The impact of climate change on the development of marine aquaculture: a case study on Japanese scallop aquaculture in Funka Bay, Hokkaido, Japan

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Contents

- Introduction
  - Japanese scallop aquaculture
  - Climate change prediction

- Methodology
  - Original suitable site model
  - CC prediction model

- Results and discussion
  - Original suitable sites model
  - CC prediction model

- Conclusion
Japanese scallop culture

- 30 species of scallop harvested in the world and 20 species are cultured (Bourne, 2000)
- Japanese scallop is the dominant species
- Japan 2\textsuperscript{nd} world producers
- Scallop cultivated: in the north part of Japan.
- Aquaculture: 40% scallop productions (MAFF, 2005; FAO, 2007)

![Production chart showing scallop species contributed to production]

- Patinopecten (Mizuhopecten) yessoensis 75.9%
- Patinopecten megellanicus 13.2%
- Zygoclamis patagonica 3.8%
- Pecten maximus 2.3%
- Argopecten purpuratus 2.2%
- Others 2.6%

![Map showing locations of scallop cultivation in Japan]
Sustainable scallop culture

Ideal habitat & Environmental condition

Monitoring program

Climate change

Scallop aquaculture

CCRF: Code of Conduct for Responsible Fisheries
EAA: Ecosystem Approach for Aquaculture
Future changes in surface temperature for the end of the 21st century

Possible impacts on the productivity across the coastal and marine systems (Beukema and Dekker, 2005; Harley et al., 2006; Baba et al., 2009)
Objective

To examine the potential impact of climate change on the development of scallop aquaculture

Investigate the indirect impact of CC on suitable sites of scallop aquaculture
Characteristic of the study area

- Depth, maximum 107 m and mean 38 m
- 2315 km\(^2\) surface area, and a 195 km coastline
- Water replace 2 time a year: OW & TW
Methodology

ORIGINAL MODEL

- Satellite
- Map (analog and digital)

Spatial data construction

Criteria map construction (Factors and constraints)

Score and weight determination; GIS models

Suitable site of scallop aquaculture

CLIMATE CHANGE PREDICTION MODELS


Predicted models

- Increased SST 4°C (A1FI)
- Increased SST 2°C (B2)
- Increased SST 1°C (B1)

SeaWiFS Data

- Chl-a
- NLw555 - SST

Spatial data

- Bathymetry
- Scallop larvae
- Exist. scallop

Suitable site of scallop aquaculture

- Suitable site (SST 4°C)
- Suitable site (SST 2°C)
- Suitable site (SST 1°C)

A hydrographic (1:50,000)

Maps: April–July 2003

GPS data
Original model construction

- Built on hierarchical structure
- Scoring: 1 (least suitable) - 8 (most suitable)
  (Radiarta et al., 2008)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Suitability score</th>
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<tr>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Bathymetry (m)</td>
<td>&gt; 20.0</td>
</tr>
<tr>
<td>Larvae level (No./ton)</td>
<td>&gt;1000</td>
</tr>
<tr>
<td>Distance to town (km)</td>
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</table>

\[ V(x_i) = \sum_j w_j r_{ij} \]

\( w_j \) = weight, \( \sum w_j = 1 \),
\( r_{ij} \) = the attribute transformed into score (1-8)
The most preferred alternative is the maximum \( V(x_i) \) value
Scallop site selection

Goal

Submodels

Weight

Criteria

Physical

0.5

SST

0.3

SS

0.2

Bathymetry

0.6

Larvae

0.4

Chl-a

0.46

Town

0.31

Piers

0.23

Land Fac.

Constraints

Harbor

Industry

Original model construction
Original model verification

Model verification

- To determine how much the existing scallop culture matched with the suitability sites model
- By making comparisons between the suitable-sites models and existing scallop aquaculture operations
CC model construction

- Consider only change of SST values
- Assume other variables constant

Suitable sites

(IPCC, 2007)

Predicted models

SST Increased 4 °C

SST Increased 2 °C

SST Increased 1 °C
Results and discussion

Area of interest

- Suitable area based on 60 m depth → to minimize operation costs and difficulty in mooring systems
- Potential area about 1038 km² (45%)
Final original model

Scores and proportional area (%)

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<th>High</th>
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<td>0.01</td>
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<td>4</td>
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<td>6</td>
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<td>7</td>
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<tr>
<td>8</td>
<td>29</td>
<td>29</td>
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</table>
### Original model verification

#### Scores and proportional area (%)

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<th>Score</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.2</td>
<td>3.0</td>
<td>24.8</td>
<td>60.0</td>
<td>8.0</td>
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</table>

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[Map of the area with color-coded suitability scores]

Final Model
CC – Prediction model

Scenario

Suitability scores

Suitability area (%)

Original model
SST: 1 degree
SST: 2 degree
SST: 4 degree
Prediction models showed CC impact on development of scallop culture.

Continues study on the impact of climate change on the scallop aquaculture development are challenging and need further research.

Change of suitability score: 8-7 8-8
Conclusions

- Funka Bay has a potential area for scallop aquaculture development, indicated by high suitable area (≈ 30%, score 8).
- Change of surface temperature (climate change) significantly affected the suitable areas.
- Climate change impact needs to be considered for future development of marine aquaculture.
Thank you

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