Proposal of site selection guidelines for fish farming in Japanese coastal waters

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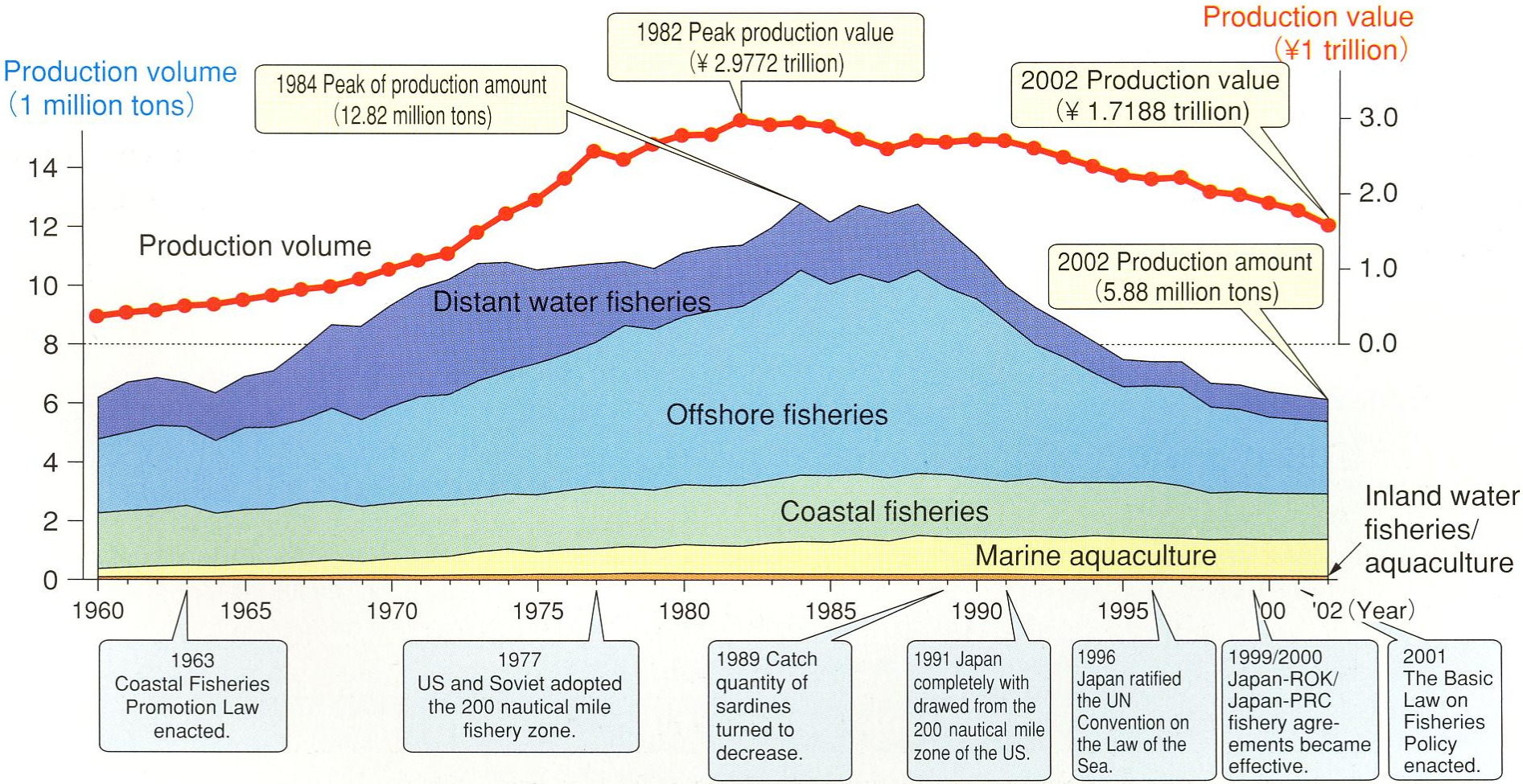
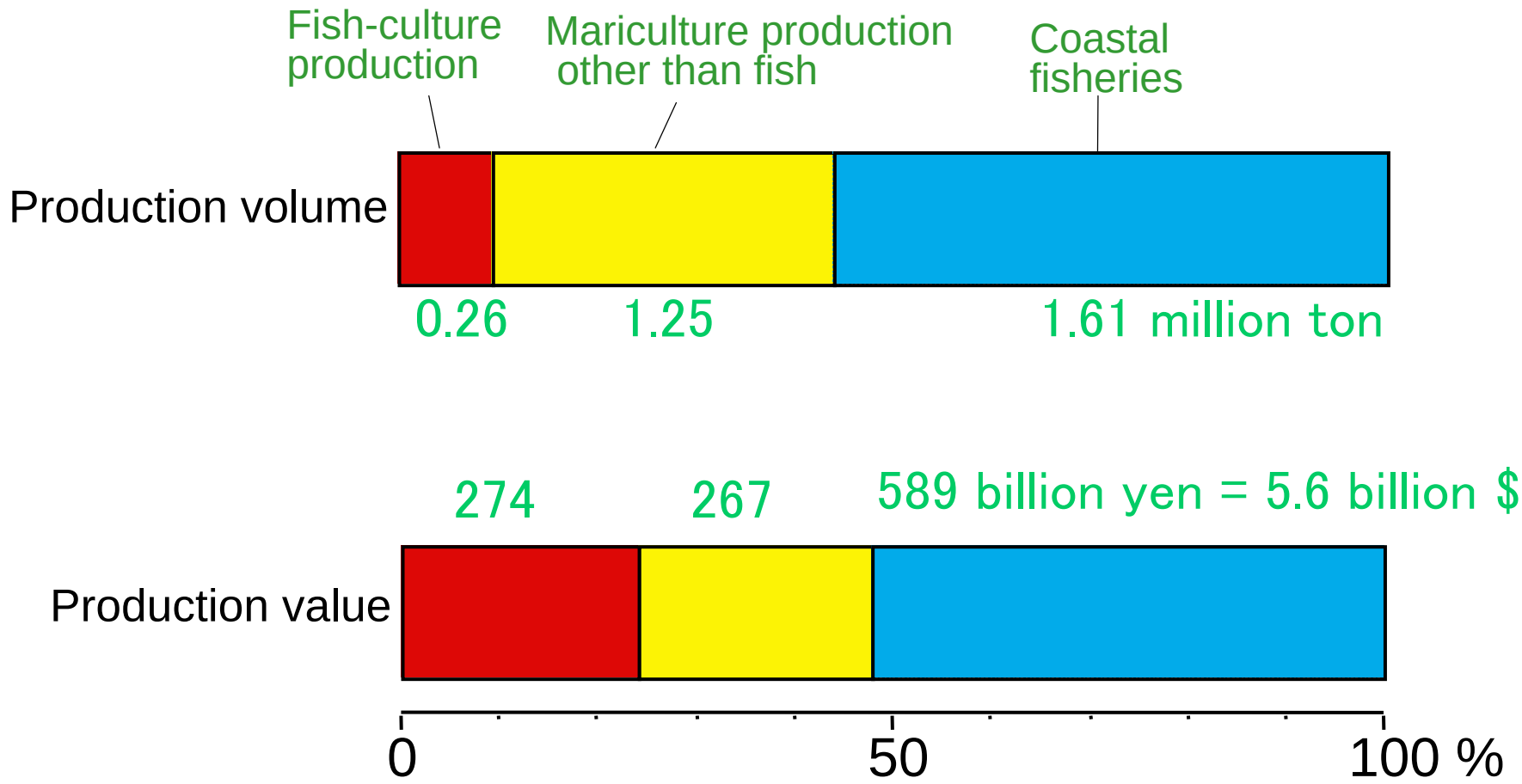
Transition in fisheries production during 40 years in Japan



The production of distant water and offshore fisheries has been decreasing since the late 1980's, whereas the mariculture production has been increasing steadily.

Relative importance of mariculture in the coastal fisheries production



In present, the production volume and production value of mariculture are nearly equal to the coastal fisheries production. The production value of fish aquaculture occupies one forth of the total coastal fisheries production.

Mariculture industry contributes to the local economy, however···

Intensive culture of finfish and shellfish generates large amounts of waste in the form of leftovers, feces and pseudofeces.

Particulate organic matter settles on the seabed under mariculture facilities, resulting in deoxygenation and buildup of sulfides, which sometimes damage culture organisms.

Such negative effects have become conspicuous since the commencement of fish farming in the mid 1960’s and its subsequent rapid development during the 1970’s and 1980’s.

For maintaining sustainable aquaculture,
it is necessary

- ★ to assess farm environments objectively,
- ★ to conduct mariculture within the range of the assimilative capacity.

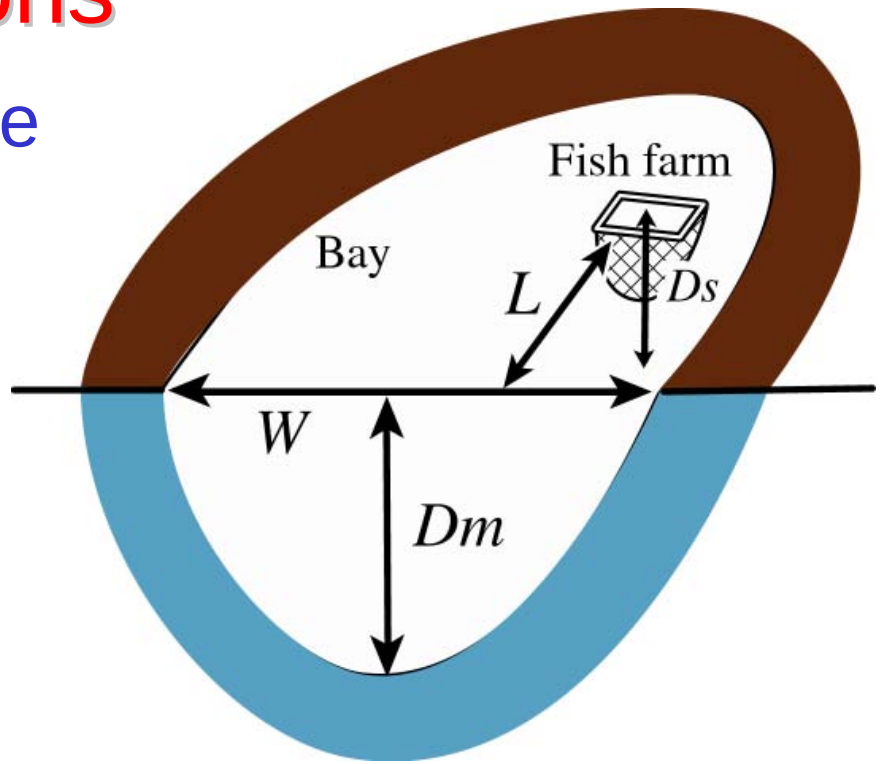
Then, how can we know the assimilative capacity?

We tried to develop a convenient and simple way to estimate the assimilative capacity, and proposed two indices that are representative of the assimilative capacity.

Proposal of an index of topographic conditions

ED: Embayment Degree

$$ED = \frac{L}{W} \times \frac{\overline{Dm}}{Dm} \times \frac{\overline{Ds}}{Ds}$$



Offshore, deeper area ➡ smaller value

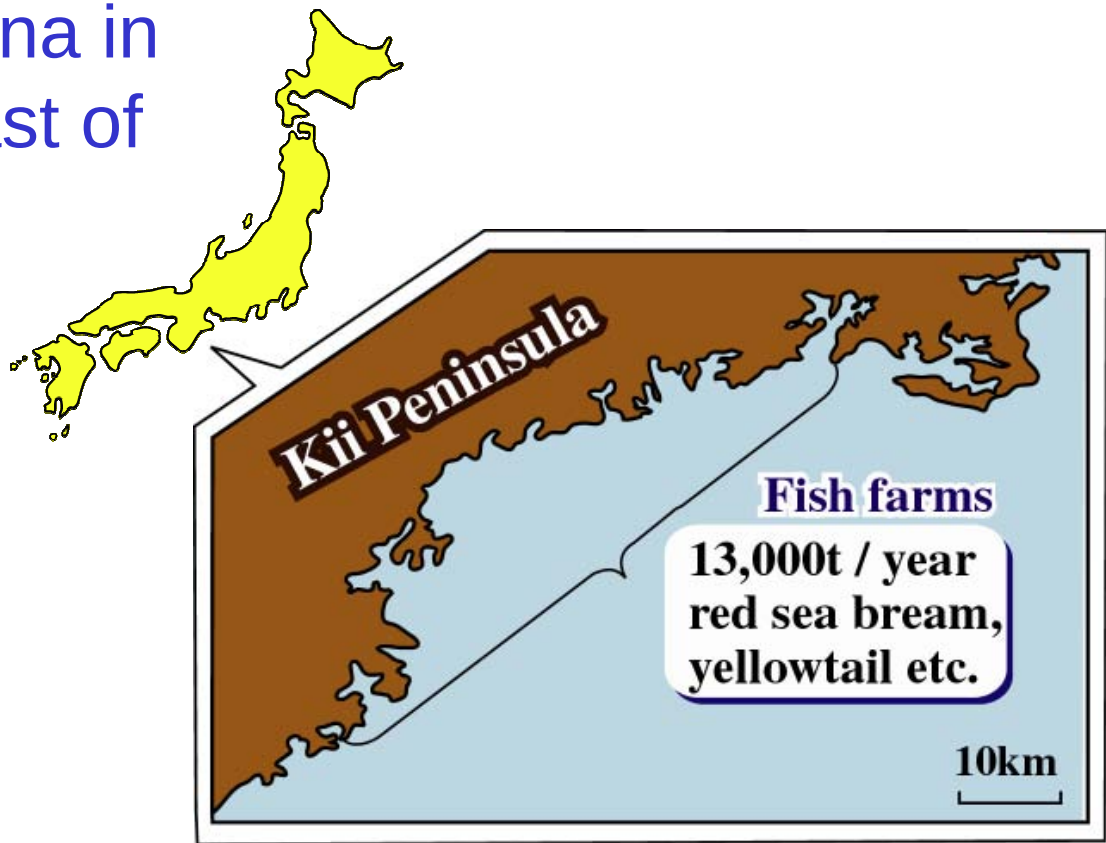
inshore, shallower area ➡ larger value

Is macrofauna, which is generally used as bio-indicator, determined in the gradients of fish production and ED?

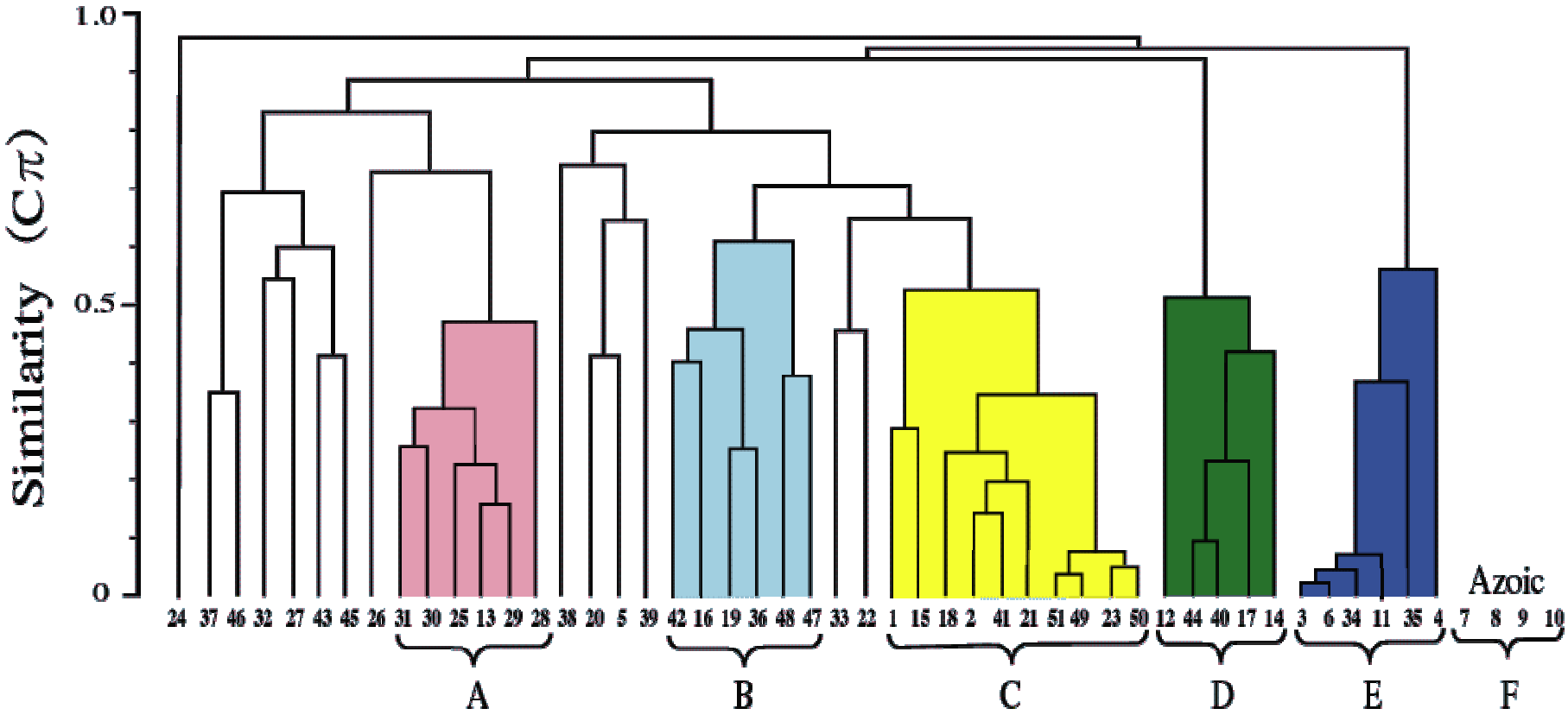
If the answer is yes, usefulness of ED as an index of the assimilative capacity will be proved.

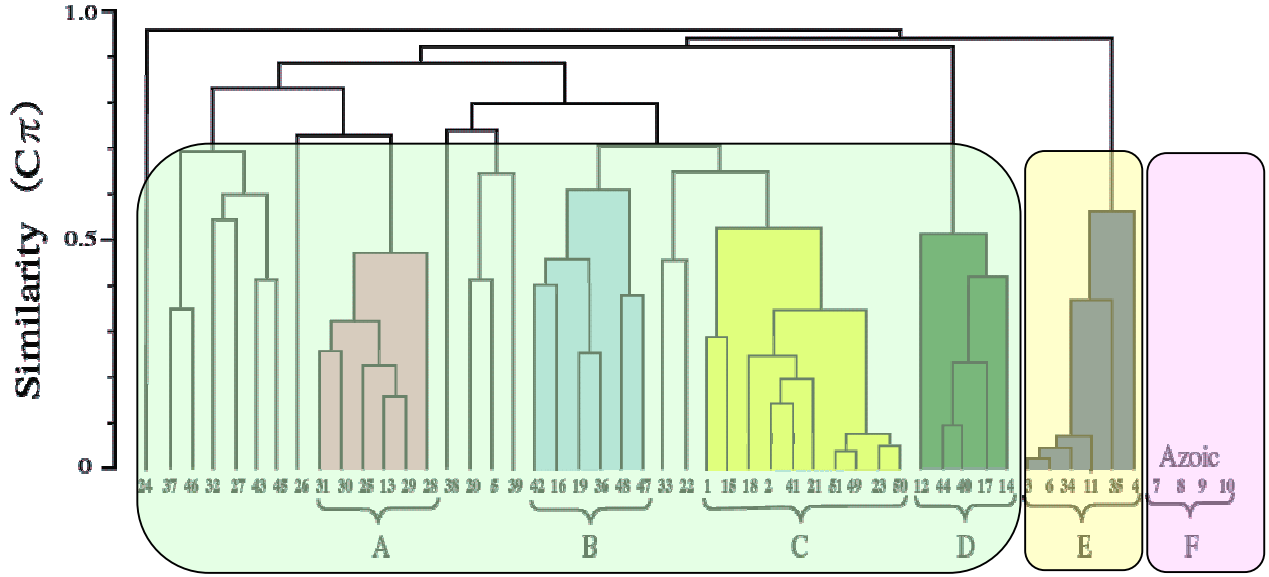
We examined macrofauna in fish farms along the coast of Kumano-nada.

Samples were collected from 51 stations at 22 fish farms located in 10 small bays during a summer period.



5 assemblages and 4 azoic stations based on the cluster analysis of the macrofauna





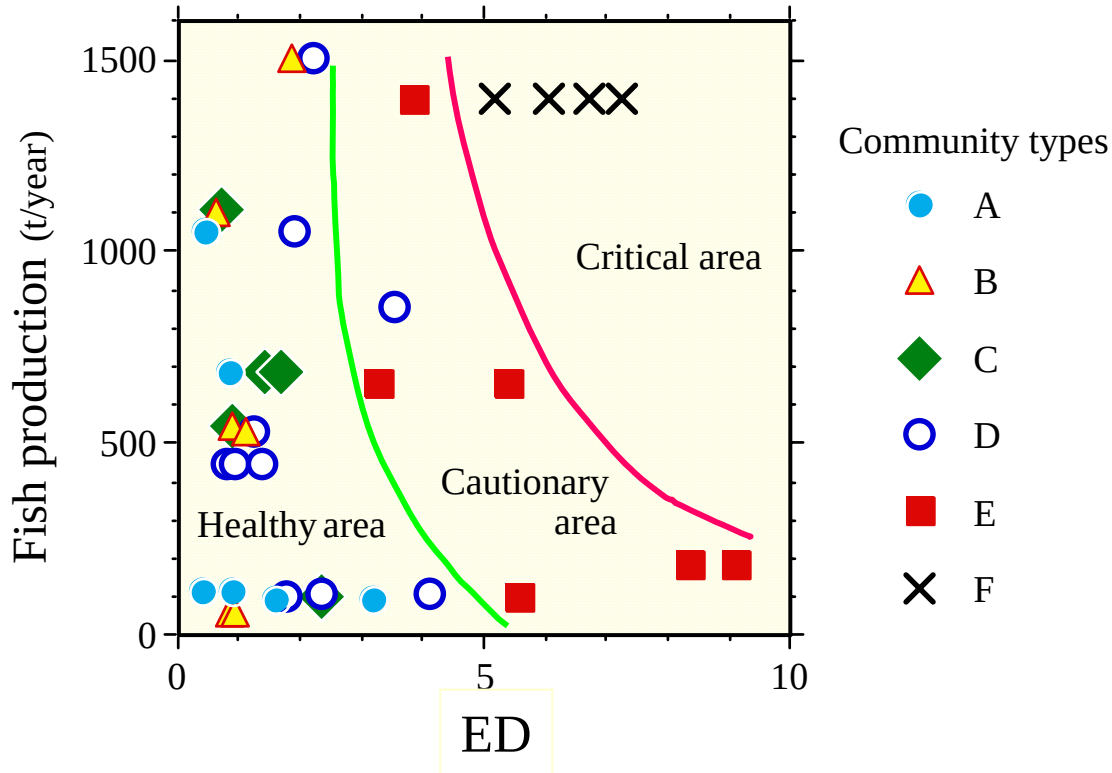
The assemblages are classified into 3 groups:

- A, B, C and D are characteristic of a healthy zone
  ···high diversity, saturated DO & unenriched sediments

- E is characteristic of a cautionary zone
  ··· pollution indicator species, small biomass, low density, hypoxia & enriched sediments

- F is characteristic of a critical zone
  ··· azoic conditions, anoxic & highly enriched sediments

Assemblages in the gradients of fish production and ED



Three groups are arranged regularly in the gradients of fish production and ED, indicating that …..

★ both fish production and topographic conditions affect environments and macrofauna, and

★ ED is a good index of the assimilative capacity.

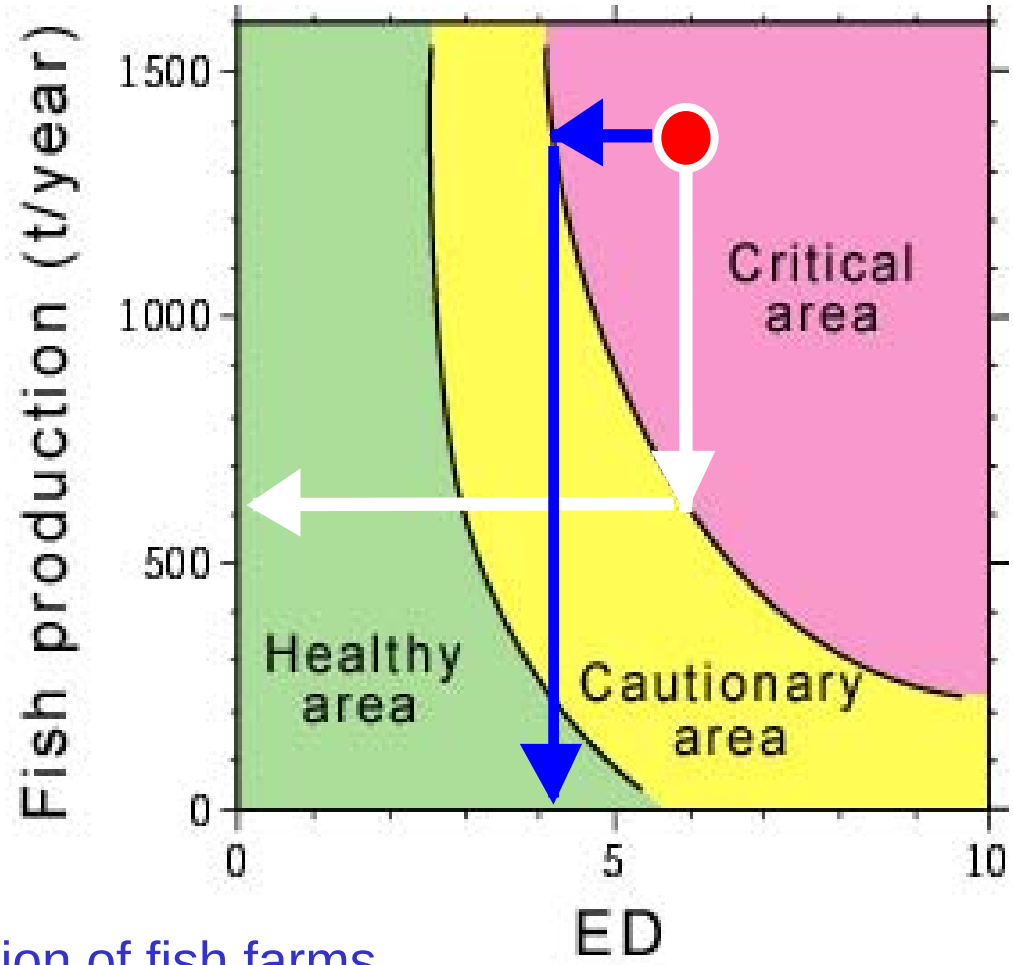
Use of ED for suitable siting

Suitable siting for fish farming and upper limit of fish production can be estimated.

In case a fish farm with 1400 t /yr is located in the critical zone with ED of 6,

★ this farm should be shifted to the area with ED of <4, or

★ annual production should be lowered to <600 t, in order to alleviate the critical conditions.



ED is a good index for site selection of fish farms. However, it is unknown whether ED is applicable to all localities under variable topographic and oceanographic conditions.

Proposal of ISL

We propose ISL (Index of Suitable Location).
ISL is based on more direct variables
that control waste dispersal and oxygen supply,
i.e. water depth (*D*) and current velocity (*V*)

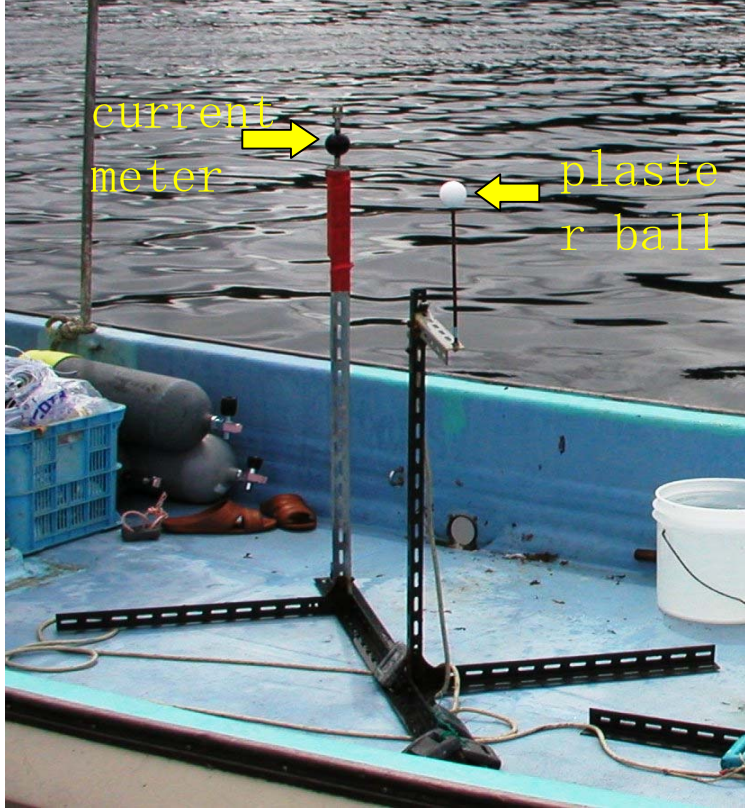
$$\mathrm{ISL} = DV^2$$
$$= \underbrace{\boxed{DV}}_{\text{waste dispersal}} \times \boxed{V} \Rightarrow \text{oxygen supply}$$

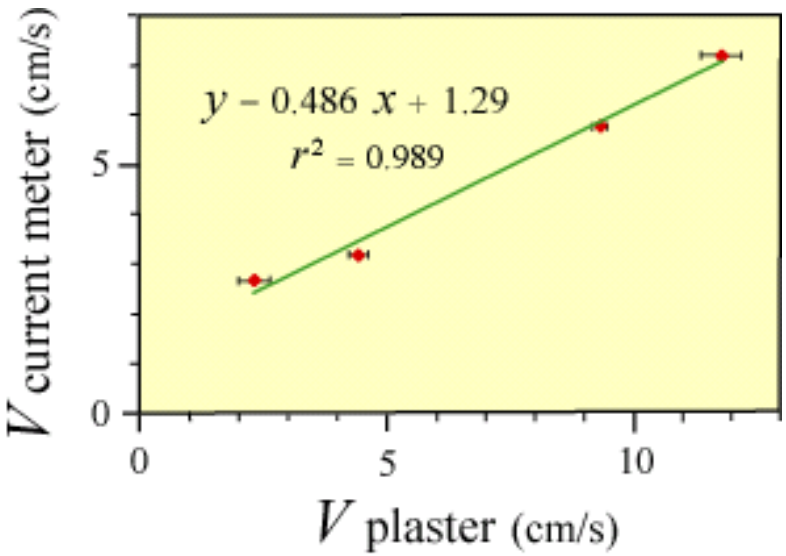
Plaster-ball survey

★ For comparison of the current velocity between stations, it is necessary to measure velocities at the same time.

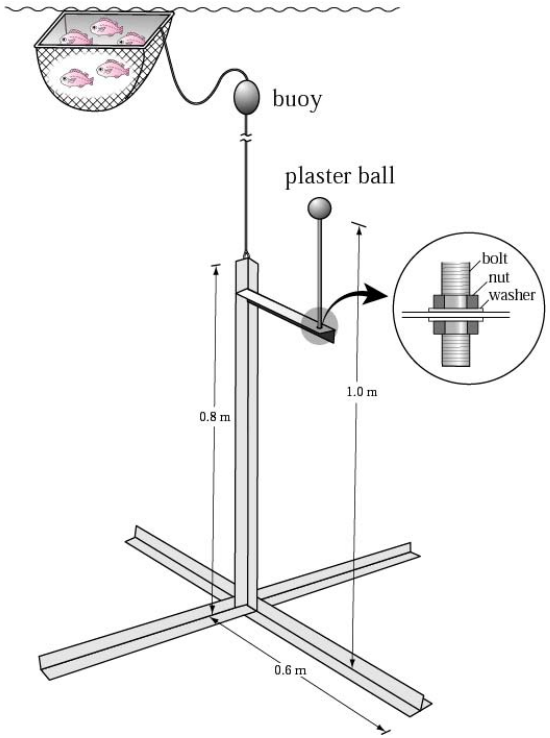
★ We used plaster balls as a convenient device to estimate the current velocity, because...

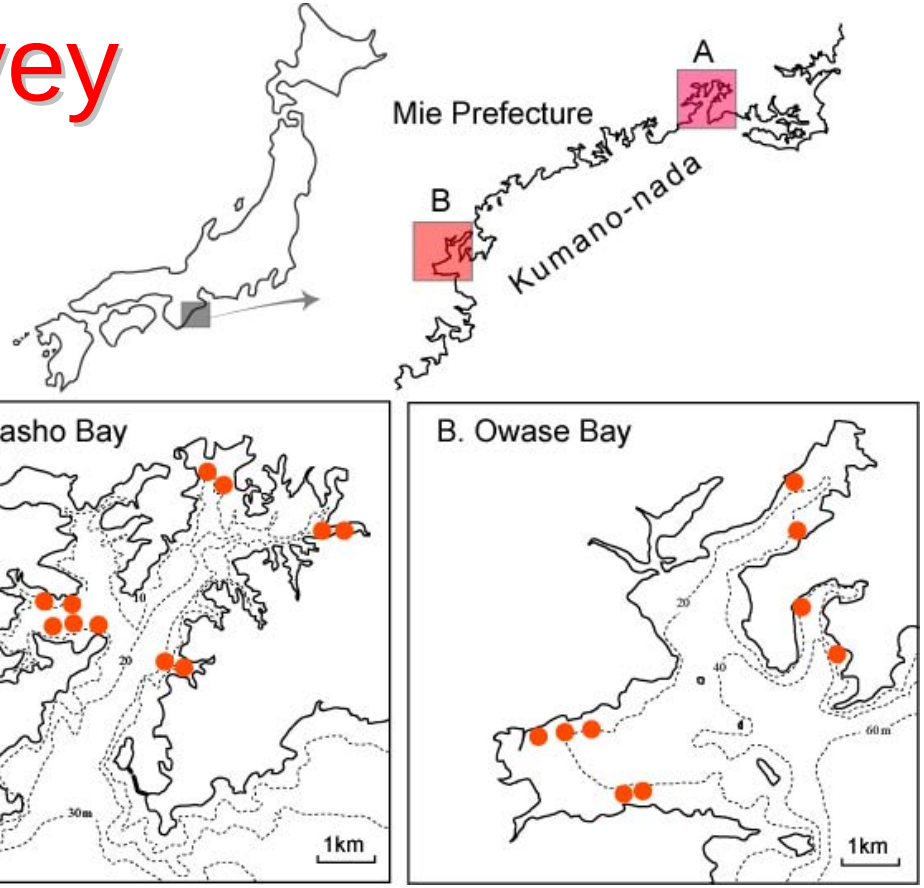
★ there is a positive correlation betwee values determined by the current meter and the plaster-ball method (Komatsu & Kawai 1992).





Field survey

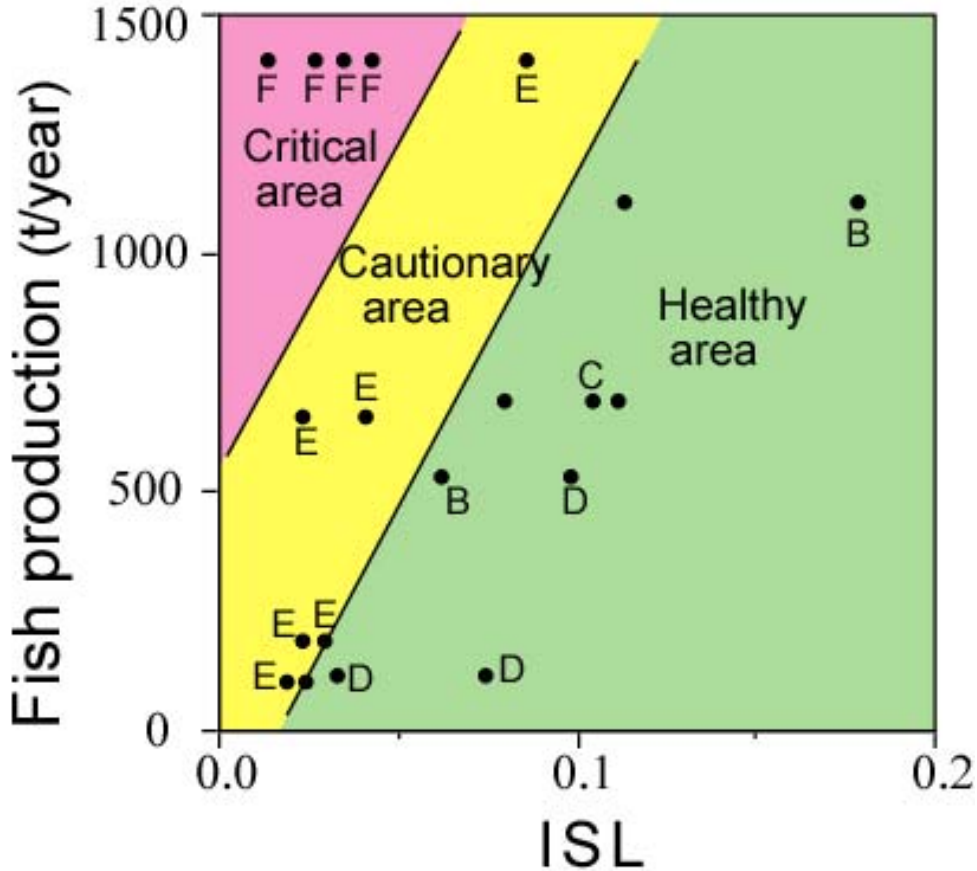




A plaster ball was fixed on the frame of a stand. Stands were set 1 m above the seabed at 20 stations in 8 fish farms at the same time for 50 hours during neap- and spring-tide periods, and ISL values were calculated.

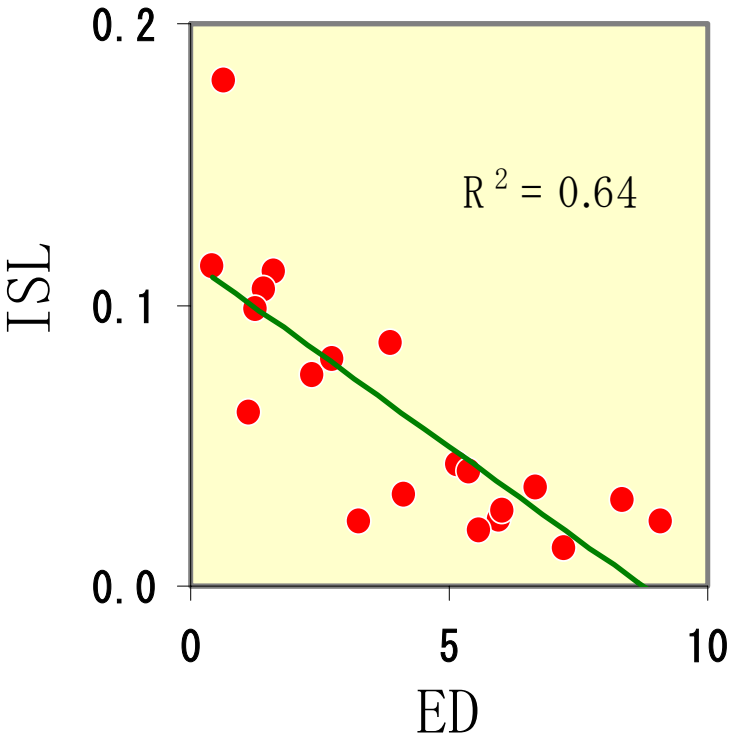
Use of ISL for suitable siting

Macrofaunal assemblages, which were found by the previous ED survey, are placed in a grid of ISL vs. fish production.



Three groups are arranged regularly in these gradients, indicating that ISL is a good index for assessing the assimilative capacity of fish farms.

Comparison between ED & ISL



Index	Device	Simplicity	Generality
ED	Chart	◎	△
ISL	Plaster ball	○	◎

★ ED is effective for comparison of environments among neighboring fish farms under similar oceanographic conditions.

★ ISL incorporates direct factors that control the waste dispersal and oxygen supply. ISL can be used widely to assess the suitability of fish farms.

Summary

Based on an idea that location of a fish farm in a bay, bathymetry and current velocity determine the assimilative capacity, we proposed two indices (ED & ISL).

Environmental conditions can be explained in the gradients of fish production and ED/ISL.

ED & ISL are convenient indices that fish farmers can evaluate their own farms through a chart and plaster balls.

Issues concerning the mariculture in Japan

Our two indices indicate that offshore mariculture is most effective approach to sustainable aquaculture. However, offshore mariculture requires a large amount of investment for building facilities and farm mechanization based on sufficient funds. We have sociological and economical problems for promoting the offshore aquaculture.

★ Operations are small-scale based on a family labor force by aged workers.

★ This brings low income and subsequently weak management funds.

It is necessary to integrate the small-scale farming into a large-scale, intensive industry for environmental conscious, sustainable mariculture in Japan.

Thank you…