Spatio-temporal model for mariculture suitability of Japanese scallop (*Mizuhopecten yessoensis*) in Funka and Mutsu Bays, Japan

*Christopher Mulanda **Aura**[1,2], Sei-Ichi Saitoh[1], Yang Liu[1] and Toru Hirawake[1]

[1]Laboratory of Marine Environment and Resource Sensing, Graduate School of Fisheries Sciences, Hokkaido University, 3-1-1, Minato, Hakodate, Hokkaido, 041-8611, Japan. [2]Kenya Marine and Fisheries Research Institute, P.O. Box 81651-80100, Mombasa, Kenya.

*Email: auramulanda@yahoo.com

W1: Identifying critical multiple stressors of North Pacific marine Ecosystems and indicators to assess their impacts

Oct. 12th 2012, Hiroshima, Japan

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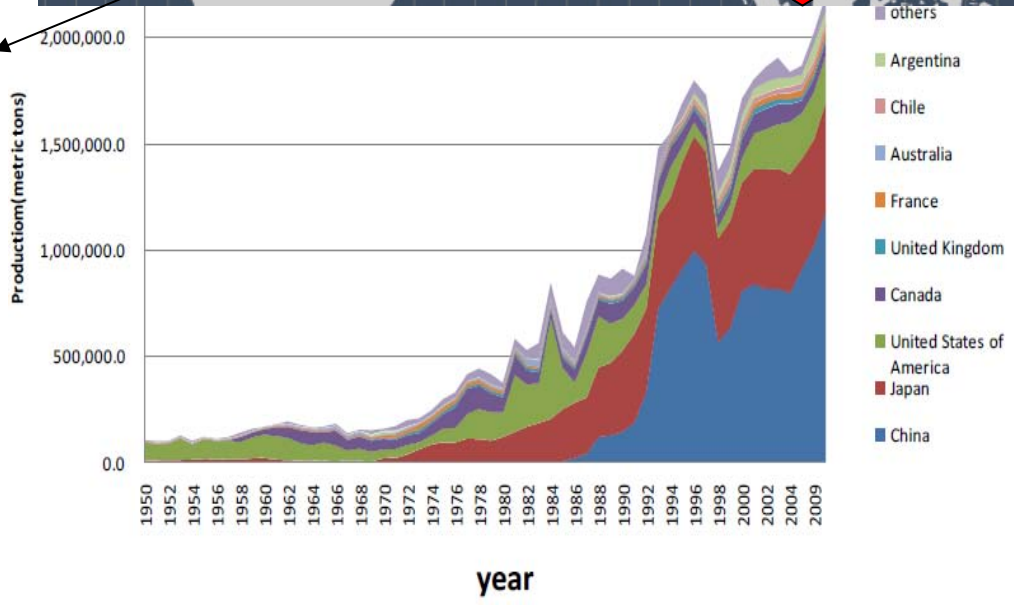
Introduction: Global & local Scallop Production

- Mainly in China and Japan (FAO 2009)!
- Over 40% of scallop production in Japan is from Aquaculture (FAO, 2009).
- It is cultivated in Japan because of its good food quality & high productivity (Ito, 1991).



Introduction

Site selection

Sustainability

Modelling

- Minimize risk of environmental load
- Solve coastal space demand
- Determine potentiality of coastal firms
- Determine indicators/stressors

Introduction

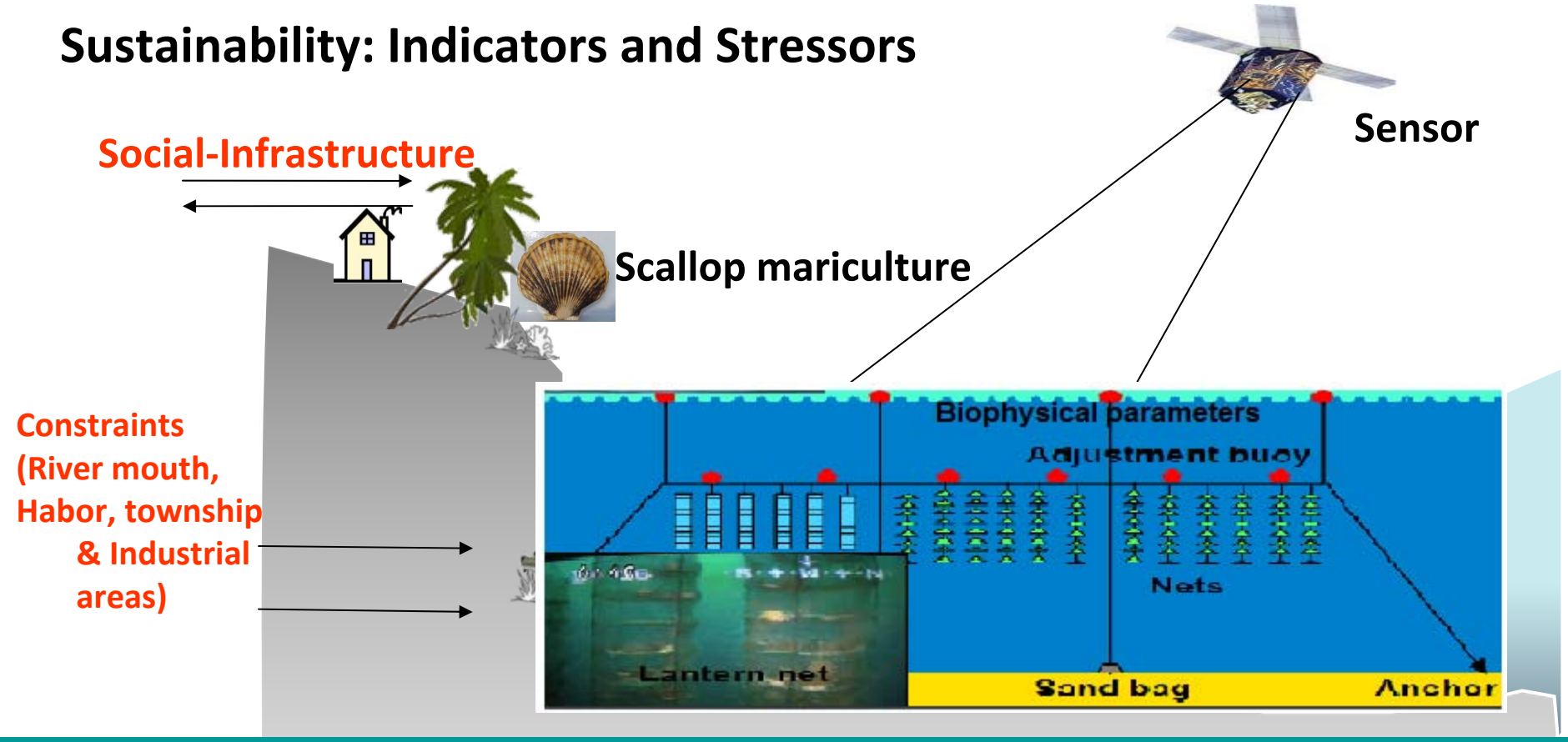
- World aquaculture vulnerable to adverse impacts of natural, socioeconomic, environmental & technological conditions (FAO, 2009).

- E.g. Marine cage culture in Chile, Oyster farming in France & Shrimp farming in Mozambique had high mortality-loss of production (FAO, 2009).

- Funka & Mutsu are semi-enclosed bays, in same eco-region, similar types of currents, hanging scallop mariculture facing competition from other ventures & in rapid growth.

Objective

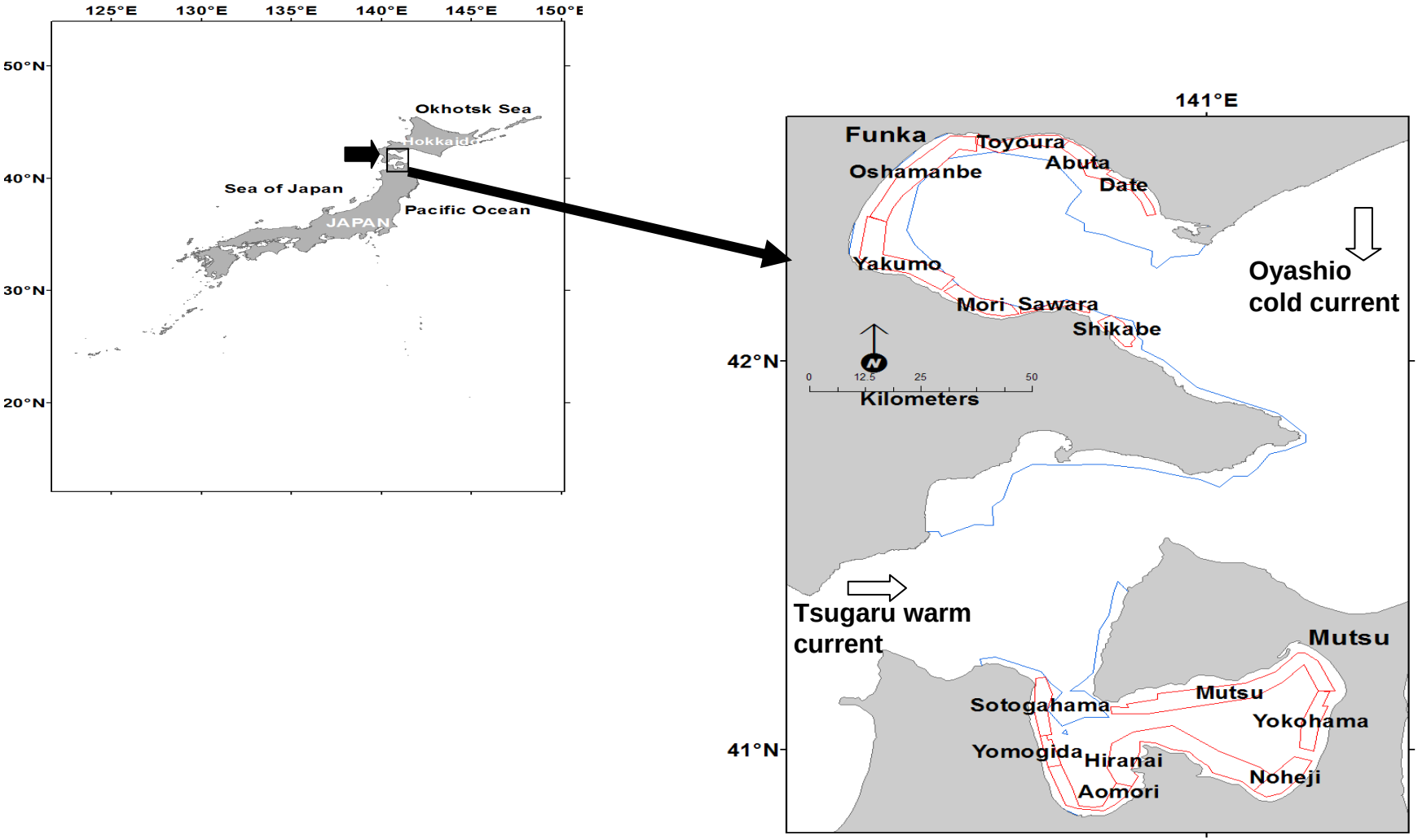
Sustainability: Indicators and Stressors



To develop & assess the spatio-temporal models using coastal ecosystem indicators and stressors for scallop mariculture suitability in Funka & Mutsu Bays' ecoregion.

Materials and Methods

Study Area



Dominant scallop sites

≤60 m delineation

Suitability Model

Parameter	Type of Data	Resolution	Source of Data
Chlorophyll-*a*	Satellite	1 km	MODIS/Aqua
Sea surface temperature	Satellite	1 km	MODIS/Aqua
Secchi disk depth (*SDD)	Satellite	1 km	Kd490 (MODIS/Aqua)
Bathymetry	Digital	150 m	JODC
Social-infrastructure/constraints	Satellite	10 m	ALOS AVNIR-2 2011
Scallop production	Analog/digital		Funka = MARINENET HOKKAIDO Website Mutsu = Aomori Prefecture website

***SDD =1.04 x $K_d(490)^{-0.82}$**

[Chen et al., 2007.]

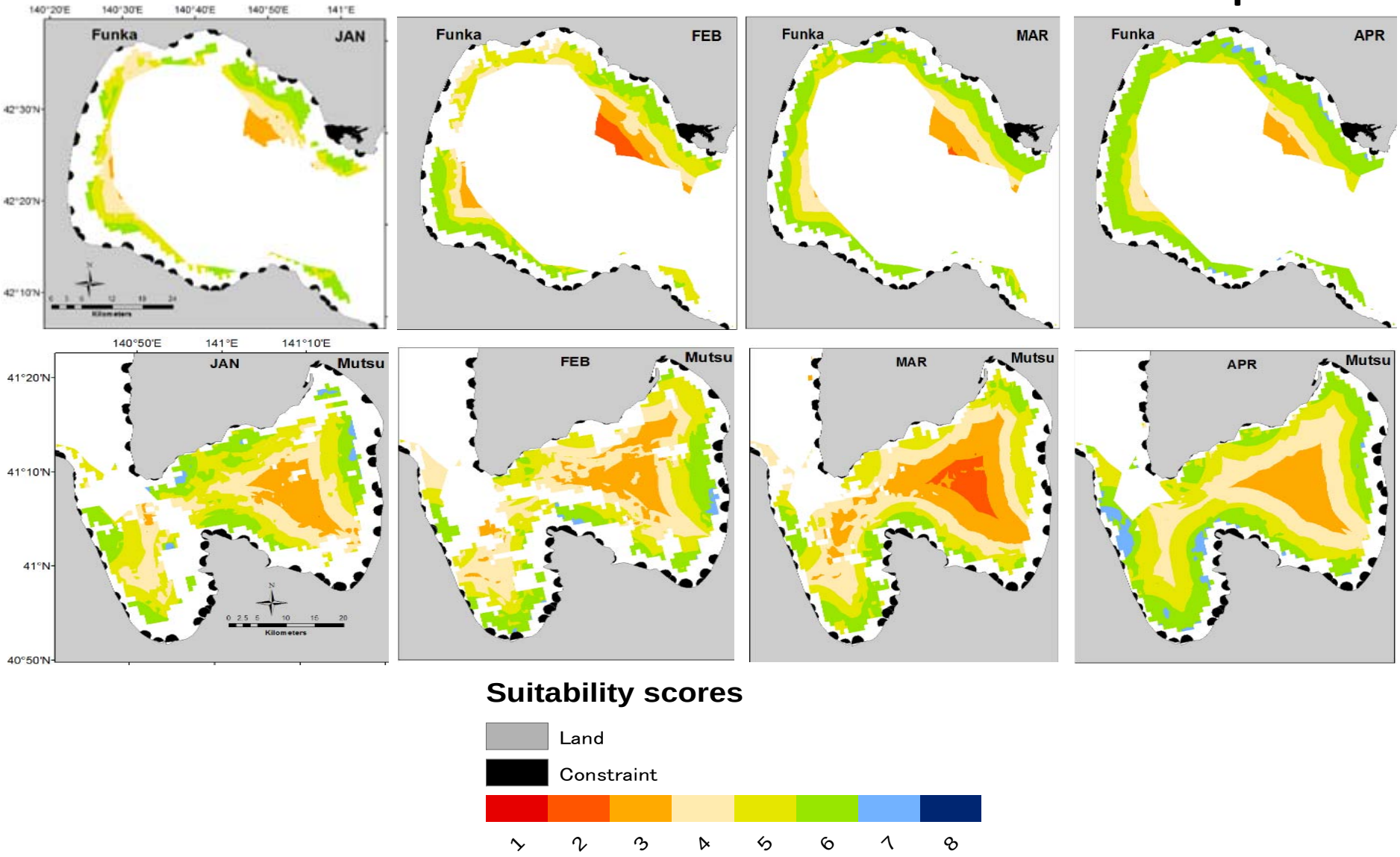
w_j = weight, $\Sigma w_j = 1$,

r_{ij} = **attribute** transformed to **spatial score** (**1-8**)

Most preferred alternative is maximum *V*(*xi*) value

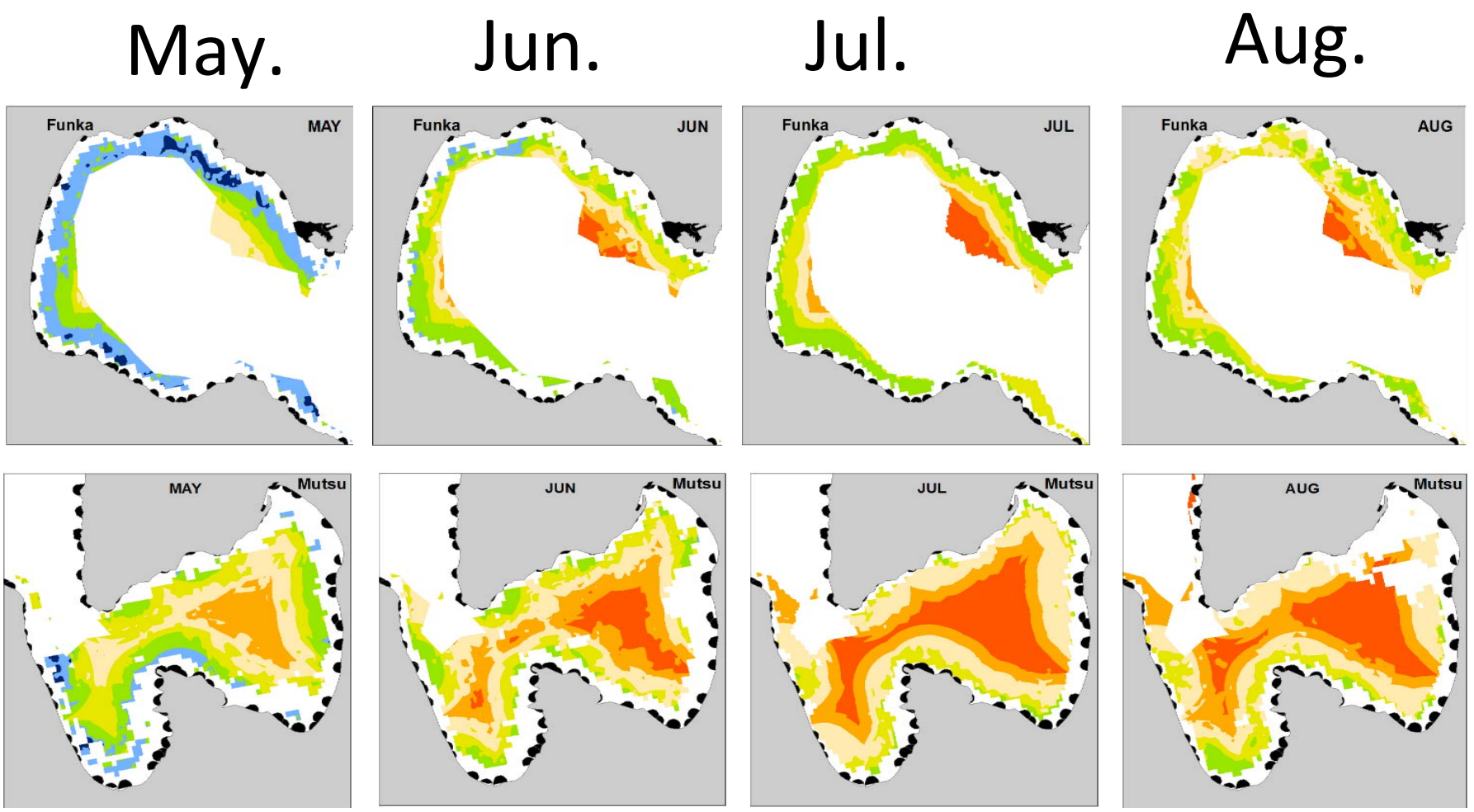
Results and Discussion: Monthly Model Example

2009 monthly model

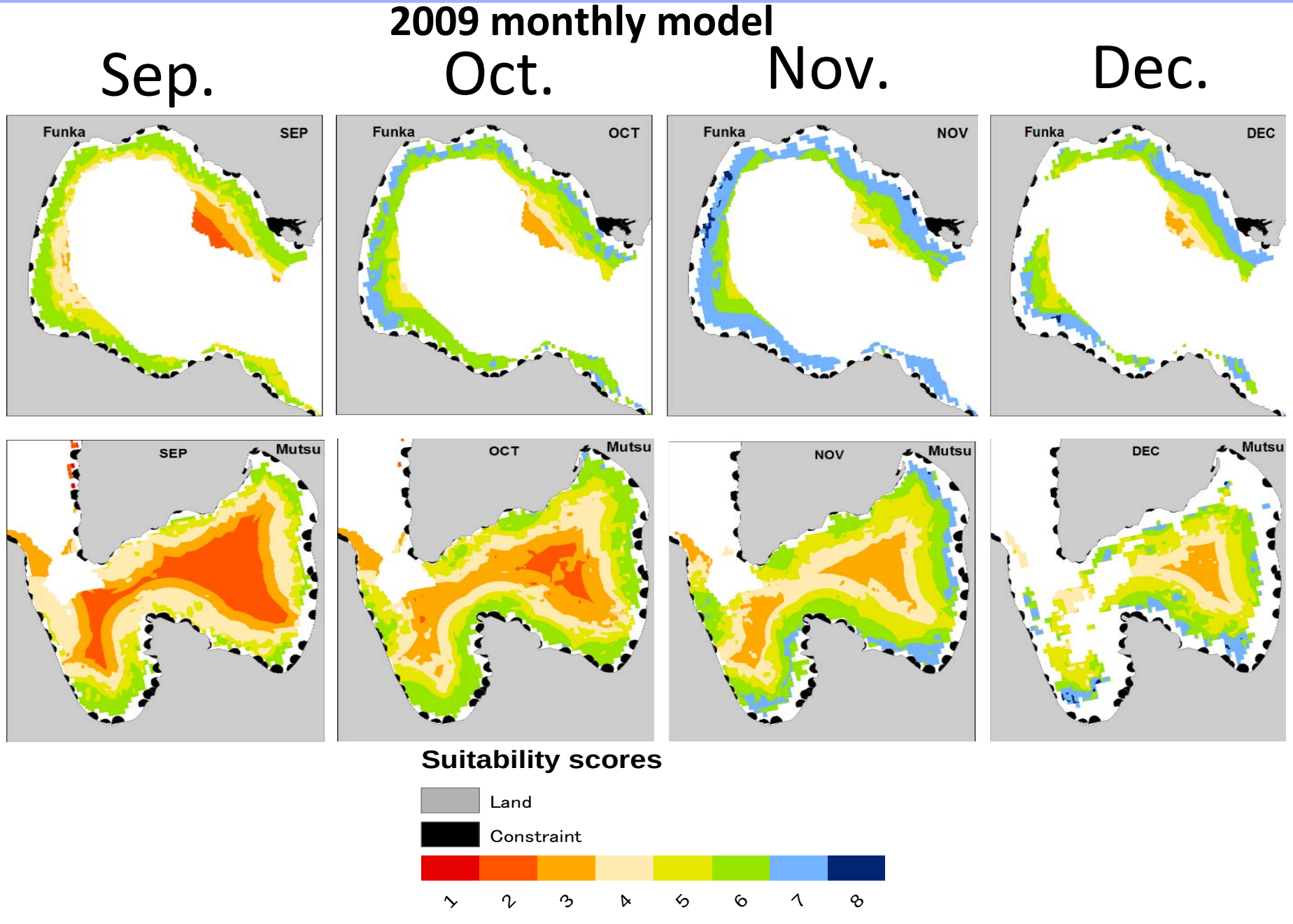


Results and Discussion: Monthly Model Example

2009 monthly model

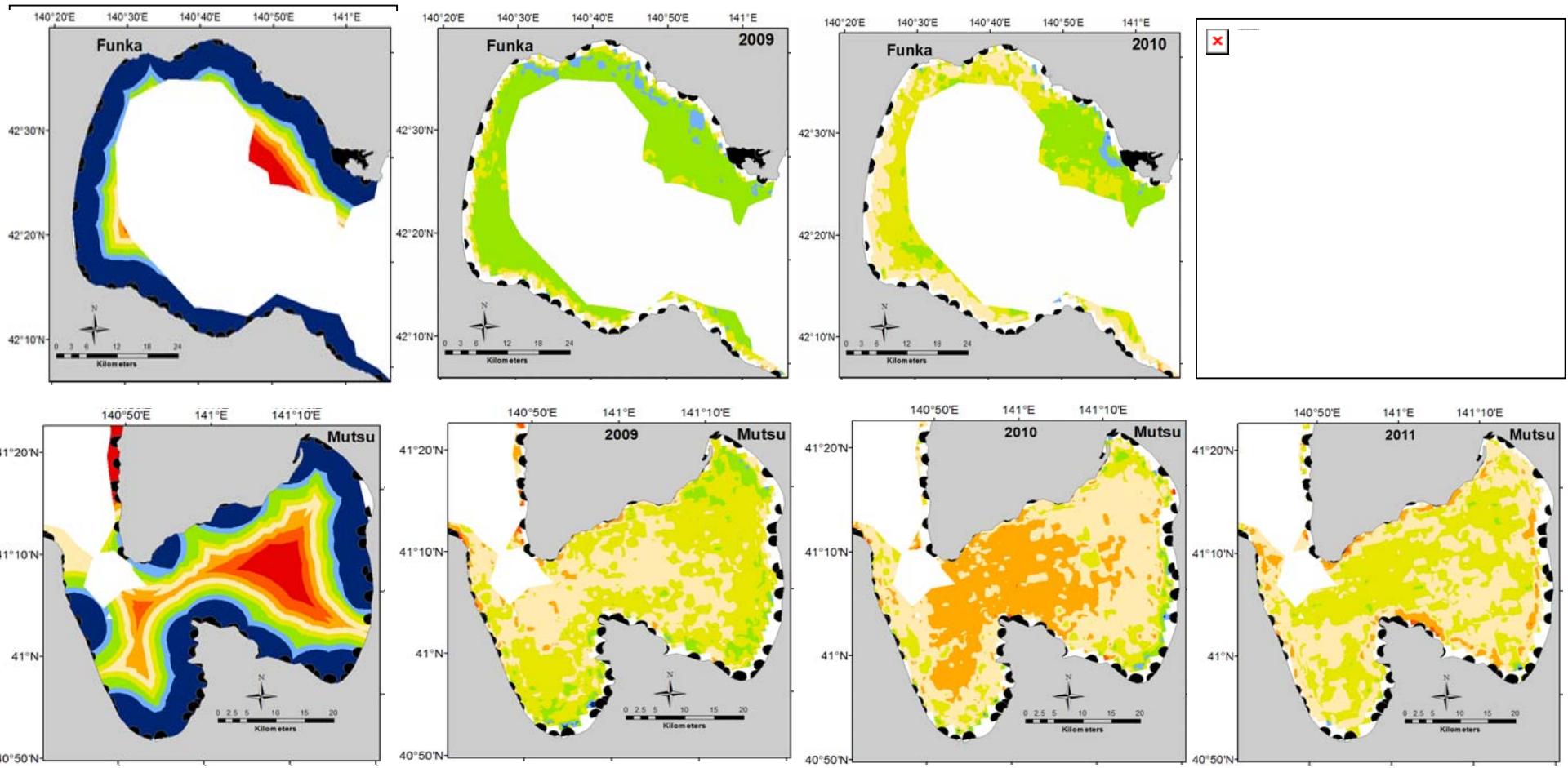


Results and Discussion: Monthly Model Example



Biophysical and Socio-infrastructure Sub-models

2008 2009 2010 2011



Suitability scores

Land

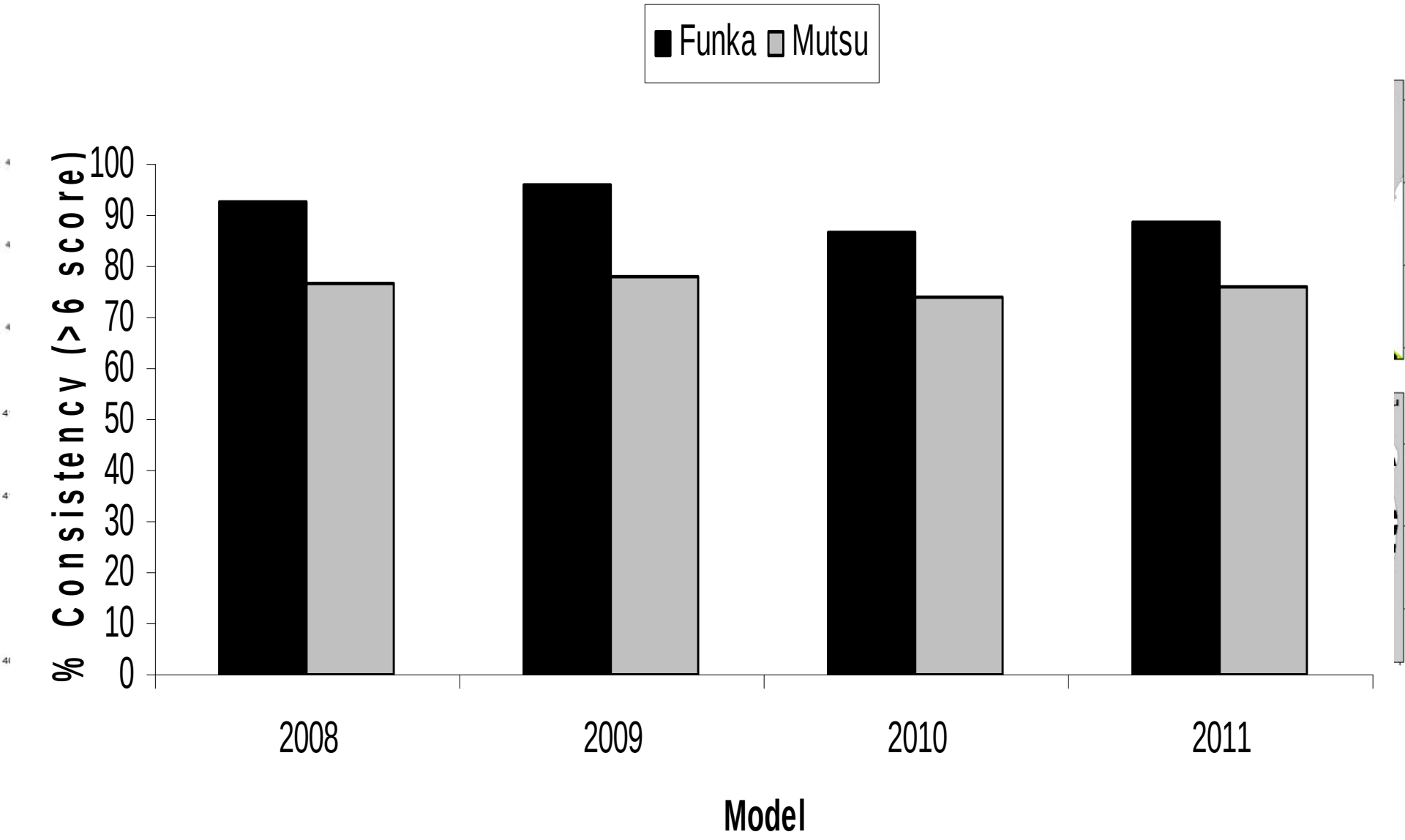
Constraint

1 2 3 4 5 6 7 8

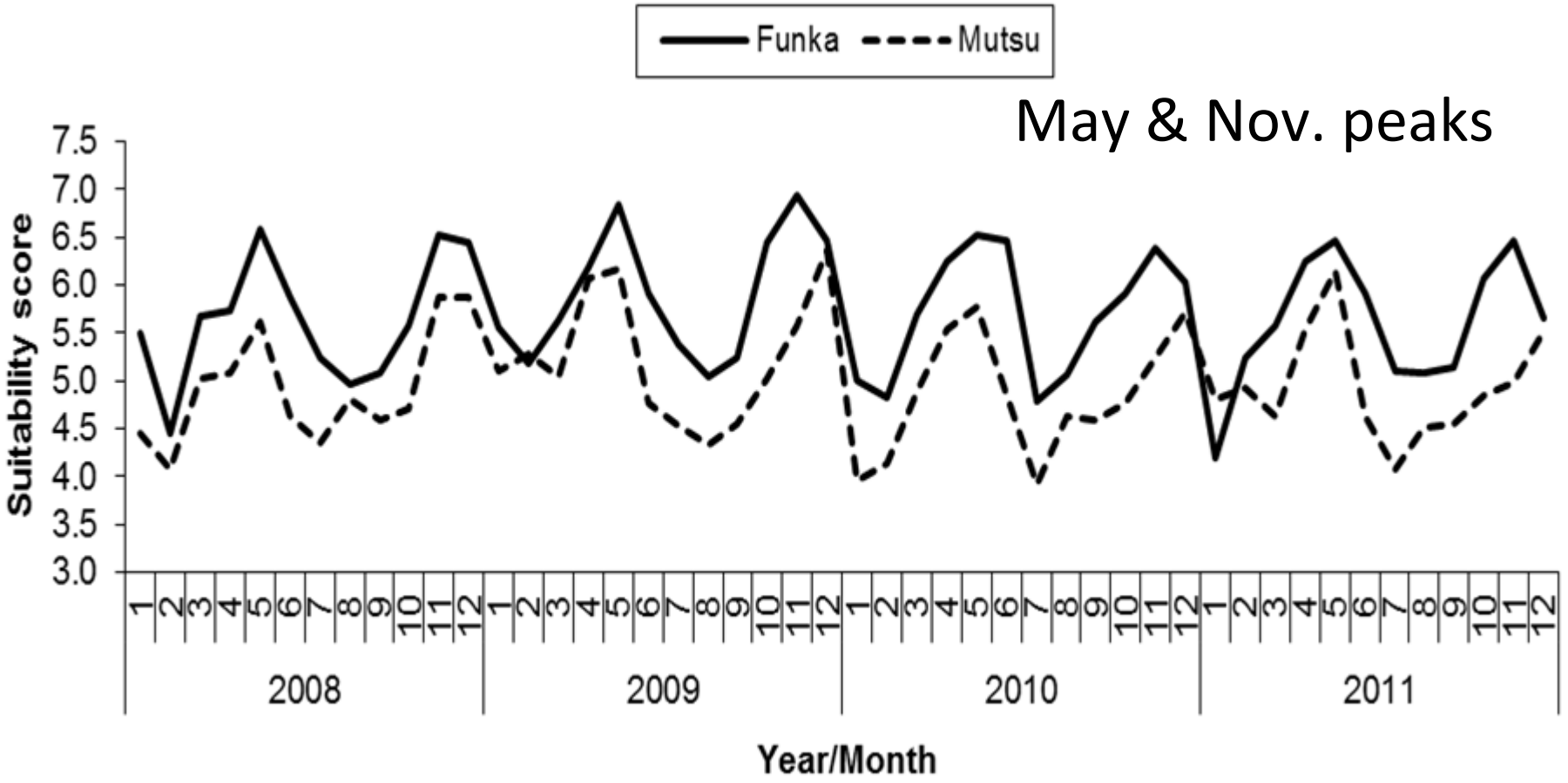
Funka = 53.1%

Mutsu = 55.7%

Final models and Validation

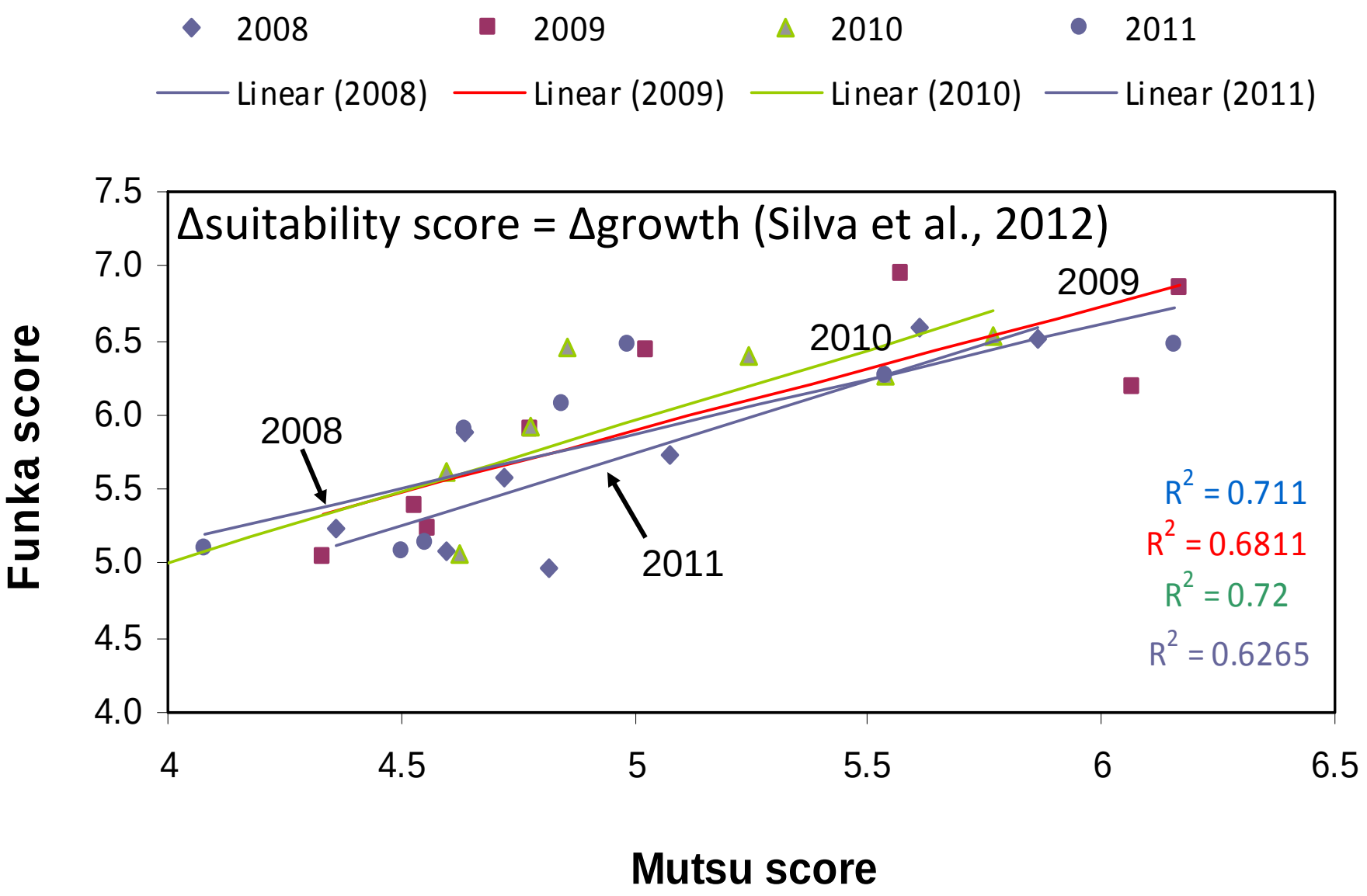


Period with greatest impact on scallop growth?



Area (Km^2)	Funka	Mutsu
Potential area	1024	856
Constraints	265	250

Scallop growth variation (Apr-Nov)?



Indicator/Stressor/Model performance

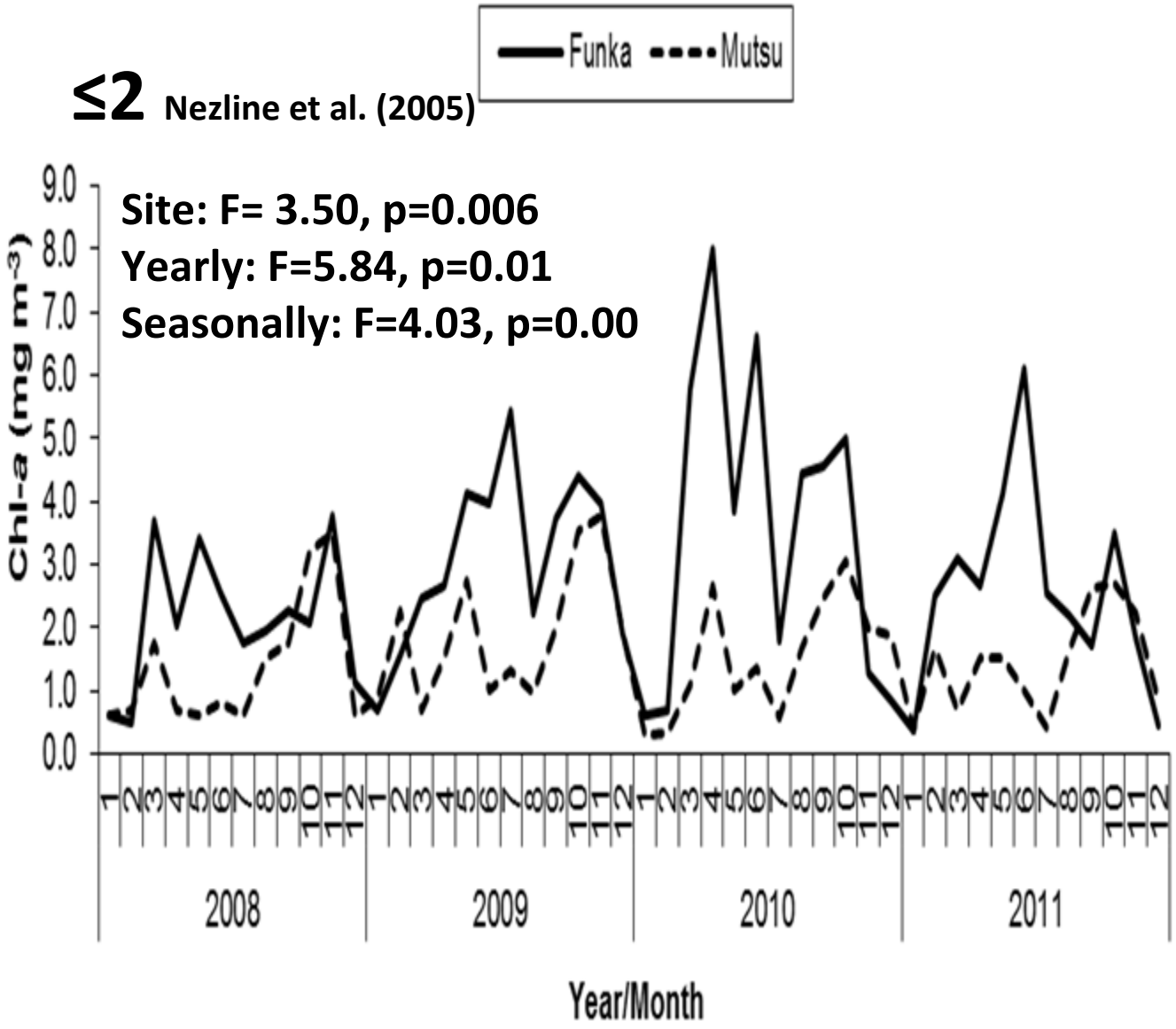
Model/parameter % of potential area													
Score	Model	SST		Chl-*a*		SSD		Depth		Soc-inf		Overall	
		F	M	F	M	F	M	F	M	F	M	F	M
1	2008	8.7	8.9	0.1	0.9	73.3	75.7	2.1	1.7	4.7	3.5	0.0	0
	2009	6.7	7.1	0.0	1.4	57.4	66.6	2.1	1.7	4.7	3.5	0.0	0
	2010	15.8	16.3	0.1	1.7	54.8	71.5	2.1	1.7	4.7	3.5	0.0	0
	2011	12.4	12.0	0.1	0.0	61.5	59.8	2.1	1.7	4.7	3.5	0.0	0
2	2008	4.5	4.8	0.3	0.7	14.4	13.7	2.0	1.4	3.6	1.9	0.5	0
	2009	3.6	3.8	0.1	0.4	22.7	23.4	2.0	1.4	3.6	1.9	0.4	0
	2010	14.8	16.1	0.2	0.3	25.4	24.6	2.0	1.4	3.6	1.9	1.1	0
	2011	5.4	6.0	0.2	0.2	24.2	27.5	2.0	1.4	3.6	1.9	0.1	0
3	2008	16.4	16.3	11.6	10.5	5.3	7.7	2.2	1.1	5.4	4.2	10.7	11.5
	2009	6.5	7.2	1.2	1.5	9.4	12.6	2.2	1.1	5.4	4.2	6.3	6.9
	2010	26.3	28.6	8.5	9.1	8.6	9.8	2.2	1.1	5.4	4.2	12.7	14.5
	2011	5.4	5.6	2.8	5.4	6.3	8.9	2.2	1.1	5.4	4.2	6.1	9.4
4	2008	27.2	28.1	24.9	21.6	2.4	6.4	2.3	3.2	8.0	6.6	18.1	18.1
	2009	16.6	17.0	16.8	15.7	4.1	9.8	2.3	3.2	8.0	6.6	14.7	16.7
	2010	25.2	26.0	17.9	17.4	3.8	7.8	2.3	3.2	8.0	6.6	16.6	17.6
	2011	15.0	14.8	14.0	13.9	2.7	5.9	2.3	3.2	8.0	6.6	15.3	17.1

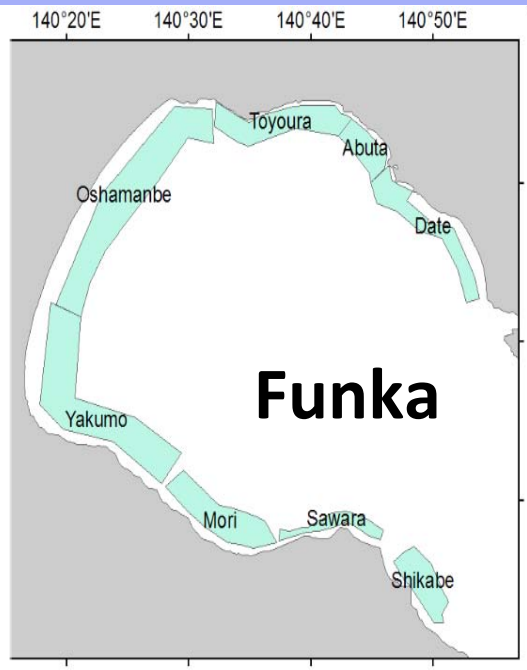
Indicator/Stressor/Model performance

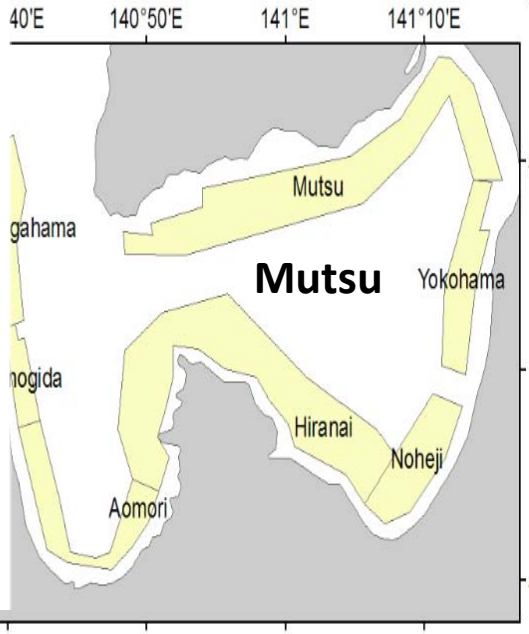
		Model/parameter % of potential area											
Score	Model	SST		Chl-*a*		SSD		Depth		Soc-inf		Overall	
		F	M	F	M	F	M	F	M	F	M	F	M
5	2008	14.4	14.0	9.6	8.1	1.5	3.2	2.5	1.5	7.2	6.2	21.9	18.3
	2009	30.1	23.0	8.3	8.9	2.2	1.4	2.5	1.5	7.2	6.2	19.6	17.5
	2010	9.6	6.6	4.5	4.1	2.5	3.7	2.5	1.5	7.2	6.2	20.1	19.3
	2011	34.6	22.1	13.4	14.2	1.4	1.8	2.5	1.5	7.2	6.2	26.1	15.0
6	2008	15.7	13.0	31.8	21.5	1.1	1.0	2.8	1.8	9.5	12.8	39	37.5
	2009	15.4	13.6	47.0	39.1	1.4	0.9	2.8	1.8	9.5	12.8	42.6	40.5
	2010	5.4	4.4	19.9	43.5	1.5	2.2	2.8	1.8	9.5	12.8	34.3	27.1
	2011	16.0	15.0	41.2	30.3	0.9	2.1	2.8	1.8	9.5	12.8	39.4	41.9
7	2008	11.8	10.6	6.1	5.3	0.6	1.0	2.8	3.2	8.7	10.9	34.6	12.7
	2009	20.0	17.3	7.5	6.5	0.9	0.7	2.8	3.2	8.7	10.9	41.9	15.1
	2010	2.5	1.5	4.5	3.3	1.0	2.0	2.8	3.2	8.7	10.9	26.9	12.1
	2011	10.4	7.4	10.2	9.7	0.8	1.0	2.8	3.2	8.7	10.9	39.8	14.1
8	2008	1.3	1.1	14.6	13.7	1.4	0.8	83.3	81.8	53.1	55.7	10.5	0.1
	2009	1.1	1.9	11.7	12.6	1.9	1.5	83.3	81.8	53.1	55.7	12.4	0.1
	2010	0.4	0.6	7.2	6.7	2.4	3.1	83.3	81.8	53.1	55.7	8.6	0.0
	2011	0.8	0.5	17.6	16.3	2.1	1.7	83.3	81.8	53.1	55.7	15.7	0.1

Biophysical indicator: Chlorophyll-*a*

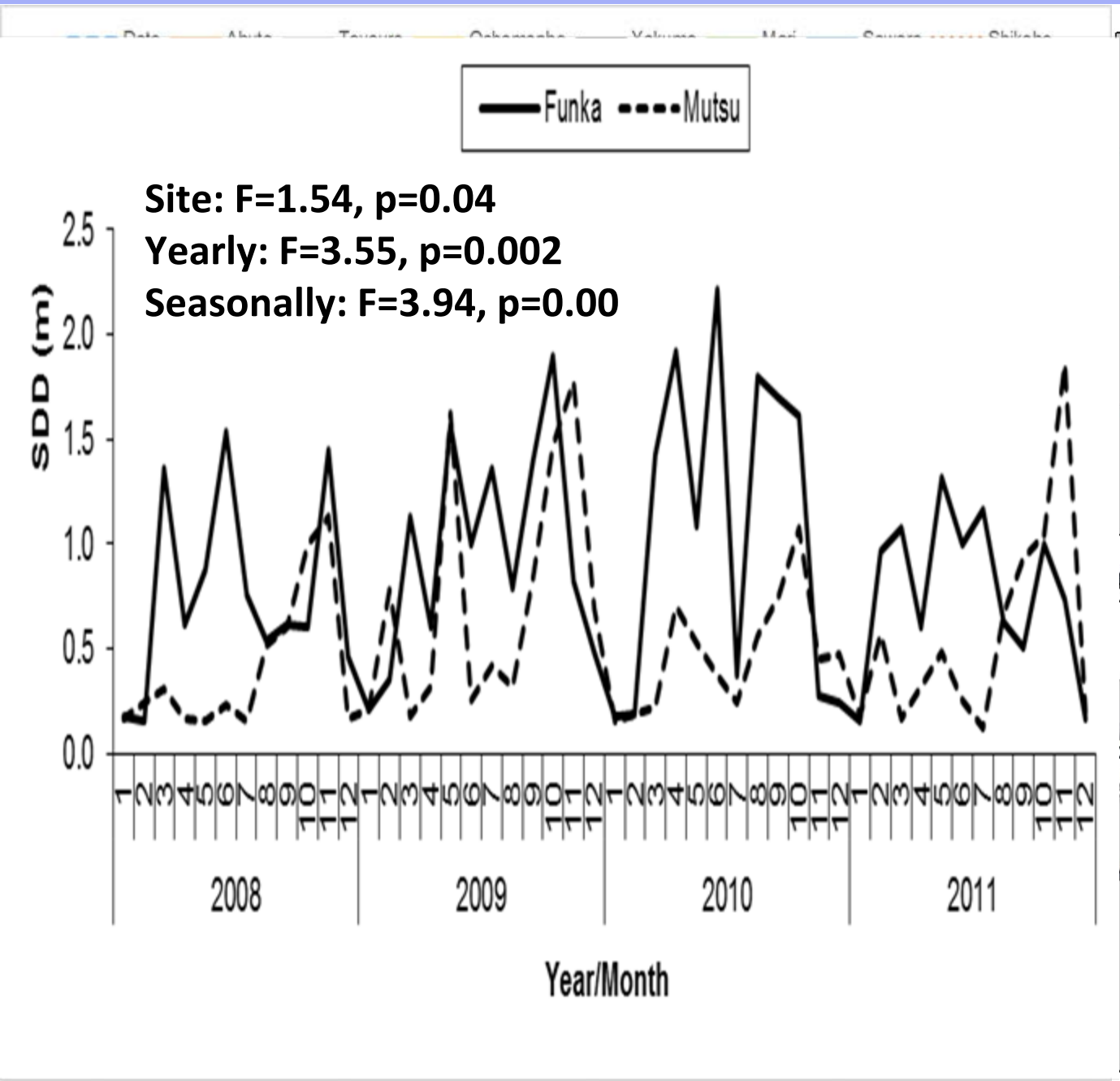
≤2 Nezline et al. (2005)

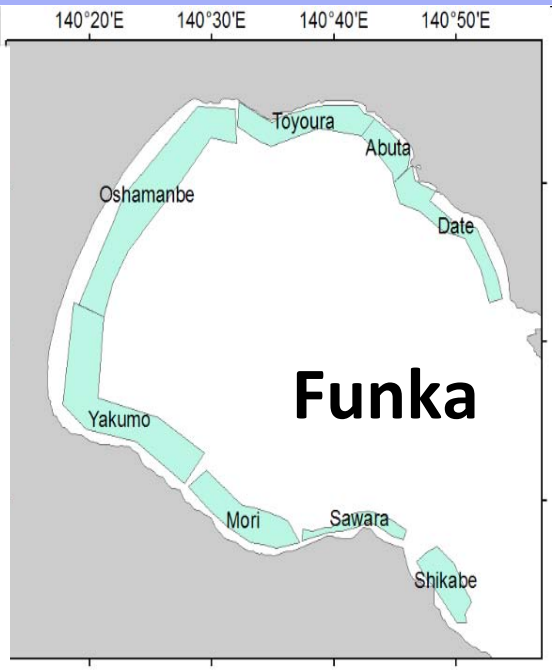


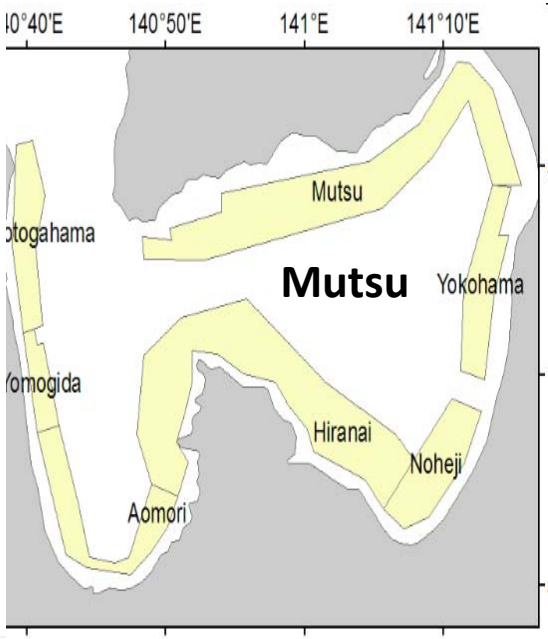




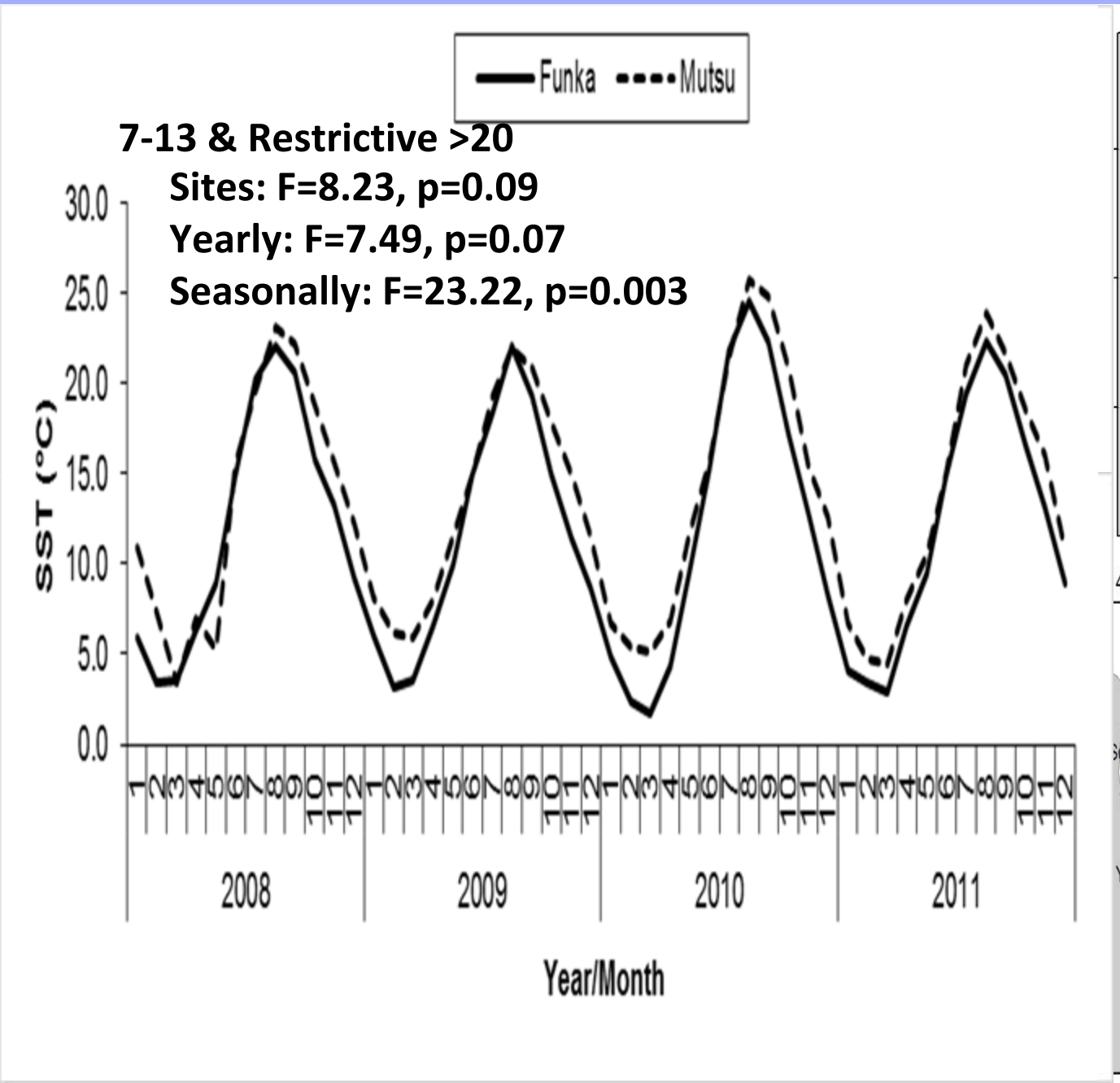
Biophysical indicator: SDD

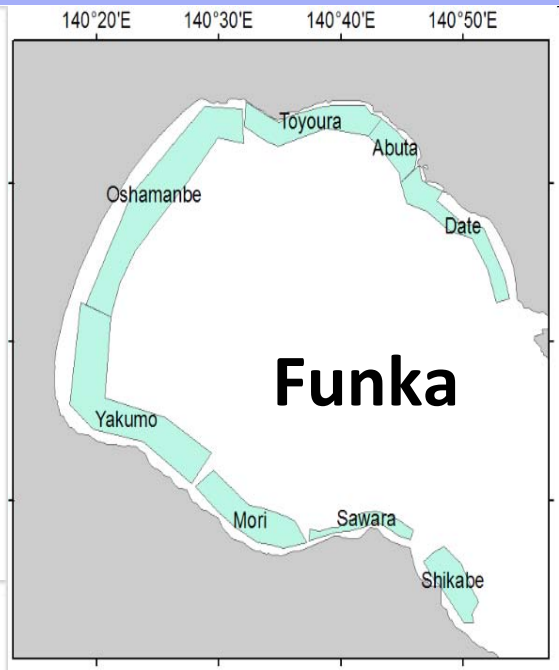


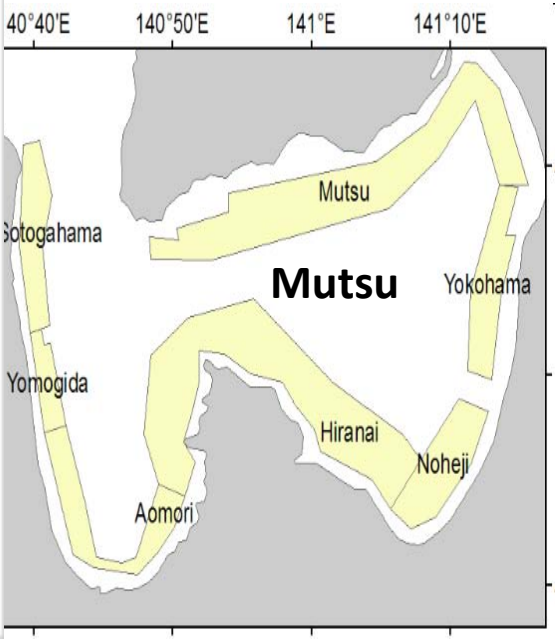




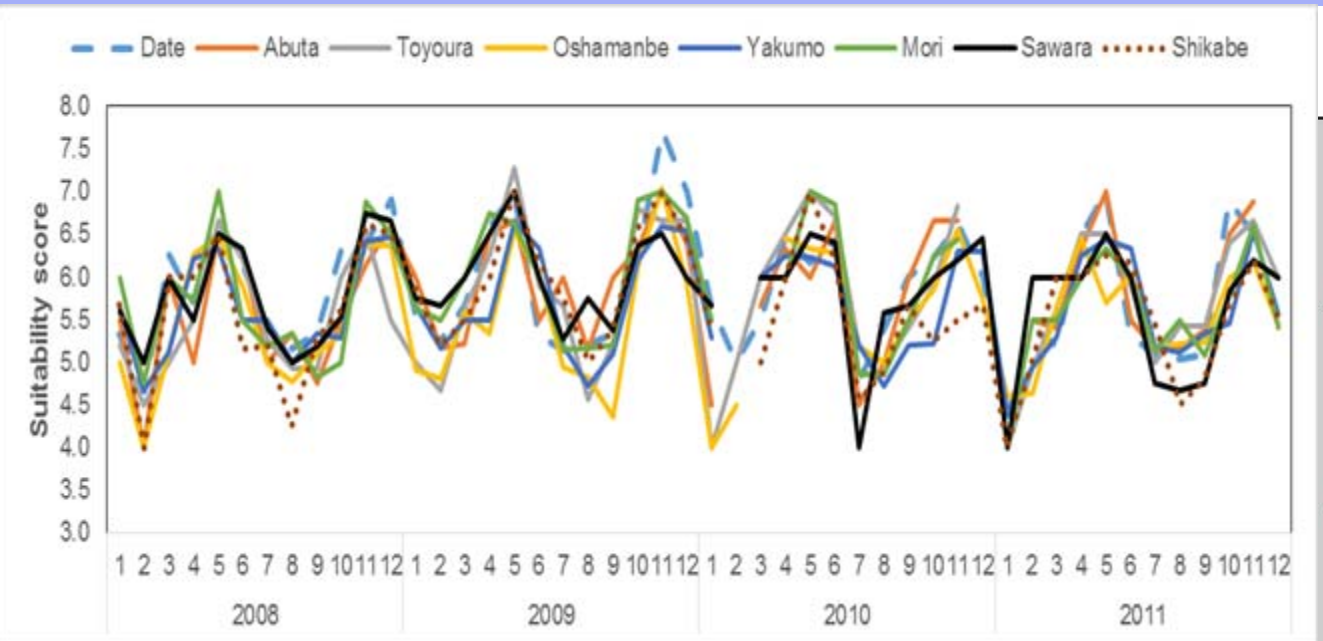
Biophysical indicator: SST

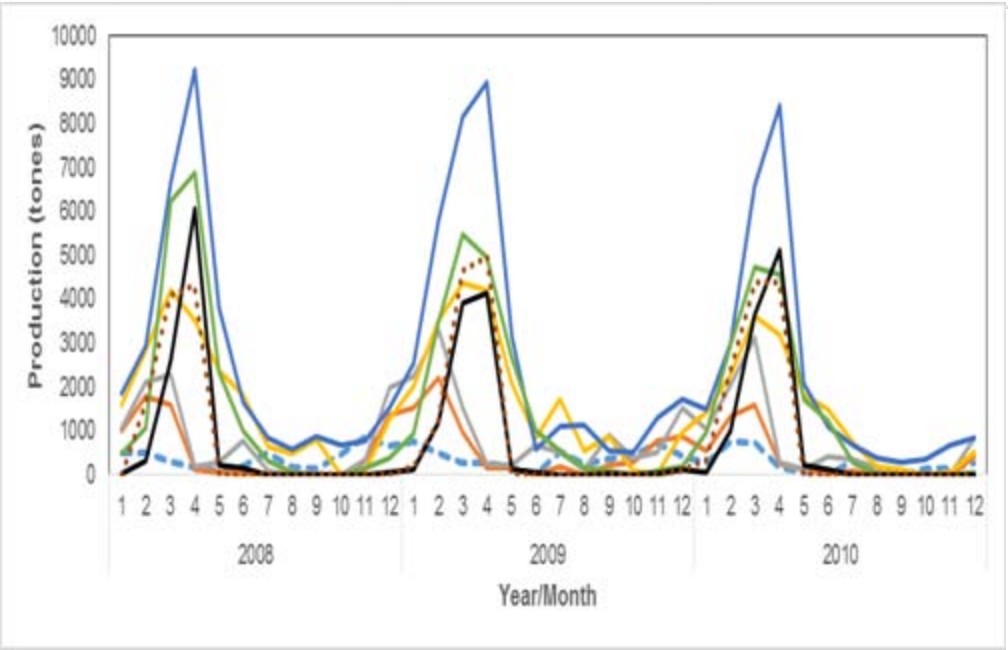


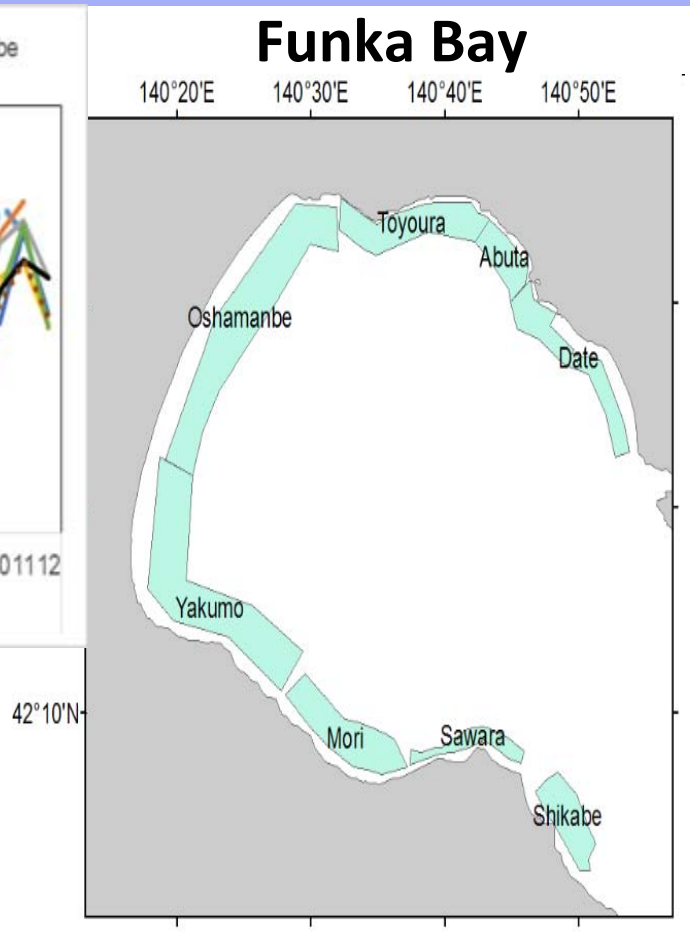




Further validation

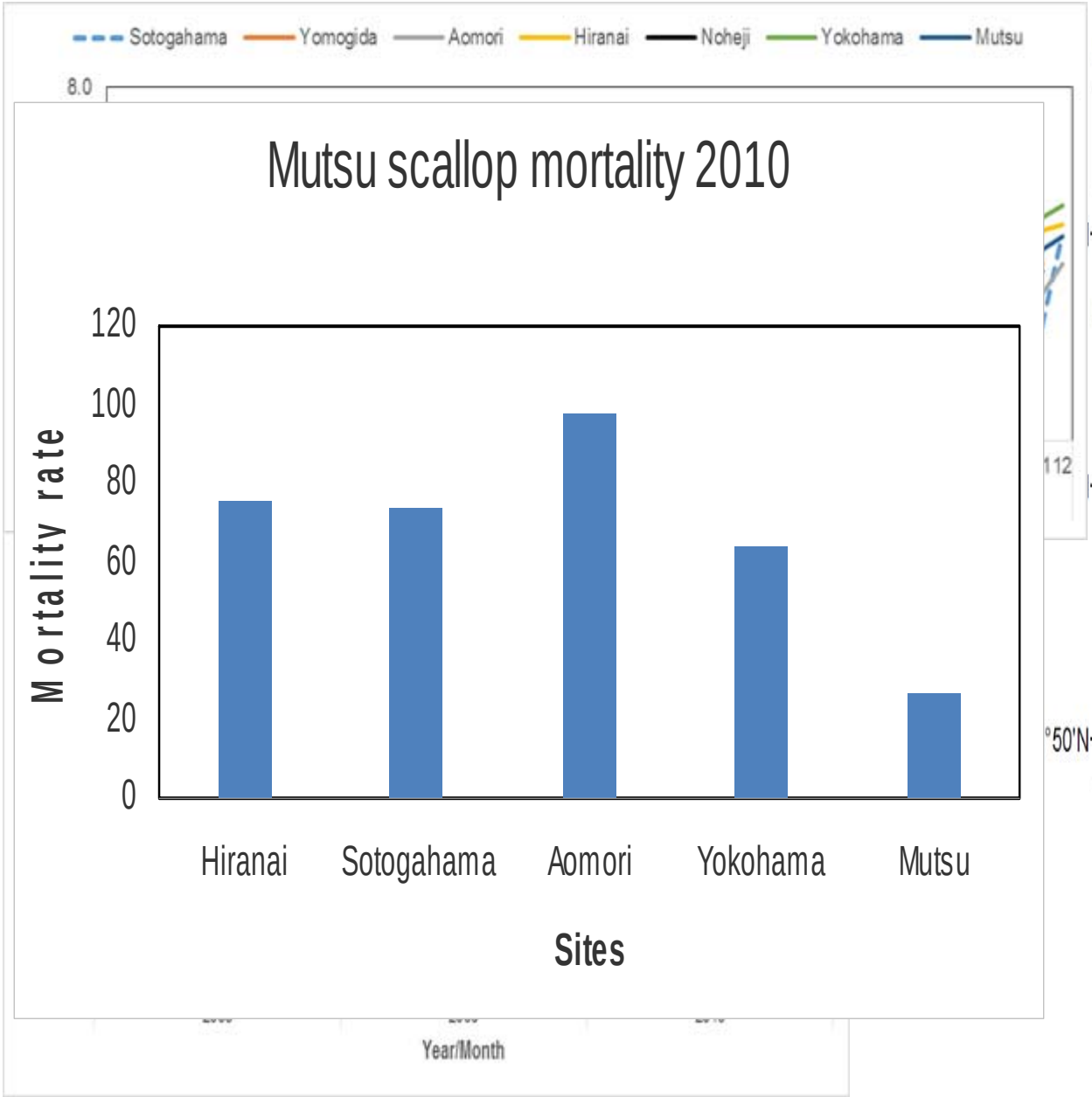


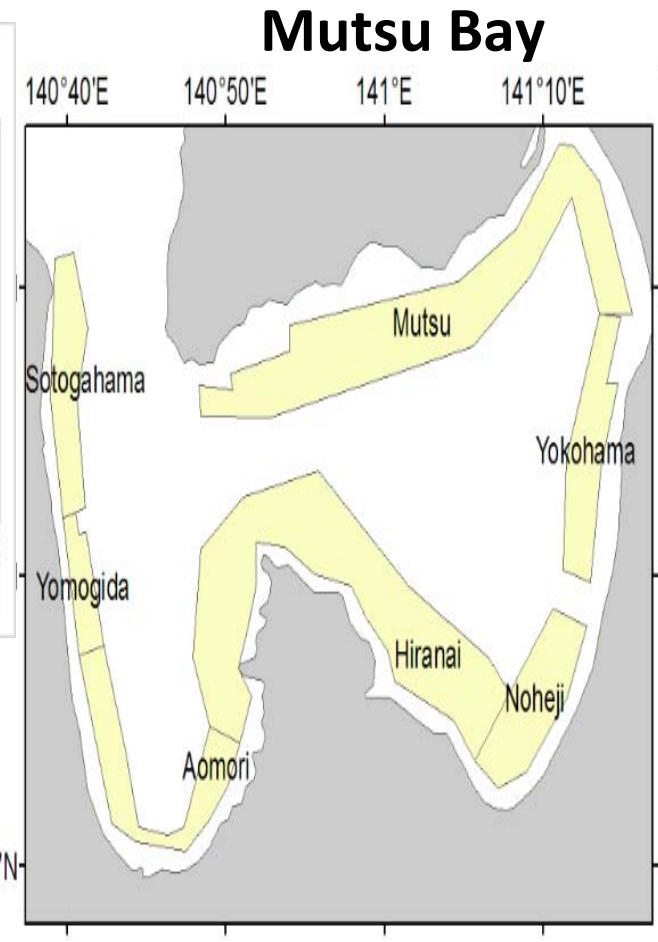




Consistency = 73%

Further validation





Consistency = 71%

Conclusions

- Funka Bay high score of 7 & Mutsu Bay high score of 6.
- Spatio-temporal variations in suitability scores & indicator/stressor concentrations within & between both bays.
- Constraints (stressors) limited scallop potential area.
- Elevated SST in August & September (>20° C in both bays)-scallop mortality in Mutsu Bay in 2010-stressor
- Chl-*a* (>5 mg m^{-3} in Funka Bay) in 2010 model - stressor.
- Low SDD in high scallop production sites-a stressor .

Conclusions

- Model displayed a high degree of reliability due to consistency with existing scallop mariculture.

- GIS-based MCE-ascertain degree of stressors & indicators in coastal ecosystems & delineation of scallop potential sites-in Ecosystem Approach to Aquaculture (EAA) & Integrated Coastal Zone Management (ICZM).

- Further addition of environmental impact (EC) & currents (velocity) indicators would strengthen the models further.

Thank you

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