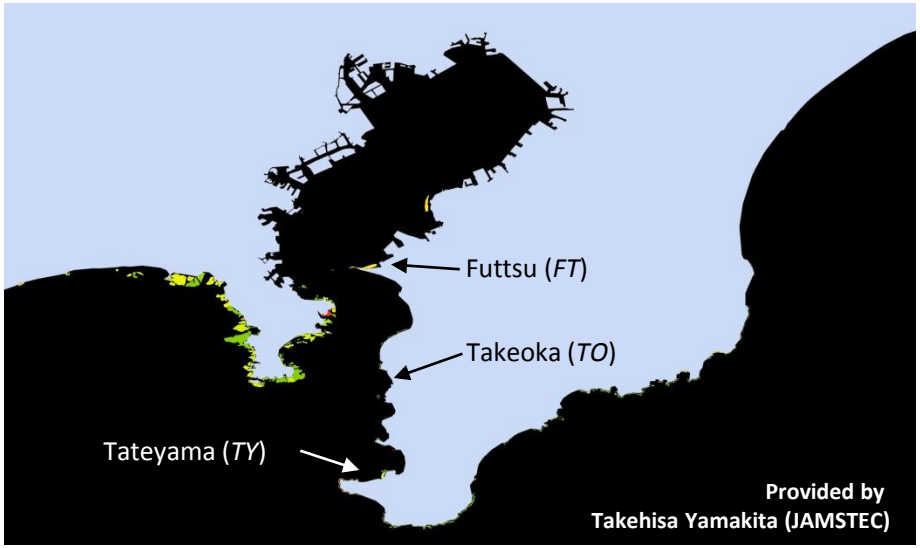


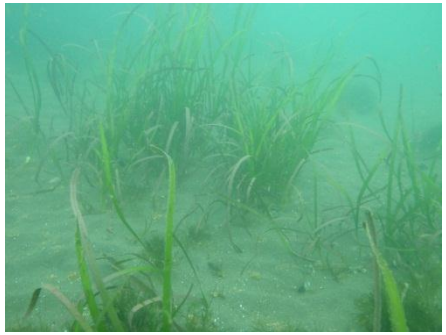


Focus on two-phase spatial scales in two sites





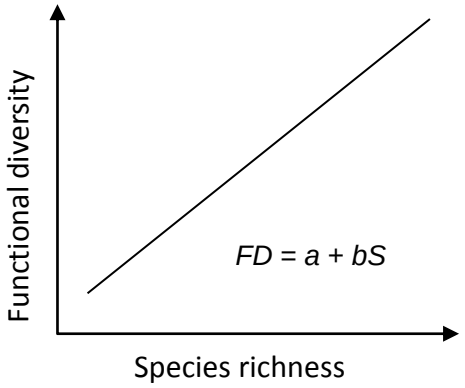


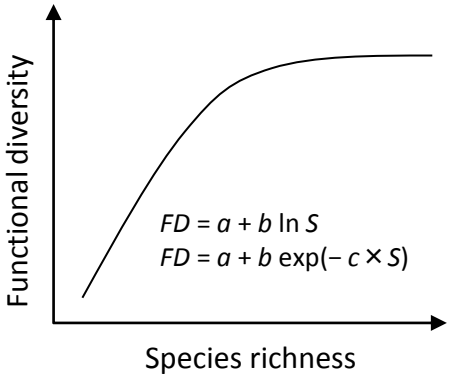


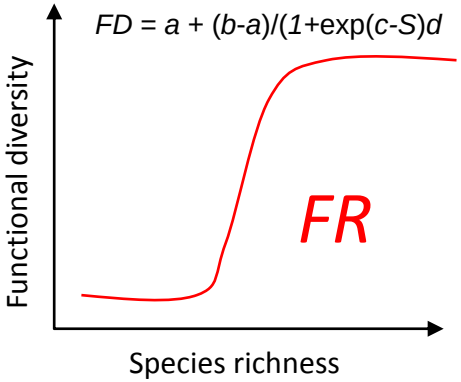
Tokyo Bay (Uchibo)

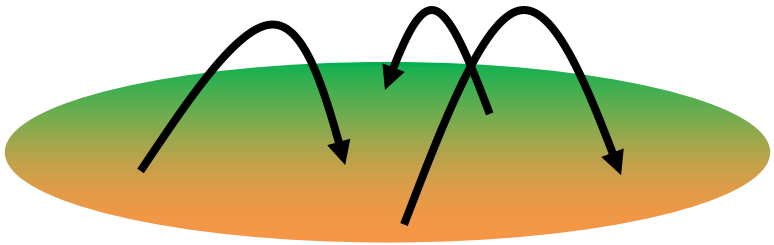
(Yamakita and Nakaoka 2010, Yamada et al. 2011)

FR in local scale (Sasaki et al. 2009)

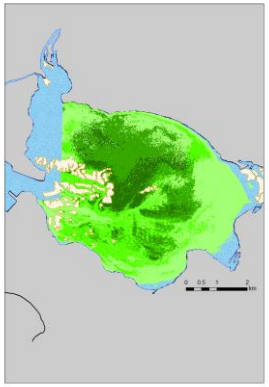






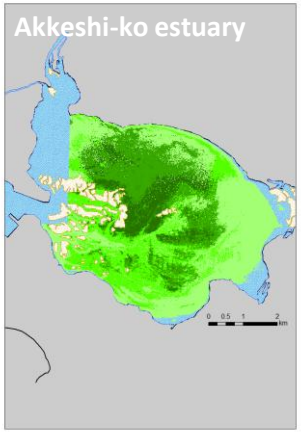


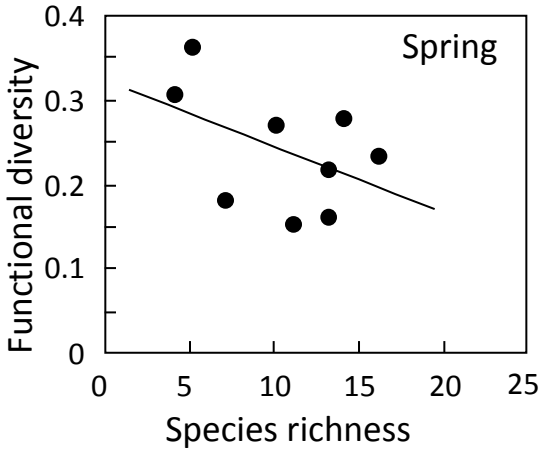
Intrinsic complementarity

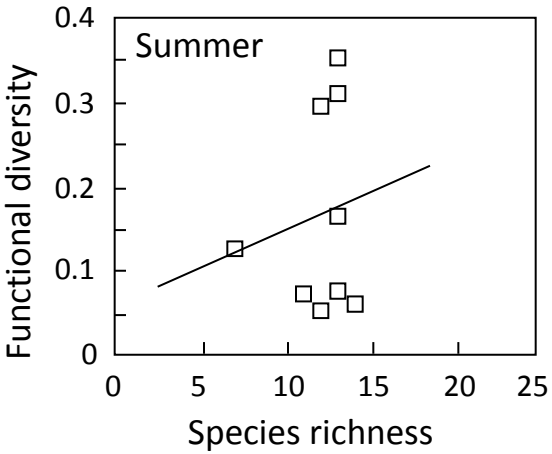


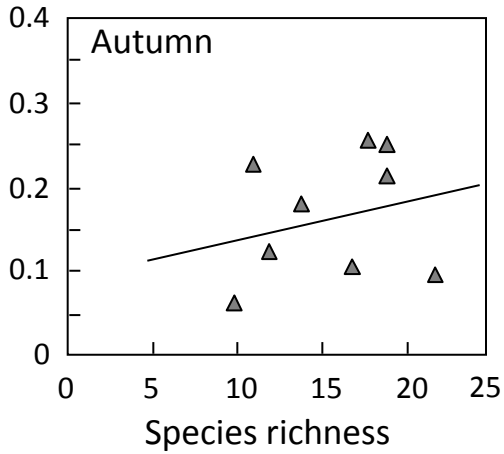
Curve fit was decided based on AIC value

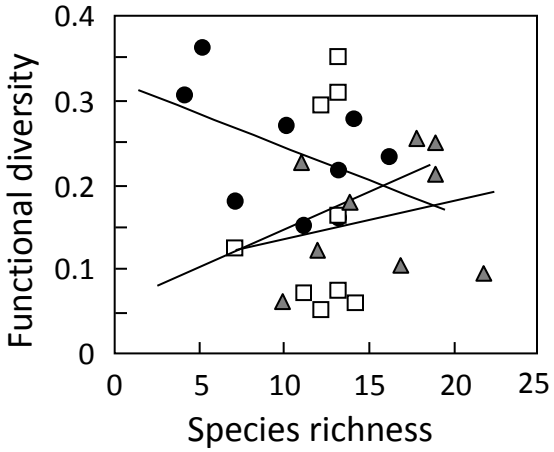
FR in local scale (Akkeshi-ko estuary)

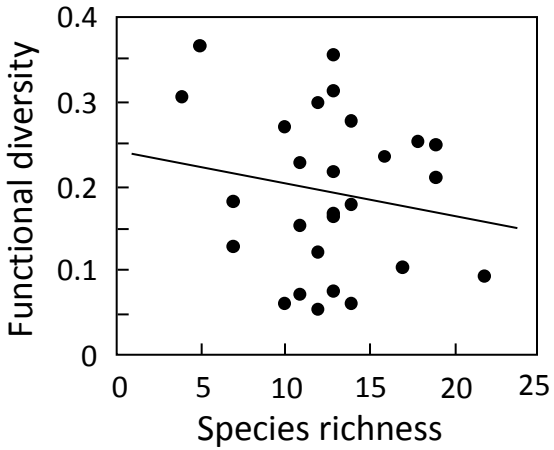






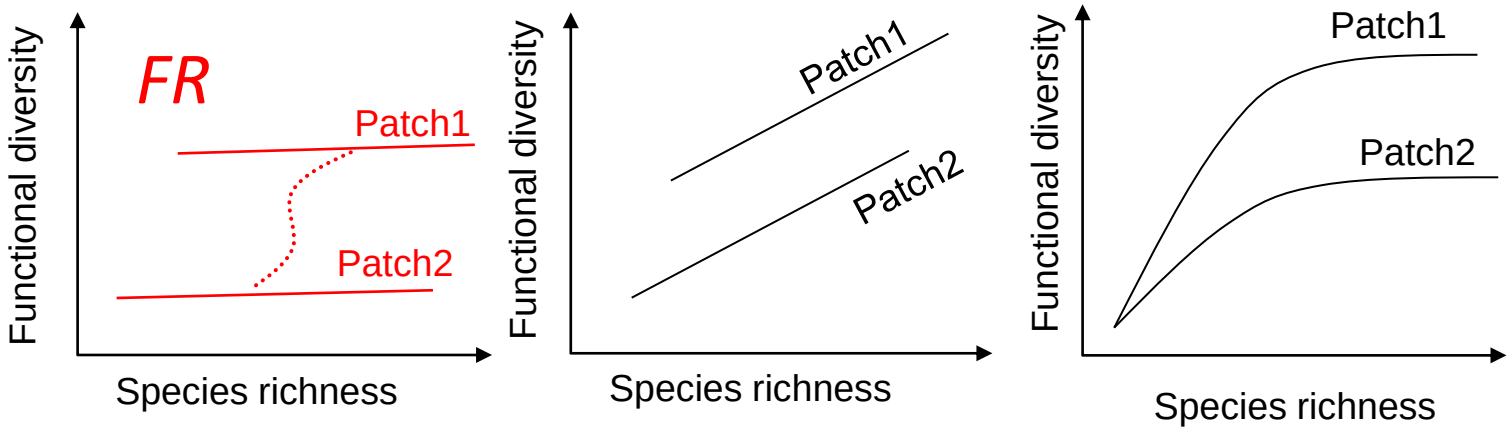


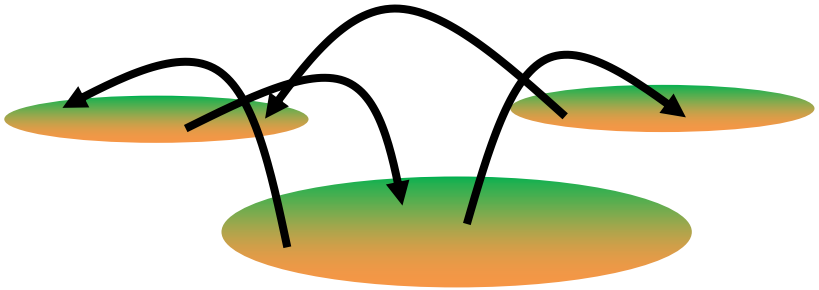




FR was not shown in local scale.

FR in regional scale (among patches) (Yamada et al., 2011)

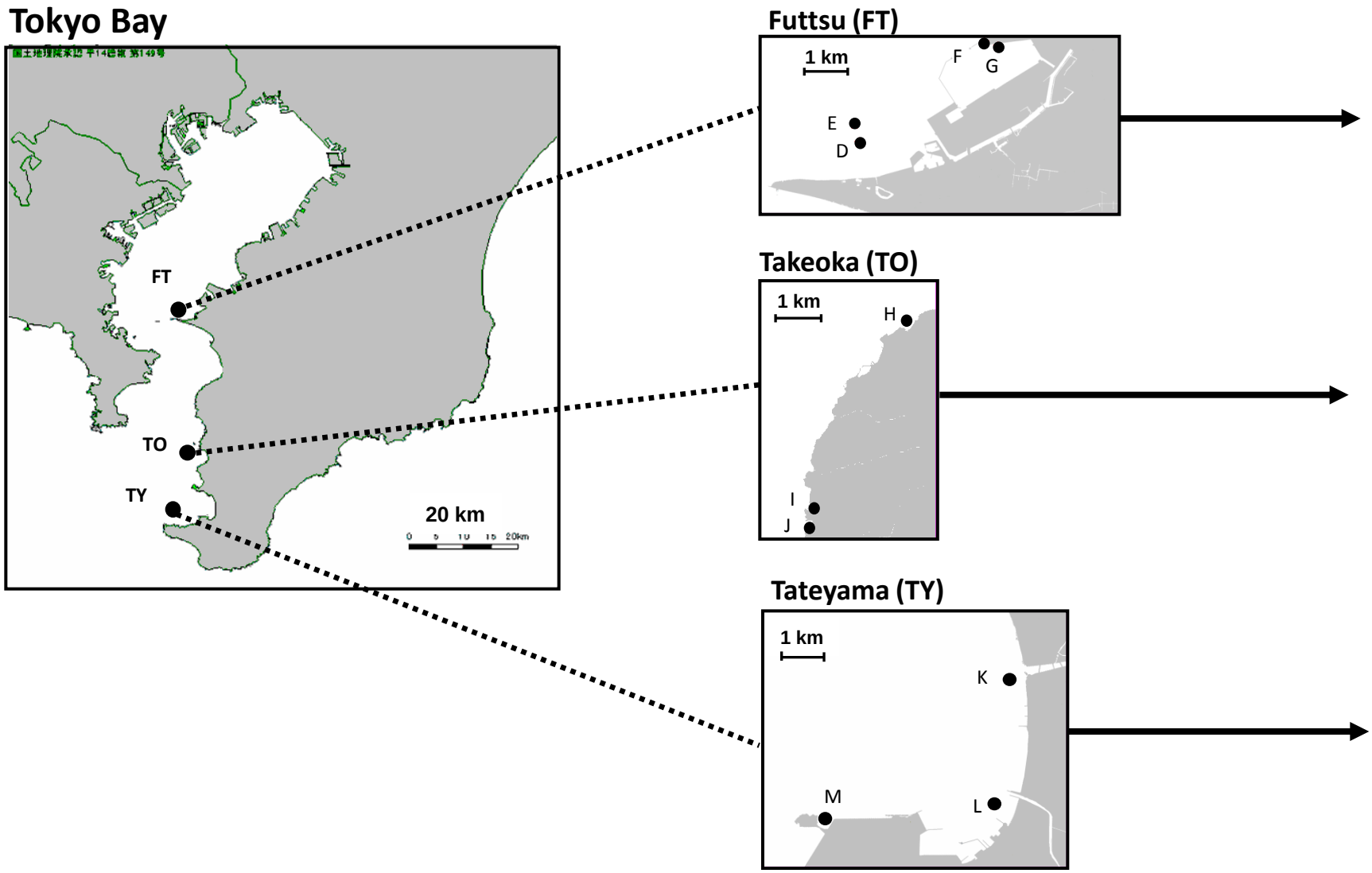




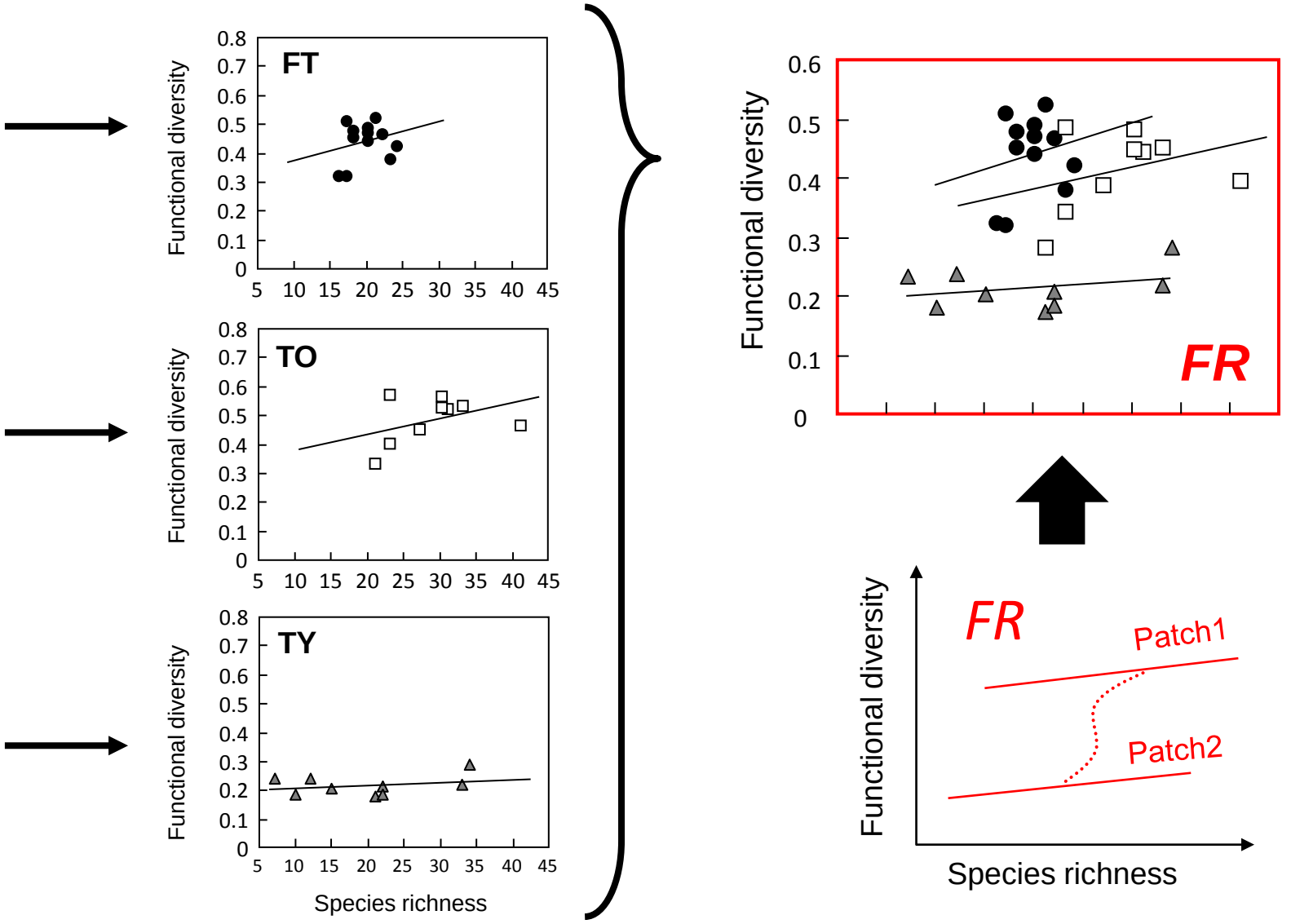
Extrinsic complementarity

Curve fit was decided based on AIC value

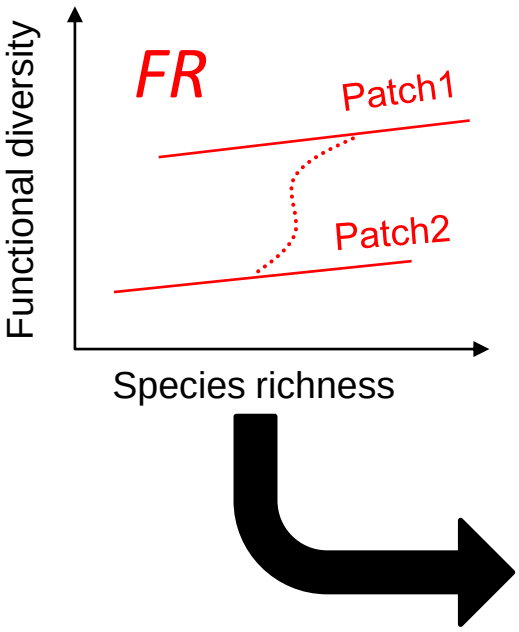
FR in regional scale (among patches) [Tokyo Bay(Uchibo)]



FR in regional scale (among patches) [Tokyo Bay(Uchibo)]



FR may be realized in dynamics among seagrass patches!



Functional complementarity

among seagrass patches?

Although the results of this study is merely phenomenological theory, such pattern of fauna among seagrass patches has been mentioned and supported empirically by previous studies.

(e.g., Duffy et al. 2000, Poor 2004, Whanpetch et al. 2010)

Summary and discuss

Local scale → Functional heterogeneity

Regional scale → Functional homogeneity

? Facilitated by *meta-community* ?

In macrofauna of seagrass ecosystems,
Functional Redundancy (*FR*) may depend on spatial scale,
that would be facilitated by meta-community

Future perspective

[One scenario from the perspective of *Functional Redundancy* (*FR*)]

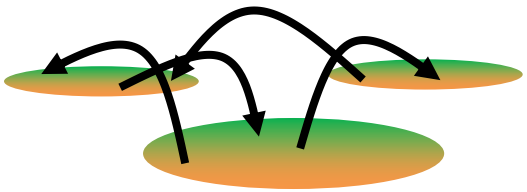
Proper arrangement (conservation) of seagrass beds within a Bay

→ Forming ***Meta-communities*** of macrofaunal species

→ **Functional Redundancy (*FR*)** among patches

→ **Resilience** (High *Ecosystem Functions*)

→ Sustainably utilize
Coastal Ecosystem Service
with conservation



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