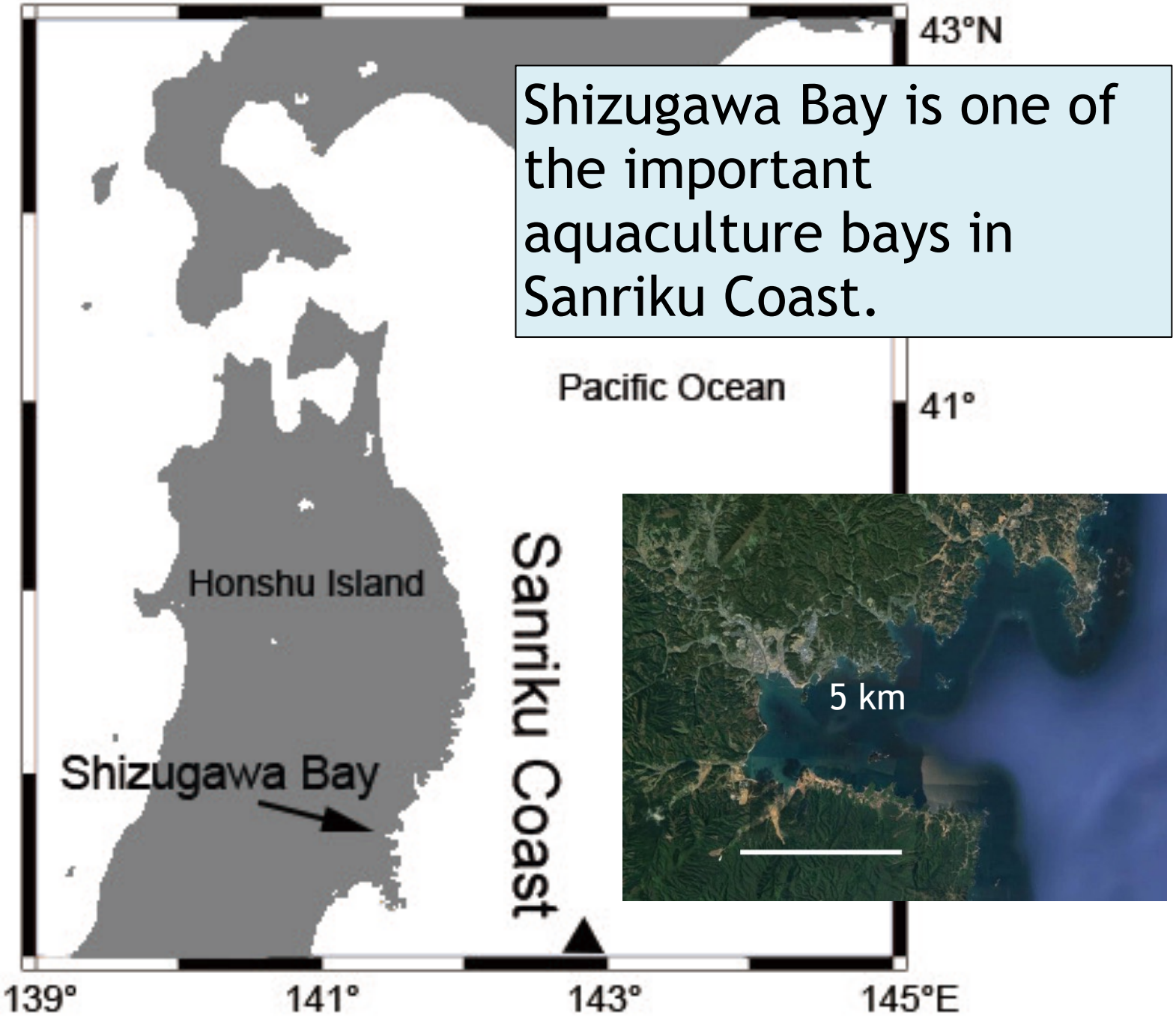
Modern Satoumi approach to an open rias-type bay, Shizugawa bay, Sanriku coast, Japan after the hit by the huge tsunami in 2011 for realizing sustainable environment and prosperous aquaculture

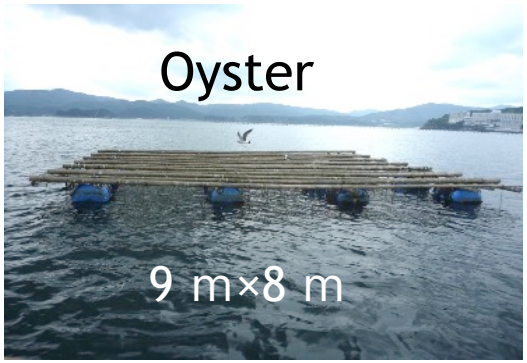
Teruhisa Komatsu, Shigeru Montani, Chihiro Yoshimura, Osamu Nishimura, Shuji Sasa, Yamamoto and Tetsuo Yanagi

Sanriku Coast

Aquacultures are developed and the most important fisheries in the coastal sea due to semi-enclosed bays.


Shizugawa Bay is one of the important aquaculture bays in Sanriku Coast.
43°N
Pacific Ocean
41°
Honshu Island
Sanriku Coast
Shizugawa Bay
5 km
139°
141°
143°
145°E

Aquaculture in Shizugawa Bay



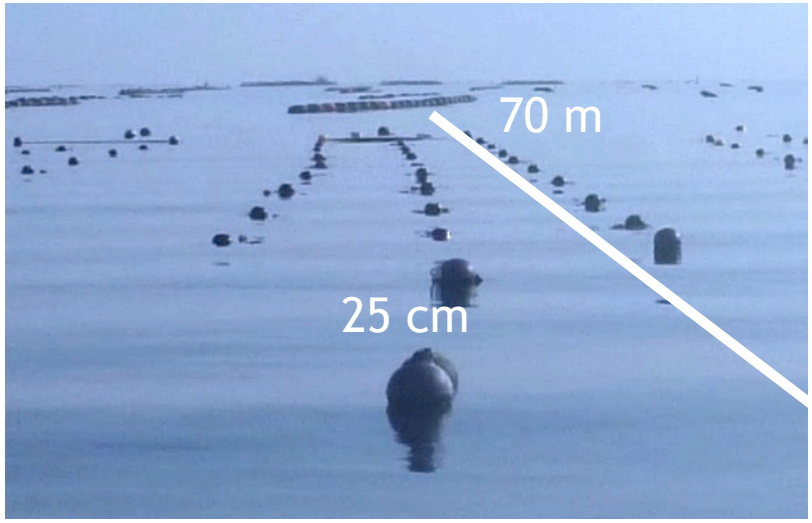
Oyster culture is the most important aquaculture in Shizugawa Bay

Oyster (*Crassostrea gigas*)

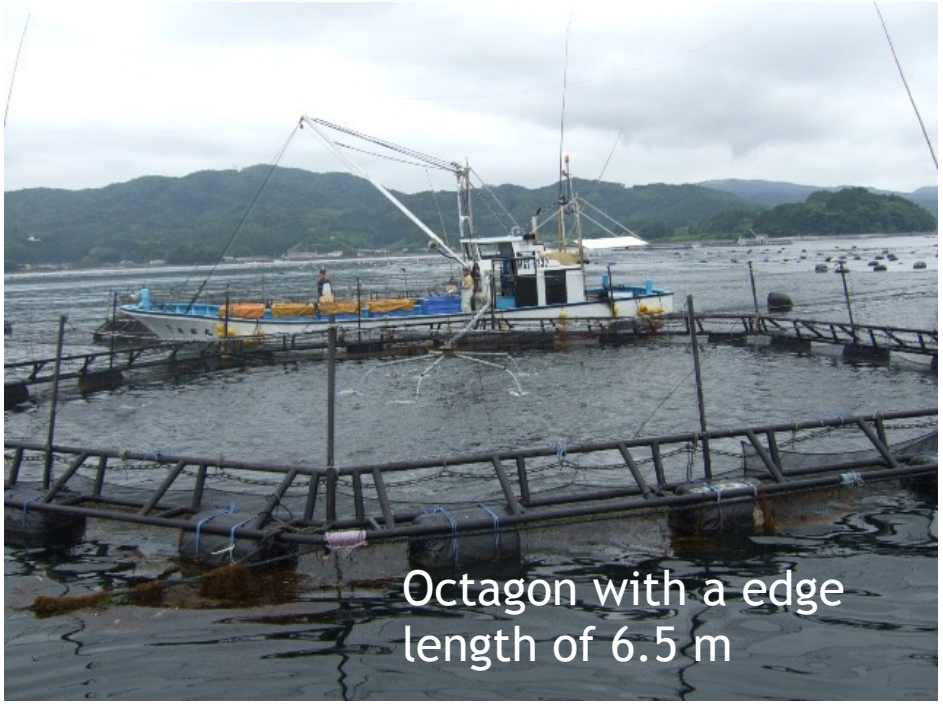
Ascidian (*Halocynthia roretzi*)

Deployed for all the year

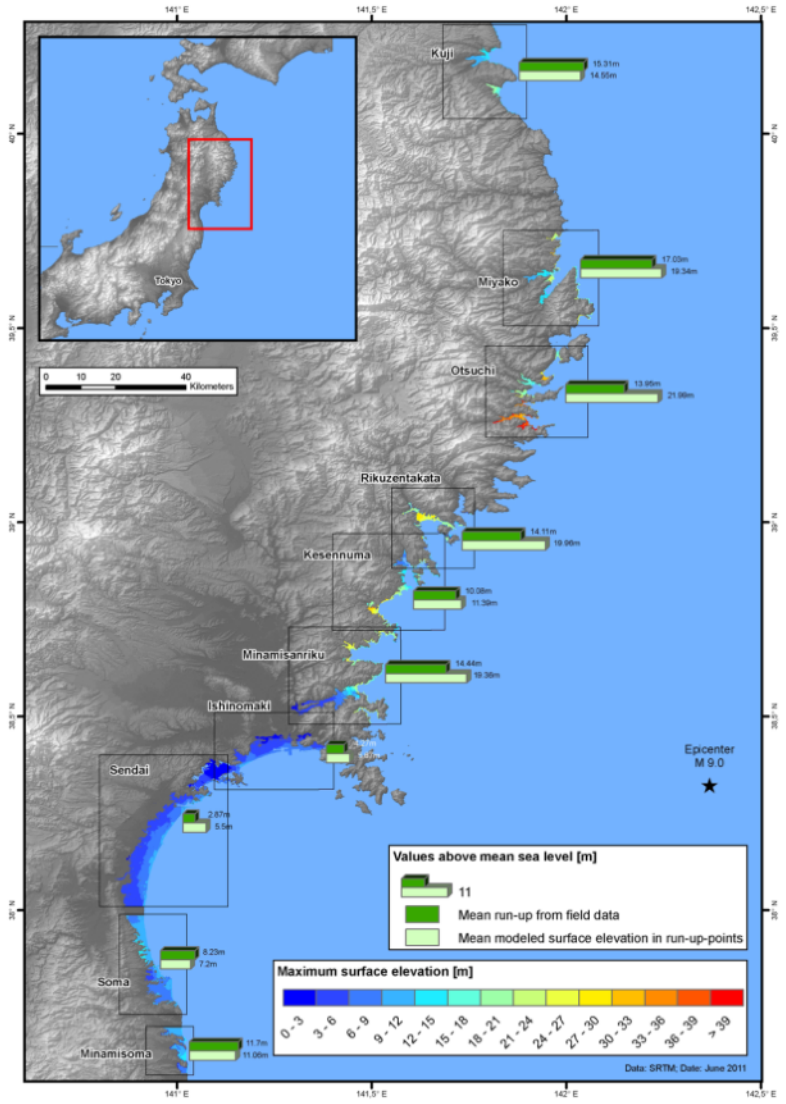
Seaweed (*Undaria pinnatifida*), wakame in Japanese, from October to April



Coho salmon (*Oncorhynchus kisutsh*) culture from mid-March to early August

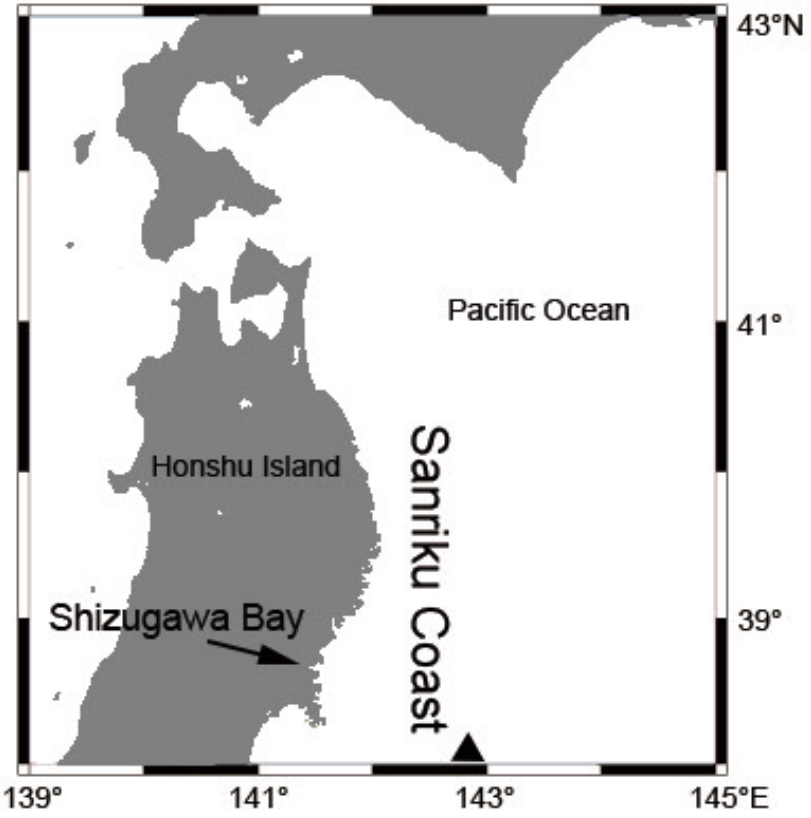


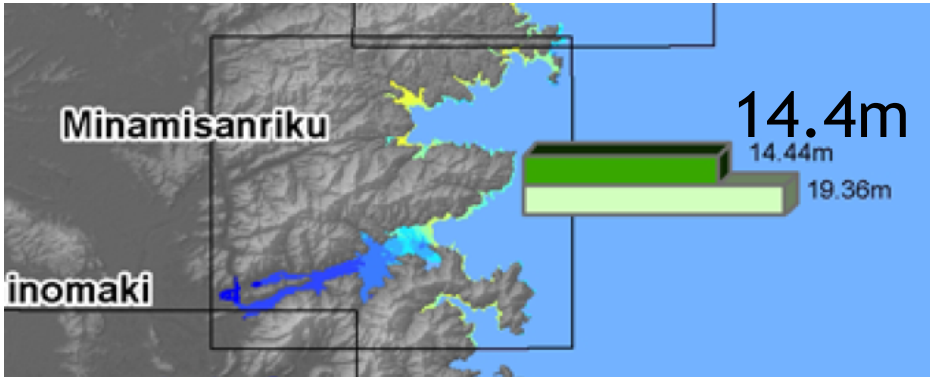
Huge tsunami on 11 March 2011

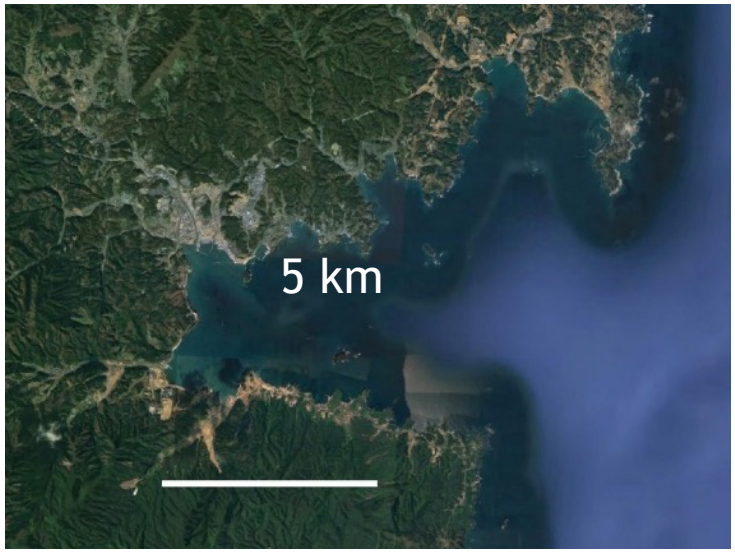


Huge tsunami hit mainly Sanriku Coast

Shizugawa Bay





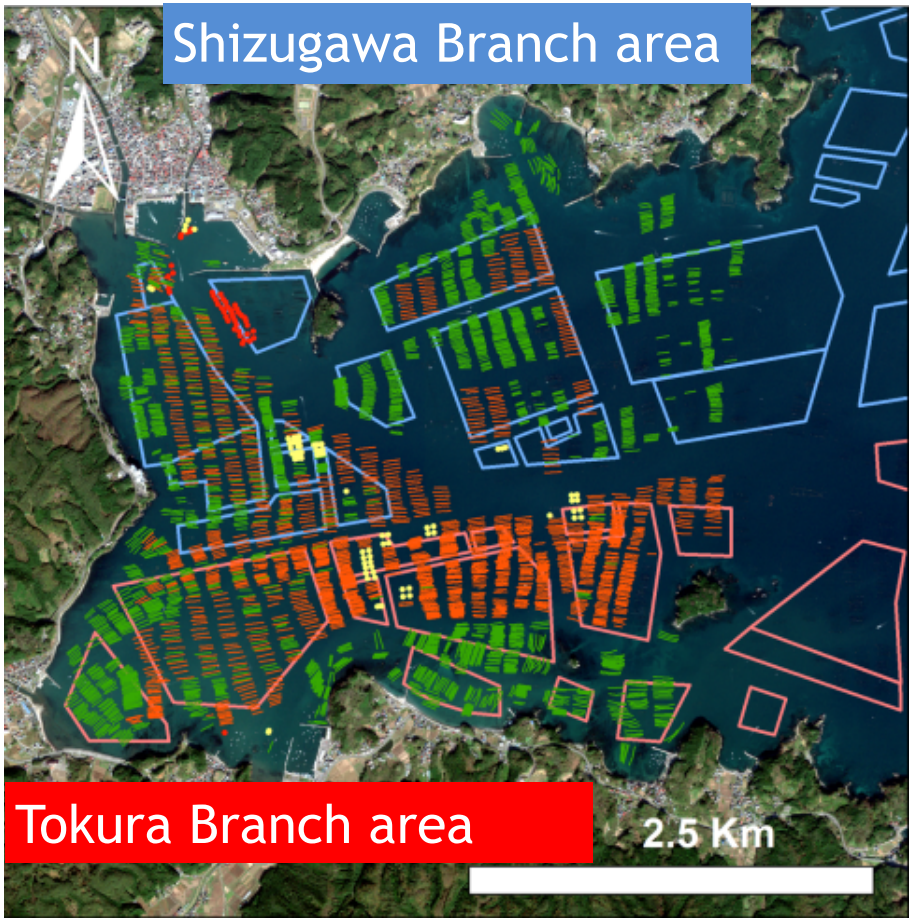


Objectives of the study

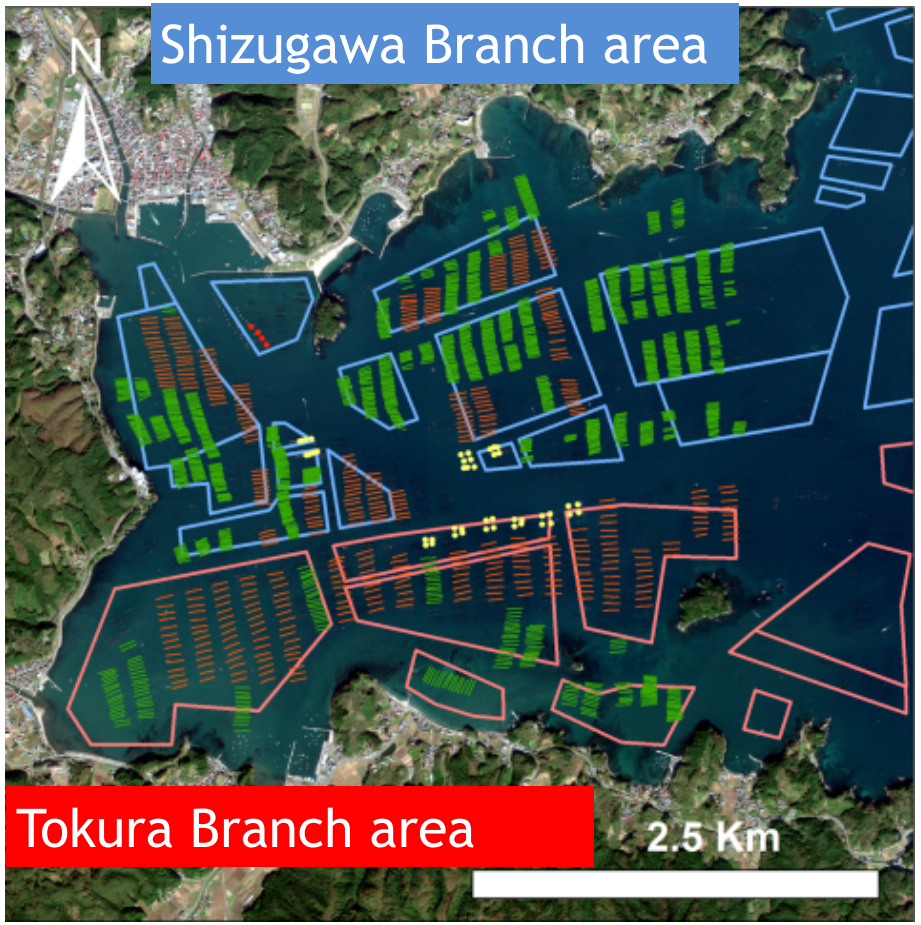
- Monitoring succession of coastal ecosystems and human activities after the tsunami 2011
- Clarifying material flow in Shizugawa Bay and quantifying contributions of forests to the material flow
- Making physical-biochemical model for predicting marine environments in Shizugawa Bay including aquaculture activities
- Establishing “Council for examination of future Shizugawa Bay” with fishermen’s cooperative, local governments, NPO (WWF) and natural and social scientists
- Discussing on fisheries and marine environments to realize sustainable fisheries and healthy bay through Satoumi activities

Monitoring

Reduction of oyster culture rafts after the tsunami in 2011 by fishermen



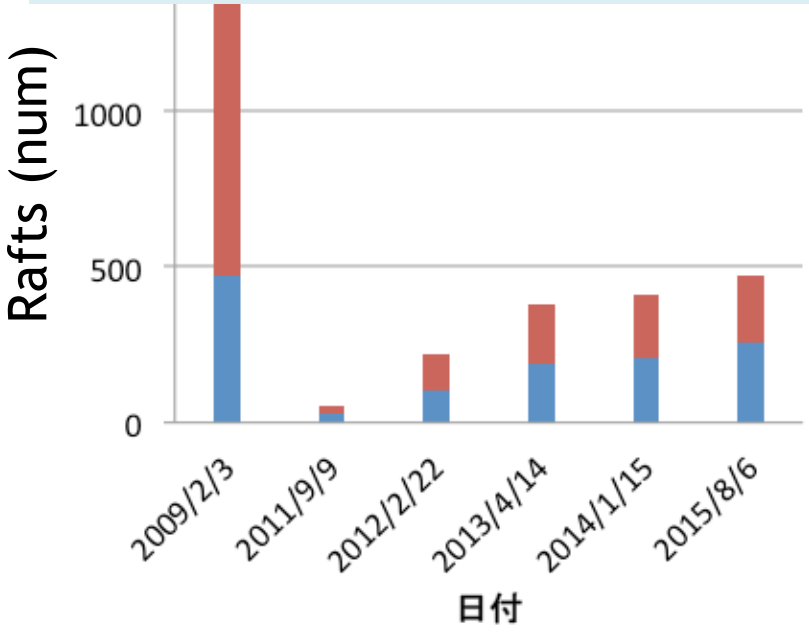
3 February 2009



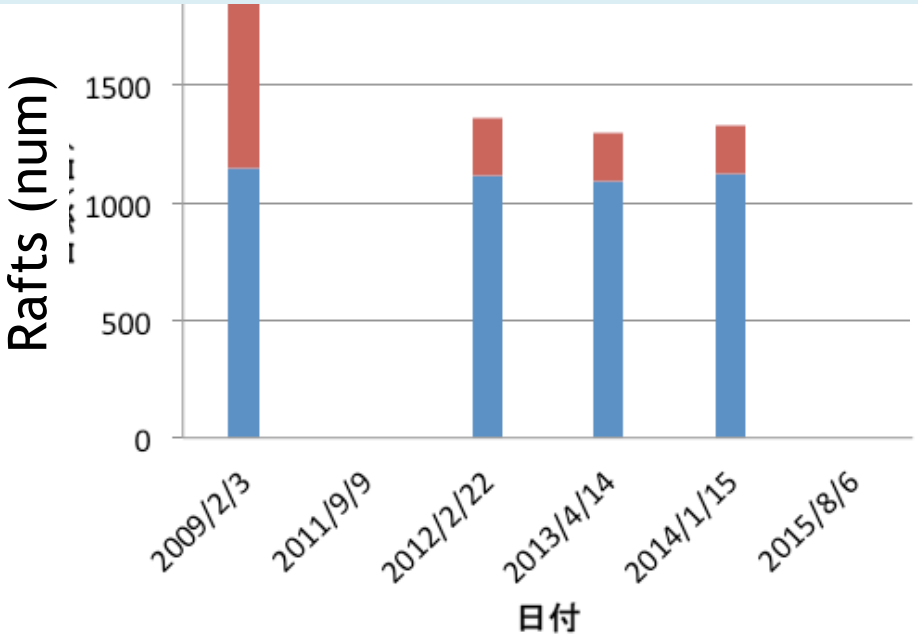
15 January 2014

Red and blue polygons indicate aquaculture areas permitted to Tokura Branch and Shizugawa Branch of Shizugawa District Fishermen's Cooperative
Green, red and yellow are seaweed, oyster and salmon aquaculture, respectively

Temporal changes in aquaculture facilities of oyster and seaweed in Tokura (red) and Shizugawa (blue) areas



Oyster



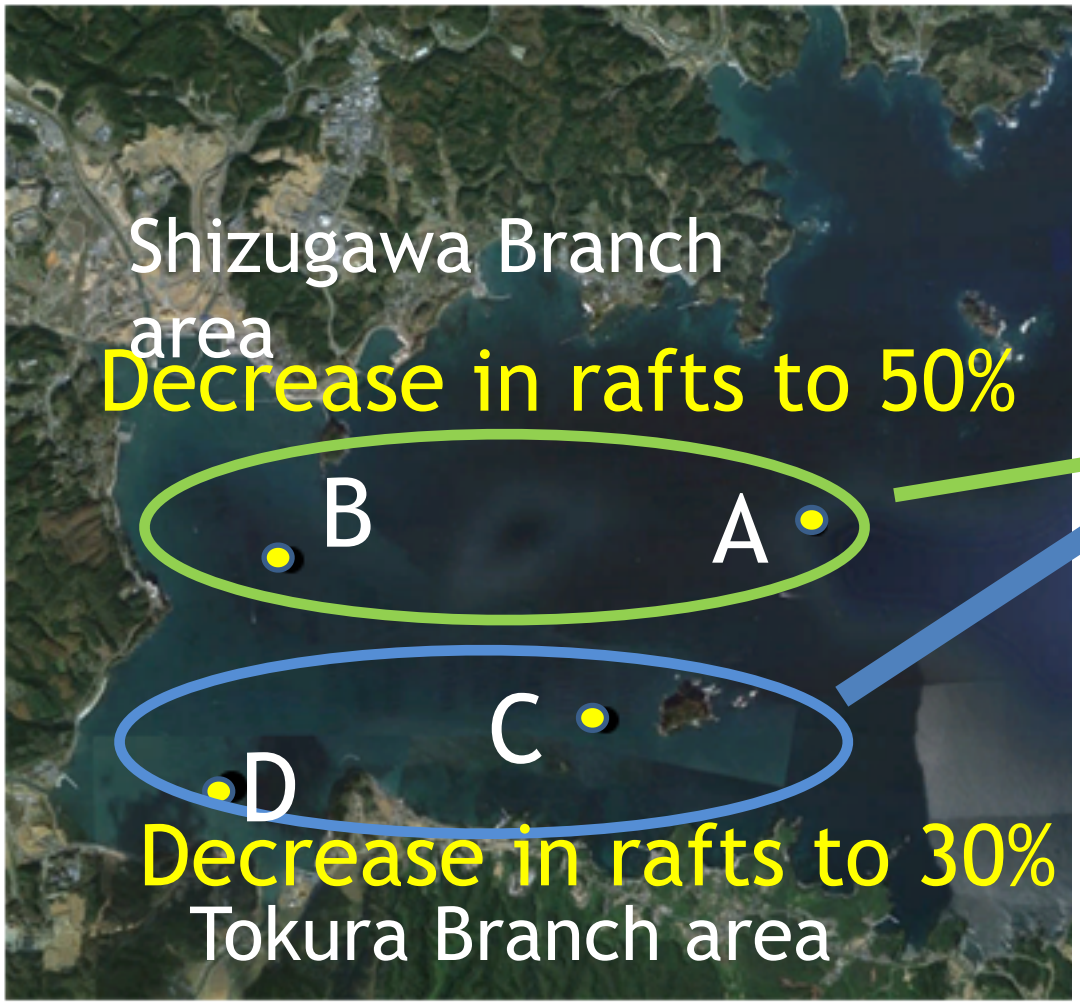
Seaweed

Decreases of rafts to 30% in Tokura and 50% in Shizugawa

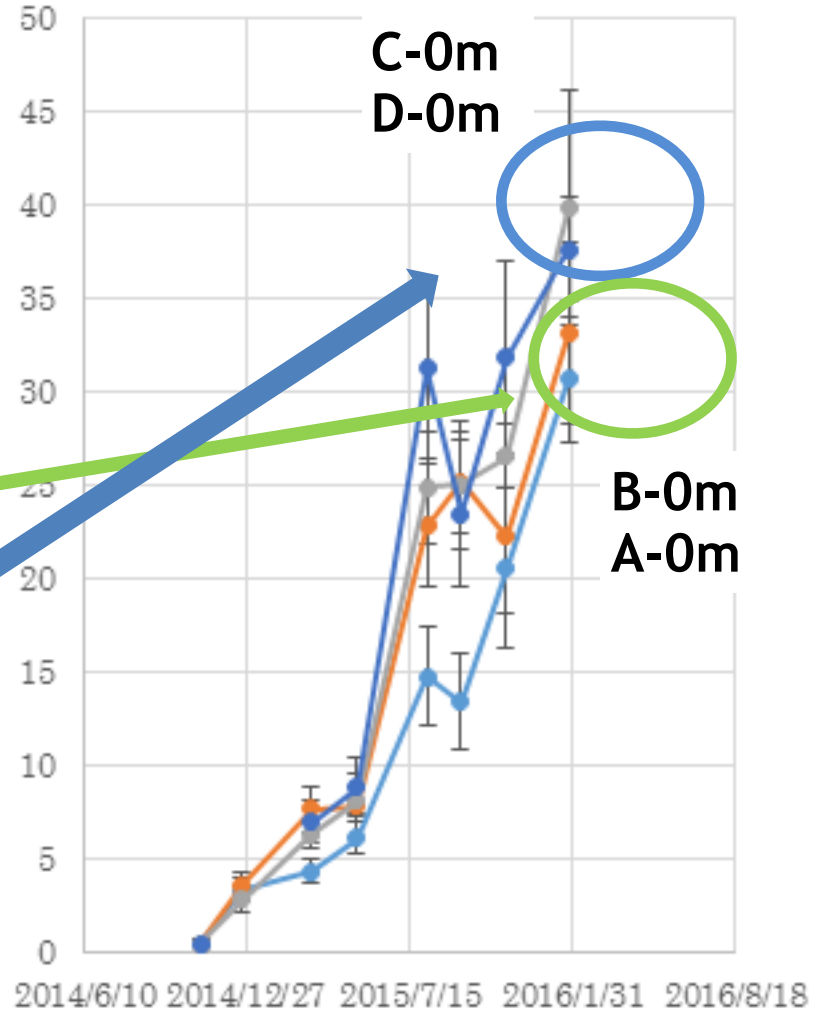
Decrease of rafts to 30% in Tokura

Sustainable production and

Growth of oysters

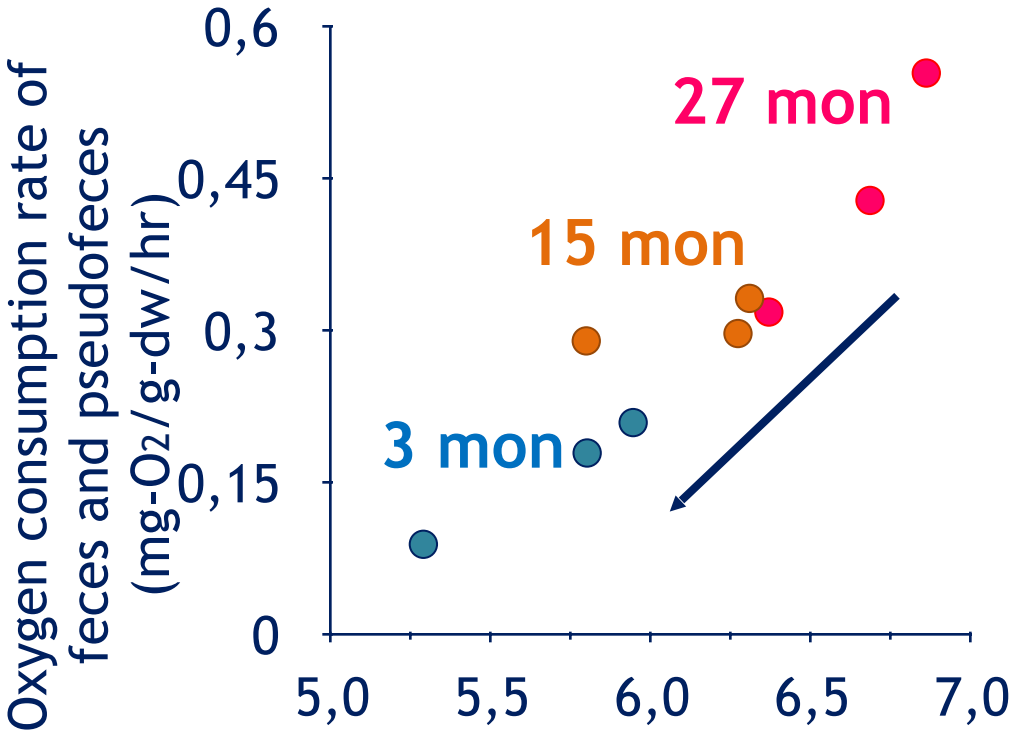


Wet weight of flesh (g/ind)



Oysters in Tokura grow better than in

Organic carbon content in feces and pseudofeces of oyster depending on age



Organic carbon content in feces and

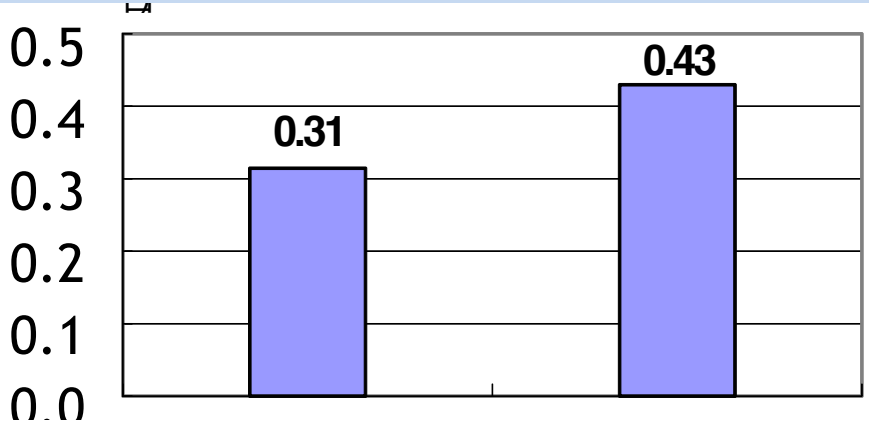
Increase in oxygen consumption rate due to increase in organic carbon content in feces and pseudofeces through decrease in assimilation rate by aging

Increase in growth of oyster due to diminution of rafts shortens culture duration from more than 18 months to more than 10 months

Increase in flesh of oyster (>20g/ind)

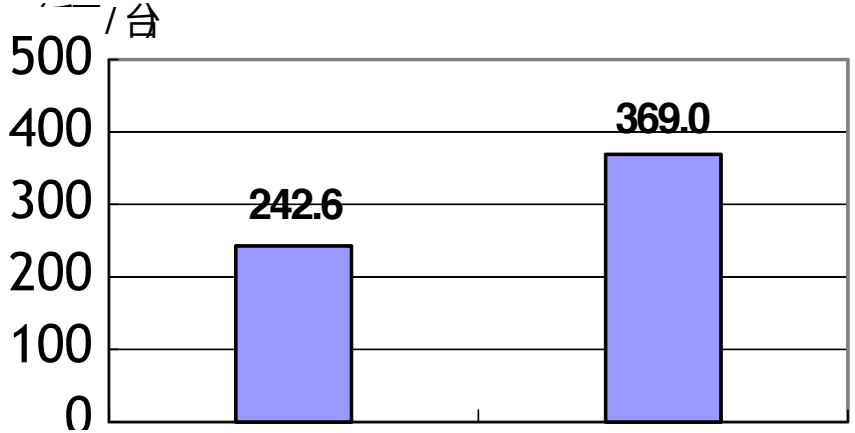
Decrease of rafts increases productivity of oyster with decrease in environmental load

Catches and amounts before and after the reduction of rafts



2009 before the tsunami　2014 after the tsunami

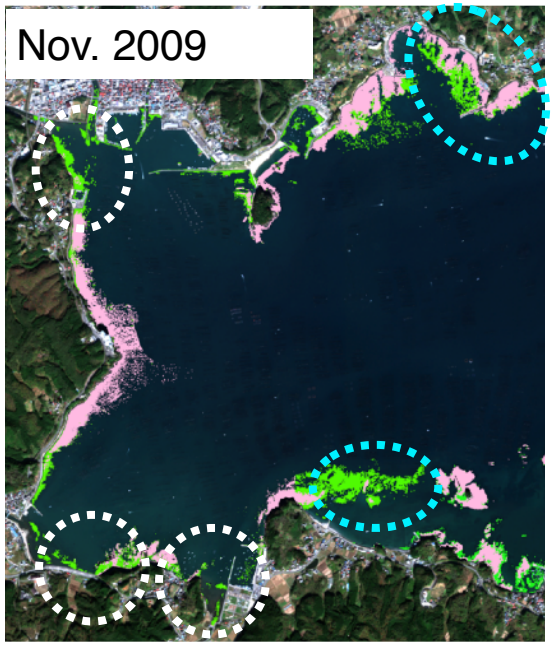
Catch (ton/raft)

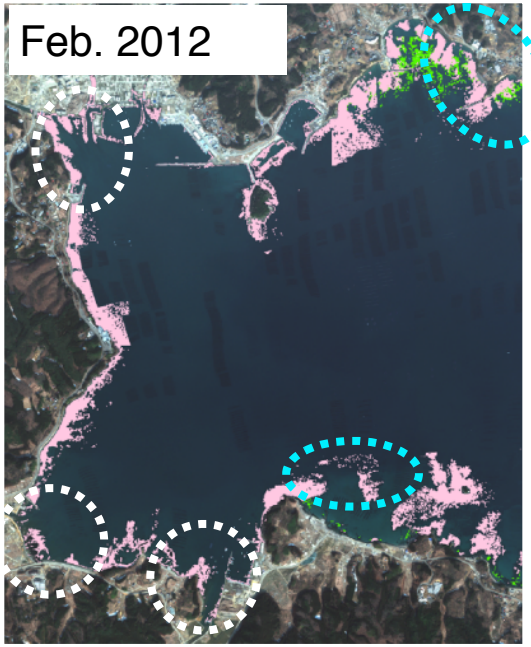


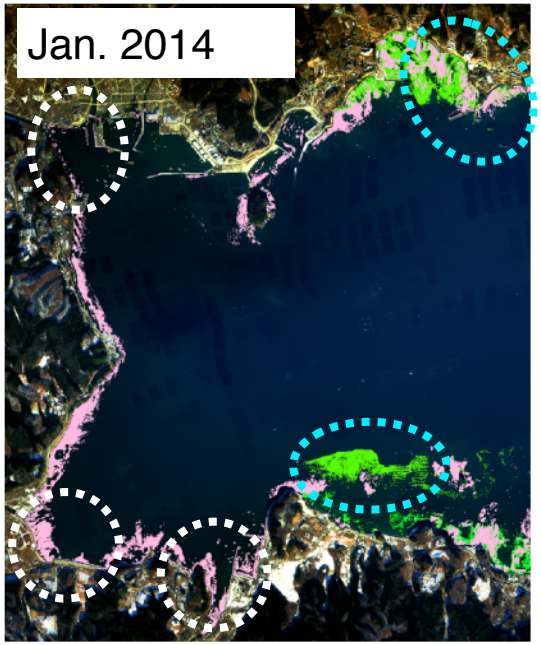
2009 before the tsunami　2014 after the tsunami

Amount of landing (thousand yen/raft: ~10$/raft)

Monitoring a recovery process of seagrass and seaweed beds with satellite remote sensing





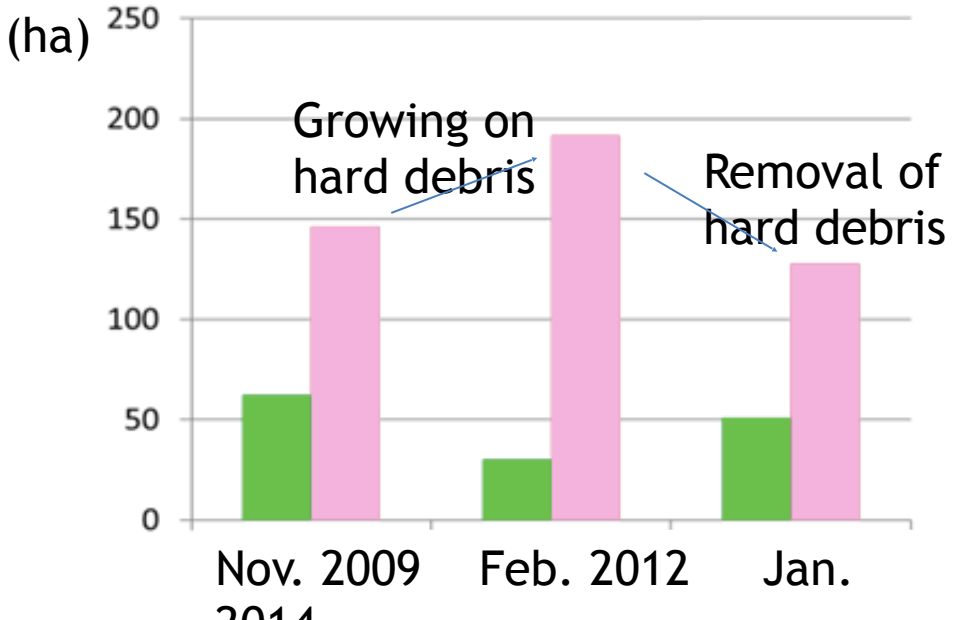


Seagrass beds

Seaweed beds

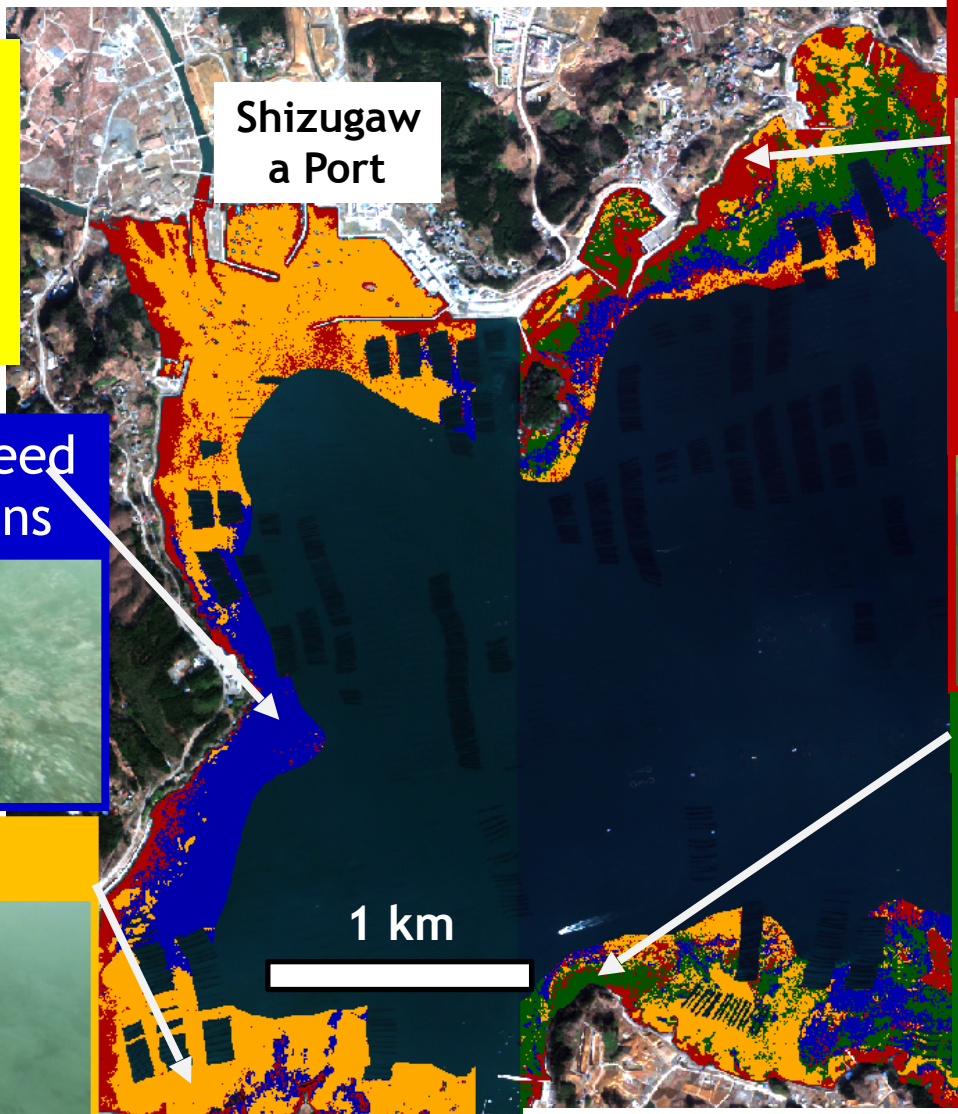
Recovered seagrass beds

Seagrass beds not recovered yet



Visualization of devastated seaweed beds with satellite remote sensing

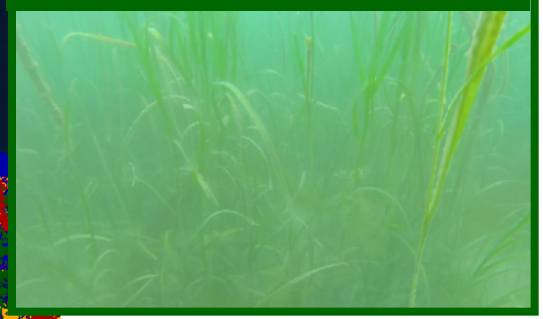
Importance of monitoring of a transitional coastal ecosystem



Seaweed bed: *Sargassum horneri*

Seaweed bed: *Saccharina japonica*

Seagrass bed

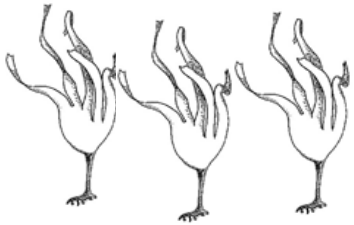


Devastated seaweed beds by sea urchins

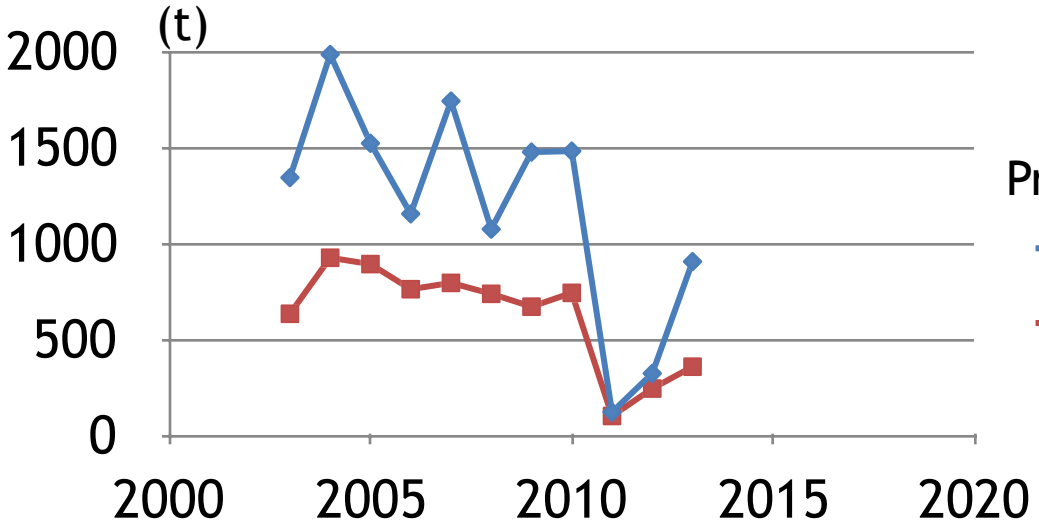
Muddy bottom

(GeoEye-1 shot on 12 Feb. 2015)

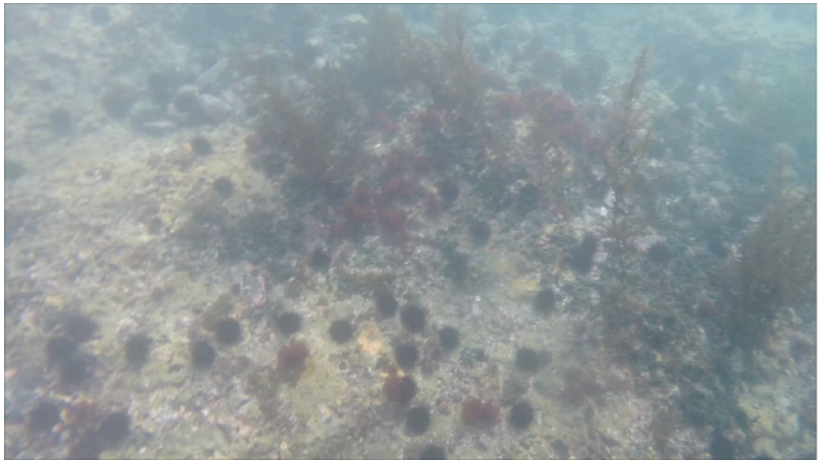
Sea urchin fisheries to support biodiversity in coastal waters: Satoumi activity



Explosive increase in sea urchins due to stop of fisheries



Landing of sea urchins (t) Statistics of agriculture, forestry and fisheries



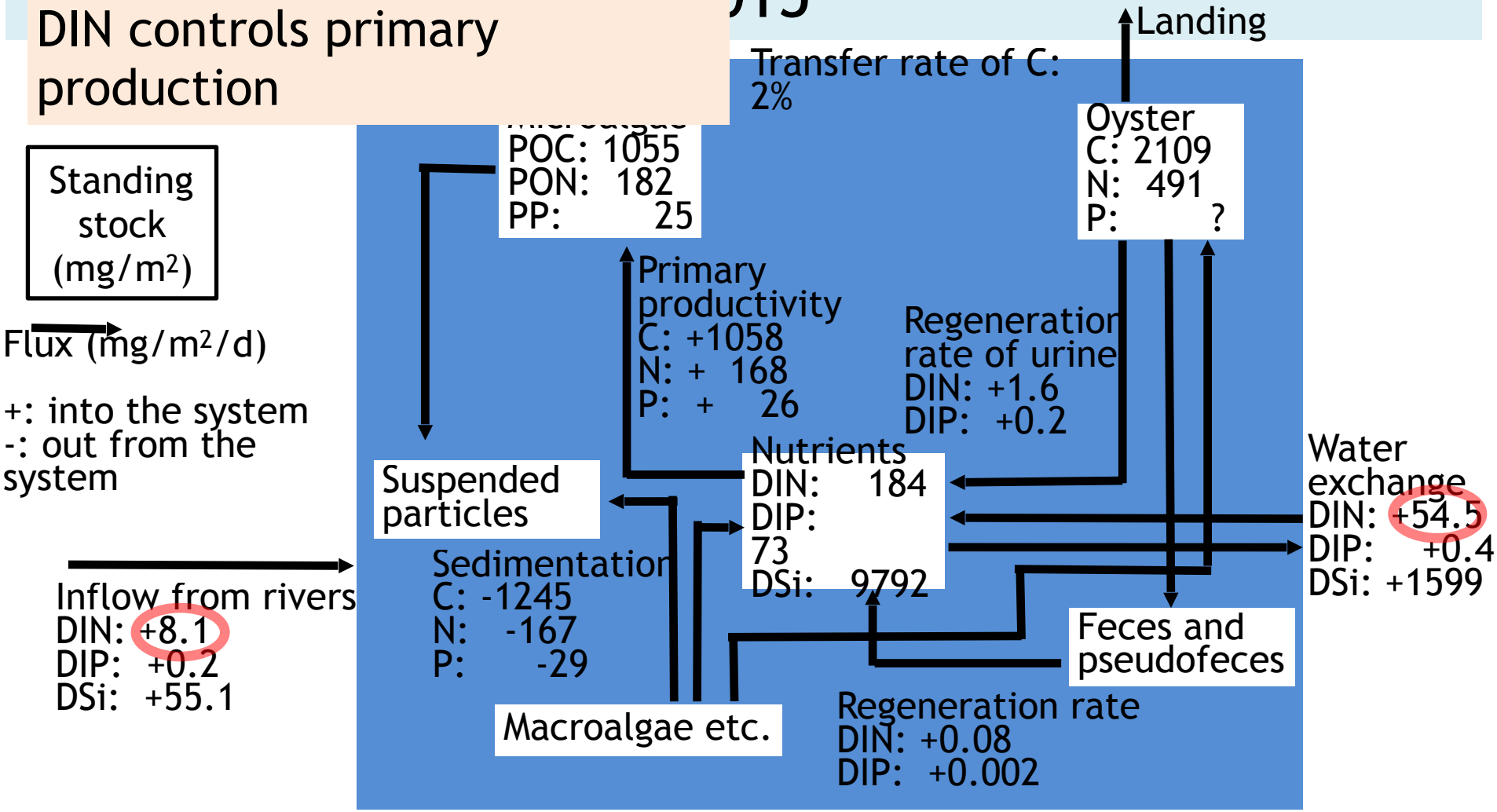
West of Tsubaki Island in January 201

Trophic cascade

Material flow

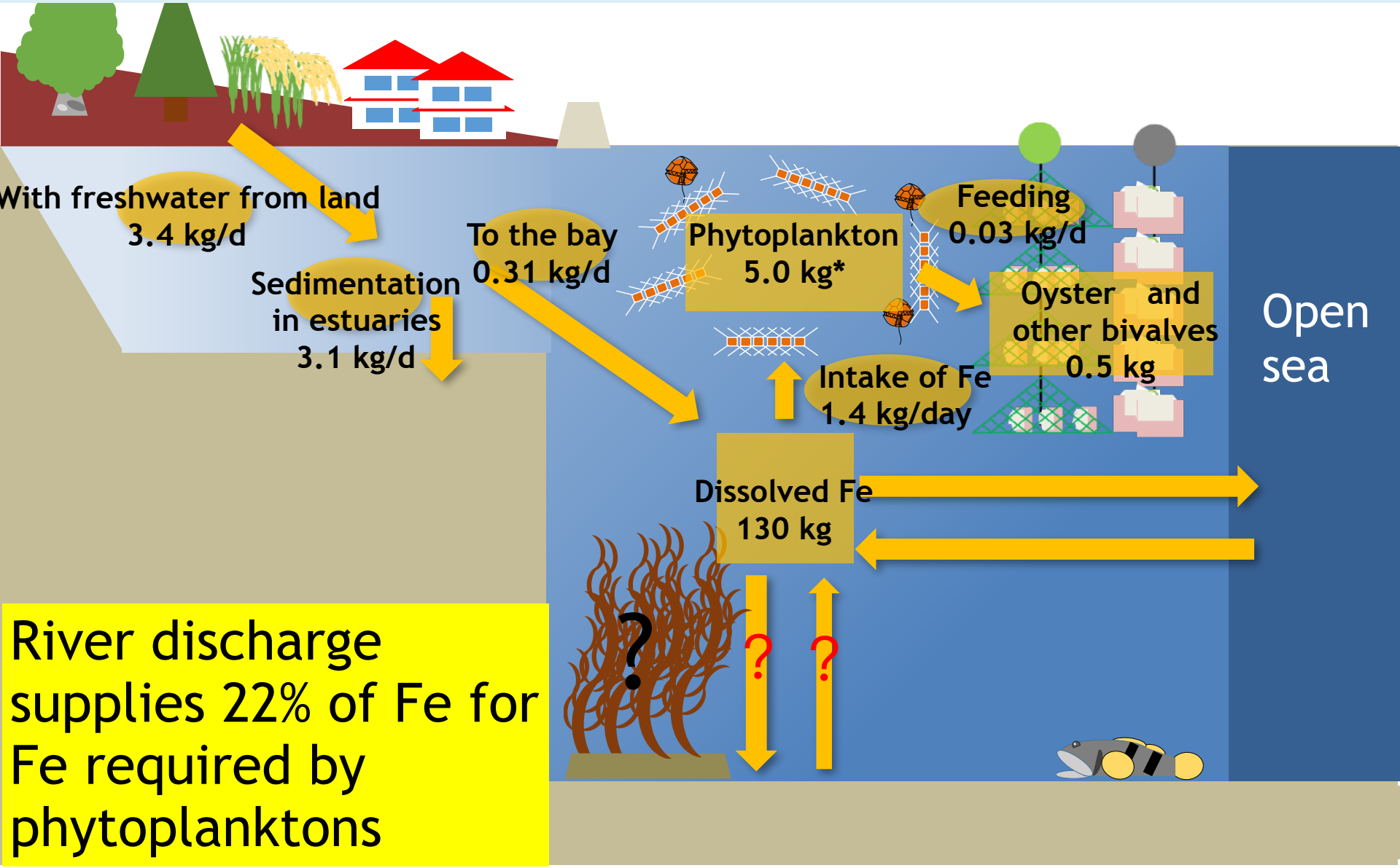
Preliminary overview on standing stocks and flux of nutrients in inner area of Shizugawa Bay in October 2015

DIN controls primary production



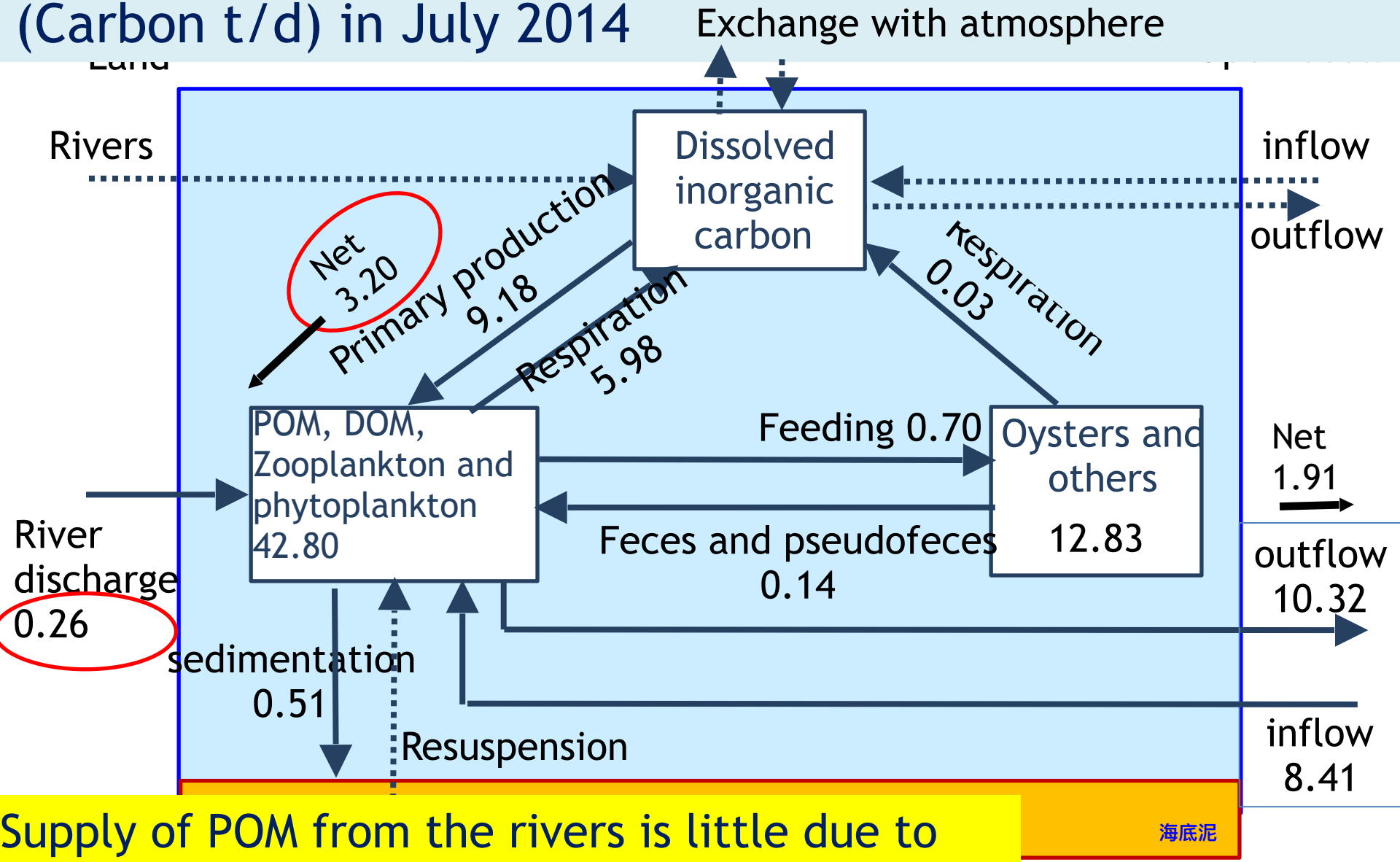
DIN from the rivers is a quarter of that from the open sea
DIN from oyster is 7% of its standing stock in the bay

Preliminary overview of standing stock and flux of Fe in inner area of Shizugawa Bay in July2014



River discharge supplies 22% of Fe for Fe required by phytoplanktons

Preliminary overview of particulate organic matter (Carbon t/d) in July 2014



Supply of POM from the rivers is little due to small quantity of water discharge Primary production is the most important for POM

Standing stock: t

flux: t/d

Model development

Co-design of future scenario with fishermen's cooperative

Reproduction and prediction of marine environments in Shizugawa Bay by using ecological simulation

Co-design with Fishermen, administrators of Minami-Sanriku Town and Miyagi Prefecture and us

Reproduction：

Marine environments before and after the tsunami for tuning the model

Prediction：

Number of rafts and their deployment, and land use including forests for examining sustainable fisheries to harmonizing healthy marine environments

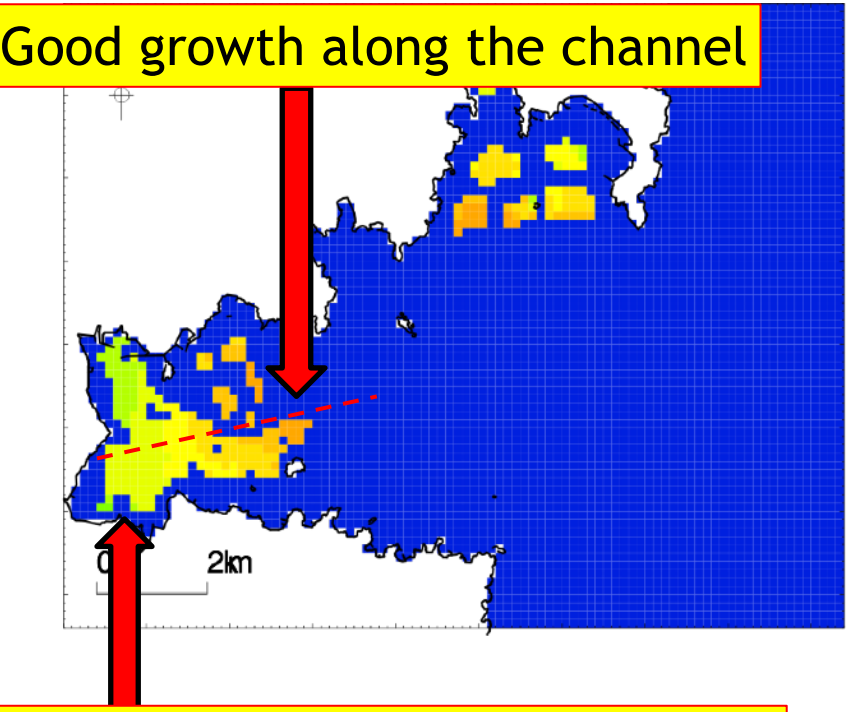
Co-design: discussion for developing an ecological model of Shizugawa Bay on 14 July 2013

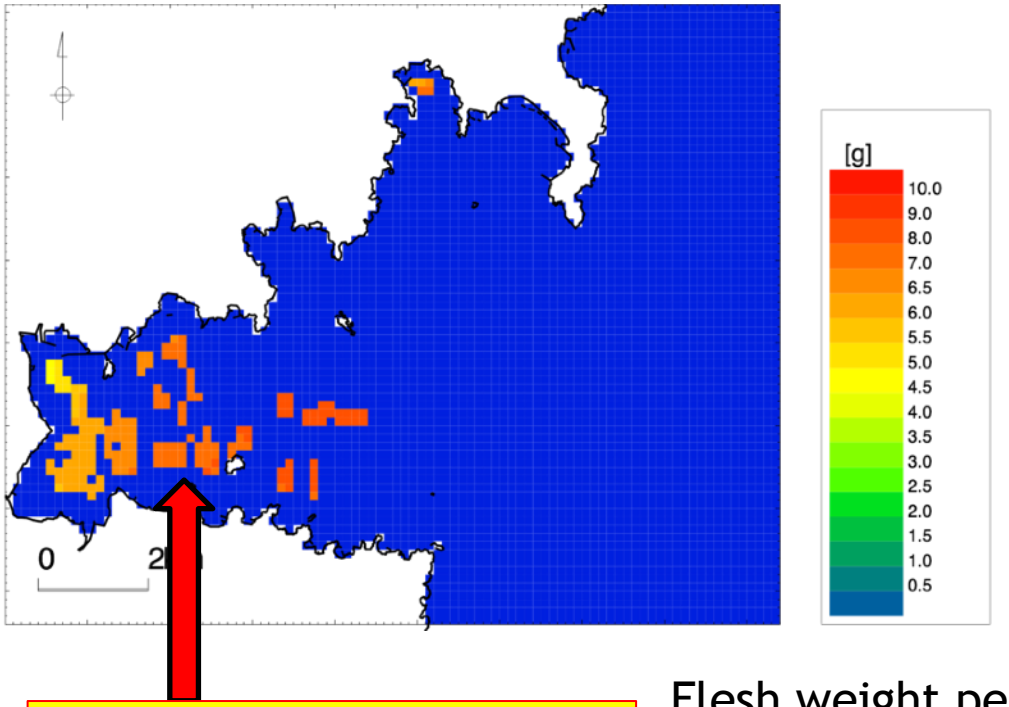
Discussion among Minamisanriku Town, Shizugawa Bay Management Committee of Miyagi Fisheries Cooperative to explore the number of rafts and deployment for sustainable aquaculture and healthy marine environments

A simulation result of oyster flesh weight

One year old oyster on 1 October 2009

One year old oyster on 1 October 2014



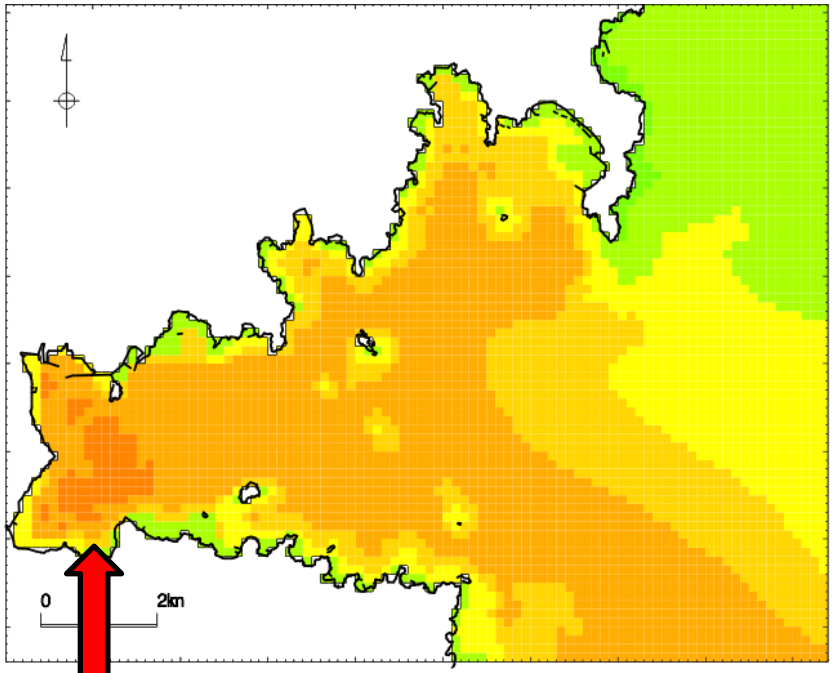


in 2009 before the reduction of oyster aquaculture

in 2014 after the reduction of oyster aquaculture

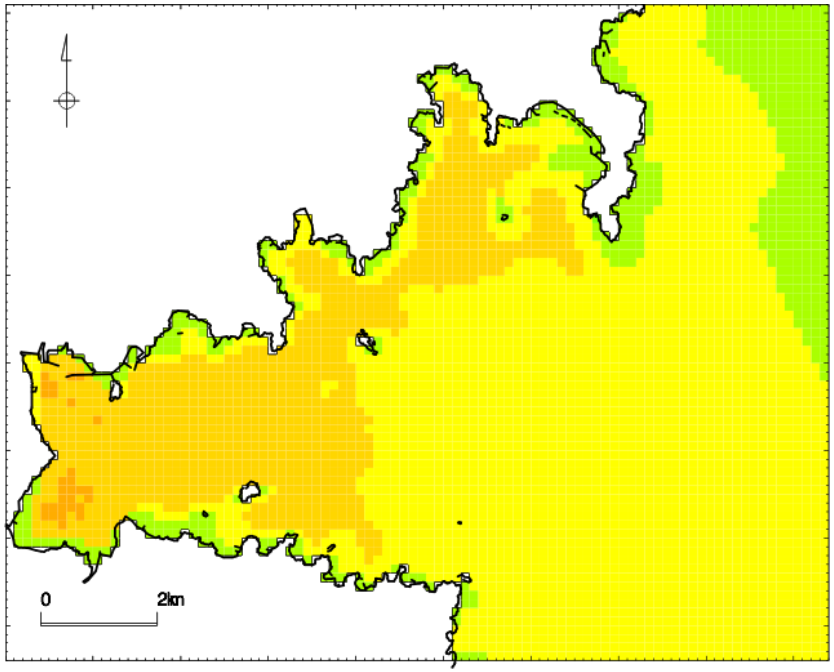
Dissolved oxygen contents in a bottom layer

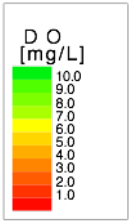
Before the tsunami
on 15 September 2009



DO is less than 4mg/L

After the tsunami
on 15 September 2014





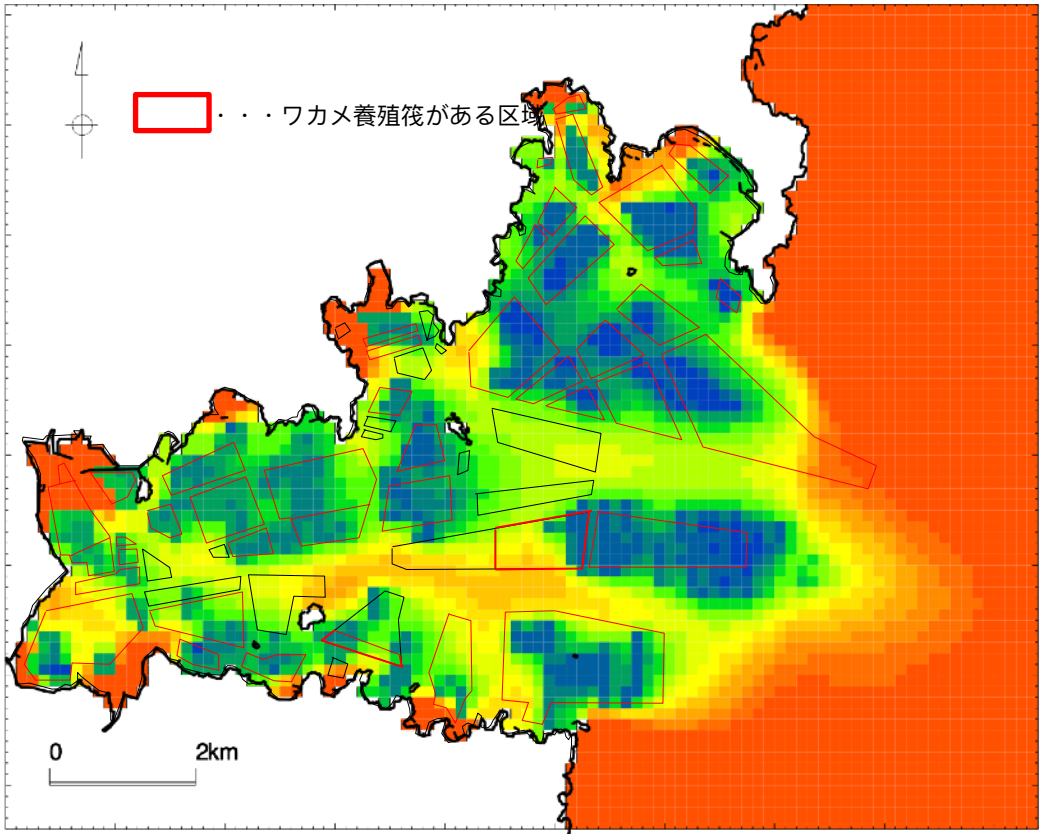
No low DO area is observed

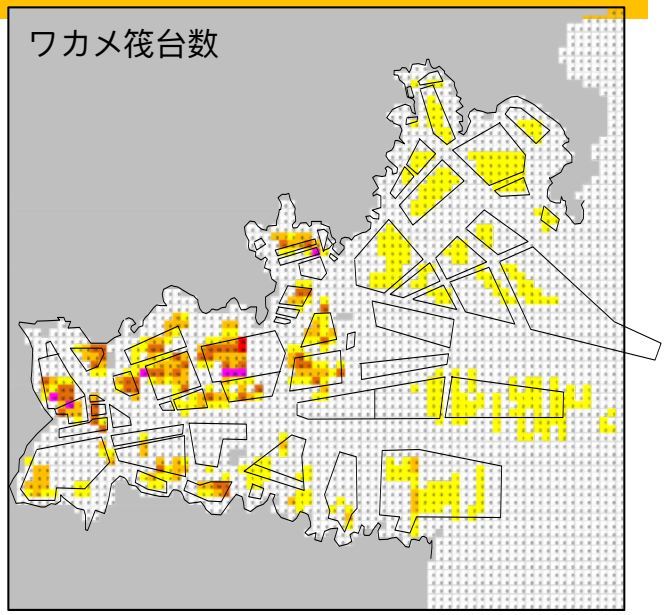
DO droped in summer before the tsunami

※環境省「水質汚濁に係る生活環境の保全に関する環境基準の見直し」によると、**底層DO（溶存酸素量）が4mg/L以下になると、貧酸素への耐性の低い生物の生息に影響が出る可能性あり**

現在の海水中の窒素（ＤＩＮ）濃度

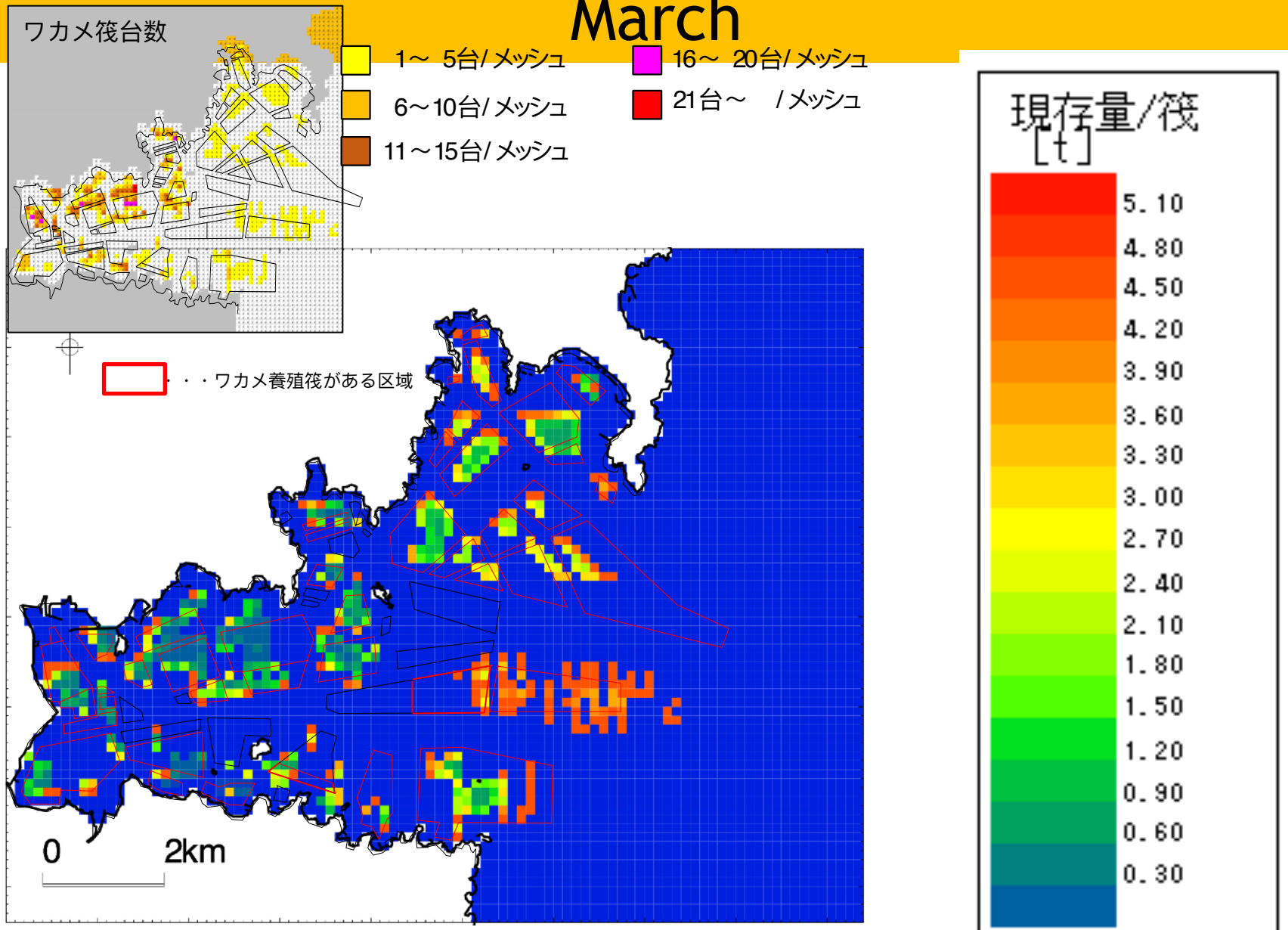
DIN濃度平面図（３月平均：表層）





ワカメ色落ち基準（文献値）
0.028mg/L（2.0μM）
ワカメＤＩＮ半飽和定数
0.011mg/L（0.8μM）

Potential of wakame production per raft in March



Scenarios

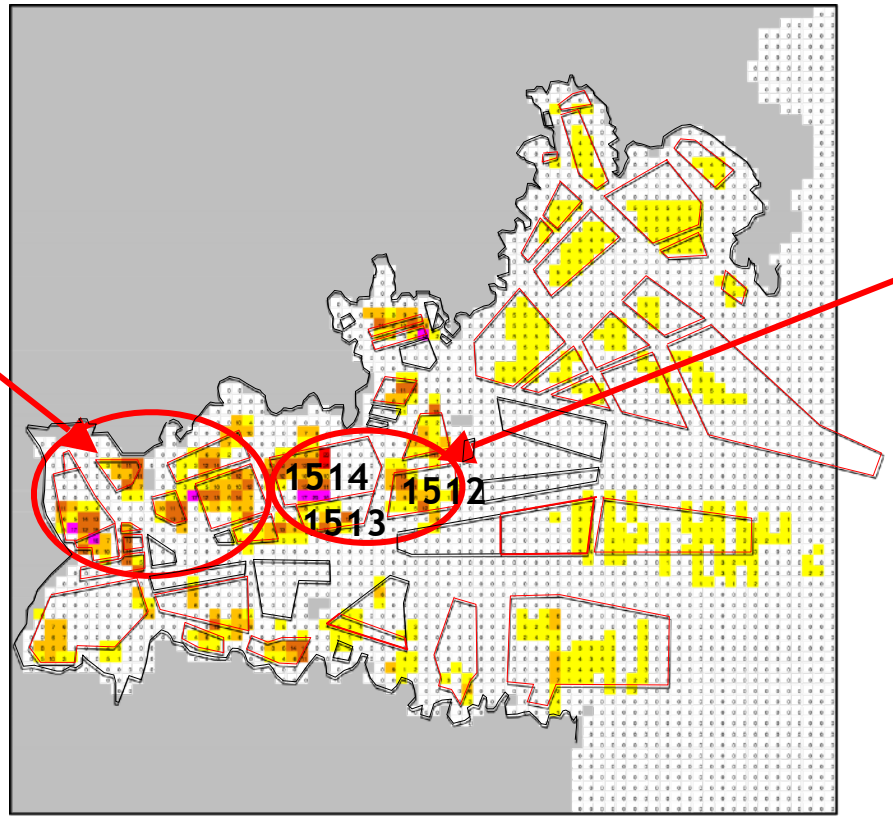
Case 1 reduce Wakame rafts to 75% in the bay head
reduce of ascidian and scallop rafts to 75% and convert 25% to wakame rafts in the bay center area

Case 2 reduce Wakame rafts to 50% in the bay head
reduce ascidian and scallop rafts to 50% and convert 50% to wakame rafts in the bay center area

Case 3 reduce Wakame rafts to 25% in the bay head
reduce ascidian and scallop rafts to 25% and convert 75% to wakame rafts in the bay center area

Bay head area

Reduction of wakame rafts

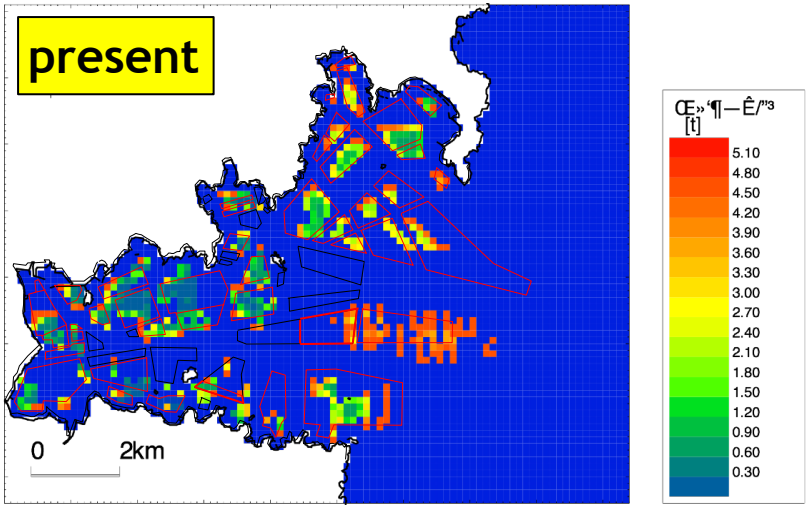


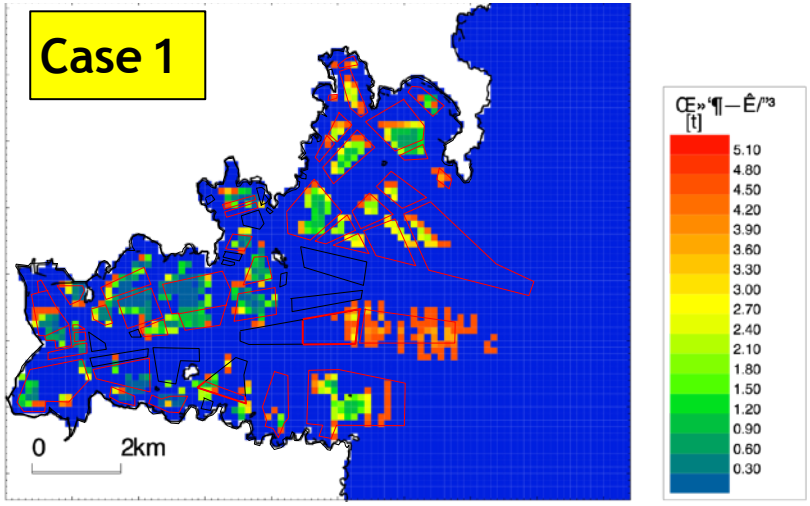
Central bay area

Ascidian and scallop rafts are convert to wakame rafts

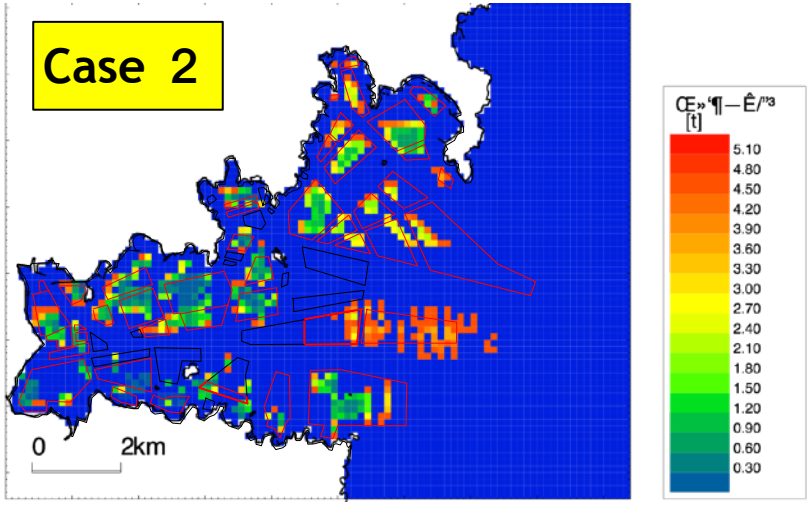
results

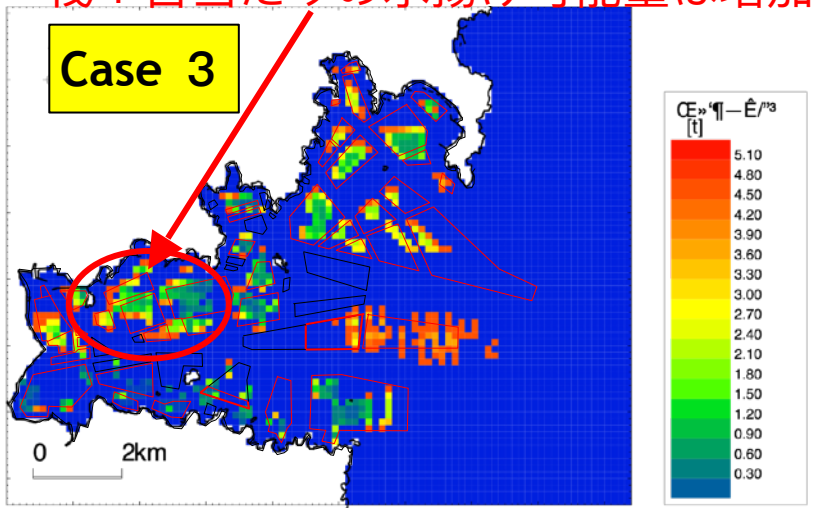
Potential wakame production per raft in March





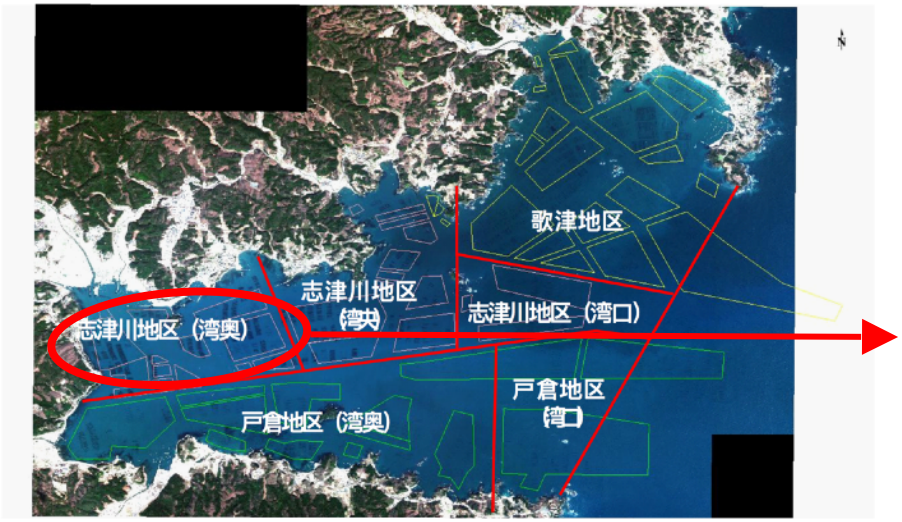
筏１台当たりの水揚げ可能量は増加



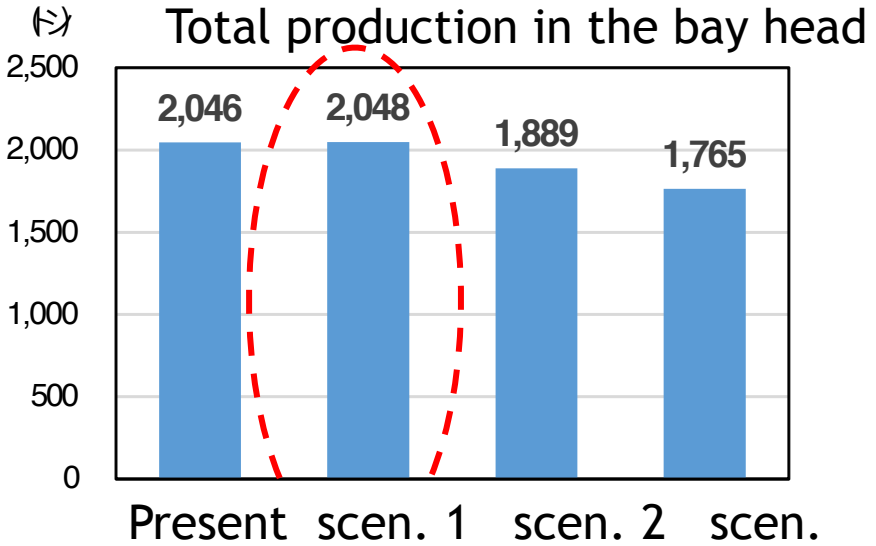


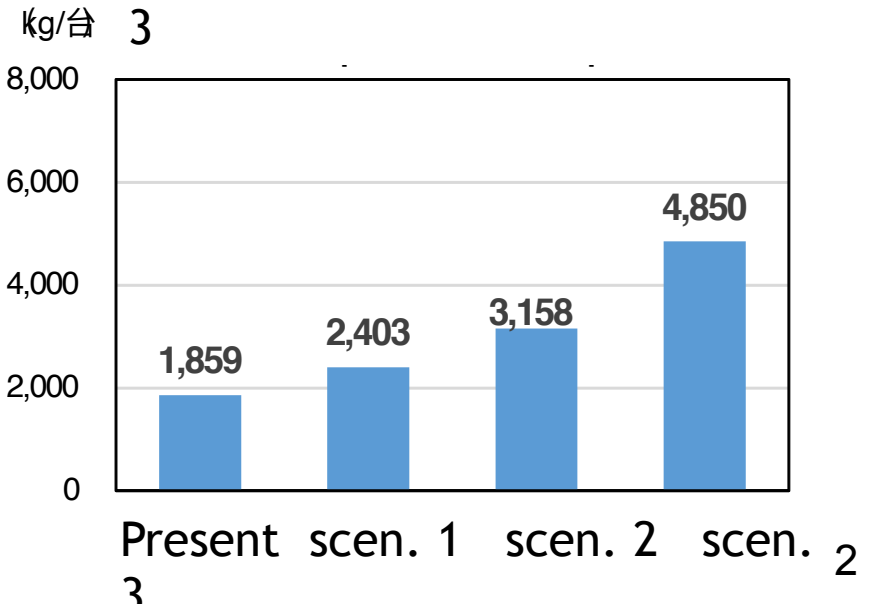
Results: potential production of wakame in the bay head

ワカメの水揚げ可能量の変化：志津川地区（湾奥部）



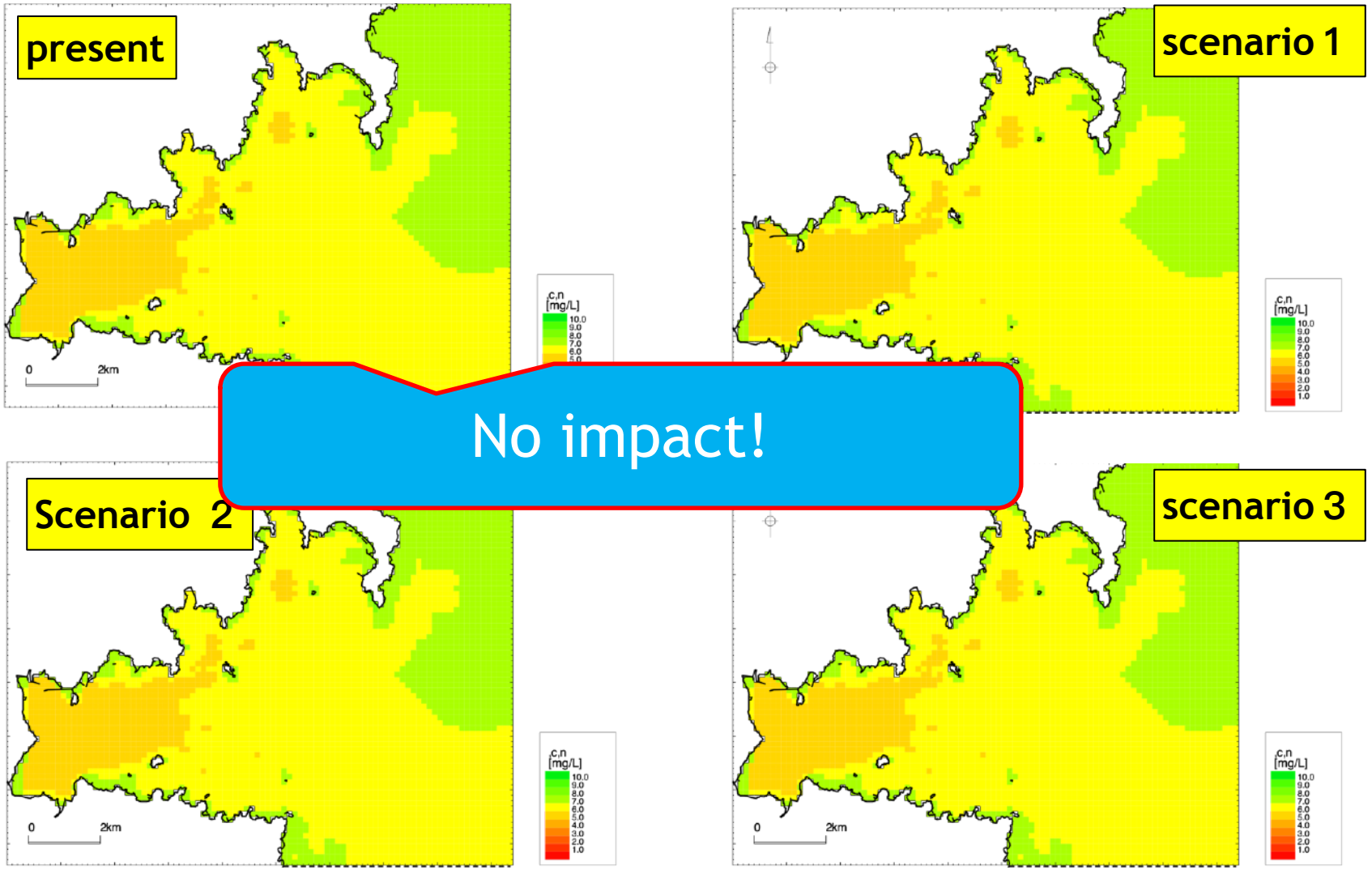
Reduction to 75% doesn't change the total production





Predicted DO in the bottom layer

Minimum of DO in a year



Council for examination of future Shizugawa Bay

Sharing results with fishermen, local government officers

The first council for examination of future Shizugawa Bay

1．Date　30 April 2015

2．Place　Public hall of Shizugawa Town

3．Organizer　Committee for examination of future Shizugawa Bay

4．Participants：16 fishermen, 3 cooperative officers, 3 Miyagi Prefecture officers, 2 Minami Sanriku Town officers, 1 journalist, 1 WWF officer and 10 researchers

5．Objective　Introduction of project of Shizugawa Bay Research and discussion on the research results and environments of Shizugawa Bay in the future

The second council for examination of future Shizugawa Bay

1．Date　19 May 2016

2．Place　Conference room of Shizugawa Branch, Miyagi Prefectural Fisheries Cooperative

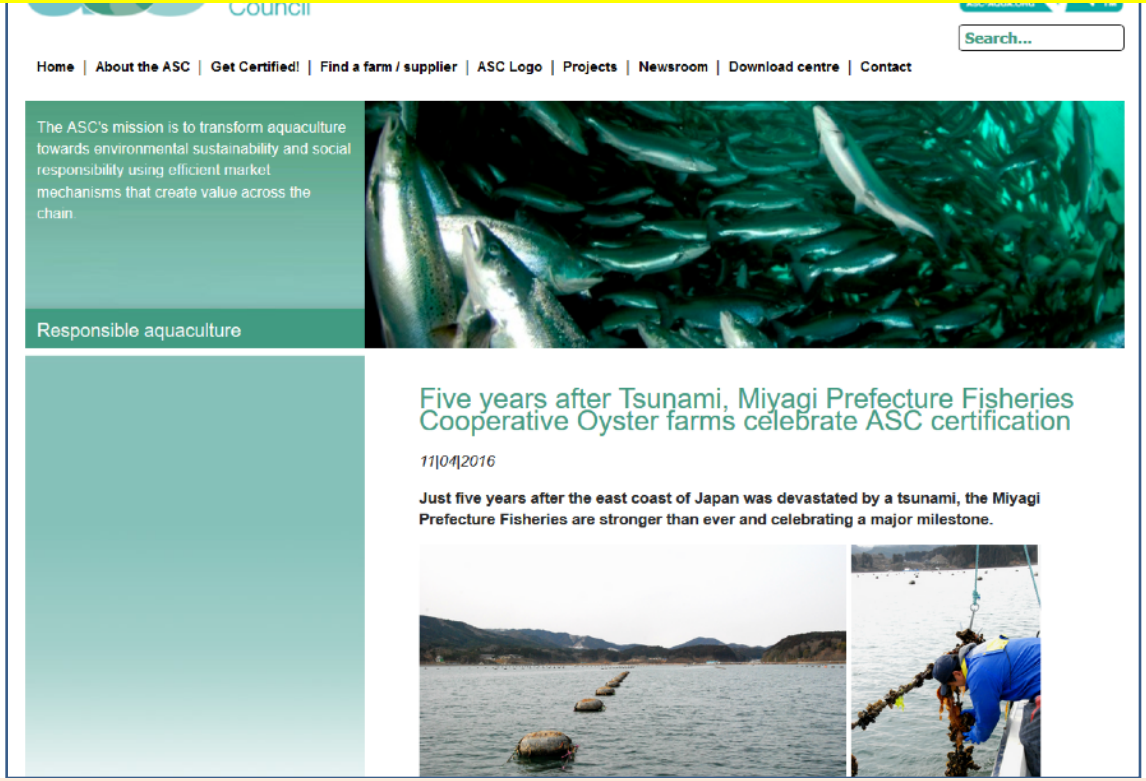
3．Organizer　Council for examination of future Shizugawa Bay

4．Participants：　6 fishermen, 3 cooperative officers, 2 Miyagi Prefecture officers, 1 Ministry of Environment officer, 1 Ishinomaki City officer, 1 WWF officer and 11 researchers

5．Objective　Introduction of project of Shizugawa Bay Research and discussion on the research results, environments of Shizugawa Bay in the future and ASC certificate with marine environments.

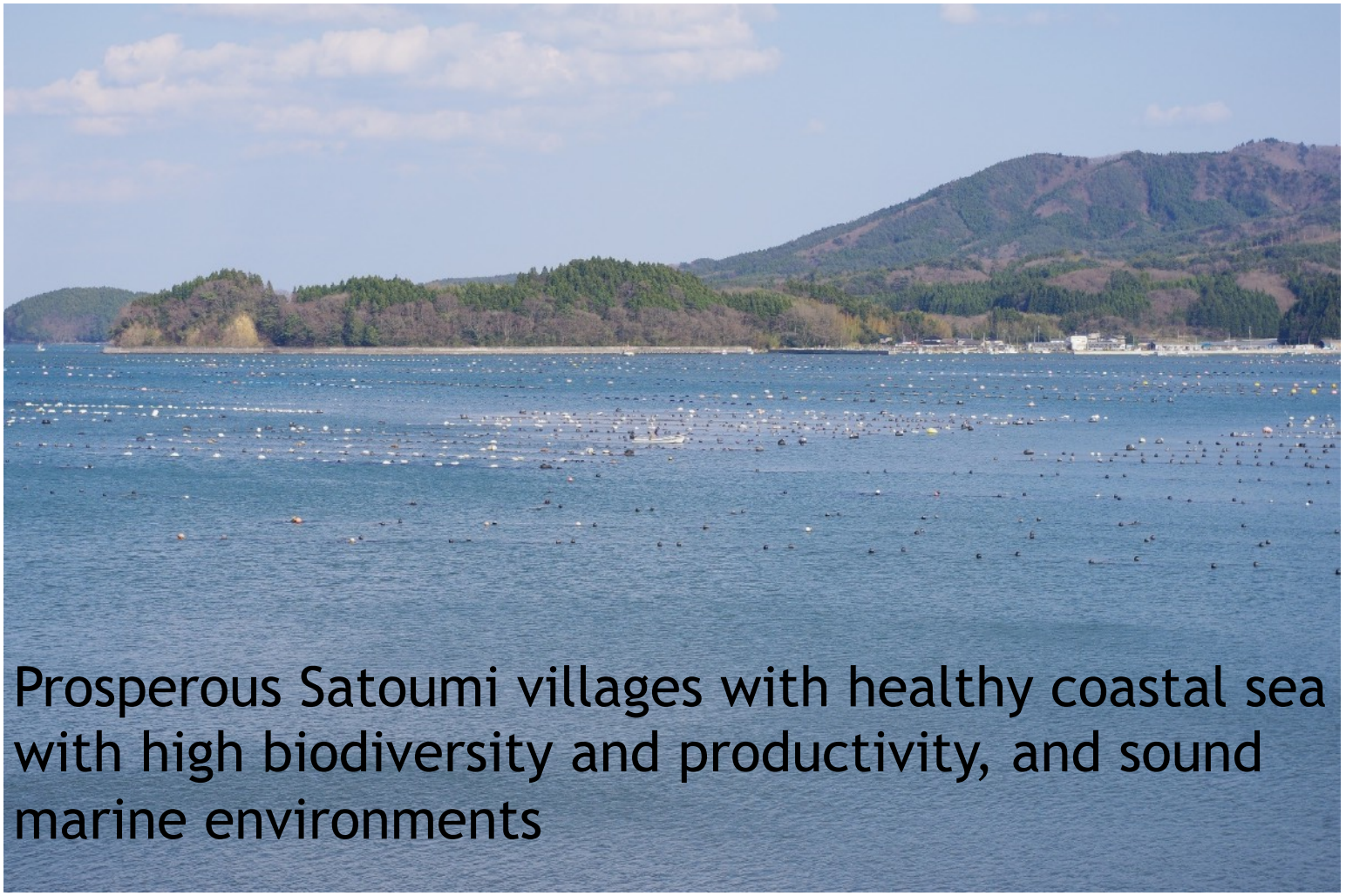
Co-design, co-production, co-delivery

Co-production with Fishermen's Cooperative and W W F



Providing rafts and environment data for acquisition of ASC certificate pproving sustainable aquaculture and respect for healthy environments

Merci beacoup!
Thank you very much!



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