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**Evaluation and prediction of marine biodiversity changes
using species distribution models**

Dissertation

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Table of contents

Summary	v
Acknowledgements.....	x
Chapter 1 General Introduction	1
1.1 Marine ecosystems and their biodiversity	2
1.2 Information of marine biodiversity	3
1.3 General description of species distribution modeling.....	5
1.4 Future prediction of marine biodiversity	7
1.5 Objectives and chapter outline	8
References	10
Chapter 2 Predictions of kelp distribution shifts along the northern coast of Japan.....	15
2.1 Introduction.....	15
2.2 Methods	18
2.2.1 Scope and species	18
2.2.2 Data collection	19
2.2.3 Species distribution models	19
2.2.4 Environmental dataset for estimating species distribution.....	20
2.2.5 Environmental dataset for future projections	21
2.3 Results.....	22
2.3.1 Species distribution and biodiversity of Laminariaceae	22

2.3.2 Future projections-----	24
2.4 Discussion -----	25
2.4.1 Species distribution and biodiversity of Laminariaceae-----	25
2.4.2 Future projections-----	28
2.4.3 Implications for conservation and resource management-----	30
2.5 Conclusions -----	32
Reference-----	34
Tables-----	44
Figures-----	48

Chapter 3 Fine-scale distribution of tropical seagrass beds in Southeast

Asia-----	52
3.1 Introduction-----	52
3.2 List of data files -----	53
3.3 Metadata -----	54
3.3.1 Geographic coverage -----	54
3.3.2 Methods -----	54
3.4 Data structure -----	58
3.5 Accessibility-----	61
Reference-----	62

Chapter 4 Estimated distribution of tropical seagrasses species in

Southeast Asia and their conservation status -----	64
4.1 Introduction-----	64

4.2 Methods	67
4.2.1 Scope and species	67
4.2.2 Data collection	67
4.2.3 Species distribution models	68
4.2.4 Environmental dataset for estimating species distribution	69
4.2.5 Implications for conservation and resource management	70
4.3 Results	71
4.3.1 Species distribution and biodiversity of seagrasses	71
4.3.2 Protection status of the seagrasses	72
4.4 Discussion	73
4.4.1 Species distribution estimates	73
4.4.2 Conservation status	75
4.5 Conclusions	76
Reference	78
Tables	84
Figures	93

Chapter 5 Current species distribution and future projection for copepods

in the western North Pacific	95
5.1 Introduction	95
5.2 Methods	98
5.2.1 Target area and species	98
5.2.2 Data collection	99
5.2.3 Species distribution models	100

5.2.4 Environmental data set -----	100
5.2.5 Future projection -----	101
5.3 Results-----	102
5.3.1 Species distribution and their seasonal variation -----	102
5.3.2 Future projection -----	103
5.4 Discussion -----	104
Reference-----	111
Tables -----	119
Figures-----	123
 Chapter 6 General Discussion -----	 127
6.1 Evaluation and prediction of marine biodiversity using species distribution models -----	 128
6.2 Problems associated with species distribution modeling -----	129
6.2.1 Data collection -----	129
6.2.2 Environmental factors -----	130
6.2.3 Temporal scale-----	132
6.2.4 Spatial scale-----	133
6.3 Future projection for marine ecosystems -----	134
6.4 Social implementation-----	135
6.5 Conclusion and implications-----	136
References-----	139

Summary

Chapter 1

Information on marine biodiversity patterns is important to facilitate systematic conservation planning. In this chapter, I examined patterns of marine biodiversity and their information. Marine biodiversity of the western Pacific is the highest in the world, whereas there is a large scientific knowledge gap. To fill the knowledge gap, I examined effectiveness of species distribution models (SDMs). In this thesis, I examined how SDMs are effective to understand patterns of marine biodiversity across different taxonomic groups. I also examined their future changes because climate change is one of the main factors causing decline of marine biodiversity.

Chapter 2

Japanese kelps are important because they offer valuable ecosystem functions in coastal ecosystems, and because they are important food resources. The present study aimed to predict future shifts in major kelp species in northern Japan under different climate change scenarios. From a database of kelp species in cold seawater in Japan, I extracted 1,958 data points to estimate the distribution of 11 kelp species that inhabit the waters around northern Japan. Distributions of the past (1980s) and the future (2040s and 2090s) were estimated using a species distribution model (MaxEnt). Variation in summer and winter sea surface temperatures was most responsible for the estimated distribution patterns for most species; the length of natural rocky coasts and wave height were also important for some species. A forecast of shifts in distributions based

on different Intergovernmental Panel on Climate Change (IPCC) scenarios showed that kelp species diversity in Japan would significantly decrease. By the 2090s, their habitat range overall was estimated to decline to 30–51% of that of the 1980s with moderate warming (RCP 4.5) and to 0–25% with severe warming (RCP 8.5). The model predicted that 6 of 11 kelp species in cold seawater may become extinct around Japan by the 2090s (RCP 8.5). Commercially important species, such as *Saccharina japonica*, are also expected to decline greatly, which may affect kelp fisheries and aquaculture in northern Japan.

Chapter 3

Southeast Asia is a hotspot of global seagrass diversity, offering valuable ecosystem services for human life. However, historically there have been large gaps in the scientific knowledge of the distribution of seagrass beds in this region. Information on the distribution has not been updated in global databases since the publication of the World Seagrass Atlas in 2003, which was based on data mostly obtained up until the late 1990s. I collected most recent data on seagrass bed distribution from 8 ASEAN countries plus southern China and southern Japan, and integrated these data into a GIS-database. A total of 718 polygon data and 917 points data were uploaded in this paper, which were obtained from 96 scientific articles and reports published after 2000, including those written in local languages. Among them, 8.9% of the data have associated information on seagrass bed size and 39.0% have associated information on seagrass species composition. Data obtained from Vietnam, Cambodia, Singapore, Timore Leste, and Southern China cover almost all the coastlines of each country, whereas data

for the Philippines, Indonesia, Malaysia and Myanmar still have large gaps in areal coverage. The data set has a few points from Brunei Darussalam, the Paracel Islands, Spratly Islands and Pratas Islands, which are areas that I lacked information on for a long time. The obtained data will be useful to understand the current status of seagrass beds and to help facilitate better conservation and management of coastal areas in this region.

Chapter 4

Southeast Asia is the hotspot of the global seagrass diversity, offering valuable ecosystem services to human. However, there have been great scientific gaps in the knowledge on the distribution of tropical seagrass beds in this region. Information on broad-scale distribution has not been updated in a global database since the late 1990s. Here I estimated each seagrass species distribution using a species distribution model (MaxEnt) relating seagrass present data with spatial data on environmental factors (water temperature, depth, slope, diffuse attenuation coefficient at 490 nm, river effect, mangrove and coral reef areas). This integrated analysis revealed that species diversity was highest around coral reef areas such as in Ryukyu Islands, the Philippines, Sabah Malaysia, Sulawesi Island, Andaman Islands and Myanmar. I then examined the conservation status of these seagrass species by analyzing how much of their distribution areas overlaps with current marine protected areas (MPAs). The wide distribution species such as *Cymodocea rotundata*, *C. serrulate*, *Halodule pinifolia*, *H. uninervis*, *Syringodium isoetifolium*, *Enhalus acoroides*, *Halophila ovalis* and *Thalassia hemprichii* were covered by MPAs for 11-43%. For, an endangered

species *H. beccarii*, MPAs covered around 11-14% of their estimated distribution. However, the area protected by MPAs with strict regulation (Categories I to III) were lower (2-12% and 4-6%, respectively). The obtained results from this study will contribute to updating global map of seagrasses biodiversity, and to facilitating effective management of seagrass beds at various levels of decision-making processes (from governments to local communities).

Chapter 5

Patterns of marine biodiversity in the pelagic ecosystems of the North Pacific remain unknown due to large data gaps. This study aimed to make a broad-scale but fine-resolution estimate of the distribution of major copepod species in the western North Pacific and to forecast future shifts in their distributions with ongoing climate change. More than 30,000 data on the occurrence of 12 target species (4 cold-water species and 8 warm-water species), an amount that doubled after incorporating Odate Collection data around Japanese waters, were used to estimate current species distribution by developing a species distribution model that related species occurrence data to ocean environmental data. The estimated distribution of copepods varied greatly among seasons, probably reflecting their vertical migration behavior. Environmental variables related to variation in primary productivity—such as net primary production, chlorophyll *a* and silicates—helped to explain the species distribution, although their relative importance varied greatly among seasons and between cold- and warm-water species. Future projections of the copepod distribution based on different emission scenarios by IPCC predicted a northerly expansion for both cold- and

warm-water species. The predicted change was more pronounced with the business-as-usual scenario (RCP 8.5) and for warmer water species, with their southern limit of distribution predicted to shift 100 to 500 km north by 2090–2100. The variation in the sensitivity to water temperature rise between the cold- and warm-water species is thought to reflect differences in their ecology and distributional area.

Chapter 6

The data on marine biodiversity still have large gaps in the western Pacific region. I demonstrated that combination of high-quality species occurrence data, appropriate environmental data for target species and fine scale SDMs can successfully estimate biodiversity patterns in this gap region. This integrated approach is applicable to other marine taxa and contribute to the systematic conservation planning of marine biodiversity. Furthermore, the approach improves the accuracy of future prediction of marine biodiversity patterns in response to ongoing climate changes, which helps to establish mitigation/adaptation plans by various decision-makers.

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CHAPTER 1 General Introduction

Species Distribution Models (SDMs) can estimate and predict shifts in distribution patterns of species by relating the occurrence data with environmental factors (Beaugrand et al. 2015, García Molinos et al. 2016). SDMs are a useful tool to estimate species distribution in information lacking regions and to predict distributional changes. For marine species, SDMs have been applied widely to a variety of species in the Atlantic and Eastern Pacific (Chefaoui et al. 2016, Filbee-Dexter et al. 2016, Helaouët and Beaugrand 2009, Johnson et al. 2011, Moy and Christie 2012, Reygondeau and Beaugrand 2011, Valle et al. 2014), whereas, they have been less used for species living in the western Pacific region. This dissertation aimed to evaluate species biodiversity in this region using various sets of environmental data, and to predict future changes in marine biodiversity patterns. The dissertation is composed mainly of three independent studies, focusing on different marine taxa (kelps, seagrasses and zooplankton) inhabiting different habitats (nearshore bottoms and offshore pelagic water) and climate regions (cold temperate and tropical regions). First, I studied kelp species diversity and predicted future shifts in northern Japan under different climate change scenarios (Chapter 2). Secondly, I studied tropical seagrass species in SE Asia. Although Southeast Asia is a hotspot of global seagrass diversity (Short et al. 2007), historically there have been large gaps in the scientific knowledge of seagrass species (Fortes et al. 2018). I firstly made a database by collecting most recent data on seagrass distribution in this region (Chapter 3). I then estimated tropical seagrass species diversity in Southeast Asia (Chapter 4). The last study focused on major copepod species and estimated the distribution and future shifts

in the western North Pacific where marine biodiversity is the highest in the world (García Molinos et al. 2015, Tittensor et al. 2010), but the patterns of marine biodiversity in the pelagic ecosystems remain unknown due to large data gaps (Chapter 5). Finally, I explain the major achievement of this dissertation with implications to future research directions (Chapter 6).

1.1 Marine ecosystems and their biodiversity

Marine biodiversity provides various ecosystem services to human, such as provisional, supporting, regulation and cultural services (Costanza et al. 1997, Duraiappah et al. 2005). Habitat-forming species such as kelp, seagrass, mangroves and coral reefs support high species richness and an abundance. Ecosystem services provided by marine biodiversity have been threatened by various types of human-induced stressors, including overexploitation, eutrophication, coastal development and the introduction of non-native species (Beaugrand et al. 2015, Steneck and Carlton 2001, Halpern et al. 2008). Furthermore, ongoing climate change will affect the distribution of many marine species globally through environmental changes such as temperature rise and ocean acidification (Harley et al. 2006; Orr et al., 2005). However, our knowledge of the global patterns of marine biodiversity is still limited. In Japan, for example, a total of 33,629 marine species have been reported in Japanese waters and the knowledge was extremely variable among the taxa although it was estimated that more than 70% of Japan's marine biodiversity remained undescribed. (Fujikura et al. 2010). Evaluation of marine biodiversity patterns and the prediction of their

changes are needed for systematic conservation planning and evaluation of ecosystem services facing multiple pressures of human economic activities.

1.2 Information of marine biodiversity

In the past decade, massive efforts have been made toward elucidating marine biodiversity in the world's oceans such as by the Census of Marine Life project (Census of Marine Life, 2010). Studies on broad-scale marine biodiversity have been facilitated by the development of open-access global databases, such as GBIF (<http://www.gbif.org/>), OBIS (<http://www.iobis.org/>), FishBase (<http://www.fishbase.org/>) and AlgaleBase (<http://www.algaebase.org/>). Information on the distribution of marine life in Japanese waters has been collated in BISMaL (<http://www.godac.jamstec.go.jp/bismal/e/index.html>). Using these databases, global patterns of marine biodiversity have been estimated for a variety of taxa (Costello & Chaudhary 2017, Kaschner et al. 2016, Tittensor et al. 2010) and future changes in species distribution have been predicted by modeling under different climate change scenarios (Beaugrand et al. 2015, García Molinos et al. 2016). Nevertheless, data on marine species remain insufficient and still contain large geographic gaps around the western Pacific region. Filling these information gaps is necessary to understand the current distribution patterns and to forecast changes in regional marine biodiversity.

There are a few outstanding data sets in Japan such as FRA-Plankton Dataset and Kelp Dataset facilitated by Environment Research and Technology Development Fund (S9-5) of the Ministry of the Environment, Japan (Nakaoka et al. 2017, Tadokoro and Sugisaki 2019). The Japan Fisheries Research and

Education Agency have been conducting long-term, large-scale sampling of zooplankton around Japanese waters since the 1950s, and the collected specimens have been stored as the “Odate Collection” (Odate 1994). The data from the Odate Collection have been used to analyze long-term changes in zooplankton diversity and abundance around the Tohoku region of the western North Pacific in relation to changes in oceanographic conditions (Chiba et al. 2009). Now, a total of >260,000 data from zooplankton records from the Odate Collection are available, making it possible to analyze the current distribution and future changes in copepods in the western North Pacific.

The distribution data of Laminariales in Japan contained a total of 27,189 recorded occurrences from literature, government reports and museum herbarium in the BISMAL (Nakaoka et al. 2017). In addition, National Museum of Nature and Science Specimens (<http://db.kahaku.go.jp/webmuseum/>) and a data paper of seaweed in Japan (Kumagai et al. 2016) also contain occurrences data of Laminariales. Combination of these data set is outstanding for analyzing the current distribution and future changes.

This study also provides recent data on tropical seagrass bed distribution in Southeast Asia. This data set was compiled data on seagrass distribution from more than 96 literature locally published in each country after 2000 including those written in local Asian languages (Japanese, Chinese, Vietnamese, and Indonesian). The obtained data were presented either by polygon data (a total of 718 data) or point data (917 data) both associated with the information on seagrass bed area and seagrass species composition if available. The obtained fine-resolution, broad-scale data are useful to understand the current status of

seagrass beds and to help facilitate better conservation and management of coastal areas in this region.

1.3 General description of species distribution modeling

The SDMs identify the relationships between the presence and absence of a species and environmental variables. Many algorithms are existing according to data types and quality. Types of data for SDMs can be divided into these three types; (a) presence only data, (b) presence/absence data, and (c) categorical/abundance data. It is important to select the appropriate ensembles of SDMs understating both advantages and weaknesses of each algorithms (Guisan et al. 2017, Table 1-1).

Among the algorithms, maximum entropy modeling (MaxEnt) has been most used commonly because it is robust against georeferencing errors using presence-only records (Elith et al. 2011, Graham et al. 2008, Phillips et al. 2006). It outperforms most other algorithms, such as generalized linear models, generalized additive models and random forests, and is particularly appropriate for marine species due to difficulty of confirming absence (Aguirre-Gutiérrez et al. 2013, Guisan et al. 2017, Elith et al. 2006, Ready et al. 2010). MaxEnt also performs well in estimating potential range shifts for a species due to climate change (Hijmans and Graham 2006).

Table 1-1 Types of data for SDMs and their advantages and disadvantages

Data types	Representative SDMs	Advantages and disadvantages
(a) Presence only data	Maximum Entropy (MaxEnt)	Presence only data from natural museum specimen or literature. Heavily biased sampling data influence the model results.
(b) Presence and absence data	Generalized linear models (GLM) Generalised additive models (GAM) Multivariate adaptive regression splines (MARS) Random forests (RF) Boosted regression tree (BRT)	Presence / absence data is more accurate than presence only data. If the target species is not confirmed in their habitat range, environmental variables at that survey point is treated as inappropriate. If there is no absent data, random selection of absence data (pseudo-absence) causes model errors.
(c) Categorical or Abundance data	Generalized linear model (GLM) Generalized additive models (GAM) Joint species distribution model (JSDM)	Estimation of quantitative data from environmental variables. Sampling data errors reflect to the model results. Difficult to collect wide range data

1.4 Future prediction of marine biodiversity

Ongoing climate change will affect the global demographics, abundance, distribution and phenology of many marine species through multiple environmental changes, such as water temperature increase, sea level rise and ocean acidification (Harley et al. 2006; Orr et al. 2005; Poloczanska et al. 2016; Yara et al. 2012). Future projections suggest that changes in community composition and local species loss would occur worldwide (e.g., Beaugrand et al. 2015; García Molinos et al. 2016), which can further affect the use of marine resources by human, such as by fisheries and aquacultures. However, our knowledge of the patterns of marine biodiversity and their future response to climate change is limited in the western Pacific region (Fishery agency Japan 2017; Poloczanska et al. 2016).

Japan's long-term strategy under the Paris Agreement within the United Nations Framework Convention on Climate Change (UNFCCC) (Cabinet Decision 2019) sets a target to reduce 80% of Greenhouse gases (GHGs) emissions by 2050. In addition, national strategy for the conservation and sustainable use of biological diversity 2012-2020 also set a long-term goal by 2050. To achieve this target, predicting future changes in marine biodiversity should be made not only over the long term (e.g. 2090-2100 target), but also over shorter time scale (e.g., 2040-2050 target). In this dissertation, future predictions of kelp and copepods were made for these two time targets.

1.5 Objectives and chapter outline

The general objective of this dissertation is to evaluate species biodiversity of different marine taxa using various environmental variables and to predict their future changes in the western Pacific region. Although this region hosts the highest marine biodiversity in the world (García Molinos et al. 2015), our knowledge on broad-scale patterns of marine biodiversity is still limited. This dissertation is composed mainly of three independent studies, focusing on kelps in the cold temperate zone, seagrasses in the tropical area, and zooplankton in the pelagic ecosystem.

After the general introduction given here (Chap. 1), Chapter 2 examined the past distribution of kelp species in cold seawater in northern Japan and predicted changes in their distribution based on different scenarios for future ocean climates. I first developed SDMs for 11 kelp species in cold seawater belonging to the order Laminariales. I then examined which combination of environmental factors explained the species distribution patterns. Based on the relationships between occurrence and environmental data, I projected changes in the distribution of each species and species diversity using models of the future ocean environment based on different emission scenarios.

Chapter 3 tried to compile recent data on tropical seagrass bed distribution in Southeast Asia where was a hotspot of global seagrass diversity. To fill large gaps in the scientific knowledge, I compiled data on seagrass distribution from the literature locally published in each country after 2000 and created a geographic information system (GIS) database. I looked for references not only in English, but also in local Asian languages (Chinese, Vietnamese, and

Indonesian). Using the established database, Chapter 4 investigated the seagrass species distribution covering the whole southeastern Asia with fine resolution based on recent information collected after 2000. I used more than 1600 data on seagrass species occurrence for the period between 2000 and 2019 from the database developed in Chapter 3. I then examined which combination of environmental factors explained the species distribution patterns. I also examined the conservation status of these seagrass species by analyzing how much of their distributed areas overlap with current marine protected areas (MPAs) in each country.

Chapter 5 estimated the current broad-scale distribution of major copepod species in the western North Pacific and forecast future changes in their distribution based on different IPCC scenarios. I developed species distribution models for some dominant copepod species using the zooplankton database and ocean environmental data. Then, I examined which combination of environmental factors explained the current distribution pattern. Based on the obtained relationship between occurrence and environmental data, I forecast future changes in the distribution of each species using a model of the future ocean environment.

This dissertation concluded with a general discussion (Chapter 6), summarizing and integrating the overall results of these studies, discussing the implication of results in evaluation of marine biodiversity, and suggesting important directions for future research.

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Chapter2

Predictions of kelp distribution shifts along the northern coast of Japan

2.1 INTRODUCTION

Ongoing climate change will affect the global demographics, abundance, distribution and phenology of many marine species through environmental changes, such as water temperature increases and ocean acidification (Harley et al. 2006; Orr et al. 2005; Poloczanska et al. 2016; Yara et al. 2012). Future projections suggest that changes in community composition and local species loss would occur worldwide (e.g., Beaugrand et al. 2015; García Molinos et al. 2016), which can further affect the use of marine resources by human, such as by fisheries and aquacultures. However, our knowledge of the patterns of marine biodiversity and their future response to climate change is limited in the northwest Pacific Ocean region (Fishery agency Japan 2017; Poloczanska et al. 2016).

Kelp forests are one of the most important coastal habitats from temperate to near polar regions. They are highly productive, performing valuable ecosystem functions, such as habitat provision and acting as a food source to many marine organisms (Bennett et al. 2016; Bertocci et al. 2015; Smale et al. 2013; Vásquez et al. 2014). Japanese kelps are also important food resources. In 2015, around 16,000 tons of kelp were harvested in Hokkaido (wild 12,453 tons and cultured 4,310 tons), the main production area in Japan, with a total yield of 22.7 billion JPY (Sasaki 2017). However, kelp forests are decreasing globally at a rate of 1.5% to 18% per year due to anthropogenic-related factors, such as water temperature increases, water quality deterioration, sedimentation and land

reclamation (Araújo et al. 2016; Connell et al. 2008; Krumhansl et al. 2016; Steneck et al. 2002). In Japan, the area of seaweed beds decreased greatly in the late 20th century (Environmental Agency Japan 1994; 1999; Kumagai et al. 2018). The decline of kelp species can cause community-wide impacts because it can also lead to the decline of kelp-associated animals such as fish and crustaceans (Bertocci et al. 2015; Teagle & Smale 2018). It can also cause decrease in ecosystem functions such as nutrient cycling, energy flow and coastal defense (Smale et al. 2013). Thus, understanding current status and predicting future changes in major kelp species are essential to protect marine biodiversity of kelp forest and plan sustainable use of its ecosystem services.

Water temperature increases because of climate change has been considered one of the most critical drivers of kelp forest decline. Kelps are sensitive to increases in water temperature because this phyletic group originally occurs from temperate to cold water regions (Assis et al. 2016). Decreases in kelp forests have been reported as a result of water temperature increases from various parts of the world (Filbee-Dexter et al. 2016; Johnson et al. 2011; Moy and Christie 2012), including temperate waters around Japan (Tanaka et al. 2012; Kumagai et al. 2018). Future shifts in distribution and abundance have been predicted for some kelp species in the Atlantic Ocean (Assis et al. 2016; Assis et al. 2017; Assis et al. 2018; Franco et al. 2018; Gorman et al. 2013; Raybaud et al. 2013) and offshore Japan (Kuwahara et al. 2006, Takao et al. 2015). However, information on kelp forecasts is still insufficient in northern Japan, especially for species living in cold temperate regions (i.e., 40°N and higher), where kelp harvesting is important for the fisheries industry.

Recently, studies on broad-scale marine biodiversity have been facilitated by the development of open-access global databases, such as GBIF (<http://www.gbif.org/>), OBIS (<http://www.iobis.org/>), FishBase (<http://www.fishbase.org/>) and AlgaeBase (<http://www.algaebase.org/>). Information on the distribution of marine life in Japanese waters has been collated in BISMaL (<http://www.godac.jamstec.go.jp/bismal/e/index.html>).

Using these databases, global patterns of marine biodiversity have been estimated for a variety of taxa (Tittensor et al. 2010; Kaschner et al. 2016) and future changes in species distribution have been predicted by modeling under different climate change scenarios (Beaugrand et al. 2015, García Molinos et al. 2016). Nevertheless, data on marine species remain insufficient and still contain large geographic gaps around the northwest Pacific Ocean. Filling these information gaps is necessary to understand the current distribution patterns and to forecast changes in regional marine biodiversity.

In this study, I estimated the past distribution of kelp species in cold seawater in northern Japan and predicted changes in their distribution based on different Intergovernmental Panel on Climate Change (IPCC) scenarios for future ocean climates. I first developed species distribution models (SDMs) for 11 kelp species in cold seawater belonging to the order Laminariales. The models reconstructed species distribution for the 1980s because at this time water temperatures had not been increasing around northern Japan (Meteorological Agency Japan, 2017). I then examined which combination of environmental factors explained the species distribution patterns. Based on the relationships between occurrence and environmental data, I projected changes in the

distribution of each species and species diversity using models of the future ocean environment (CMIP5; Taylor et al. 2012) based on different emission scenarios from representative concentration pathways (RCPs 4.5 and 8.5; Moss et al. 2010). I particularly addressed the question of whether the use of summer and winter temperatures affects distribution predictions differently because temperature sensitivity varies seasonally in different kelp life stages (Kamiya et al. 2006).

2.2 METHODS

2.2.1 Scope and species

In this study, the research area was along the coast of northern Japan between 35.7°N and 45.5°N and 139.4°E and 145.8°E except Northern Territories (Fig. 2-1). Forty-five species of Laminariales occur along the coast of Japan (Yoshida et al. 2015). I targeted 11 kelp species in cold seawater belonging to the three families that are dominant in northern Japan (Table 2-1). Other species that also occur in the study area were excluded from the analyses because of insufficient occurrence data to retain model accuracy (<20 data points). Among the 11 species, *Saccharina japonica* the widest distribution, ranging from 39°N (Sea of Japan) and 37°N (Pacific coast of Honshu) to the northernmost point of Hokkaido (45°N). In contrast, *Arthrothamnus bifidus*, *Saccharina angustata*, *Saccharina cichorioides*, *Saccharina cichorioides f. coriacea*, *Saccharina gyrata* and *Saccharina longissima* were recorded only from Hokkaido.

2.2.2 Data collection

The distribution data of Laminariales in Japan contained a total of 27,189 recorded occurrences from literature, government reports and museum herbarium in the BISMaL (Nakaoka et al. 2017). In addition, national museum of nature and science specimens (<http://db.kahaku.go.jp/webmuseum/>) and data paper of seaweed in Japan (Kumagai et al. 2016) are also containing occurrences data of Laminariales. I extracted 1,958 of these data of the 11 targeted kelp species recorded between the 1950s and 1980s from these databases and the data paper (Table 2-S1). The data were most abundant and covered the widest areas of Japan in the 1980s when a nationwide census of algal bed distribution was conducted by the Ministry of the Environment (Environment Agency Japan, 1994). Fewer data were collected in and after the 1990s because additional nationwide monitoring programs were not conducted. Water temperatures around northern Japan did not significantly increase from 1950 to 1990 (Meteorological Agency Japan, 2017). I thus set the baseline period to examine the effect of temperature increases on kelp distribution as the 1980s and used all of the occurrence data collected between the 1950s and 1980s to retain sufficient data for species distribution ranges.

2.2.3 Species distribution models

The SDMs identify the relationships between presence of a species and environmental variables. Many algorithms exist for SDMs, among which maximum entropy modeling (MaxEnt) has been most used commonly because it is robust against georeferencing errors using presence-only records (Elith et al.

2011, Graham et al. 2008, Phillips et al. 2006). It outperforms most other algorithms, such as generalized linear models, generalized additive models and random forests, and is particularly appropriate for marine species (Aguirre-Gutiérrez et al. 2013; Elith et al. 2006, Ready et al. 2010). MaxEnt also performs well in estimating potential range shifts for a species due to climate change (Hijmans and Graham 2006). Therefore, I chose to use MaxEnt in this study. All MaxEnt models were run using the default settings (version 3.3.3k; Phillips et al. 2006) and replicated 10-fold cross validation. Random test percentage for the cross validation used 20% of the data. The model accuracy was examined by the area under the curve (AUC) (Fielding and Bell 1997) for which values >0.7 are commonly accepted (Raes and ter Steege 2007; Swets 1988). Predicted logistic values of each grid were converted to presence/absence values using a threshold of 0.5; a probability lower than this threshold was classified as absence and higher probabilities classified as presence. The converted model results of 11 species were summed to estimate variation in kelp species diversity.

2.2.4 Environmental dataset for estimating species distribution

I created a database of five environmental variables based on large-scale modeling in the northern Atlantic Ocean (Franco et al. 2018; Gorman et al. 2013; Raybaud et al. 2013) at 5 km resolution. The variables were (1) coldest month sea surface temperature (SST), (2) warmest month SST, (3) annual mean SST, (4) mean significant wind wave height and (5) the length of natural and semi-natural rocky coasts. From these variables, I excluded the annual mean SST because of collinearity with the coldest and warmest month SST because

collinearity can decrease accuracy of prediction in ecological models including SDM (Dormann et al. 2013). As a result, four environmental variables were used in the SDMs (Table 2-2). Data collected during the 1990s were used for the wind wave height due to difficulty of acquiring long-term measured data sets. I set the resolution of all variables to a 5 km grid by interpolation with the inverse distance weighting method (Bartier and Keller 1996). Summer and winter SSTs correlated over the entire study area, and thus it was difficult to include both in one SDM for each species. Therefore, I constructed two SDMs for each species, (1) a combination of warmest month SST, wind wave height and rocky coast length and (2) coldest month SST, wind wave height and rocky coast length, and these are called the “summer model” and “winter model”, respectively.

2.2.5 Environmental dataset for future projections

Monthly mean SSTs were obtained from a climate model, MIROC-ESM (Watanabe et al. 2011). This model is one of the most recent climate models developed in the Coupled Model Intercomparison Project Phase 5 (CMIP5; Taylor et al. 2012) with a future emission scenario based on the RCPs (Moss et al. 2010); it was also used in the Fifth Assessment Report of the IPCC (Stocker et al. 2013). The biases between the observed and the model values were corrected by adding the anomaly of the model to the observed climatology using the method of Yara et al. (2011). I used climate change projections from the 2040s to 2090s under RCP 4.5 and 8.5 simulations (Fig. 2-S1) to examine the effects of ocean warming on potential habitats. Sea surface temperatures during the 1980s were substituted with RCP climate scenario water temperature data

for both the summer and winter models and suitability was recalculated by MaxEnt for each species. The shift in latitudinal distribution of each kelp species was compared between the Pacific coast and Sea of Japan. The percent occurrence within each degree of latitude (e.g., 39.00°N to 39.99°N) was calculated by dividing the number of grids with a species' presence probability >0.5 by the total number of grids. Even though it is influenced by a warm current, the coastal area of the Sea of Okhotsk was classified to the Pacific coast in this study for graphical presentation. This classification was based on the coastal survey of the Monitoring Sites 1000 (Biodiversity Center of Japan, Ministry of the Environment 2008).

2.3 RESULTS

2.3.1 Species distribution and biodiversity of Laminariaceae

The predicted distribution of 11 kelp species in the 1980s varied from 30 to 320 grids in the winter model and 27 to 313 in the summer model (Table 2-3). *Saccharina japonica* had the widest distribution, ranging from 39°N to 45°N along the Pacific Ocean coast and 42°N to 45°N along the Sea of Japan (Fig. 2-2a, 2-S2a). *Costaria costata*, the second most abundant species, was suggested to occur in the same range as *S. japonica*; however, the distribution in the Sea of Japan was limited (Fig. 2-2b, 2-S2b). *Saccharina cichorioides* was also predicted to occur both in the Pacific Ocean and Sea of Japan, but only at 43°N or higher (Fig. 2-2c, 2-S2c). *Agarum clathratum* was estimated to occur between 42°N and 44°N in the Pacific. In the Sea of Japan, presence at 45°N was predicted by the summer model, but not by the winter model (Fig. 2-2d, 2-S2d). Another seven

species were estimated to occur only along the Pacific coast. *Alaria crassifolia* was estimated between 39°N and 43°N (Fig. 2-3a, 2-S3a), *S. angustata* between 42°N and 43°N (Fig. 2-3b, 2-S3b) and *Kjellmaniella crassifolia* between 41°N and 43°N (Fig. 2-3c, 2-S3c). The estimated distributions of *A. bifidus*, *S. cichorioides* f. *coriacea*, *S. gyrata* and *S. longissima* were very limited, occurring only around 43°N of eastern Hokkaido (Fig. 2-3d-g, 2-S3d-g). The winter and summer models showed similar results except that the summer model predicted a higher occurrence of *A. clathratum* and *C. costata*.

The distribution of 11 kelp species were well predicted by the combination of three environmental variables with mean AUC of 0.89 in both the winter and summer models (Table 2-4). The SSTs explained nearly 50% to more than 70% of the SDMs for *A. clathratum*, *A. bifidus*, *S. angustata*, *S. cichorioides* f. *coriacea*, *S. gyrata* and *S. longissima*. In contrast, the length of natural/semi-natural rocky coasts was the most influential factor for *C. costata* and *S. japonica*, and mean significant wind wave height was most significant for *A. crassifolia*, *S. cichorioides* and *K. crassifolia*. For *S. angustata*, SST and wave height equally contributed to the estimated distribution.

The species richness of Laminariaceae in cold seawater, estimated by the summation of SDMs for each species, was highest along the coast of the Pacific Ocean from 42°N to 43°N. In the Sea of Japan, it was highest at 45°N (Fig. 2-4, 2-S4).

2.3.2 Future projections

All of the species were predicted to decline in distribution by 2040s and 2090s under the two different future carbon emission scenarios (Table 2-3). The summer model with RCP 8.5 forecasted severe decline in which all of the 11 species disappeared from Japanese waters by the 2090s (except Northern Territories). Including all the 11 species, suitable habitats would decrease 42% (from 521 to 300 grids) and 61% (from 531 to 205) by the 2040s, and 75% (from 521 to 128) and 100% (from 531 to 0) by the 2090s in the worst case scenario (RCP 8.5) of the winter and summer models, respectively (Table 2-3).

For the dominant *S. japonica*, the winter model (RCP 8.5) predicted a 300 km northern shift along the coast of Pacific Ocean by the 2040s and 400 km by the 2090s. The summer model (RCP 8.5) predicted a 500 km shift north by the 2040s and extinction by the 2090s (Fig. 2-2a, 2-S2a). *Costaria costata* was predicted to also shift north along the Pacific coast, 200 km by the 2040s and 400 km by the 2090s, in the winter model with RCP 8.5; it would disappear from the Sea of Japan by the 2040s with RCP 8.5 in both models (Fig. 2-2b, 2-S2b). In the winter model with RCP 8.5, *S. cichoroides* maintained its distribution of the 1980s along the Pacific coast until the 2090s, but disappeared from both sides of the coast with RCP 8.5 in the summer model (Fig. 2-2c, 2-S2c). *Agarum clathratum* was predicted to occur between 43°N and 44°N in the Pacific by the 2040s and to totally disappear from the study area by the 2090s with RCP 8.5 (Fig. 2-2d, 2-S2d).

Alaria crassifolia, *S. angustata* and *K. crassifolia* were also predicted to shift north in both models (Fig. 2-3a-c, 2-S3a-c). In contrast, minor species, such

as *A. bifidus*, *S. cichorioides* f. *coriacea*, *S. gyrata* and *S. longissima* were predicted to go extinct by the 2040s with RCP 4.5 in both models (Fig. 2-3d-g, 2-S3d-g). *Saccharina cichorioides* f. *coriacea* and *S. longissima* were predicted to go extinct by the 2090s even with RCP 4.5 models and by the 2040s with RCP 8.5 (Table 2-3).

Forecasts of kelp species richness based on the results of a species-by-species distribution model showed a sharp decline in diversity from both the winter and summer models (Fig. 2-4, 2-S4). The reduction of species richness was most remarkable between 39°N and 43°N along the coast of the Pacific and in the whole of the Sea of Japan. The summer model predicted a more severe decline in species diversity than the winter model.

2.4 DISCUSSION

This study estimated past and future distributions of kelp species in northern Japan where previous information on their distribution is scattered. The fit of the SDMs was generally high and similar to another kelp study in the Atlantic Ocean (Franco et al. 2018). The coldest and warmest month SSTs significantly contributed to the estimation for many species. This study highlighted that the distribution range and species diversity of kelps in cold seawater in Japanese waters would greatly decrease with ongoing climate change.

2.4.1 Species distribution and biodiversity of Laminariaceae

Each kelp species occurs over different latitudinal ranges, leading to gradients in species composition from temperate to polar regions (Müller et al. 2009). Water

temperature is one of the key variables determining the global biogeography of many kelps (Franco et al. 2018; Khan et al. 2018; Müller et al. 2009). For example, water temperature explains the biomass patterns of *S. japonica* in northern Japan (Kamiya et al. 2006; Kirihaara et al. 2003). In addition, ocean currents also affect the horizontal and latitudinal distribution of algal species, including kelps (Kumagai et al. 2018). It is likely that cold ocean currents affect the variety of the species in cold seawater studied here, as shown by the fact that the highest species richness in the 1980s was estimated in eastern Hokkaido where the influence of the Oyashio Current is strongest. At the same latitudes, species diversity was higher along the Pacific Ocean coast affected by the Oyashio than the Sea of Japan, which is influenced by the warm Tsushima Current.

The coldest and warmest month SSTs were selected as key environmental factors for the SDMs in this study, which agrees with previous studies on kelp distribution in the northern Atlantic Ocean (Assis et al. 2018; Franco et al. 2018). For the family Laminariaceae, found along the Atlantic coast of Europe, the coldest SSTs contributed more than 50% and the warmest SSTs 25% to the model using MaxEnt (Franco et al. 2018). The SST was also the most important factor for several kelp species in the North Atlantic when distribution was estimated with boosted regression tree models (Assis et al. 2018). In this study, however, the distribution of some species, such as *K. crassifolia*, was not well explained by SST. These species occurred in very limited areas around Hokkaido. The spatial variation in SSTs may be too broad to predict the distribution of these endemic species.

Kelp species have evolved large and flexible thalli to endure high wave energy and current stresses (Friedland and Denny 1995). They sometimes exhibit higher diversity and abundance at sites with strong wave energy because they can avoid the feeding pressure of herbivores, such as sea urchins (Akaike et al. 2002; Kawamata 2001). Wind wave height was also important in the models for some species, but the effects varied. *Saccharina cichorioides* and *K. crassifolia* occur mostly inside a breakwater or deep water with low wave energy (Gouda and Kawai 2012; Kawashima 2012; Tani et al. 2015) and, thus, low wave height likely affects their distribution. In contrast, *S. angustata* and *S. longissima* are found along the Pacific coast where wave disturbance is high. For these species, wave height is positively correlated with the probability of their occurrence.

As kelps generally grow on rocky substrate, the length of natural/semi-natural rocky coasts also contributed to the models of many species. The occurrence of temperate kelp species, such as *Laminaria digitata*, *L. hyperborean* and *L. ochroleuca*, on the northeast Atlantic coast is a result of seafloor substrate and sediment conditions (Gorman et al. 2013). In this study, rocky coast length was the most important factor for *S. japonica* and *C. costata*, two of the most abundant species. The relative influence of habitat type is likely more important than temperature for species with wide distributions that have a broad temperature tolerance.

2.4.2 Future projections

The distribution of kelps expanded and contracted with glacial and interglacial cycles because of the influence of temperature fluctuations (Assis et al. 2016). Ongoing water temperature increases with global climate change is predicted to shift kelp distribution toward higher latitudes, as revealed in this study and others (Assis et al. 2016; Assis et al. 2017; Assis et al. 2018; Franco et al. 2018; Khan et al. 2018; Müller et al. 2009; Raybaud et al. 2013; Takao et al. 2015). In fact, shifts in the global distribution of kelp species have already been observed over the last five decades (Araújo et al. 2016; Assis et al. 2013; Filbee-Dexter et al. 2016; Kumagai et al. 2018; Krumhansl et al. 2016; Wernberg et al. 2016). Additionally, habitat changes, predicted by SST-based ocean current models, are in good agreement with observed chronological changes from Japanese historical data (Kumagai et al. 2018).

The forecast of this study showed that kelp species found offshore northern Japan are predicted to shift northward at 40 km/decade from the 1980s to the 2090s (winter model of RCP 8.5) and >70 km/decade (summer model). Similarly, Takao et al. (2015) estimated that *Ecklonia cava*, which inhabits the temperate region of Japan south of this study site, would shift north by 45 km/decade (RCP 8.5) by the 2090s, although this model did not take seasons into account. A faster distribution shift was predicted by the summer model because water temperature increases in this study area are predicted to be much higher in summer than in winter (Fig. 2-S1). Summer heat stress can directly cause biomass decrease in kelps in Hokkaido and can also negatively affect the

formation and discharge of zoospores in end of summer and autumn in this region (Kamiya et al. 2006).

Species with limited distributions at eastern part of Hokkaido are predicted to disappear from this study area instead of shifting north. This is particularly true for *A. bifidus*, *S. cichorioides* f. *coriacea*, *S. gyrata* and *S. longissima* where extinction by the 2040s was predicted even with the moderate RCP 4.5 scenario. For these species, their suitable habitats, such as lower wave energy for *S. gyrata*, and more exposed areas for *A. bifidus*, *S. cichorioides* f. *coriacea* and *S. longissima*, are less available than those species with a broader distribution, such as *S. japonica*. It is thus likely that after significant climate change suitable habitats for these species would not exist at higher latitudes due to increase in temperature.

The past (1980s) distribution of kelps estimated by the winter and summer models generally agreed, whereas the future (2040s and 2090s) distributions differed between the models with a greater decline in distribution predicted by the summer models. Previous studies have shown that both winter and summer temperatures play important roles in determining kelp abundance, growth and production by affecting different life phases (Kamiya et al. 2006, Kawai et al., 2014, Kiriwara et al, 2003, 2006). Past studies on marine algae distribution shifts mostly take seasonal variation into account (e.g., Assis et al. 2018; Franco et al. 2018; Khan et al. 2018; Kumagai et al. 2018; Takao et al. 2015). Summer water temperature increases in northern latitudes was predicted to be much higher than winter (Fig. 2-S1) and thus comparisons of models using

the SSTs of different seasons may lead to more accurate predictions of future changes in marine biodiversity.

2.4.3 Implications for conservation and resource management

The present study demonstrated that the distribution of kelp species in cold seawater areas of northern Japan would drastically decrease in area and all 11 species would disappear by the end of this century under the most extreme climate scenario (RCP 8.5). This result offers very important implications for the conservation of endangered kelps and resource management of commercially important kelps, such as *S. japonica*, *S. longissima* and *S. angustata*.

Species with narrow distribution ranges, such as *A. bifidus*, *S. angustata*, *S. cichorioides*, *S. cichorioides* f. *coriacea*, *S. gyrata*, *S. longissimi* and *K. crassifolia* were predicted to drastically decrease and face the risk of local extinction from northern Japanese waters. Among them, *S. cichorioides* occurs in the northern part of Hokkaido and its status is near threatened (Ministry of the Environment Japan 2018). This species was predicted to disappear from Japan by the 2090s (summer models with RCP 8.5). In this study, I excluded other endangered species such as *S. yendoana* and *S. kurilensis* because there was insufficient data for the models, but these species would also face a high risk of extinction due to their limited distribution. In these models, I did not include nearby colder climate regions, such as the eastern coast of the Kamchatka Peninsula (Russia), which could be a potential refuge for the species studied here. A future study should include information on these regions to examine the species-specific risk of extinction for the kelp species in cold seawater.

Economically important species, such as *S. japonica*, would also decline greatly with ongoing climate change because SSTs have a large influence on the species distribution, according to the models. Additional kelp species adapted to higher temperatures could shift northward and become dominant in this study area (Takao et al. 2015). For example, *Undaria pinnatifida*, is another commercially important species adapted to a wide range of water temperatures and currently is found from 31°N to 45°N in Japan. The depth range preference of *U. pinnatifida* is similar to *S. japonica* and other species (Epstein & Smale 2017). Thus, economically important species, such as *S. japonica*, could be replaced in their abundance with others, such as *U. pinnatifida*, in northern Hokkaido, as already observed in northernmost of Honshu from 1976 to 2001 (Kiriara et al. 2006). Furthermore, northern shift and increasing of grazing pressure from dominant sea urchin of *Strongylocentrotus nudus* also become important driver of local disappearance for the kelp species in cold seawater (Fishery agency Japan 2017; Kawai and Yotsukura 2018). This is because the water temperature increase in summer enhances food consumption of *S. nudus* (Machiguchi 1997). Further studies incorporating the effects of species interaction among plants and between plants and animals on the changes in the distribution and abundance of algal community would be necessary to elucidate the community-wide impact of climate changes in kelp forest (Bertocci et al. 2015 Seeley & Schlesinger 2012; Smale et al. 2013).

Finally, these SDMs can be utilized to find suitable sites for the reintroduction of endangered species and aquaculture of commercially important species. For example, these models predict Rebun and Rishiri Islands in the

northern part of Hokkaido would be suitable habitats for *S. cichorioides*, which have not been recorded in this region (Fig. 2-2c). In fact, the Hokkaido Fisheries Experiment Station has carried out aquaculture tests of *S. cichorioides* around these islands and produced some successful yield (Gouda and Kawai 2011; Nabata et al. 2003). For the conservation of endangered species, conducting field surveys in areas where previous records are absent is worthwhile to accumulate more precise knowledge on the status of kelp species in cold seawater.

2.5 Conclusions

This integrated analysis of 11 kelp species in cold seawater coastal areas of northern Japan revealed that species diversity was highest around southern and eastern Hokkaido along the Pacific Ocean coast. Diversity was influenced by the cold ocean current and strong wave exposure to the rocky substrate. Forecasts based on models using winter and summer SST changes predicted a rapid northward shift of major species, similar to what has been predicted for kelps in the Atlantic Ocean and other marine organisms. As a result, species diversity would greatly decline by the end of the 21st century even in the modest IPCC scenarios. Some kelp species have high economic value and are important ingredients in traditional Japanese cuisine. In addition, kelp provides habitats and food to various marine animals, including economically important species such as sea urchin and abalone. Thus, the declines in kelp species predicted in this study would greatly affect marine biodiversity and coastal ecosystem dynamics, as well as coastal fisheries and the economy and culture of Japan. The findings of the present study could be used to help plan management options for fisheries

and other coastal ecosystem services that are rapidly changing with ongoing climate change.

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Table 2-1. Kelp species analyzed in this study.

Family	Scientific name	Number of data				
		1950s	1960s	1970s	1980s	Total
Alariaceae	<i>Alaria crassifolia</i> Kjellman	14	143	64	77	298
Costariaceae	<i>Agarum clathratum</i> Dumortier	8	40	53	24	125
	<i>Costaria costata</i> (C. Agardh) D.A. Saunders	0	24	79	131	234
Laminariaceae	<i>Arthrothamnus bifidus</i> (S.G. Gmelin) Ruprecht	7	3	11	43	64
	<i>Saccharina angustata</i> (Kjellman) C. Lane, C. Mayes, Druehl & G.W. Saunders	24	29	76	35	164
	<i>Saccharina cichorioides</i> (Miyabe) C. Lane, C. Mayes, Druehl & G.W. Saunders	0	0	8	28	36
	<i>Saccharina cichorioides</i> f. <i>coriacea</i> F. coriacea (Miyabe) Selivanova, Zhigadlova et G.I. Hansen, comb. nov.	5	6	6	53	70
	<i>Saccharina gyrata</i> (Kjellman) C. Lane, C. Mayes, Druehl & G.W. Saunders	8	9	21	23	61
	<i>Saccharina japonica</i> ^a (Areschoug) C. Lane, C. Mayes, Druehl & G.W. Saunders	57	227	129	366	779
	<i>Saccharina longissima</i> (Miyabe) C. Lane, C. Mayes, Druehl & G.W. Saunders	0	9	6	56	71
	<i>Kjellmaniella crassifolia</i> Miyabe	5	4	2	45	56
Total		128	494	455	881	1958

^a *Saccharina japonica* (Areschoug) C. Lane, C. Mayes, Druehl & G.W. Saunders is including

var. *diabolica* (Miyabe) Yotsukura, Kawashima, T. Kawai, T. Abe & Druehl

var. *ochotensis* (Miyabe) Yotsukura, Kawashima, T. Kawai, T. Abe & Druehl

var. *religiosa* (Miyabe) Yotsukura, Kawashima, T. Kawai, T. Abe & Druehl

Table 2-2. Environmental variables used for the species distribution models.

Environmental variable	Unit	Time period	Resolution	Source
Coldest and warmest month	degree	1982 - 1990	25 km	1)
sea surface temperature	Celsius		(0.25 degree)	
Mean significant height of wind waves	m	Jan. 1990 – Dec, 1999	150 km (1.5 degree)	2)
Length of natural and semi-natural rocky coasts	km/grid	1984-1993	5 km	3)

- 1) National Climatic Data Center (2007). GHRSSST Level 4 AVHRR_OI Global Blended Sea Surface Temperature Analysis. Ver. 1.0. PO.DAAC, CA, USA. Dataset accessed [2013-Feb-20th] at doi:10.5067/GHAAO-4BC01
- 2) 40 years reanalysis, Wave model, Analysis data ECMWEF (European Centre for Medium-Range Weather Forecasts)
- 3) Environmental Agency (1994). The report of the coast line survey in the 4th national survey on the natural environment.

Table 2-3. Predicted number of grids for 11 species in cold seawater based on different climate scenarios in the winter and summer models.

Model	Family	Species	1980s	RCP4.5 2040s	RCP4.5 2090s	RCP8.5 2040s	RCP8.5 2090s
Summer Model	Alariaceae	<i>Alaria crassifolia</i>	117	62	57	58	0
	Costariaceae	<i>Agarum clathratum</i>	176	106	34	77	0
		<i>Costaria costata</i>	216	81	68	69	0
	Laminariaceae	<i>Arthrothamnus bifidus</i>	28	0	0	0	0
		<i>Saccharina angustata</i>	70	81	25	65	0
		<i>Saccharina cichorioides</i>	127	88	64	71	0
		<i>Saccharina cichorioides f. coriacea</i>	34	0	0	0	0
		<i>Saccharina gyrata</i>	27	0	0	0	0
		<i>Saccharina japonica</i>	313	284	111	124	0
		<i>Saccharina longissima</i>	34	0	0	0	0
		<i>Kjellmaniella crassifolia</i>	47	28	2	4	0
		All species ^a	531	426	160	205	0
Winter Model	Alariaceae	<i>Alaria crassifolia</i>	135	132	101	122	52
	Costariaceae	<i>Agarum clathratum</i>	128	89	48	76	0
		<i>Costaria costata</i>	196	129	91	116	45
	Laminariaceae	<i>Arthrothamnus bifidus</i>	30	0	0	0	0
		<i>Saccharina angustata</i>	61	85	50	68	0
		<i>Saccharina cichorioides</i>	131	127	99	116	31
		<i>Saccharina cichorioides f. coriacea</i>	32	0	0	0	0
		<i>Saccharina gyrata</i>	30	0	0	0	0
		<i>Saccharina japonica</i>	320	319	160	177	84
		<i>Saccharina longissima</i>	34	0	0	0	0
		<i>Kjellmaniella crassifolia</i>	50	40	28	36	2
		All species ^a	521	415	264	300	128

^a All species; total number of grids in which more than one species occurred.

Table 2-4. Contribution (%) of each environmental variable and AUC of the species distribution models for 11 species of Laminariaceae.

Family	Species	Summer Model				Winter Model			
		SST	Mean significant height of wind waves	Length of natural /semi-natural rocky coasts	AUC	SST	Mean significant height of wind waves	Length of natural /semi-natural rocky coasts	AUC
Alariaceae	<i>Alaria crassifolia</i>	30.4	38.6	31.0	0.90	25.0	42.3	32.7	0.89
Costariaceae	<i>Agarum clathratum</i>	71.8	14.1	14.1	0.80	71.2	12.6	16.2	0.80
	<i>Costaria costata</i>	41.4	9.7	49.0	0.78	32.8	17.2	50.0	0.78
Laminariaceae	<i>Arthrothamnus bifidus</i>	58.0	30.7	11.3	0.97	46.5	38.3	15.3	0.97
	<i>Saccharina angustata</i>	52.9	41.4	5.7	0.92	47.3	47.2	5.5	0.92
	<i>Saccharina cichorioides</i>	14.4	80.8	4.8	0.87	9.2	85.4	5.4	0.85
	<i>Saccharina cichorioides f. coriacea</i>	57.8	32.5	9.7	0.97	48.0	38.3	13.8	0.97
	<i>Saccharina gyrata</i>	77.1	10.2	12.7	0.97	56.4	23.6	20.0	0.97
	<i>Saccharina japonica</i>	38.3	16.3	45.4	0.69	34.7	10.8	54.5	0.69
	<i>Saccharina longissima</i>	58.4	33.7	8.0	0.97	49.0	39.7	11.3	0.97
	<i>Kjellmaniella crassifolia</i>	3.4	74.5	22.1	0.94	2.0	75.5	22.5	0.95

Mean		45.8	34.8	19.4	0.89	38.4	39.2	22.5	0.89

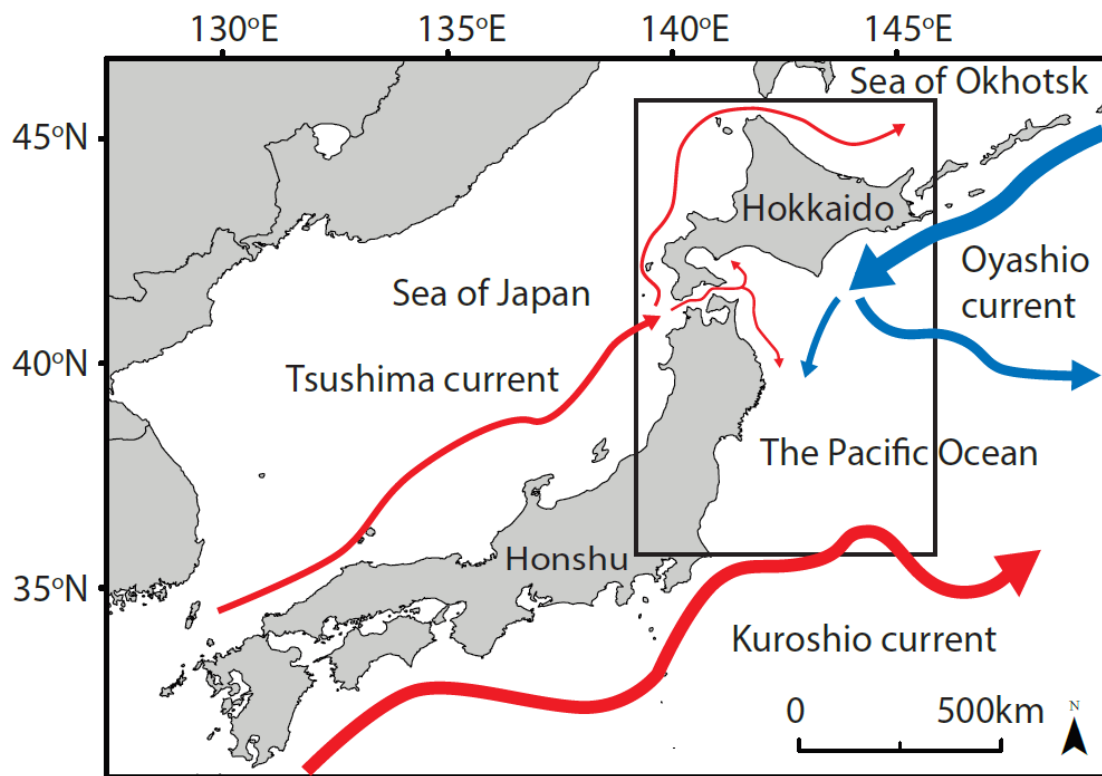


Fig. 2-1. Study area (outlined in bold) and major ocean currents around Japan. The warm currents are in red and the cold currents in blue. Current data are based on Nishimura (1981).

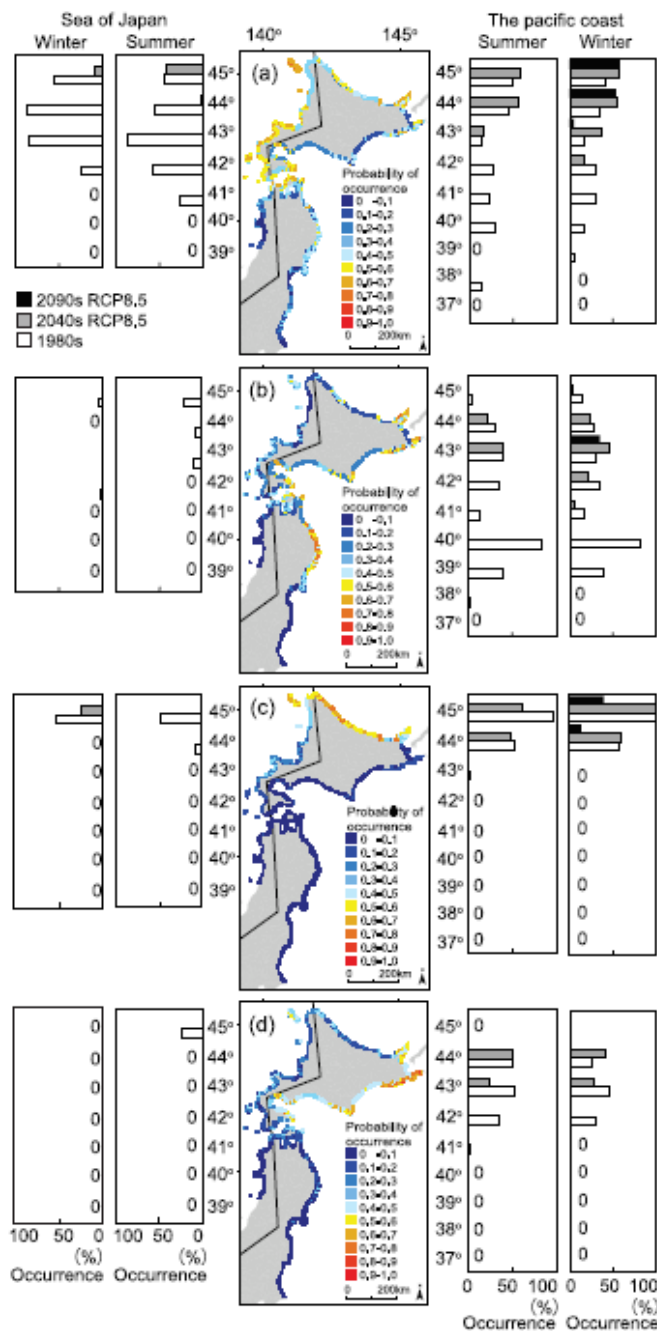


Fig. 2-2. Estimated distribution of four kelp species that occur both along the Pacific coast and in the Sea of Japan. The maps show their distribution in the 1980s; the bar graphs represent occurrence (%) by latitude in the Sea of Japan (left) and the Pacific Ocean (right) in the 1980s (white column), and predicted distribution in the 2040s (gray column) and 2090s (black column) based on the RCP 8.5 scenarios. (a) *Saccharina japonica*, (b) *Costaria costata*, (c) *Saccharina cichorioides*, (d) *Agarum clathratum*

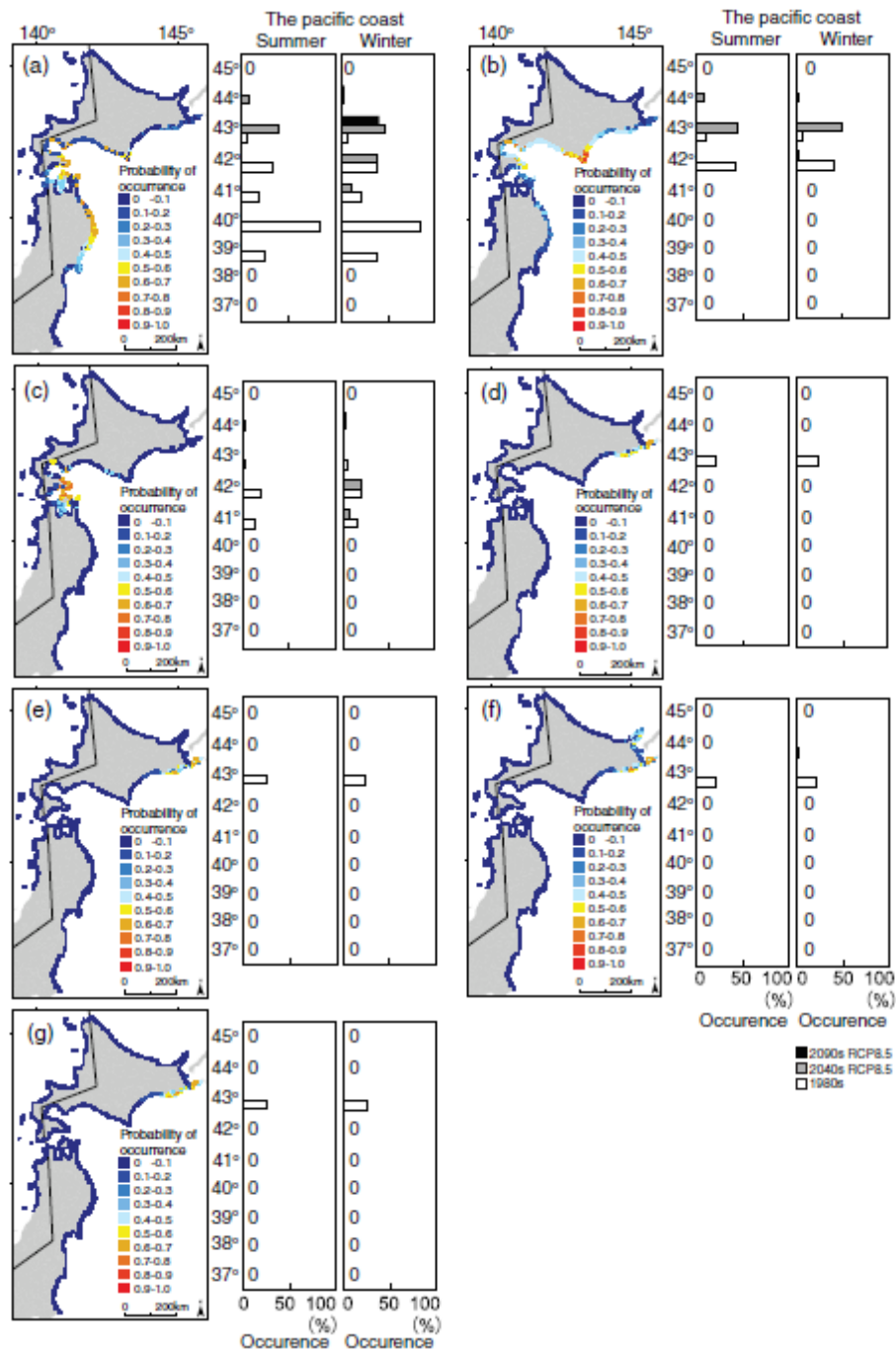


Fig. 2-3. Estimated distribution of seven kelp species that were found only along the Pacific coast. The maps show their distribution in the 1980s; the bar graphs represent occurrence (%) by latitude in the 1980s (white column), and predicted distribution in the 2040s (gray column) and 2090s (black column) based on the RCP 8.5 scenarios. (a) *Alaria crassifolia*, (b) *Saccharina angustata*, (c) *Kjellmaniella crassifolia*, (d) *Arthrothamnus bifidus*, (e) *Saccharina cichorioides* f. *coriacea*, (f) *Saccharina gyrata*, (g) *Saccharina longissima*.

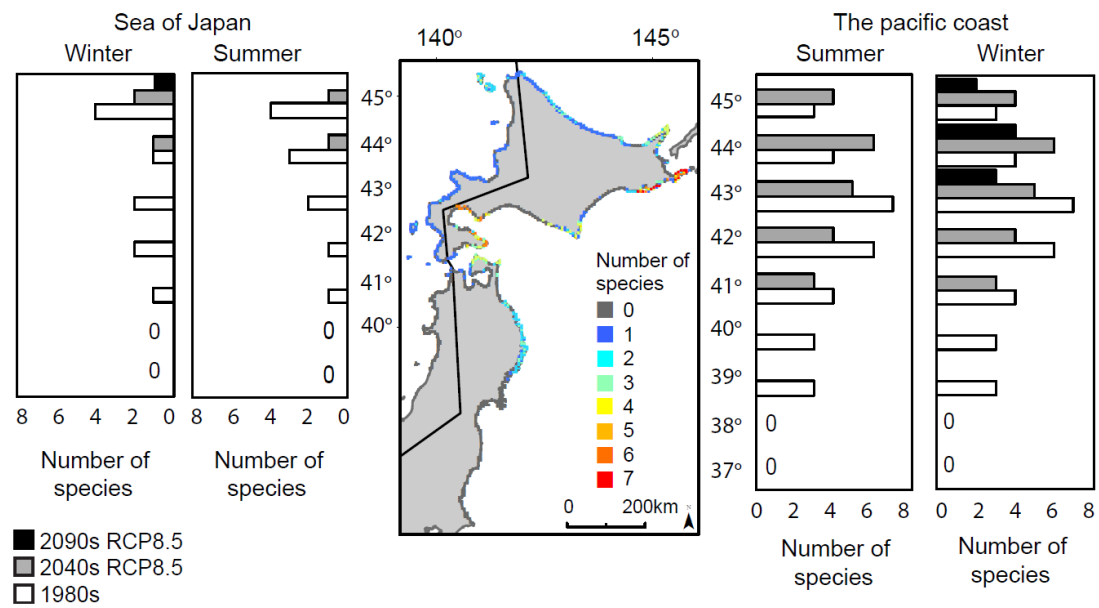


Fig. 2-4. Estimated species richness of the kelps in cold seawater. The maps show the species richness in the 1980s; the bar graphs represent number of species by latitude in the Sea of Japan (left) and the Pacific Ocean (right) in the 1980s (white column), and predicted richness in the 2040s (gray column) and 2090s (black column) based on the RCP 8.5 scenarios.

Chapter 3

Fine-scale distribution of tropical seagrass beds in Southeast Asia

3.1 INTRODUCTION

Seagrass beds are one of the most important coastal habitats globally, offering valuable ecosystem services for human life (Constanza et al. 1997; McArthur and Boland 2006; Unsworth and Cullen 2010; Nakaoka et al. 2014). This habitat has been threatened by various types of human-induced stresses, including overexploitation, eutrophication, and coastal development (Orth et al. 2006, Waycott et al. 2009). Although Southeast Asia is a hotspot of global seagrass diversity (Short et al. 2007), historically there have been large gaps in the scientific knowledge of tropical seagrass species in this region (Fortes et al. 2018). For example, in a global analysis on temporal changes in seagrass beds, Waycott et al. (2009) estimated that seagrass beds are disappearing at a rate of 7% year⁻¹ globally. However, they only included two pieces of data from East and Southeast Asia, and so the estimated decreasing rate of seagrass beds globally was likely underestimated because of a lack of long-term quantitative scientific data from Asia. Thus, there is an urgent need for more information on the current status of seagrass bed distribution in this region to facilitate the management of marine biodiversity and sustainable use of marine resources.

Open-access data on seagrass bed distribution globally have been available since 2003 following the publication of the World Atlas of Seagrasses (WAS) and by the online release of its GIS data set through Ocean Data Viewer also in 2003 (Green and Short 2003; UNEP-WCMC and Short 2016;

<http://data.unep-wcmc.org/> 9th, April 2018 accessed). However, the data set has not been updated and the resolution is still low in the Asian region compared with developed regions such as North America, Europe and Australia. With the increasing awareness of the importance of seagrass beds, multiple surveys on the status of seagrass beds have been conducted by governmental managers and scientists in Asian countries since the 2000s, although most of them have been published in local literature in native languages, which are difficult to access by internet surveys in English.

This data paper provides recent data on tropical seagrass bed distribution in Southeast Asia. I compiled data on seagrass distribution from the literature and reports locally published in each country after 2000 and created a geographic information system (GIS) database. The obtained data were presented either by polygon data (a total of 718 data) or point data (917 data) both associated with the information on seagrass bed area and seagrass species composition if available. The obtained fine-resolution, broad-scale data will be useful to understand the current status of seagrass beds and to help facilitate better conservation and management of coastal areas in this region that are still under great threat from various types of human-induced stresses.

3.2 List of data files

Seagrass point DB.csv

Seagrass polygon DB.csv

Reference DB.csv

Seagrass polygon DB.shp

3.3 Metadata

3.3.1 GEOGRAPHIC COVERAGE

The geographic scope of this study covers from S 11.010° to N 30.424° in latitude and from E 94.229 ° to 140.702 ° in longitude (geodetic system: WGS84). The area includes all the coastlines of Brunei Darussalam, Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Timor-Leste, Vietnam, and the southern coasts of China and Japan. The northern boundary is set so that it covers the northern limit of tropical seagrass species; i.e., Fujian province in China (Zheng et al 2013) and the southern part of Kagoshima prefecture in Japan (Nature Conservation Bureau, Environment Agency and Marine Parks Center of Japan, 1994). The data from Thailand were not included in this data paper because recent GIS-based information on seagrass bed distribution has already been made publically available by the Thai Government Department of Marine and Coastal Resources (<http://marinegiscenter.dmcg.go.th/>, 9th April 2018, accessed).

3.3.2 METHODS

A. Literature collection

Data were collected from more than 96 scientific articles or reports. I searched the literature using the terms “seagrass” and “target country name” through the

Web of Science, Google Scholar and Google. In an online survey, I looked for references not only in English, but also in local Asian languages (Japanese, Chinese, Vietnamese, and Indonesian). Together with the online literature survey, I also visited Vietnam and asked key researchers there about the seagrass distribution literature published in Vietnamese. From the collected literature, I only use seagrass distribution literature and reports published after 2000.

B. Data processing

I compiled data into two formats to make the GIS database; point data and polygon data. Seagrass bed distribution maps in the original literature were georeferenced using the ArcGIS georeference tool, and seagrass bed outlines were manually traced using the editor tool. In some of the literature, the position of seagrass beds are shown over large areas that sometimes extend to areas of very deep water (> 100 m). For these data, I narrowed down the distribution to the shallower, coastal area to which tropical seagrass can survive (Duarte 1991). As a result, a total of 718 polygon data and 917 points data were installed in the GIS database (Fig.3-1). Each point and polygon datum has associated data on the seagrass species composition, and each point datum also has that of seagrass bed area (ha), if available.

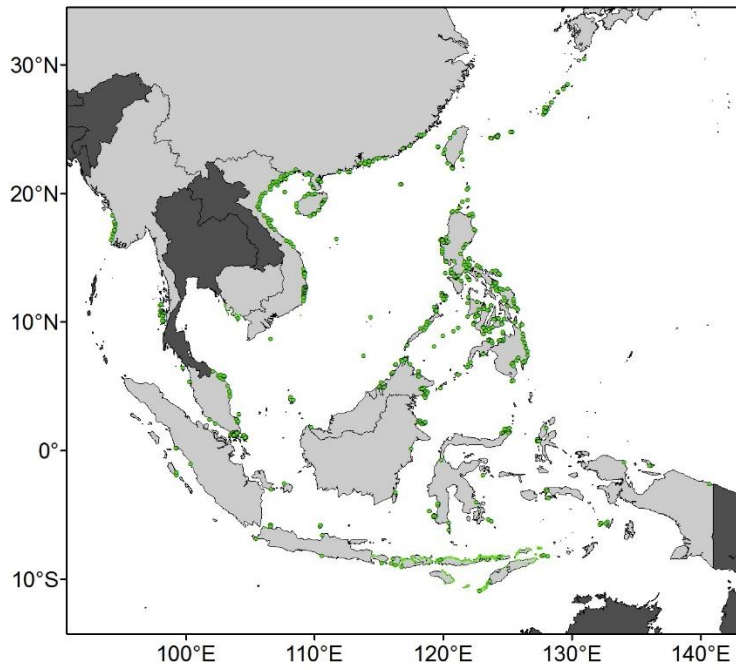


Fig.3-1. Plotted seagrass beds in Southeast Asia from the current database for the period of 2000-2019.

Table 3-1 The number of point and polygon data in each country

Country	Number of point data	Number of polygon data	Total
Brunei Darussalam	2	0	2
Cambodia	0	17	17
Indonesia	182	343	525
Malaysia	91	0	91
Myanmar	58	0	58
the Philippines	312	102	414
Singapore	43	9	52
Southern China	95	0	95
Southern Japan	45	157	202
Timor-Leste	0	30	30
Vietnam	89	60	149
Total	917	718	1635

3.4 DATA STRUCTURE

A. File Format

The data files are saved in the comma delimited (csv) text file format. The GIS polygon data files are formatted in shape file and compressed into the commonly used zip format.

B. List of Files

Variables in file name	Description
Seagrass point DB.csv	Attribute table of point data for seagrass bed distribution including coordinates, area and seagrass species composition
Seagrass polygon DB.csv	Attribute table of polygon data for seagrass bed distribution including coordinates and seagrass species composition
Reference DB.csv	Reference database of both point and polygon data
Seagrass polygon DB.shp	Polygon data of seagrass bed distribution from the literature for GIS compressed into the commonly used zip format

C. Data Table Details

Seagrass point DB.csv

Variables in file name	Description
ID	ISO country code alpha-3, data category and serial number
No	Serial number
Locality	Local place name
Site	Site name from the literature
Lat	Latitude coordinated WGS84 DDD
Long	Longitude coordinated WGS84 DDD
Reference	First author name, publication year
Source	Data information source
Country	ISO country code alpha-3
Area Literature	Area (ha) from the literature
Remarks	Remarks
Species	Presence or absence of each seagrass species from the literature at the site; 1: presence, 0: absence, Acronyms denote genus and species; Cs: <i>Cymodocea serrulata</i>, Cr: <i>Cymodocea rotundata</i>, Ea: <i>Enhalus acoroides</i>, Hb: <i>Halophila beccarii</i>, Hd: <i>Halophila decipiens</i>, Hm: <i>Halophila minor</i>, Ho: <i>Halophila ovalis</i>, Hs: <i>Halophila spinulosa</i>, Hp: <i>Halodule pinifolia</i>, Hu: <i>Halodule uninervis</i>, Rm: <i>Ruppia maritima</i>, Si: <i>Syringodium isoetifolium</i>, Th: <i>Thalassia hemprichii</i>, Tc: <i>Thalassodendron ciliatum</i>, Zj: <i>Zostera japonica</i>

Seagrass polygon DB.csv

Variables in file name	Description
ID	ISO country code alpha-3, data category and serial number
No	Serial number
Locality	Local place name
Site	Site name from the literature
Lat	Latitude coordinated WGS84 DDD Weighted center of the polygon
Long	Longitude coordinated WGS84 DDD Weighted center of the polygon
Reference	First author name, publication year
Source	Data information source
Country	ISO country code alpha-3
Area GIS	Calculated area (ha) of polygon data using GIS
Area Literature	Area (ha) from the literature
Remarks	Remarks
Species	Presence or absence of each seagrass species from the literature at the site; 1: presence, 0: absence, Acronyms denote genus and species; Cs: <i>Cymodocea serrulata</i>, Cr: <i>Cymodocea rotundata</i>, Ea: <i>Enhalus acoroides</i>, Hb: <i>Halophila beccarii</i>, Hd: <i>Halophila decipiens</i>, Hm: <i>Halophila minor</i>, Ho: <i>Halophila ovalis</i>, Hs: <i>Halophila spinulosa</i>, Hp: <i>Halodule pinifolia</i>, Hu: <i>Halodule uninervis</i>, Rm: <i>Ruppia maritima</i>, Si: <i>Syringodium isoetifolium</i>, Th: <i>Thalassia hemprichii</i>, Tc: <i>Thalassodendron ciliatum</i>, Zj: <i>Zostera japonica</i>

Reference DB.shp

Variables in file name	Description
ID	ISO country code alpha-3 and serial number
Reference	Citation and Digital Object Identifier (DOI)

Seagrass polygon DB.csv

Variables in file name	Description
ID	ISO country code alpha-3 and serial number

3.5 ACCESSIBILITY

A. License

This data set is provided under a Creative Commons Attribution 4.0

International license (CC-BY 4.0)

(<https://creativecommons.org/licenses/by/4.0/>). Cite this data paper as appropriate credit.

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Chapter 4

Estimated distribution of tropical seagrasses species in Southeast Asia and their conservation status

4.1 Introduction

Seagrass beds are the key habitats in the coastal ecosystem of the world (Duke and Schmitt, 2016; Jenkins and Houtan, 2016; Short et al., 2007). These habitats support high primary productivity and support rich fauna, including endangered and commercially important species (Heck et al., 2003; Kikuchi and Pere's, 1977; Nakaoka, 2005; Williams and Heck Jr, 2001). They also provide other types of valuable ecosystem services to humans, such as water quality control, disaster resilience and blue carbon stock, which economic values per area highly exceed those by terrestrial ecosystems (Costanza et al., 1997). However, seagrass beds are disappearing rapidly from the world due to various human activities such as coastal habitat alterations, water quality deterioration, and climate change (Duarte et al. 2008; Duarte 2011; Orth et al. 2006; Waycott et al. 2009).

Southeast Asia hosts a total of 19 species of seagrasses in which seagrass diversity is the highest in the world (Green and Short, 2003). Here, seagrass beds locate mostly in conjugation with other important coastal habitats such as mangrove and coral reefs (Duarte et al. 2008). Seagrass beds plays important roles in supporting high ecosystem functions of tropical coastal ecosystems by supporting high fisheries stocks (Cullen-Unsworth and Unsworth 2013), sequestering carbon from other habitats (Miyajima et al. 2015) and providing habitats for endangered iconic species such as dugong and green

turtles (Aragones et al. 2006). However, they are also facing various human impacts reflecting high human population densities along the Asian coast (Dolar et al. 2005). Furthermore, the data on seagrass bed distribution and their status in SE Asia were not sufficient compared to those from developed countries (Waycott et al. 2009). A GIS-based broad-scale map of seagrass distribution are now available in World Atlas of Seagrasses (<https://data.unep-wcmc.org/>). Nevertheless, the data from SE Asia are mostly based on those collected before 2000 (Green and Short 2003) which contains many data with imprecise geographic information. Species-by-species distribution is less available than seagrass bed distribution in this region, with large information gap still exist in regions like Myanmar, northern Borneo Island and southern Indonesia. As different seagrass species have different types of ecosystem functions and services (Nordlund et al. 2016), it is important to know species distribution of seagrass beds at both large and small spatial scales to promote their effective conservation and management at various levels of governance (from national government to local governmental units of each country).

Recently, studies on broad-scale and fine-scale estimation of marine biodiversity have been facilitated by the establishment of open-access global databases, such as GBIF (<http://www.gbif.org/>), and OBIS (<http://www.iobis.org/>), and by the development of new statistical methods/tools for species distribution estimation, such as MaxEnt, GAM and Random Forest Models (Guisan et al. 2017). Using these databases and statistical tools, spatial patterns of marine biodiversity have been estimated for a variety of taxa over various scales, from global level to regional and local levels (Tittensor et al. 2010; Kaschner et al.

2016). For seagrasses, Jayathilake & Costello (2018) recently estimated species-by-species distribution covering the whole distributional ranges of world seagrasses. However, spatial resolution of environmental data they used (grain size of 1 arc degree) was not sufficient to precisely estimate the distribution of each species and to utilize the information for conservation and management purposes at level of local governmental unit. Finer-scale estimation of seagrass species and seagrass beds was carried out by some studies such as Downie et al. (2013) although these studies targeted some specific regions which are not useful for management purposes at national or international levels. These recent analyses also clarified that there are still large information gaps around Indian and west Pacific Oceans (Forest et al. 2018; Jayathilak & Costello 2018). Filling these information gaps and providing species distribution data covering broad extent but with finer resolution are necessary to understand the current distribution patterns of seagrasses in biodiversity-rich SE Asian region and to promote their effective management at various decision-making levels (Ooi et al 2011; Forest et al. 2018; Jayathilak & Costello 2018).

The aim of this paper is to estimate the seagrass species distribution covering the whole southeastern Asia with fine resolution based on recent information collected after 2000. To achieve this purpose, I collected more than 1600 data on seagrass species occurrence for the period between 2000 and 2019 by intense literature survey, and compiled them in a GIS database (Chapter 3; Sudo and Nakaoka, 2019 under review). I estimated each seagrass species distribution using a species distribution model (MaxEnt) relating seagrass present data with spatial data on environmental factors (temperature, depth, slope,

diffuse attenuation coefficient at 490 nm, river effect, mangrove forest area and coral reef area). I then examined the conservation status of these seagrass species by analyzing how much of their distributed areas overlaps with current marine protected areas (MPAs) in each IUCN category. The obtained results from this study will contribute to updating global map of seagrasses biodiversity, and to facilitating effective conservation and management of seagrass beds at various levels of decision-making processes (from governments to local communities).

4.2 METHODS

4.2.1 Scope and species

In this study, a research area is set along the coast of Southeast Asia between 10.0° S and 30.0° N, and between 90.0° E and 140.0° E. Nineteen species of seagrasses occur in Southeast Asia (Fortes et al. 2018) among which I targeted 10 species from the 3 families that are dominant in Southeast Asia (Table 4-1). The other species were excluded from the analyses because of taxonomic unreliability and insufficient number of occurrence data to retain model accuracy. *Zostera japonica* and *Halophila beccarii* occurred limited range in this region. Using the large evaluation range overestimates AUC and outputs. Thus, the evaluation ranges were limited to countries with occurrence data for these two species.

4.2.2 Data collection

I constructed a seagrasses species composition database in Southeast Asia which contained a total of 1,634 occurrence data from 666 sites among 14

countries. Data were collected from more than 82 scientific articles published after 2000 (Sudo and Nakaoka, 2019 under the review). I searched the literature using the terms “seagrass” and “target country name” through the Web of Science, Google Scholar and Google. In an online survey, I looked for references not only in English, but also in local Asian languages (Japanese, Chinese, Vietnamese and Indonesian).

4.2.3 Species distribution models

The SDMs identify the relationships between the presence of a species and environmental variables. Many algorithms exist for SDMs, among which maximum entropy modeling (MaxEnt) has been most used commonly because it is robust against georeferencing errors using presence-only records (Elith et al. 2011, Graham et al. 2008, Phillips et al. 2006). It outperforms most other algorithms, such as generalized linear models, generalized additive models and random forests, and is particularly appropriate for marine species (Aguirre-Gutiérrez et al. 2013; Elith et al. 2006; Ready et al. 2010). MaxEnt also performs well in estimating potential range shifts for a species due to climate change (Hijmans and Graham 2006). Therefore, I chose to use MaxEnt in this study.

All MaxEnt models were run using the default settings (version 3.3.3k; Phillips et al. 2006) and replicated 10 times subsampling. Random test percentage for the subsample used 20% of the data. The model accuracy was examined by the area under the curve (AUC) (Fielding and Bell 1997) for which values >0.7 are commonly accepted (Raes and ter Steege 2007; Swets 1988). Predicted logistic values of each grid were converted to presence/absence values

using an equal training sensitivity and specificity logistic threshold. This threshold provides restricted thresholds compared with 10 percentile training presence logistic threshold as suggested by Phillips and Dudík (2008). A probability lower than this threshold was classified as absence and higher probabilities classified as presence. The converted model results of 10 species were summed to estimate variation in seagrass species diversity. A spatial filtering of occurrence localities improves the models using uneven sampling effort (Boria et al 2014; Kramer-Schadt et al 2013). I randomly extracted maximum 2 occurrence data from 1 arc grid (around 110km×110km) to improve the biased data set.

4.2.4 Environmental dataset for estimating species distribution

Past global studies on marine biodiversity estimation were conducted at resolution coarser than 50 km grid size (e.g., Tittensore et al. 2010, Kaschner et al. 2016). However, more recent study attempted to estimate species distribution at finer resolution such as by 1 km grid size (e.g., Jayathilake and Costello 2018). In this study, I ran SDM at the resolution of 2 km. First, I created a database of 10 environmental variables based on large-scale modeling at 2 km resolution (Table 4-2). I evaluated the range of 2 km from the coastal lines. The variables were (1) depth (average), (2) depth (maximum), (3) slope, (4) monthly climatology mean SST in February, (5) monthly climatology mean SST in August, (6) diffuse attenuation coefficient at 490 nm (KD490) in February, (7) KD490 in August, (8) mangrove area (9) coral reef area and (10) river effect.

From these variables, I excluded the depth (maximum) because of collinearity with the depth (average). The collinearity can decrease accuracy of

prediction in ecological models including SDM (Dormann et al. 2013). In addition, these data were lower contribution percent compared to the average. As a result, 9 environmental variables were used in the SDMs (Table 4-2). This study set the resolution of all variables to a 2 km grid by interpolation with the natural neighbor method (Sambridge et al. 1995). February and August SSTs were highly correlated over the entire study area, and thus it was difficult to include both variables in one SDM. KD490s in February and August also correlated each other. Therefore, I constructed two SDMs for each species respectively, (1) a combination of February SST, February KD490, depth, slope, mangrove area, coral reef area and river effect (February model), and (2) August SST, August KD490, depth, slope, mangrove area, coral reef area and river effect (August model).

Size of watershed affects seagrass species due to freshwater, nutrient and sedimentation inputs (van der Zon 2010). I develop an indicator of river effect (RE) as follows;

$$RE = \text{watershed area} / \text{distance from river mouth}^2$$

The river effect was used for 446 watersheds which are larger than 1000 km.

4.2.5 Conservation status of the seagrass species

The area of marine protected areas (MPAs) was obtained from Protected Planet (<https://www.protectedplanet.net/marine> 26th Oct 2019, accessed). For each MPA, the degree of protection level was classed following the IUCN protected areas category I–IV (Table 4-3). Category I, II and III have several restrictions for the human uses such as research, fishing, tourism, renewable energy, shipping

and aquaculture. On the other hands, category IV, V and VI only have few restrictions (Day et al., 2012; Le Gouvello et al., 2017). I then analyzed how much grids where each seagrass species estimated to occur were covered with each category of MPAs.

4.3 RESULTS

4.3.1 Species distribution and biodiversity of seagrasses

The species richness varied from 1 to 10 species for each 2 x 2 km grid, with the highest species diversity (10 species) observed mostly in the Ryukyu Islands, the Philippines, Sabah Malaysia, Sulawesi Island, Andaman Islands and Myanmar (Fig. 4-1).

Cymodocea rotundata, *H. pinifolia*, *E. acoroides*, *H. ovalis* and *T. hemprichii* had the widest distribution with estimated grid number of > 28,000, ranging whole evaluation area along the Pacific Ocean coast and Indian Ocean (Table 4-6, 4-S1-1). These species are followed by *Cymodocea serrulata*, *H. uninervis* and *S. isoetifolium*, which were estimated to occur at 23,000 - 26,000 grids. *Halophila beccarii* and *Z. japonica* occurred in smallest areas (8,034 and 1,792 grids). Distribution of *H. beccarii* was limited to Myanmar, Thailand, Malaysia, Singapore, Vietnam, China and the Philippines, and that of *Z. japonica* to Vietnam, China and Japan.

Cymodocea rotundata, *H. pinifolia*, *H. uninervis*, *E. acoroides* *H. ovalis* and *T. hemprichii* were estimated to have wide distribution, ranging over whole evaluation area along coasts of the Pacific Ocean and Indian Ocean. *Cymodocea serrulata* and *S. isoetifolium* were estimated to occur mostly in the coral reef

areas such as the Philippines, around Sulawesi Island and Andaman Islands. *Enhalus acoroides* were estimated to occur mostly around mangrove-dominated areas such as Malaysia, Thailand and Myanmar. Distribution of *H. beccarii* and *Z. japonica* was limited to the flat areas such as around river mouths.

The distribution of 10 seagrass species were well predicted in the February model by the combination of seven environmental variables with AUC ranging between 0.73 and 0.97 (mean 0.84) (Table 4-4). For *C. serrulata* and *S. isoetifolium*, coral reef area explained the most of their distribution with its contribution exceeding 80%. For *C. rotundata*, *H. pinifolia*, *H. uninervis*, *E. acoroides* and *T. hemprichii*, coral reef area explained 40-70% and SST February 15-37% of the most of their distribution. For *H. ovalis*, these two variables almost equally contributed. For *H. beccarii* and *Z. japonica*, the slope explained more than 80%. River effect was partially contributing (12-15%) to the distribution of *H. pinifolia*. *H. uninervis*, *H. beccarii* and *H. ovalis*, whereas mangrove area contributed 19.5% to the distribution of *E. acoroides*.

Model fitness was generally lower by the August model than the February model, especially for *H. pinifolia* and *H. ovalis* (Table 4-4).

4.3.2 Protection status of the seagrasses

Percentage of seagrass species that located within the existing MPAs varied greatly among the species (Table 4-7, 4-8). Among them, *C. rotundata*, *C. serrulata*, *H. pinifolia*, *H. uninervis*, *S. isoetifolium*, *E. acoroides*, *H. ovalis* and *T. hemprichii* were estimated to occurred more than 5000 girds within MPAs in the

February model. *Halophila beccarii* and *Z. japonica*, in contrast, had only 945 grids and 536 grids within MPAs, respectively (Table 4-4-7).

For *C. rotundata*, *C. serrulata*, *H. pinifolia*, *H. uninervis*, *S. isoetifolium*, *E. acoroides*, *H. ovalis* and *T. hemprichii*, the categorized Ia (strict nature reserve) and Ib (wilderness area) covered 100 - 300 grids and 10 - 70 grids, respectively. In addition, category II (national parks) covered more than 1000 grids. For *H. beccarii* and *Z. japonica*, category II covered 325 and 130 grids respectively. For *C. rotundata*, *C. serrulata*, *H. uninervis*, *S. isoetifolium*, *E. acoroides*, *H. ovalis* and *T. hemprichii*, category III Natural Monument only covered 2-4 grids (Table 4-7).

The species occurrence in MPAs were generally more by August model although among-species variation in relative coverage followed the same pattern with February model (Tables 4-7, 4-8).

4.4 Discussion

4.4.1 Species distribution estimates

This study estimated recent distributions of seagrass species in the Southeast Asia where there have been great scientific gaps in the knowledge on the marine biodiversity including seagrass species. The fit of the SDMs was moderately similar to the preceding studies on seagrasses in the Atlantic Ocean and over global scale (Valle et al. 2014; Jayathilake & Costello 2018). The coral reef area was significantly contributed to the estimation for several species. This study highlighted that the species diversity of seagrasses was the highest in the coral reef abundant region. It was estimated that seagrass species diversity in the

Andaman Islands and Myanmar were much higher than previous report (Short et al. 2007). Furthermore, the comparisons with current effective MPAs revealed that less than 10% (4-8%) of their distribution was overlapped with MPAs with some restriction on human usage (categories I-III).

As expected, the estimated distribution was different among seagrass species. For the most species analyzed here, coral reef area was highly related to their occurrence because more than 70% of the seagrass beds occurred back reef (shallow sedimentary area inside the coral reef fringe) in this region (Ooi et al. 2011). In contrast, around 20% of seagrass beds occurred estuary (Ooi et al. 2011). In this study, the distribution of *E. acoroides* and *H. beccarii* were well explained by slope. These species occurred in estuary and in front of mangrove tidal flat areas which composed of soft muddy bottom (Abu Hena et al 2017; Nakajima et al.2014)

The February SSTs were selected as one of the key environmental factors for the SDMs in this study, which agrees with previous studies which showed that temperature is the key factor in determining *Cymodocea* distribution in the northern Atlantic Ocean and Mediterranean (Chefaoui et al. 2016), and all the seagrass species in the world (Jayathilake and Costello 2018). In the global study by Jayathilake and Costello (2018), the maximum SSTs contributed more than 50% to the model using MaxEnt, whereas contribution of SST in this study was smaller. The difference is likely related to the range of temperature each study covered. This study covered the latitude of N30° to S10°. among which variation in temperature is less than the global comparisons. Furthermore, this study extend covers more area in Northern Hemisphere, which may explain why

February SST contribute more than August SST. In this study, however, the distribution of *C. serrulata* and *S. isoetifolium* were not well explained by SST. The spatial variation in SSTs may be too small to predict the distribution of these species.

Seagrass species diversity is highly affected by sediment conditions and siltation, which is tightly related to the terrestrial input from rivers (Terrados et al. 1997). Seagrass beds located near large river mouths showed higher silt-clay content in the sediments and nutrient loading, and species composition was positively related to distance to the river mouth (Terrados et al. 1997). *Halodule uninervis*, *E. acoroides* and *H. ovalis* were estimated to occur near the river mouth (Nakaoka et al 2004; van Katwijk et al 2011), and *H. beccarii* at river estuary where mangroves are abundant (Abu Hena et al 2017). This result agrees with these studies as relatively higher contribution of river effect was observed for these species compared to others.

4.4.2 Conservation status

Setting MPAs is one of the most effective management for protecting marine biodiversity (Sala & Giakoumi, 2017). MPAs can protect seagrass beds against coastal development, habitat damage from over and destructive fishing (Short and Wyllie-Echeverria, 1996), and prevent increasing aquaculture inside the MPAs. It should be also noted, however, MPAs do not always have significant effect on seagrass conservation especially when adjacent terrestrial area is not properly managed (Quiros et al. 2017).

IUCN protected area management categories are useful as a global standard for the planning, establishment and management of protected areas (Dudley, 2008). The categories Ia (strict nature reserve) and Ib (wilderness area) are highly effective for the seagrass conservation, and the category II (national park) can prevent large-scale coastal development, and aquaculture activities. In contrast, the categories V and VI allow human activities like fisheries and aquaculture (Day et al. 2012), and thus not effective enough for the conservation of seagrass beds. The present study showed that although coverage by overall MPAs are high in Southeast Asia, the proportion of categories which are effective in protecting seagrass beds (Categories I, II and III) were not so high.

The coverage of seagrasses by MPAs estimated here is similar to a former study by Torres-Pulliza et al. (2013), which showed that around 30% of seagrass beds distribution in the Lesser Sunda ecoregion, extending from Bali, Indonesia to Timor-Leste, was covered by MPAs. The coverage of coral reef was 28.6% in this evaluation range (K. Sudo, unpublished data).

4.5 Conclusions

This integrated analysis of 10 seagrass species in the coastal areas of Southeast Asia revealed that species diversity was the highest around the Ryukyu Islands, the Philippines, Sabah Malaysia, Sulawesi Island, Andaman Islands and Myanmar. The distribution of 10 seagrass species were predicted better with the February models, which may be due to the study area skewed toward Northern Hemisphere. MPAs with strict regulation (Category I,II and III) covered 4-8% of the estimated distribution of each species.

The results of estimated distribution of each seagrass species can be utilized to find suitable sites for the reintroduction and conservation of endangered species such as *H. beccarii*, and to conduct field surveys in areas where previous records are absent to improve our knowledge of seagrass species diversity in Southeast Asia. In this study, I excluded other narrow range species, such as *Halophila spinulosa* and *Thalassodendron ciliatum* because available data were too small for the models. These species would be facing more risk of local extinction than other wider occurrence species analyzed here. A future study should include information on these species to examine the status of distribution, conservation status and risk of local extinction for these species.

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Table 4-1. Seagrass species analyzed in this study.

Family	Scientific name	Number of occurrence data	IUCN Red List status
Cymodoceaceae	<i>Cymodocea rotundata</i>	237	VU
	<i>Cymodocea serrulata</i>	90	
	<i>Halodule pinifolia</i>	38	
	<i>Halodule uninervis</i>	202	
	<i>Syringodium isoetifolium</i>	140	
Hydrocharitaceae	<i>Enhalus acoroides</i>	256	
	<i>Halophila beccarii</i>	49	
	<i>Halophila ovalis</i>	284	
	<i>Thalassia hemprichii</i>	291	
Zosteraceae	<i>Zostera japonica</i>	47	

Table 4-2. Environmental variables used for the species distribution models.

Environmental variable	Unit	Time period	Resolution	Source
Depth (average)	m	-	0.03 km (15 arc seconds)	1)
Depth(maximum)	m	-	0.03 km (15 arc seconds)	1)
Slope	degree	-	2km	1)
Monthly climatology mean SST in February	degree	2003-2019	4km	2)
Monthly climatology mean SST in August	degree	2002-2019	4km	2)
Diffuse attenuation coefficient at 490 nm in February	m ⁻¹	2003-2019	4km	3)
Diffuse attenuation coefficient at 490 nm in August	m ⁻¹	2002-2018	4km	3)
Mangrove area	ha/grid	1996-2016	Polygon	4)
Coral reef area	ha/grid	1954-2018	Polygon	5)
River effect	-	-	-	6)

1) Tozer, B. , D. T. Sandwell, W. H. F. Smith, C. Olson, J. R. Beale, and P. Wessel, Global bathymetry and topography at 15 arc seconds: SRTM15+, Accepted Earth and Space Science, August 3, 2019.

2) NASA Ocean color MODIS Aqua 11μ day and night time SST
<https://oceancolor.gsfc.nasa.gov>

3) NASA Ocean color MODIS Aqua Diffuse attenuation coefficient at 490 nm
<https://oceancolor.gsfc.nasa.gov>

- 4) Bunting P., Rosenqvist A., Lucas R., Rebelo L-M., Hilarides L., Thomas N., Hardy A., Itoh T., Shimada M. and Finlayson C.M. (2018). The Global Mangrove Watch – a New 2010 Global Baseline of Mangrove Extent. *Remote Sens.* 2018, 10, 1669; doi:10.3390/rs10101669
- 5) UNEP-WCMC, WorldFish Centre, WRI, TNC (2018). Global distribution of coral reefs, compiled from multiple sources including the Millennium Coral Reef Mapping Project. Version 4.0, updated by UNEP-WCMC. Includes contributions from IMaRSUSF and IRD (2005), IMaRS-USF (2005) and Spalding et al. (2001). Cambridge (UK): UNEP World Conservation Monitoring Centre.
URL: <http://data.unepwcmc.org/datasets/1>
- 6) Lehner, B., Verdin, K., Jarvis, A. (2008): New global hydrography derived from spaceborne elevation data. *Eos, Transactions, AGU*, 89(10): 93-94.

Table4-3 IUCN protected area category and the types of management objectives (Dudley, 2008)

Protected area category and international name	Management objectives
Ia . Strict Nature Reserve	Managed mainly for science
Ib . Wilderness Area	Managed mainly to protect wilderness qualities
II . National Park	Managed mainly for ecosystem protection and recreation
III . Natural Monument	Managed mainly for conservation of specific natural/cultural features
IV . Habitat/ Species Management Area	Managed mainly for conservation through management intervention
V . Protected Landscape/Seascape	Managed mainly for landscape/seascape conservation and recreation
VI . Managed Resource Protected Area	Managed mainly the sustainable use of natural ecosystem

Table 4-4 Contribution (%) of each environmental variable in the February model and AUC of the SDMs for 10 species of seagrasses

Family	Scientific name	Coral reef area (ha)	SST Feb. (degree)	River effect	Mangrove area (ha)	Slope (degree)	Depth mean (m)	KD490 Feb.	AUC
Cymodoceaceae	<i>Cymodocea rotundata</i>	70.0	14.9	7.3	1.6	1.9	0.1	4.4	0.80
	<i>Cymodocea serrulata</i>	83.0	4.4	5.8	0.2	3.3	0.3	3.0	0.84
	<i>Halodule pinifolia</i>	40.9	37.4	12.1	8.5	0.7	0.1	0.5	0.73
	<i>Halodule uninervis</i>	44.1	29.4	14.9	0.3	7.8	2.1	1.4	0.85
	<i>Syringodium isoetifolium</i>	81.0	8.3	5.9	0.7	3.4	0.0	0.7	0.85
Hydrocharitaceae	<i>Enhalus acoroides</i>	44.5	20.7	5.3	19.5	3.7	0.4	5.9	0.80
	<i>Halophila beccarii</i>	0.3	1.5	11.7	0	84.7	0.9	0.9	0.95
	<i>Halophila ovalis</i>	35.6	40.7	14.1	3.6	4.7	1.1	0.3	0.81
	<i>Thalassia hemprichii</i>	52.5	22.8	8.0	1.8	4.2	7.4	3.4	0.81
Zosteraceae	<i>Zostera japonica</i>	0.0	1.6	1	0.9	95.1	0.8	0.6	0.97
mean		45.2	18.2	8.6	3.7	21.0	1.3	2.1	0.84
SD		27.5	13.7	4.2	5.8	34.6	2.1	1.8	

Table 4-5 Contribution (%) of each environmental variable in the August model and AUC of the SDMs for 10 species of seagrasses

Family	Scientific name	Coral reef area (ha)	SST Aug. (degree)	River effect	Mangrove area (ha)	Slope (degree)	Depth mean (m)	KD490 Aug.	AUC
Cymodoceaceae	<i>Cymodocea rotundata</i>	80.1	2.2	11.9	2.4	2.9	0	0.5	0.80
	<i>Cymodocea serrulata</i>	83.2	0.3	8.9	0.8	3.5	0.1	3.2	0.81
	<i>Halodule pinifolia</i>	58.1	3.8	13.9	11.6	1.6	1.1	9.8	0.65
	<i>Halodule uninervis</i>	58.3	2	23.3	0.7	10.9	2.8	2	0.98
	<i>Syringodium isoetifolium</i>	87.1	0.8	7.9	0.6	3.3	0.1	0.3	0.85
Hydrocharitaceae	<i>Enhalus acoroides</i>	58.3	5.4	6.3	23.3	3.1	0.4	3.2	0.80
	<i>Halophila beccarii</i>	0.2	0.4	0.1	0.2	96.2	0	2.8	0.93
	<i>Halophila ovalis</i>	45.2	18.1	22.4	1.6	9.4	1	2.3	0.69
	<i>Thalassia hemprichii</i>	63.5	2	14.2	2.2	6.3	9.4	2.4	0.79
Zosteraceae	<i>Zostera japonica</i>	0.1	1.9	1	0.7	95.2	0.8	0.3	0.95
mean		53.4	3.7	11.0	4.4	23.2	1.6	2.7	0.82
SD		31.0	5.3	7.9	7.4	38.3	2.9	2.7	

Table 4-6. Predicted number of grids for 10 seagrass species in the February and August models

Family	Scientific name	Feb. model (grids)	Aug. model (grids)	Total number of evaluation grids
Cymodoceaceae	<i>Cymodocea rotundata</i>	28,562	33,131	128,418
	<i>Cymodocea serrulata</i>	23,174	78,311	128,418
	<i>Halodule pinifolia</i>	32,386	64,823	128,418
	<i>Halodule uninervis</i>	25,545	57,788	128,418
	<i>Syringodium isoetifolium</i>	25,854	39,184	128,418
Hydrocharitaceae	<i>Enhalus acoroides</i>	27,663	55,397	128,418
	<i>Halophila beccarii</i>	8,034	5,732	40,142
	<i>Halophila ovalis</i>	32,356	63,893	128,418
	<i>Thalassia hemprichii</i>	29,876	50,116	128,418
Zosteraceae	<i>Zostera japonica</i>	1,792	1,962	16,890

Table 4-7 Number of estimated grids overlapped with MPAs in each IUCN category in the February model

Family	Scientific name	IUCN category								Total
		Ia	Ib	II	III	IV	V	VI	NR	
Cymodoceaceae	<i>Cymodocea rotundata</i>	221	61	1441	4	432	903	2456	1239	6757
	<i>Cymodocea serrulata</i>	233	47	1320	2	343	712	2417	974	6048
	<i>Halodule pinifolia</i>	135	13	1194	0	324	951	2066	1484	6167
	<i>Halodule uninervis</i>	230	28	1276	3	313	721	1932	1132	5635
	<i>Syringodium isoetifolium</i>	200	62	1395	2	421	855	2453	1119	6507
Hydrocharitaceae	<i>Enhalus acoroides</i>	154	38	1080	3	306	843	1790	1006	5220
	<i>Halophila beccarii</i>	0	0	325	0	249	81	1	289	945
	<i>Halophila ovalis</i>	187	37	1313	2	383	774	2325	1593	6614
	<i>Thalassia hemprichii</i>	272	42	1578	4	408	774	2619	1144	6841
Zosteraceae	<i>Zostera japonica</i>	0	0	130	0	16	21	141	228	536

Ia : Strict Nature Reserve, Ib : Wilderness Area, II : National Park, III : Natural Monument or Feature, IV : Habitat/Species

Management Area, V : Protected Landscape/ Seascape, VI : Protected area with sustainable use of natural resources, NR :

Not reported

Table 4-8 Number of estimated grids overlapped with MPAs in each IUCN category in the August model

Family	Scientific name	IUCN category								Total
		Ia	Ib	II	III	IV	V	VI	NR	
Cymodoceaceae	<i>Cymodocea rotundata</i>	482	116	3141	5	1281	1407	4898	2698	14028
	<i>Cymodocea serrulata</i>	357	74	1844	5	561	876	3754	1376	8847
	<i>Halodule pinifolia</i>	410	102	2784	5	712	1109	4454	2630	12206
	<i>Halodule uninervis</i>	470	138	2548	1	1104	1045	4049	1783	11138
	<i>Syringodium isoetifolium</i>	385	82	2096	5	683	1120	4280	1589	10240
Hydrocharitaceae	<i>Enhalus acoroides</i>	445	81	2663	0	603	1194	4038	1727	10751
	<i>Halophila beccarii</i>	0	0	339	0	125	5	31	290	790
	<i>Halophila ovalis</i>	395	95	2721	2	780	1051	3979	2229	11252
	<i>Thalassia hemprichii</i>	385	81	2320	8	803	1019	3789	1795	10200
Zosteraceae	<i>Zostera japonica</i>	0	0	111	0	16	23	142	123	415

Ia : Strict Nature Reserve, Ib : Wilderness Area, II : National Park, III : Natural Monument or Feature, IV : Habitat/Species

Management Area, V : Protected Landscape/ Seascape, VI : Protected area with sustainable use of natural resources, NR :

Not reported

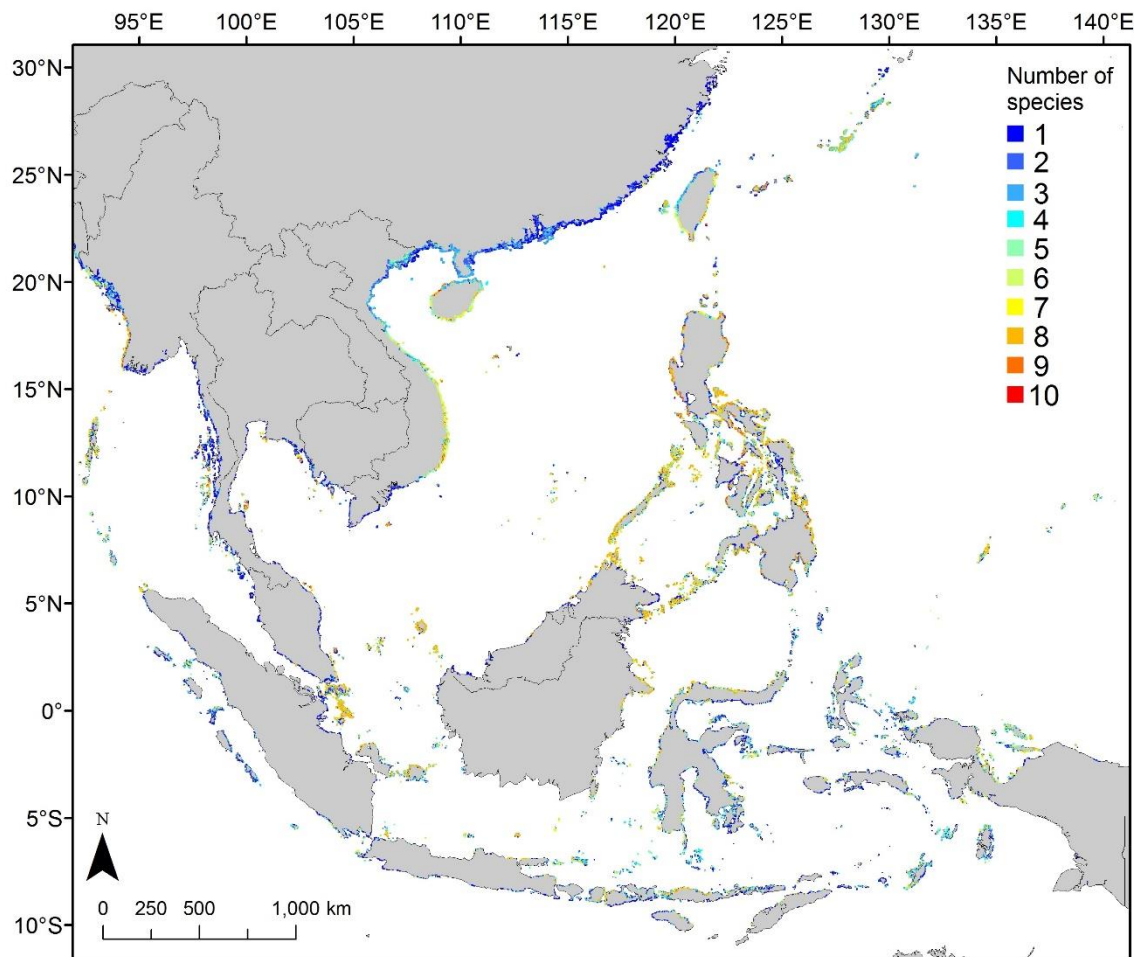


Fig.4-1. Estimated species richness of 10 seagrasses in the February model.

The maps show the species richness in the 2000-2019.

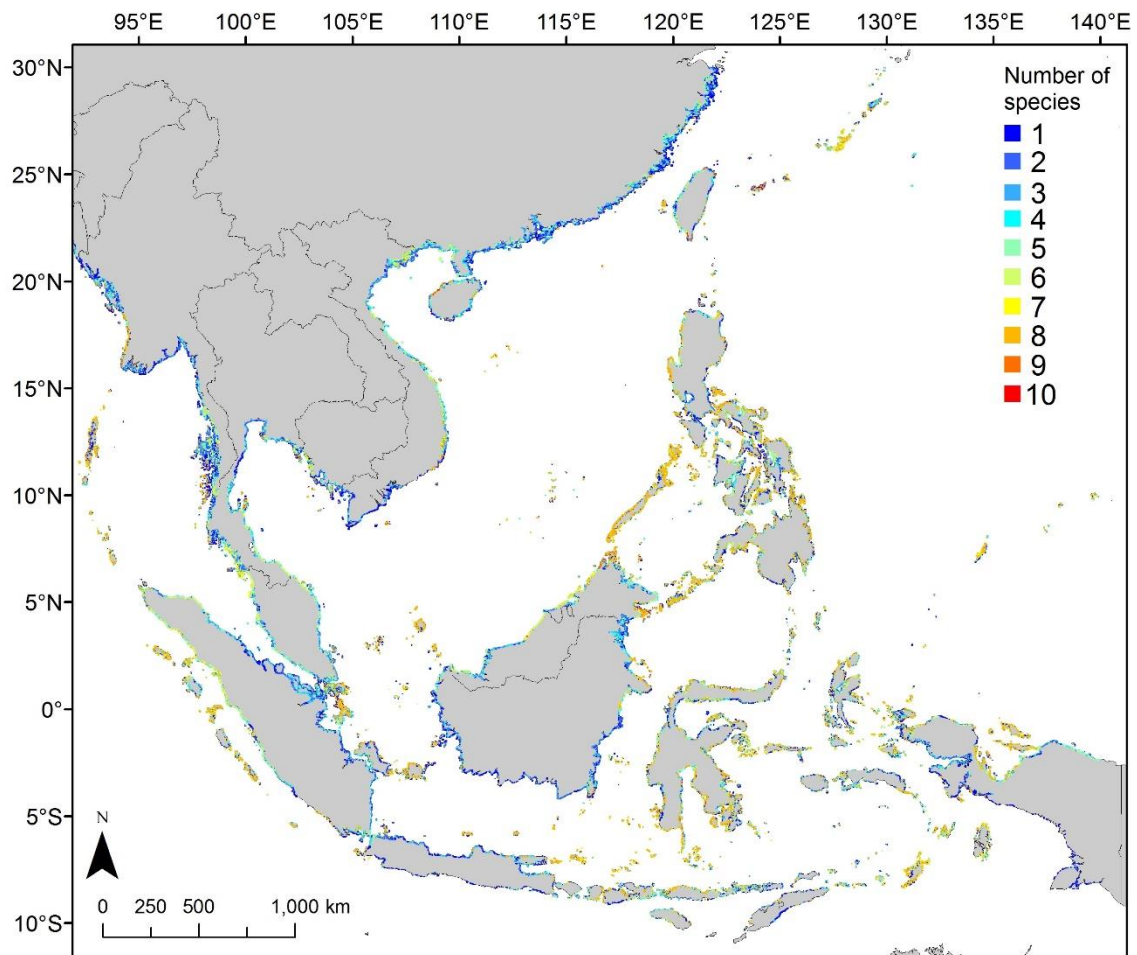


Fig.4-2. Estimated species richness of 10 seagrasses in the August model.

The maps show the species richness in the 2000-2019.

Chapter5

Current species distribution and future projection for copepods in the western North Pacific

5.1 INTRODUCTION

Global marine biodiversity has been threatened by various types of human-induced stressors, including overexploitation, eutrophication, coastal development and the introduction of non-native species (Steneck and Carlton 2001, Halpern et al. 2008). Furthermore, ongoing climate change will affect the distribution of many marine species globally through environmental changes such as temperature rise and ocean acidification (Harley et al. 2006; Orr et al., 2005). However, our knowledge of the global patterns of marine biodiversity is still limited.

In the past decade, massive efforts—for example, the Census of Marine Life (Census of Marine Life, 2010)—have been made toward analyzing marine biodiversity in the world's oceans. The new data on species distribution is now shared by databases such as GBIF (<http://www.gbif.org/>), OBIS (<http://www.iobis.org/>), FishBase (<http://www.fishbase.org/>) and Algal Bases (<http://www.algaebase.org/>). Using such data, global patterns of marine biodiversity have been estimated for a variety of taxa (Tittensor et al. 2010, Kaschner et al. 2013), and future changes in species distribution have been predicted by modeling based on different scenarios of future climate change (Beaugrand et al. 2015, Molinos et al. 2015). Nevertheless, global databases on marine species still have large gaps in geographical coverage, especially in the

eastern Asia and western Pacific regions where marine biodiversity is the highest in the world (Tittensor et al. 2010, Molinos et al. 2015).

Pelagic copepods are dominant zooplankton in the open ocean and play an important role in the food web and material cycle (Roemmich & McGowan 1995; Beaugrand 2010). Changes in copepod distribution and biomass likely affect consumer dynamics in higher trophic levels, which are important food resources for humans. Copepods also play an important role for biological pump process (Volk and Hoffert, 1985; Longhurst and Harrison, 1989; Longhurst, 1991; Ducklow et al., 2001). Photosynthetically produced organic matter is transported from the surface layer to deep layer by vertical migration and subsidence of copepods (Turner 2015).

Copepods also play an important role for biological pump process (Volk and Hoffert, 1985; Longhurst and Harrison, 1989; Longhurst, 1991; Ducklow et al., 2001). Photosynthetically produced organic matter is transported from the surface layer to deep layer by vertical migration and subsidence of copepods (Turner 2015). Therefore, understanding copepod distribution at large regional scales covering major oceans such as the Pacific and predicting future changes in these taxa with climate change are critical to plan for and effectively manage pelagic ecosystems and marine resources. Past studies have clarified some basic global patterns, for example, that copepod species diversity is highest around the equator and decreases with latitude (Rombouts et al. 2009, 2010) and that they undergo large shifts in distribution and body size with long-term changes in oceanographic conditions (Chiba et al. 2009, Beaugrand et al. 2010). Existing zooplankton monitoring system can contribute to filling in gaps of global indicators

for Biodiversity Targets of the United Nations Strategic Plan for Biodiversity 2010–2020 (Chiba et al. 2018). Attempts to project future changes have been made in the North Atlantic Ocean (Helaouët 2009; Reygondeau & Beaugrand, 2011) but not in the western North Pacific Ocean due to the large gaps in distribution data for major species.

The Japan Fisheries Research and Education Agency have been conducting long-term, large-scale sampling of zooplankton around Japanese waters since the 1950s, and the collected specimens are stored as the “Odate Collection” (Odate 1994). The data from the Odate Collection have been used to analyze long-term changes in zooplankton diversity and abundance around the Tohoku region of the western North Pacific in relation to changes in oceanographic conditions (Chiba et al. 2009). Now, a total of >260,000 data from zooplankton records from the Odate Collection are available, making it possible to analyze the current distribution and future changes in copepods in the western North Pacific by integrating these data into existing worldwide datasets. Part of the Odate Collection consists of samples collected monthly, which also enables us to analyze seasonal changes in the occurrence pattern. Zooplankton generally undergo seasonal vertical migration (Kobari et al. 2003). Past studies on global distribution analyses did not take into account such seasonal variation due to the lack of sufficient seasonal data (Chust et al. 2013, Reygondeau & Beaugrand 2011, Beaugrand et al. 2015, Molinos et al. 2015).

In this study, I aimed to determine the current broad-scale distribution of major copepod species in the western North Pacific and to project future changes in their distribution based on different IPCC scenarios of future ocean climates. I

first developed species distribution models for some dominant species using the occurrence and ocean environmental data; then, I examined which combination of environmental factors explains the current distribution pattern. Based on the obtained relationship between occurrence and environmental data, I then forecast future changes in the distribution of each species using a model of the future ocean environment (CMIP5; Taylor et al. 2012) based on future emission scenarios from the Representative Concentration Pathways (RCPs; Moss et al. 2010). In particular, I focused on the different responses of cold- and warm-water species, which have different biological traits such as body size, life history and vertical migration patterns (Mackas & Tsuda 1999, Tsuda 2013). I also compared estimated species distribution and its future projection among different seasons of the year. These patterns vary greatly, reflecting the seasonal vertical migrations of each species.

5.2 Materials and Methods

5.2.1 Target area and species

The research area of this study was in the western North Pacific around Japan (Fig.1), where the Odate Collection has been sampled (between 25.4°N and 50.0°N and between 124.0°E and 164.9°W). Three species of the genus *Neocalanus* (*N. cristatus*, *N. flemingeri* and *N. plumchrus*) and one of *Eucalanus* *bungii* are dominant in the subarctic Pacific, and their biomass occupies 67% of mesozooplankton in the Oyashio current area (Ikeda et al. 2008). I targeted these four species as representative of the cold-water species. In contrast, warm-water species have no dominant species, and the species diversity increases towards

lower latitudes (Rombouts et al. 2009, 2010). The abundance of some warm-water species increased in the transition zone after the North Pacific climatic regime shift in 1976/1977 (Chiba et al. 2009). In this study, I targeted eight species of warm-water copepods based on Chiba et al. (2009). The species are *Oithona longispina*, *Oithona plumifera*, *Oithona setigera*, *Oncaea mediterranea*, *Oncaea conifera*, *Clausocalanus arcuicornis*, *Lucicutia flavicornis* and *Paracalanus aculeatus*.

5.2.2 Data Collection

More than 30,000 data on the presence of 12 target species were taken from the Odate Collection, OBIS and GBIF, among which those of the Odate Collection comprised more than 60% of the total data (Table 5-1). Data describing species presence between 2000 and 2014 were used to represent the current distribution. The presence data from January to March were grouped as winter, from April to June as spring, from July to September as summer, and from October to December as autumn.

The Odate Collection was collected by vertical tow using the North Pacific Standard Net between 0 and 150 m depth. Mesh size is 0.330–0.335 mm. Data on OBIS and GBIF were collected by various methods. I used the data in which the sampling depth was recorded and where it was shallower than 200 m deep. Scientific names were checked using the database WoRMS (<http://www.marinespecies.org/>). I dealt with *Oithona spinirostris* as a synonym of *Oithona setigera* and with *Oncaea conifer* as a synonym of *Triconia conifera*.

5.2.3 Species distribution model

Species distribution models (SDMs) identify the relationships between the presence-only records of a species and environmental variables. Many algorithms exist for species distribution modeling, among which Maximum Entropy modeling (MaxEnt) has been used most commonly because it is robust against georeferencing errors (Elith et al. 2011, Graham et al. 2008, Phillips et al. 2006) and because it outperforms most other algorithms such as GLM, GAM and RF, especially for marine species (Elith et al. 2006, Ready et al. 2010, Aguirre-Gutierrez et al. 2013). MaxEnt also performs well in estimating potential range shifts for species due to climate change (Hijmans & Graham 2006). Therefore, I selected MaxEnt for this study. All MaxEnt models were run using the default settings (version 3.3.3k; Phillips et al. 2006) with a random test percentage of 25% for model training and replicated 100 times. Predicted logistic values of each grid were converted to presence/absence values using the 10-percentile training presence logistic threshold. A number lower than this threshold is classified as zero, and a number higher is classified as one.

5.2.4 Environmental data set

I created a database of 11 environmental measures based on global-scale modeling for copepods (Rombouts et al. 2009, 2010). The environmental dataset was similar to Helaouët et al. (2011) in the North Atlantic. The 11 environmental measures were sea surface temperature (SST), salinity, dissolved oxygen, nitrate, phosphate, silicate, net primary production, chlorophyll-a, depth, ocean surface currents and mixed-layer depth (Table 5-2). The prediction range was

limited in winter due to sea-ice cover and in autumn due to lack of primary production data north of 55°N.

SST and salinity data sets were already formatted as monthly standardized data per unit area of a 0.25 latitude/longitude degree grid at a global scale, whereas the resolution of other environmental variables were different. I set the resolution of all the variables to a 0.25-degree grid by interpolating lower resolution data using the nearest neighbor resampling and by averaging higher resolution data. I used the surface data of all the environmental datasets because subarctic copepods migrate vertically within a depth of 0–50 m (Kobari & Ikeda 1999, 2001a, 2001b, Shoden et al. 2005), and because previous research on copepod distribution modeling applied the surface layer data set (Rombouts et al. 2009, 2010, Helaouët 2009, Reygondeau & Beaugrand 2011). To represent each season, I used February data for winter, May for spring, August for summer and November for autumn.

5.2.5 Future projection

Monthly mean sea surface temperature for future projection was obtained from a high-resolution climate model, MIROC4h (Sakamoto et al. 2012). This model is one of the most recent climate models developed in the Coupled Model Intercomparison Project Phase 5 (CMIP5; Taylor et al. 2012) with a future emission scenario based on the Representative Concentration Pathways (RCPs; Moss et al. 2010), which was used in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5; Stocker et al. 2013). I used the climate change projections from 2000 to 2100 under the RCP 4.5 and

8.5 simulations to examine the effects of ocean warming on future potential habitats. Current sea surface temperature variables were substituted for CMIP5 climate scenario data, and suitability was recalculated by MaxEnt for each species in each season.

5.3 RESULTS

5.3.1 Species distribution and their seasonal variation

Results of species distribution models showed that cold-water species mainly occurred in the latitudinal range of 36 ° N to 65 °N, whereas warm-water species mainly between 25 °N and 45 °N during 2000–2014 (Figs. 5-2, 5-S1 and 5-S2).

Cold-water species underwent large seasonal variation in distribution. The distribution was limited to near coastal areas of northern Japan in winter. It increased greatly in area from spring to summer toward the northeastern offshore region. In autumn, its range decreased, especially along the southeastern edge compared to the summer distribution (Fig. 5-2).

Warm-water species also showed some seasonal change in their distribution, but their variation was less pronounced compared to the cold-water species. The species richness was lowest in winter, with a peak estimated around the southeastern coast and offshore of Honshu Island. The range and species richness increased from summer to autumn with the peak in species diversity occurring along the latitude of 35 °N to 40 °N both in the western Pacific and the Sea of Japan (Fig. 5-2).

Species distribution was well predicted by the combination of 11 variables, with AUC more than 0.96 for the cold-water species and more than 0.92 for the warm-water species (Tables 5-3 and 5-4). For the cold-water species, silicate was the most contributing factor in winter and spring, and it was also an important factor in summer and autumn. Chlorophyll a was a major factor in winter and autumn, and salinity was a major factor in spring and summer. Other factors partially contributing to explain the distribution (with percent contribution of >10%) included net primary production in spring and summer, dissolved oxygen in spring, and nitrogen in winter (Table 5-3).

For the warm-water species, net primary production was the most contributing factor in autumn and spring, and it was also important in winter. Mixed-layer depth was the most contributing factor in summer, and it was also important in spring. Salinity was a major factor in winter, silicate in spring and summer, sea surface temperature in summer and winter, and phosphate in autumn. Other factors partially contributing to explain the distribution (with percent contribution of >10%) included dissolved oxygen in autumn, chlorophyll a in winter, and nitrogen in autumn (Table 5-4).

5.3.2 Future projection

For cold-water species, future forecasts based on the CIMP5 model predicted rapid expansion toward the northern part of the current distribution with both the RCP 8.5 and RCP 4.5 models (Figs. 5-3 and 5-S3). These species will expand their distribution northward, especially in the Sea of Okhotsk and the northern part of the Sea of Japan. On the other hand, neither the RCP 8.5 nor the

RCP 4.5 models showed large changes in the southern limit. As a result, species richness increases in most areas north of 45 °N.

For the warm-water species, both the RCP 8.5 and RCP 4.5 models predicted the expansion of copepod distribution northward (Figs. 5-4, and 5-S4). The expansion is most remarkable in the southern part of the Sea of Okhotsk, but these species can also reach the northern part. The RCP 8.5 model showed that the southern limit would shift 100 to 500 km north by 2090–2100, whereas it would not change greatly according to RCP 4.5. Predicted species richness will increase greatly in the southern Sea of Okhotsk and the northernmost part of the Sea of Japan, whereas it will decrease in most areas south of 40 °N with RCP 8.5 and south of 36 °N with RCP 4.5.

5.4 DISCUSSION

Broad-scale estimations of species and their future forecasts have been conducted for copepods in the North Atlantic based on long-term monitoring data and species distribution models (Helaouët 2009, Reygondeau & Beaugrand 2011). This study is the first report using broad-scale but fine-resolution estimates and future predictions for the western North Pacific species. The research was made possible by incorporating data from the Odate Collection, which doubled the available data on the occurrence of target copepod species in the study area (Table 1). The fit of the MaxEnt, represented by the AUC index of predictive accuracy, was very high compared to similar studies conducted for zooplankton and benthic animals in other regions (Burn et al. 2016, Reiss et al. 2011). This study also analyzed seasonal variation in the occurrence of copepod species that

undergo seasonal vertical migration (Kobari et al. 2003). In past studies, large-scale SDMs of zooplankton were based on annual data (Beaugrand et al. 2015, Reygondeau et al. 2011) because seasonal data were insufficient.

Cold-water species of copepods mainly occur in the subarctic gyre. Predicted distribution with SDM coincided with the field survey conducted along the 180° E line between 39° N and 47° N (Chiba et al. 2012). A large seasonal variation was detected in the cold current species with the smallest range of the surface distribution predicted in winter, then increasing rapidly from spring to summer. Cold-water copepods generally stay in the deep layer of the water column in winter (Kobari et al. 2003, Ikeda et al. 2008) then increase in biomass in the 0–250 m surface layer after the phytoplankton spring bloom (Kobari et al. 2003, Ikeda et al. 2008). The distribution of *Calanus finmarchicus* in the North Atlantic also showed a similar pattern of seasonal variation (Helaouët 2011). In contrast, the seasonal variation in the surface distribution of the warm-water species was less pronounced compared to the cold-water species. Nevertheless, the predicted range was smallest in winter for most species. Detailed life histories for the warm-water species have not been studied for the species here, but early copepodid stages of *Neocalanus gracilis* were always collected regardless of season in warm water (Shimode et al. 2009), suggesting no seasonality in reproduction. For the warm-current species, it has been reported that 93% of the total copepodid occurred between the surface and 200 m (Shimode et al. 2009). These findings suggest that seasonal vertical migration of warm-water copepods may occur at a smaller spatial scale than cold-water species (Tuda 2013).

The contribution of the environmental variables for SDMs was different between warm- and cold-water species and among seasons. In most species and seasons, chlorophyll a, silicate, net primary production and salinity contributed to the SDMs. Chlorophyll a is a proxy for the abundance of phytoplankton that are the main food resource for most copepod species (Frost 1987, Dagg 1983, Landry et al. 1993). Distribution of copepods can also be related to the availability of silicate as abundance of diatoms, one of their main food sources can be affected by the availability of silicate. For cold-water copepods, their abundance in the surface layer increases with the occurrence of spring and autumn phytoplankton blooms (Kobari et al. 2003, Ikeda et al. 2008), which may explain the high contribution of chlorophyll a on the copepod distribution in winter to spring. For warm-water copepods, the contribution of these explainable variables related to food sources was also high but less pronounced in summer. Instead, SST and mixed-layer depth become more important in summer. Warm current regions of the western North Pacific become oligotrophic in summer due to stratification that limits nutrient supply and primary productivity. The high contribution of SST and mixed-layer depth only in summer indicates that the occurrence of warm-water copepods is constrained by such summer oceanographic conditions, leading to low productivity.

The biomass of *N. plumchrus* was positively correlated with surface water PO_4 concentration during spring–summer in the Oyashio region (Tadokoro et al. 2009). In this study, phosphate contributed for the *N. plumchrus* and cold-water species especially in summer. PO_4 is an important macronutrient for phytoplankton. However, chlorophyll a did not contribute in summer. Biomass and

distributional range do not always show similar pattern of variation. Modeling of cold-water species biomass and environmental variables is essential to explain these differences.

Salinity affects many zooplankton species by altering the process of osmoregulation (Blaxter et al. 1998). In addition, salinity has been correlated with the global diversity of copepods (Rombouts et al. 2010) and the abundance of the polar biome species *Calanus finmarchicus* in the North Atlantic (Helaouët et al. 2011, Reygondeau & Beaugrand 2011). However, copepods have a broader tolerance for variation in salinity and temperature because of diel and seasonal vertical migration (Kobari et al. 2008, Yamaguchi et al. 2015). In the western North Pacific, spatial variation in salinity is primarily associated with major oceanographic currents, and the Kuroshio warm current contains a higher salinity than the Oyashio cold current (Yasuda 2003). Thus, the salinity is generally lower in higher latitudes, a variation that may match the distribution of some copepods. It is likely that salinity was selected in the model as an indirect measure of water mass that affects the spatial distribution of cold- and warm-water copepods.

Temperature influences the growth, development and reproduction of many plankton species (Halsband-Lenk et al. 2002). Projected models for warm, cold and polar copepod species abundance and biodiversity are highly correlated with SSTs in the north Atlantic (Helaouët & Beaugrand 2007, Helaouët et al. 2011, Reygondeau & Beaugrand 2011). Copepod community structures have also been correlated with SSTs in the western north Pacific (Chiba et al. 2015). However, in the present study, SST was not a major contributing factor explaining the distribution of copepod species, except for summer conditions for warm-water

species, which was explained above in relation to stratification in the summer. Factors causing the discrepancy with previous studies include the difference in oceanographic current regimes between the North Pacific and the North Atlantic (a more complex structure in the former) and in the types of objective variables (abundance data vs presence data). About the latter, abundance may be a better indicator for investigating the effects of temperature on copepod species, as revealed in the study of Chiba et al. (2009), who found that abundance of warm-water species increased in the transition zone after the North Pacific climatic regime shift in 1976/1977. Distribution itself may not respond as sensitively to the variation in temperature as abundance.

The results of future projection by different climate scenarios showed that both cold- and warm-water species will shift their major distributional range toward higher latitudes, leading to higher species diversity in the northernmost parts of this study area. Similar projection results have been obtained in other studies on copepods and other marine animals. For example, polar biome copepods were predicted to shift north in the North Atlantic (Reygondeau & Beaugrand 2011). Global-scale estimates of marine pelagic biodiversity in response to temperature change predicted an overall shift to the higher latitudes in the temperate and subarctic regions (Beaugrand et al. 2015). In this study, the predicted northern shift with increasing future surface temperature agreed with previous observations of species around Japan (Chiba et al. 2009, Yoshiki et al. 2015). In addition, latitudinal zooplankton biodiversity increased in the extratropical North Atlantic Ocean in recent decades, and the mean size of copepods also decreased (Beaugrand et al. 2010).

These results showed that a distributional shift with temperature rise would be different between the cold- and warm-water species. The southern limit of the warm-water species would shift 100 to 500 km northward with RCP 8.5 over the next 90 years, whereas the shift is not so pronounced for the cold-water species, except for some local areas such as the northern parts of the Sea of Okhotsk and the Sea of Japan. These results suggest that warm-water species are more sensitive to sea surface temperature change, which is reasonable because MaxEnt selected SST as a more important factor for the warm-water species. Previous observations support that warm-water species are sensitive to sea surface temperature (Beaugrand et al. 2010, Chiba et al. 2009, Yoshiki et al. 2015). The predicted speed of the range shift for the warm-water species (ca. 10–50 km per decade) is even slower compared to other types of marine organisms such as bony fish (50–300 km/decade) and phytoplankton (400 km/decade) (Poloczanska et al. 2013). The predicted slow range shift with temperature rise may be related to their vertical migration behavior, with which copepods can tolerate large fluctuations in temperature.

In conclusion, broad-scale but fine-resolution analyses of copepod species distribution in the western North Pacific revealed that seasonal occurrence patterns of cold- and warm-water species were largely different with different combinations of environmental variables explaining the predicted distribution for each season. Future forecasts based on the CIMP5 model predicted a northward expansion, as has been predicted for copepods in the Atlantic and for other marine organisms. The degree of sensitivity to water temperature rise differs between the cold and warm-water species, reflecting differences in their

ecologies and distributional areas. Copepods are the main food resources for higher trophic level predators in this area such as saury (*Cololabis saira*) and sardines (*Sardina pilchardus*); thus, their dynamics greatly affect the future productivity of these commercially important species. Although inclusion of the Odate Collection contributed to improve predictions of current and future distributions of zooplanktons in the Pacific, global databases still have a large information gap, especially in the temperate and tropical regions of the Pacific and Indian Ocean. Continuing efforts to fill this information gap will improve our understanding of the current global marine biodiversity status and forecast future shifts with ongoing climate change.

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Table 5-1. Data on occurrence of copepods used for this study

Type	Species	Odate collection	OBIS	GBIF	Total
Cold water	<i>Eucalanus bungii</i>	3,422	944	526	4,892
Cold water	<i>Neocalanus cristatus</i>	3,747	1,548	2,184	7,479
Cold water	<i>Neocalanus flemingeri</i>	1,957	61	0	2,018
Cold water	<i>Neocalanus plumchrus</i>	2,363	0	4,496	6,859
Warm water	<i>Clausocalanus arcuicornis</i>	910	300	0	1,210
Warm water	<i>Lucicutia flavicornis</i>	1,089	229	0	1,318
Warm water	<i>Oithona longispina</i>	760	6	0	766
Warm water	<i>Oithona plumifera</i>	1,088	214	394	1,696
Warm water	<i>Oithona setigera</i>	805	431	1	1,237
Warm water	<i>Oncaea mediterranea</i>	1,160	63	0	1,223
Warm water	<i>Paracalanus aculeatus</i>	1,052	134	1	1,187
Warm water	<i>Triconia conifera</i>	793	451	25	1,269
Total		19,146	4,381	7,627	31,154

Table 5-2. Data on the environmental variables used for this study and their sources

Environmental variable	Data source	Resolution	Average	Time range
Salinity	World Ocean Atlas 2013 version 2 https://www.nodc.noaa.gov/OC5/woa13/	1/4°	Monthly	2005–2012
Sea surface temperature	World Ocean Atlas 2013 version 2 https://www.nodc.noaa.gov/OC5/woa13/	1/4°	Monthly	2005–2012
Dissolved oxygen	World Ocean Atlas 2013 version 2 https://www.nodc.noaa.gov/OC5/woa13/	1°	Monthly	1955–2012
Nitrate concentration	World Ocean Atlas 2013 version 2 https://www.nodc.noaa.gov/OC5/woa13/	1°	Monthly	1955–2012
Phosphate	World Ocean Atlas 2013 version 2 https://www.nodc.noaa.gov/OC5/woa13/	1°	Monthly	1955–2012
Silicate	World Ocean Atlas 2013 version 2 https://www.nodc.noaa.gov/OC5/woa13/	1°	Monthly	1955–2012
Mixed-layer depth	World Ocean Atlas 1994 http://www.nodc.noaa.gov/OC5/WOA94/mix.html	1°	Monthly	1900–1992
Bathymetry	SRTM30 PLUS V11 http://topex.ucsd.edu/WWW_html/srtm30_plus.html	30"	-	-
Chlorophyll a	Sea-viewing Wide Field-of-view Sensor http://oceancolor.gsfc.nasa.gov	9 km	Monthly	1998–2010
Net primary production	Standard VGPM from MODIS 1.1 data http://www.science.oregonstate.edu/ocean/productivity/index.php Behrenfeld & Falkowski 1997	1/6°	Monthly	2003–2014
Ocean surface currents	Ocean Surface Current Analyses http://www.oscar.noaa.gov/index.html Bonjean & Lagerloef 2002	1/3°	Monthly	2012–2015

Table 5-3. Contribution percent of each environmental variable and AUC of the species distribution model (MaxEnt) for the cold-water copepod species in each season

Environmental variable	Contribution percent (%)							
	Winter		Spring		Summer		Autumn	
	Av.	±SD	Av.	±SD	Av.	±SD	Av.	±SD
Salinity	5.8	8.4	21.6	7.0	33.5	3.6	10.2	10.9
Sea surface temperature	4.1	3.8	5.1	0.7	5.7	0.8	5.5	0.9
Dissolved oxygen	3.0	4.8	14.6	4.6	1.2	0.4	9.6	1.7
Nitrogen	11.0	6.1	0.2	0.1	0.4	0.1	2.2	2.1
Phosphate	4.5	3.8	1.6	1.9	10.0	4.3	2.2	1.4
Silicate	34.3	11.6	31.8	7.8	24.3	4.7	17.9	2.2
Mixed-layer depth	1.4	0.5	1.7	0.5	7.8	1.7	1.7	1.4
Bathymetry	0.4	0.3	0.7	0.2	0.4	0.1	2.4	1.7
Chlorophyll a	26.1	6.4	10.9	3.9	0.4	0.2	42.2	5.7
Net primary production	6.1	4.3	10.6	3.4	13.7	0.7	5.2	6.5
Ocean surface currents	3.4	1.5	1.5	1.1	2.8	0.8	1.0	0.8
AUC	0.99	0.01	0.96	0.02	0.98	0.01	0.99	0.00

Table 5-4. Contribution percent of each environmental variable and AUC of the species distribution model (MaxEnt) for the warm-water copepod species in each season

Environmental variable	Contribution percent (%)							
	Winter		Spring		Summer		Autumn	
	Av.	±SD	Av.	±SD	Av.	±SD	Av.	±SD
Salinity	24.8	12.7	9.0	4.4	8.7	3.1	9.7	6.6
Sea surface temperature	10.7	8.6	8.9	2.2	20.7	8.1	4.0	2.3
Dissolved oxygen	6.0	5.0	4.4	2.5	6.4	7.1	12.1	7.7
Nitrogen	6.2	2.2	2.8	2.9	4.8	2.1	10.2	6.0
Phosphate	3.9	2.6	4.3	2.9	3.1	2.5	20.2	8.3
Silicate	5.1	2.8	15.8	7.4	17.2	7.1	9.2	7.3
Mixed-layer depth	6.6	10.2	10.1	6.7	24.1	14.3	1.1	0.5
Bathymetry	4.9	4.9	4.6	3.0	2.5	1.2	0.8	0.5
Chlorophyll a	10.4	7.3	4.1	3.8	4.2	3.5	7.9	8.1
Net primary production	19.7	8.6	33.1	10.6	5.9	6.5	23.6	6.1
Ocean surface currents	1.9	3.2	3.2	3.0	2.6	2.2	1.3	1.2
AUC	0.92	0.03	0.95	0.03	0.93	0.04	0.93	0.03

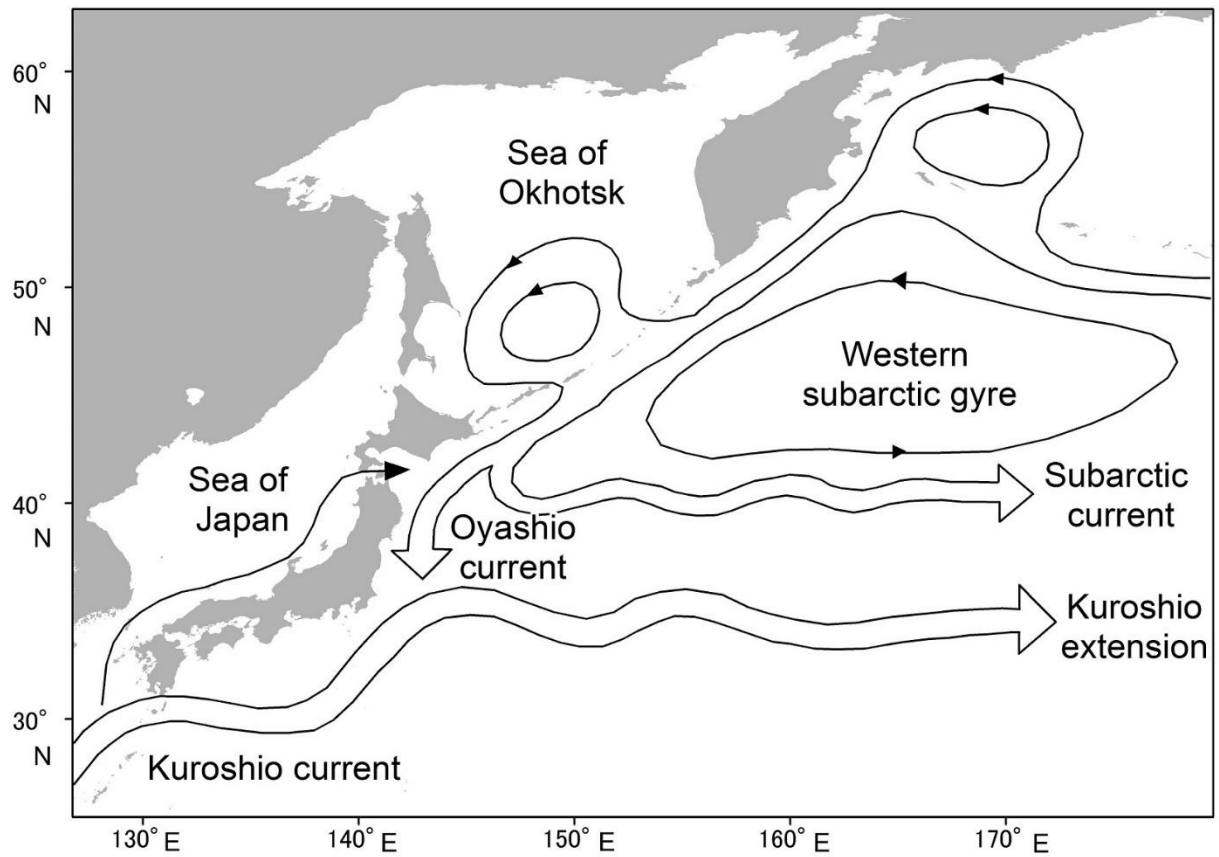


Fig. 5-1. The research area of this study and diagram of the marine currents in the western North Pacific Ocean. Modified from Qiu (2001).

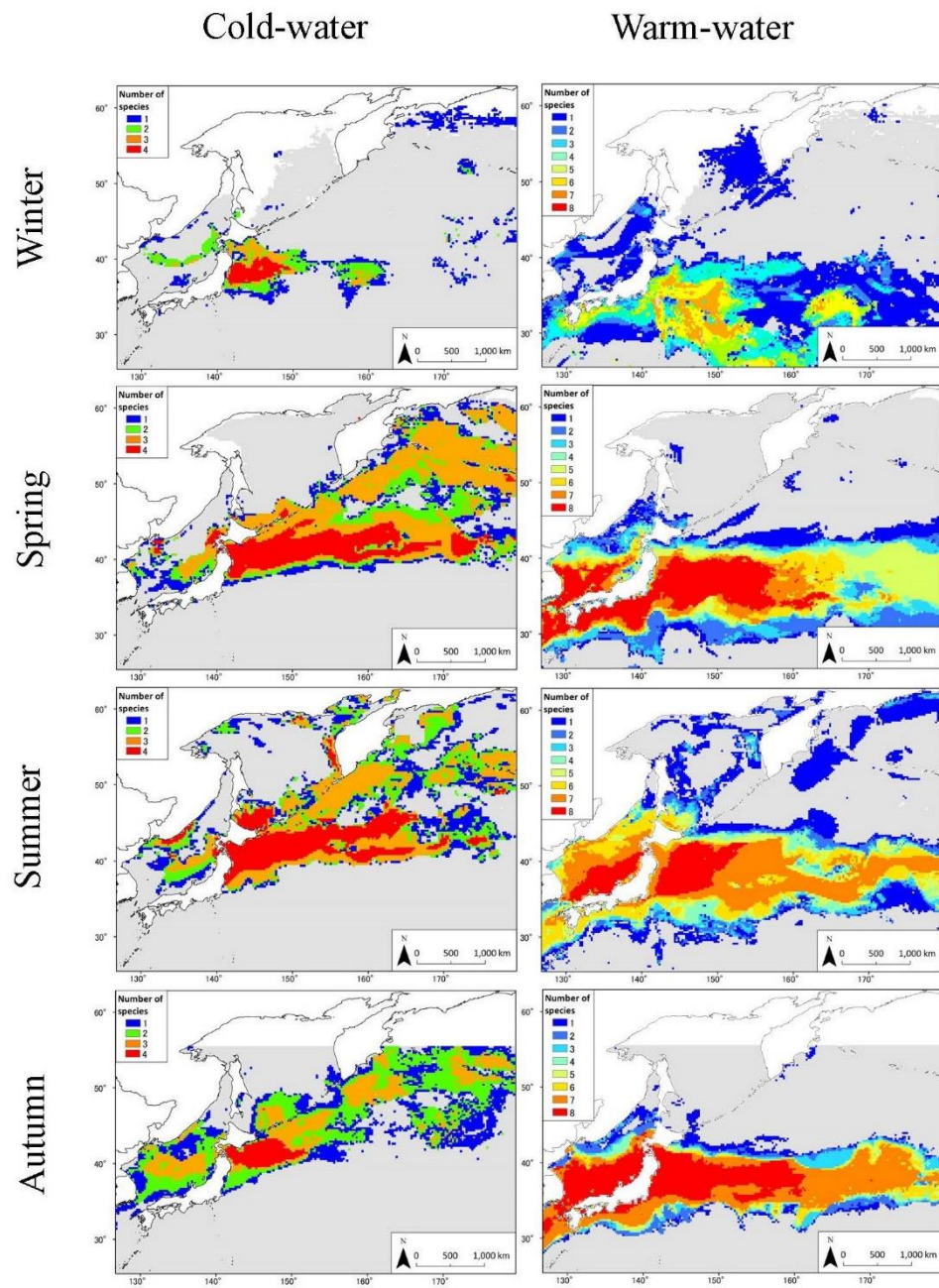


Fig. 5-2. Seasonal variation in the predicted distribution of cold- and warm-water species of copepods during 2000–2014.

Prediction range is limited in winter due to sea-ice cover. In addition, prediction range of the northern limit is N55° in autumn due to the lack of primary production data.

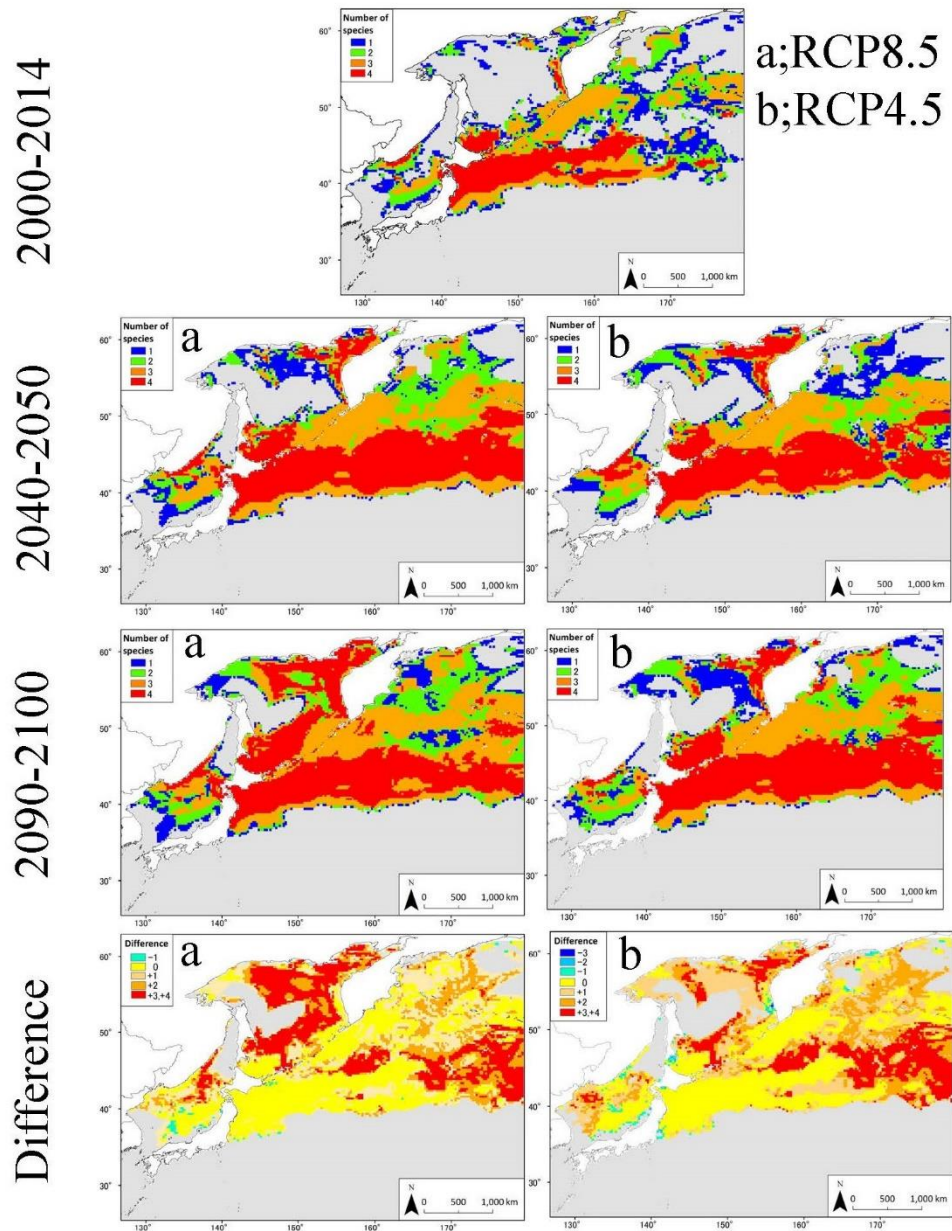


Fig. 5-3. Predicted distribution of the cold-water species of copepods in summer based on different climate scenarios.

The prediction range is limited in winter due to sea-ice cover. In addition, the prediction range of the northern limit is N55° in autumn due to the lack of primary production data.

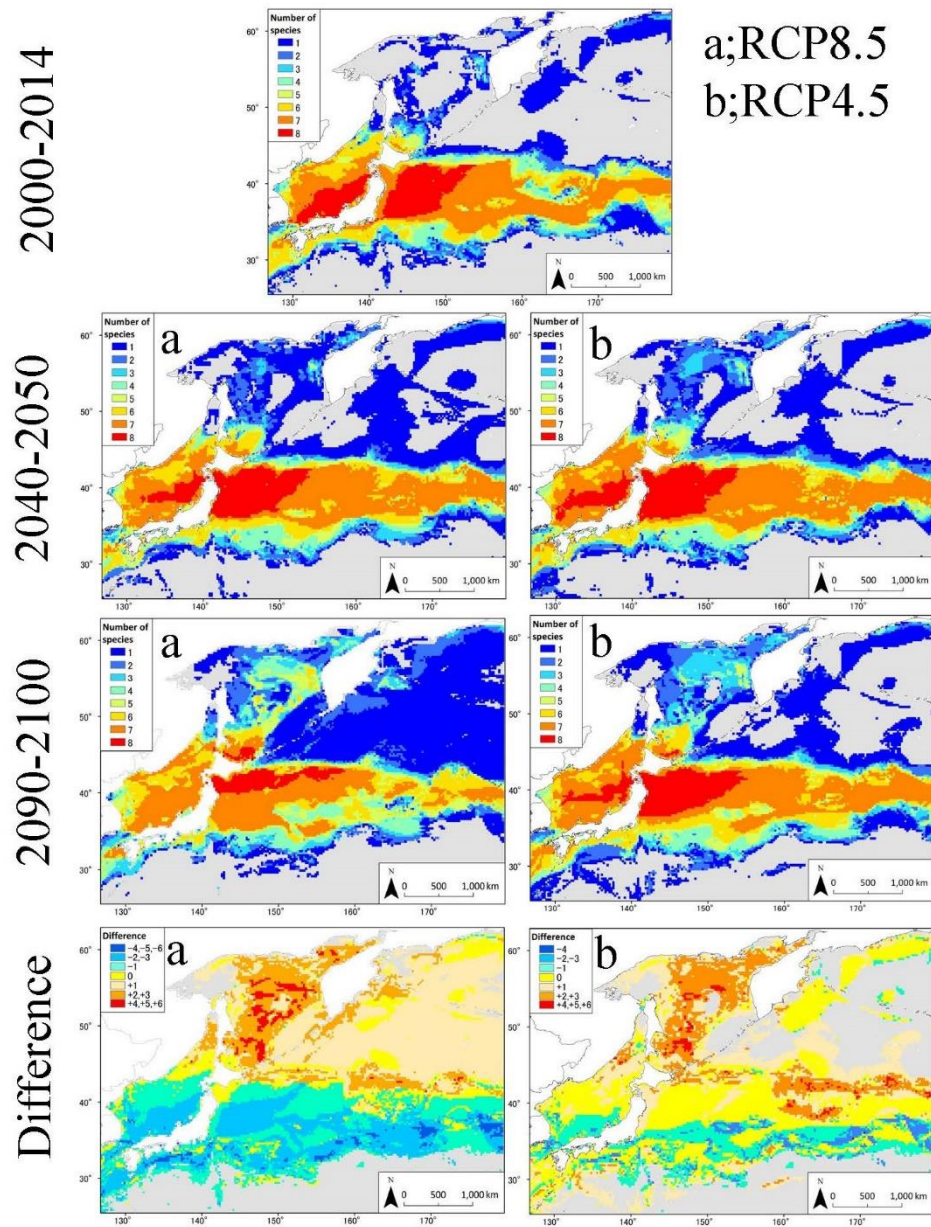


Fig. 5-4. Predicted distribution of the warm-water species of copepods in summer based on different climate scenarios.

Difference: Showing the difference in the number of species between 2000–14 and 2090–2100

CHAPTER 6 General Discussion

The results of this dissertation confirmed that combination of global databases of marine biodiversity data set, global environmental variables and SDMs that cover broad-scale extent but in fine resolution are effective to estimate the marine biodiversity. However, global biodiversity database is still insufficient in the scientific knowledge gap region such as in east Asian coast and the western Pacific. Intensive data collection effort is necessary to fill the gap. This additional effort each research in this dissertation led advanced results of patterns of biodiversity and to project their future changes in relation to ongoing climate changes.

Chapter 2 revealed kelp species diversity pattern in northern Japan and predicted large decline in the future. By the 2090s, their habitat range was estimated to decline to 30–51% of that of the 1980s with moderate warming (RCP 4.5) and to 0–25% with severe warming (RCP 8.5). Chapter 5 revealed biodiversity patterns of zooplankton and southern limit of their distribution predicted to shift 100 to 500 km north by 2090–2100. Commercially important species are also expected to decline greatly or change their migration route, which may affect fisheries and aquaculture.

Chapter 3 integrated all the available data on seagrass bed distribution and species composition in southeast Asia which has been a large gap in the scientific knowledge of the marine biodiversity. Using the established database, Chapter 4 analyzed seagrass species diversity pattern and potential species-by-species distribution in this region by SDM and evaluated their conservation status using MPA spatial data.

The overall contribution of this dissertation is to advance our knowledge on current marine biodiversity patterns in Asia-West Pacific region, and to predict their future changes with global climate changes. I found great differences in the estimated patterns and future prediction among different taxa (kelps, seagrasses and zooplankton), among ecosystems (benthic vs pelagic ecosystems) and among climate zones (cold-temperate vs tropical zones). This chapter highlights each of the main findings, discusses their implications, and provides directions for future research.

6.1 Evaluation and prediction of marine biodiversity using species distribution models

This dissertation revealed detailed marine biodiversity patterns using fine-scale environmental data set and global databases with updated new information in Asia-Western Pacific region (Chapters 2, 3, 4, 5), and their future responses under the different climate change scenarios (Chapters 2 and 5). Future projections suggest that changes in community composition and local species loss would occur both for kelp and zooplankton communities in cold-temperate zones. This dissertation contributed to fill the scientific knowledge gap of marine biodiversity in Asia-Western Pacific region. The findings can contribute to plan effective conservation of marine biodiversity and management strategy for sustainable resource use in fisheries and aquaculture (Chapters 2, 3, 4, 5).

In addition to use existing databases on marine biodiversity and ocean environments, I devoted time and efforts to create new marine biodiversity datasets and original environmental dataset and utilized them to improve the

model output (Chapters 2, 3, 4, 5). Most of SDMs research rely on already-existing data in global biodiversity information database such as OBIS, and global environmental database such as Bio-ORACLE (<http://www.bio-oracle.org/>). In addition, most of SDMs use the same environmental data set for the prediction across different taxonomy for large-scale analyses. However, large spatial biases in existing biodiversity data, and mismatch in resolution of biodiversity and ocean environmental data lead to inaccurate estimates on species distribution. In these analyses, using the spatially less biased biodiversity data and selection of appropriate environmental variables highly improved the model output which has taken ecology of each target taxa in consideration (Chapters 2, 4, 5). Throughout the dissertation, I showed selection of appropriate extent and grain for both the biodiversity and environmental data is a key to achieve a precise estimation for each species which has different distribution ranges.

6.2 Problems associated with species distribution modeling

6.2.1 Data collection

Open access global databases are useful for the global scale analyses of biodiversity. However, data on marine species remain insufficient in the southeast Asian countries compared with Europe and north America. In addition, these global data bases are not sufficient in quality of coordinate and quantity of extent for fine scale modellings. In this study, I surveyed for past literature and data which had not been registered to global databases, such as distribution data of Laminariales and zooplankton in Japan (Nakaoka et al. 2017, Tadokoro and Sugisaki 2019). Moreover, I compiled more than 96 scientific articles or reports

including local Asian languages (Japanese, Chinese, Vietnamese, and Indonesian) (Chapter 3). However, it takes long time to create database with the careful quality management. Global databases also need to improve coordinate accuracy in the future. Database managers could contribute to control data quality, which lead to more accurate estimation of marine biodiversity at various spatial and temporal scales.

6.2.2 Environmental factors

Species distribution modeling has more difficulty to apply to pelagic ecosystem compared with benthic ecosystem due to its three-dimensional environment. Some zooplankton and fish migrate vertically daily and/or seasonally. However, most occurrence data of marine species and ocean environmental data are recorded only on geographical coordinates, i.e., two-dimensional information, which causes great challenges to improve the accuracy of species distribution for pelagic species. In Chapter 5, I used the occurrence data from 0-150m depth zone, but all the environmental data were confined to 0m depth, which may cause biases in estimation. To overcome this problem, this study made models for each season separately based on the information on seasonal migration of each species. Recently some institutions and agencies have been trying to develop three-dimensional ocean environmental dataset such as by SI-CAT program (<https://si-cat.jp/>). Such efforts will make it possible to project future changes of pelagic species considering their depth distribution.

Most of species distribution modeling apply existing ocean environmental dataset products such as Bio-ORACLE (<http://www.bio-oracle.org/>) and Global

Marine Environmental Datasets (<http://gmed.auckland.ac.nz/>) for species distribution modelling and environment visualization. These databases are useful for the global scale analyses however resolution is still low for the local to regional scale analyses. In addition, these databases do not cover coastal environment. In Chapter 4, environmental dataset including river discharge from the watershed was originally created by myself using watershed and river data. Such creation of new fine-scale original data for the coastal area is expected to improve the SDMs for species inhabiting nearshore environments.

In global analysis of marine biodiversity, all the target taxonomy was analyzed using the same environmental dataset. Ignoring ecological traits of each species would lead to over/under-estimates of their distribution. For this reason, use of appropriate combination of environmental data for different taxonomic groups are recommended, such as I did in Chapters 2, 4 and 5. Overall estimation of species diversity and its future projection should be made after obtaining estimates for each species. This approach contributes to more reliable estimation of marine biodiversity and its future prediction.

Nutrient is one of the important factors for the growth and maturation of kelps (Mizuta and Maita 1991, Liu et al. 2013, Liu et al. 2015). However, obtaining fine and large scale nitrate (NO_3) data set is difficult. Liu et al. (2013) developed local scale NO_3 estimates using sea surface temperature and chlorophyll-a based on intensive observation data. If it can be estimated throughout northern Japan scale, model result and future projection will be more accurate. Although water temperature contributed to the most of species, the effects of nutrients may

change the relationships among the environmental data especially for the species to which water temperature did not contribute.

6.2.3 Temporal scale

Considering temporal extent and resolutions is critical in SDMs especially for mobile marine animals (Mannocci et al. 2017). For example, tolerance for thermal stress are different among different life stages of algae and seagrasses (Kamiya et al. 2006, Collier and Waycott 2014). Species' responses to environmental changes can occur either instantaneously or with some time lags. Kelp biomass correlated to summer water temperature of the previous year, whereas zooplankton and phytoplankton respond to changes over shorter timescales from a few weeks to a few months (Guisan and Zimmermann 2017, Helaouët et al. 2010, Kamiya et al. 2006). On the other hand, temporal extent is also critical for the SDMs due to 18.6-year nodal cycle caused by the variation in the inclination of the lunar orbit to the Earth equatorial surface and Pacific Decadal Oscillation (PDO) caused by climate oceanographic oscillations (Mantua and Hare, 2002, Osafune et al. 2006). Combinational use of large amount of occurrence data and integrated analyses of SDMs considering temporal variations are essential to solve these problems on temporal dependencies.

Climatic stressors generally affect marine organisms gradually (Kirihaara et al. 2006, Kumagai et al. 2018, Poloczanska et al. 2013), but sometimes, extreme climatic events affect them immediately and drastically. Dominant kelp species of *Eckloniopsis radicata* suddenly disappeared after 2016 at one site of Kagoshima due to rapid water temperature increase and increase of herbivore

animals (Biodiversity Center of Japan, Ministry of the Environment 2019). Southern limit population of *Zostera marina* also suddenly disappeared after 2018 due to direct impacts of typhoons passed in this area (Biodiversity Center of Japan, Ministry of the Environment 2019). More than 10-week heat wave in 2011 caused community shift from kelp forests to seaweed meadow in west coast of Australia, which altered ecological processes and subtropical community and suppressed the recovery of kelp forests (Wernberg et al. 2016). These evidences suggest that climatic stressors and extreme climatic events may lead to community wide regime shift. Development of more sophisticated models which can incorporate time-lag effects of multiple environmental processes and species interactions would be promising to overcome these problems associated with temporal scales and resolutions.

6.2.4 Spatial-scale dependency

Estimation of species distribution have been conducted at various spatial scales (from local to global scales) depending on the purpose of each study. Local scale analyses have possibility of overlook global patterns of environmental factors, which have been reported for most other marine taxa (Chefaoui et al., 2016, Jayathilak & Costello 2018). In the same way, broad-scale species distribution estimates may also overlook local scale patterns, which could cause biases in estimated results. To overcome this problem, trans-scale approach, i.e., combination of local and regional scale parameters may improve model accuracy using high quality and fine-scale environmental dataset. Furthermore, global databases often include low accuracy coordinates data and also overlook local

variation in biotic and abiotic patterns. In Chapter 4, I attempted to collect only accurate occurrence data from the literatures and created a new fine-scale original dataset by myself, which can use the local scale modeling.

6.3 Future projection for marine ecosystems

Climate change is considered to become the greatest driver for declining biodiversity in the near future. Water temperature influences species abundance, community structure and biological diversity, phenology and distributional range for the marine life. To estimate and understand those changes is necessary for the conservation of biodiversity and their ecosystem services for human well-being environment (Beaugrand et al. 2015, Duraiappah et al. 2005, García Molinos et al. 2016).

Water temperature increase is more severe in the higher latitude. In this region, species extinctions may occur due to rapid environmental changes compared to natural dispersal speed of marine organisms (Poloczanska 2013, Kumagai et al. 2018). The study of dispersal speed is also important especially for habitat forming species. Water temperature influences distribution of each marine species through physiological and ecological processes (Stuart-Smith et al. 2017).

Information on temperatures effect on different biological traits of marine species is promising for more accurate estimation of their biogeographic ranges. One of such attempts is made in Chapter 2 where I compared with the winter model and the summer model to estimate the impacts of water temperature rise on kelps based on the information that summer temperature affects productivity

and survivorship of adult stages of kelp populations whereas winter temperature determines kelp recruitment (Kiriwara et al. 2003).

Further studies incorporating the effects of species interaction among plants and between plants and animals on the changes in the distribution and abundance would also be necessary to elucidate the community-wide impact of climate changes (Kumagai et al. 2018, Takao et al. 2015), which are not taken into account in the most SDMs including the one used here. Joint Species Distribution Models (JSDMs) using Bayesian Analysis may be useful for species estimation considering the species interactions such as competition and prey-predator interactions (Warton et al. 2015).

6.4 Social implementation

The outcome of this dissertation is not only useful for marine biodiversity conservation, but also for sustainable use of marine ecosystem services by human, such as fisheries and aquaculture. For the fisheries purposes, estimation and forecast of abundance (number, biomass and productivity) is desirable beyond that of the distribution (e.g., the presence or absence of certain species) .

To estimate and forecast abundance of marine species using SDM approach, it is needed (1) to collect large amount of biomass data by the same method as I did for the presence/absence data over the wide area and (2) to prepare high resolution environmental data set to take into account for local environmental variables.

Collecting biomass data at peak time for a few years is necessary due to large seasonal and annual fluctuations of marine species. Combination of

underwater drone and sonar may help to obtain data to improve model accuracy. Furthermore, northern shift of herbivory animals such as sea urchin and fish may also affect the biomass of algae and seagrass in the future.

6.5 Conclusion and implications

Based on the main results of this dissertation, I conclude that the patterns of diversity and future changes are different among marine taxa due to variation in their ecological traits and responsible environmental factors. The integrated approach combining broad-scale occurrence data with sufficient input from data-gap region, selection of appropriate environmental variables with fine scale facilitates to estimate detailed marine biodiversity patterns to fill the scientific knowledge gap. These outputs are useful for systematic conservation planning and evaluation of ecosystem services. However, SDMs still have many limitations as discussed in the above subsection. For example, the accuracy of the models depends on the amount and distribution of data in target regions. Furthermore, coastal environmental data is insufficient to model the pelagic biodiversity in three-dimensional environment of open oceans. Based on these research achievement and limitations I encountered during these studies, I here identified some major research directions for future research as follows:

(1) Conducting back cast of SDMs is worthwhile to evaluate and improve model accuracy. Back cast is to predict past species distribution using environmental data and occurrence data at that time. In my kelp analyses, for example, evaluation is possible by comparing the forecast results and field data obtained

during 2020-2030s. The kelp occurrence data were scarce during 2000s, but more data have been collected on and after mid-2010s, such as by post-tsunami monitoring programs in Tohoku region, which will be used for such analyses.

(2) Developing SDMs considering seasonal dynamics and life histories of marine species. In this dissertation, I overcame this problem by comparing the results of different model outputs using different seasonal data (e.g., the summer and winter models for kelps, and four season models for copepods), but they are not independent as discussed in Subsection 6.2.3. SDMs considering seasonal dynamics have not been established and remain as one of the challenging area of this research field including development of statistical methods for analyzing time-series data.

(3) Development of new SDMs to achieve more accurate distribution estimate for the pelagic marine species that undergoes vertical migration. Three-dimensional ocean environmental datasets have been more and more available by some oceanographic models such as NEMURO (Aita et al. 2003, 2007). However, current SDMs are confined to two-dimensional spatial data. The breakthrough for new methods may be necessary to conduct species distribution estimation in three-dimensional environment.

(4) Considering species interaction for the future projection such as competition among species in the same trophic levels, and prey/predator interactions between primary producers (e.g. phytoplankton and benthic seagrass/seaweed),

herbivores (e.g., snails, sea urchin, herbivorous fish) and higher-level predators using joint species distribution modeling (Clark et al. 2017). For the kelp-herbivore interactions, for example, feeding rates by herbivores will be affected by SST increase and it may accelerate decline of kelps in cold seawater as observed in temperate algal bed communities (Kumagai et al. 2018, Takao et al. 2015).

(5) Expanding species estimation not only for the presence/absence, but also for their abundance and biomass, which is necessary for adaptive purposes such as ecosystem service evaluation and their use for sustainable use such as by fisheries and tourisms. Some methods such as Generalized Additive Models (GAM) and Joint Species Distribution Model (JSDM) are already available, but these methods now require great amount of quantitative data which are hardly available from East Asia-Western Pacific Region. Obtaining more quantitative data in this region as well as development of more robust modeling methods with require smaller number of data are both required to achieve this goal.

(6) Facilitating systematic conservation planning across wide array of marine taxa using SDMs. For example, determination of EBSAs (the ecologically or biologically significant areas) and MPAs can be updated by overlaying biodiversity hotspots for different types of marine taxa in Asia-West Pacific Regions. Furthermore, use of SDMs for future projection of marine biodiversity can help determining adaptation plans for setting MPAs considering future changes in species distribution with climate changes.

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**Evaluation and prediction of marine biodiversity changes
using species distribution models**

Dissertation

Supporting information

Kenji Sudo

Graduate School of Environmental Science

Division of Biosphere Science

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Supporting information

Table of contents

Chapter 2 Predictions of kelp distribution shifts along the northern coast of Japan -----2

Chapter 3 Fine-scale distribution of tropical seagrass beds in Southeast Asia ----- 39

**Chapter 4 Estimated distribution of tropical seagrasses species in Southeast Asia and
their conservation status ----- 64**

**Chapter 5 Current species distribution and future projection for copepods in the western
North Pacific ----- 71**

Chapter 2 Predictions of kelp distribution shifts along the northern coast of Japan

Supporting information

Table 2-S1 Raw data on kelp occurrence used in this study

No	scientificName	decimalLatitude	decimalLongitude	year	bibliographicCitation	Database
1	<i>Arthrothamnus bifidus</i>	42.980000	144.850000	1963	Bulletin of the faculty of fisheries Hokkaido University 14(2)37-40	BISMaL
2	<i>Saccharina japonica</i>	41.470000	140.250000	1963	Bulletin of the faculty of fisheries Hokkaido University 19(2)87-96	BISMaL
3	<i>Saccharina japonica</i>	41.930000	140.930000	1970	Bulletin of the faculty of fisheries Hokkaido University 23(4)171-176	BISMaL
4	<i>Alaria crassifolia</i>	41.730000	140.720000	1971	Bulletin of the faculty of fisheries Hokkaido University 24(4)133-138	BISMaL
5	<i>Alaria crassifolia</i>	41.730000	140.720000	1972	Bulletin of the faculty of fisheries Hokkaido University 24(4)133-138	BISMaL
6	<i>Alaria crassifolia</i>	41.750000	140.680000	1972	Bulletin of the faculty of fisheries Hokkaido University 24(4)133-138	BISMaL
7	<i>Saccharina sculpera</i>	41.930000	140.930000	1984	Bulletin of the faculty of fisheries Hokkaido University 36(2)64-68	BISMaL
8	<i>Saccharina sculpera</i>	41.880000	141.070000	1985	Bulletin of the faculty of fisheries Hokkaido University 37(3)165-170	BISMaL
9	<i>Saccharina japonica</i>	41.750000	140.880000	1986	Bulletin of the faculty of fisheries Hokkaido University 38(2)156-164	BISMaL
10	<i>Saccharina sculpera</i>	41.750000	140.880000	1986	Bulletin of the faculty of fisheries Hokkaido University 38(2)156-164	BISMaL
11	<i>Saccharina japonica</i>	41.933330	140.933330	1985	Bulletin of the faculty of fisheries Hokkaido University 39(1)14-20	BISMaL
12	<i>Saccharina japonica</i>	41.880000	141.000000	1986	Bulletin of the faculty of fisheries Hokkaido University 39(2)133-141	BISMaL
13	<i>Saccharina japonica</i>	41.750000	140.880000	1987	Bulletin of the faculty of fisheries Hokkaido University 39(2)160-166	BISMaL
14	<i>Saccharina japonica</i>	41.800000	140.670000	1990	Bulletin of the faculty of fisheries Hokkaido University 42(3)107-114	BISMaL
15	<i>Saccharina japonica</i>	41.880000	141.020000	1986	Bulletin of the faculty of fisheries Hokkaido University 42(3)96-106	BISMaL
16	<i>Costaria costata</i>	44.050000	144.250000	1990	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo H2nendo(205-216)	BISMaL
17	<i>Saccharina japonica</i>	44.100000	144.220000	1990	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo H2nendo(205-216)	BISMaL
18	<i>Saccharina japonica</i>	44.050000	144.250000	1990	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo H2nendo(205-216)	BISMaL
19	<i>Saccharina japonica</i>	44.030000	144.250000	1990	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo H2nendo(205-216)	BISMaL
20	<i>Agarum clathratum</i>	43.980000	144.870000	1990	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo H2nendo(217-229)	BISMaL
21	<i>Costaria costata</i>	43.980000	144.870000	1990	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo H2nendo(217-229)	BISMaL
22	<i>Saccharina cichorioides</i>	43.980000	144.870000	1990	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo H2nendo(217-229)	BISMaL
23	<i>Costaria costata</i>	44.580000	142.970000	1990	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo H2nendo(246-263)	BISMaL
24	<i>Saccharina japonica</i>	44.580000	142.970000	1990	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo H2nendo(246-263)	BISMaL
25	<i>Costaria costata</i>	44.430000	143.220000	1990	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo H2nendo(264-274)	BISMaL
26	<i>Saccharina japonica</i>	44.430000	143.220000	1990	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo H2nendo(264-274)	BISMaL
27	<i>Saccharina japonica</i>	44.100000	143.770000	1990	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo H2nendo(275-283)	BISMaL
28	<i>Saccharina japonica</i>	44.320000	143.400000	1970	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo s46nendo(50-51)	BISMaL
29	<i>Saccharina japonica</i>	44.350000	143.350000	1974	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo s49nendo(93-96)	BISMaL
30	<i>Saccharina japonica</i>	44.350000	143.350000	1976	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo s51nendo(113-117)	BISMaL
31	<i>Saccharina japonica</i>	44.350000	143.350000	1977	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo s52nendo(149-151)	BISMaL
32	<i>Costaria costata</i>	44.580000	142.970000	1978	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo s53nendo(176-184)	BISMaL
33	<i>Saccharina cichorioides</i>	44.580000	142.950000	1978	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo s53nendo(176-184)	BISMaL
34	<i>Saccharina japonica</i>	44.580000	142.970000	1978	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo s53nendo(176-184)	BISMaL
35	<i>Costaria costata</i>	44.030000	144.950000	1986	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo s61nendo(230-234)	BISMaL
36	<i>Costaria costata</i>	44.030000	144.930000	1986	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo s61nendo(230-234)	BISMaL
37	<i>Costaria costata</i>	44.050000	144.330000	1986	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo s61nendo(230-234)	BISMaL
38	<i>Saccharina cichorioides</i>	44.050000	144.330000	1986	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo s61nendo(230-234)	BISMaL
39	<i>Saccharina japonica</i>	44.050000	144.330000	1986	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo s61nendo(230-234)	BISMaL
40	<i>Saccharina japonica</i>	44.100000	144.230000	1988	Douritsu Abashiri Suisanshikenjo Jigyohoukokusyo S63nendo(181-187)	BISMaL
41	<i>Agarum clathratum</i>	43.855656	145.098490	1990	Environment Agency Japan 1994	BISMaL
42	<i>Agarum clathratum</i>	42.028797	143.288052	1990	Environment Agency Japan 1994	BISMaL
43	<i>Agarum clathratum</i>	41.953889	143.248521	1990	Environment Agency Japan 1994	BISMaL
44	<i>Agarum clathratum</i>	41.999947	143.157215	1990	Environment Agency Japan 1994	BISMaL
45	<i>Agarum clathratum</i>	42.024817	143.132682	1990	Environment Agency Japan 1994	BISMaL
46	<i>Agarum clathratum</i>	42.067406	143.048106	1990	Environment Agency Japan 1994	BISMaL
47	<i>Agarum clathratum</i>	42.096171	142.991470	1990	Environment Agency Japan 1994	BISMaL
48	<i>Agarum clathratum</i>	42.120653	142.921052	1990	Environment Agency Japan 1994	BISMaL
49	<i>Agarum clathratum</i>	42.130884	142.884429	1990	Environment Agency Japan 1994	BISMaL
50	<i>Agarum clathratum</i>	42.215293	142.625165	1990	Environment Agency Japan 1994	BISMaL
51	<i>Agarum clathratum</i>	42.229965	142.595735	1990	Environment Agency Japan 1994	BISMaL
52	<i>Agarum clathratum</i>	42.265842	142.492117	1990	Environment Agency Japan 1994	BISMaL
53	<i>Agarum clathratum</i>	39.403843	141.996886	1990	Environment Agency Japan 1994	BISMaL
54	<i>Alaria crassifolia</i>	42.067406	143.048106	1990	Environment Agency Japan 1994	BISMaL
55	<i>Alaria crassifolia</i>	42.096171	142.991470	1990	Environment Agency Japan 1994	BISMaL
56	<i>Alaria crassifolia</i>	42.120653	142.921052	1990	Environment Agency Japan 1994	BISMaL
57	<i>Alaria crassifolia</i>	42.130884	142.884429	1990	Environment Agency Japan 1994	BISMaL
58	<i>Alaria crassifolia</i>	41.792755	141.169658	1990	Environment Agency Japan 1994	BISMaL
59	<i>Alaria crassifolia</i>	41.787065	141.162948	1990	Environment Agency Japan 1994	BISMaL
60	<i>Alaria crassifolia</i>	41.782740	141.151435	1990	Environment Agency Japan 1994	BISMaL
61	<i>Alaria crassifolia</i>	41.782704	141.143926	1990	Environment Agency Japan 1994	BISMaL
62	<i>Alaria crassifolia</i>	41.779825	141.136768	1990	Environment Agency Japan 1994	BISMaL
63	<i>Alaria crassifolia</i>	41.787594	141.123023	1990	Environment Agency Japan 1994	BISMaL
64	<i>Alaria crassifolia</i>	41.758267	141.086821	1990	Environment Agency Japan 1994	BISMaL
65	<i>Alaria crassifolia</i>	41.756487	141.088051	1990	Environment Agency Japan 1994	BISMaL
66	<i>Alaria crassifolia</i>	41.746009	141.079037	1990	Environment Agency Japan 1994	BISMaL
67	<i>Alaria crassifolia</i>	41.742710	141.079873	1990	Environment Agency Japan 1994	BISMaL
68	<i>Alaria crassifolia</i>	41.740314	141.073032	1990	Environment Agency Japan 1994	BISMaL
69	<i>Alaria crassifolia</i>	41.730518	141.052684	1990	Environment Agency Japan 1994	BISMaL
70	<i>Alaria crassifolia</i>	41.744445	140.891525	1990	Environment Agency Japan 1994	BISMaL
71	<i>Alaria crassifolia</i>	41.748626	140.891090	1990	Environment Agency Japan 1994	BISMaL
72	<i>Alaria crassifolia</i>	41.754532	140.867624	1990	Environment Agency Japan 1994	BISMaL
73	<i>Alaria crassifolia</i>	41.755287	140.844410	1990	Environment Agency Japan 1994	BISMaL
74	<i>Alaria crassifolia</i>	41.762028	140.819705	1990	Environment Agency Japan 1994	BISMaL
75	<i>Alaria crassifolia</i>	40.157088	141.865470	1990	Environment Agency Japan 1994	BISMaL
76	<i>Alaria crassifolia</i>	40.143429	141.879887	1990	Environment Agency Japan 1994	BISMaL
77	<i>Alaria crassifolia</i>	40.062994	141.846190	1990	Environment Agency Japan 1994	BISMaL
78	<i>Alaria crassifolia</i>	39.973730	141.955306	1990	Environment Agency Japan 1994	BISMaL
79	<i>Alaria crassifolia</i>	39.948434	141.960392	1990	Environment Agency Japan 1994	BISMaL
80	<i>Alaria crassifolia</i>	39.889490	141.958409	1990	Environment Agency Japan 1994	BISMaL
81	<i>Alaria crassifolia</i>	39.886350	141.966028	1990	Environment Agency Japan 1994	BISMaL
82	<i>Alaria crassifolia</i>	39.878727	141.974403	1990	Environment Agency Japan 1994	BISMaL
83	<i>Alaria crassifolia</i>	39.834255	141.980069	1990	Environment Agency Japan 1994	BISMaL
84	<i>Alaria crassifolia</i>	39.825707	141.989271	1990	Environment Agency Japan 1994	BISMaL
85	<i>Alaria crassifolia</i>	39.777148	142.004068	1990	Environment Agency Japan 1994	BISMaL
86	<i>Alaria crassifolia</i>	39.771408	141.997978	1990	Environment Agency Japan 1994	BISMaL
87	<i>Alaria crassifolia</i>	39.709316	141.985632	1990	Environment Agency Japan 1994	BISMaL
88	<i>Alaria crassifolia</i>	39.703740	141.975557	1990	Environment Agency Japan 1994	BISMaL
89	<i>Alaria crassifolia</i>	39.681652	141.985385	1990	Environment Agency Japan 1994	BISMaL

90	<i>Alaria crassifolia</i>	39.668584	141.987520	1990	Environment Agency Japan 1994	BISMaL
91	<i>Alaria crassifolia</i>	39.652571	141.981033	1990	Environment Agency Japan 1994	BISMaL
92	<i>Alaria crassifolia</i>	39.526748	142.057154	1990	Environment Agency Japan 1994	BISMaL
93	<i>Alaria crassifolia</i>	39.483231	142.046826	1990	Environment Agency Japan 1994	BISMaL
94	<i>Alaria crassifolia</i>	39.478929	142.052399	1990	Environment Agency Japan 1994	BISMaL
95	<i>Alaria crassifolia</i>	39.458836	142.052470	1990	Environment Agency Japan 1994	BISMaL
96	<i>Alaria crassifolia</i>	39.446371	142.042267	1990	Environment Agency Japan 1994	BISMaL
97	<i>Alaria crassifolia</i>	39.436503	142.040185	1990	Environment Agency Japan 1994	BISMaL
98	<i>Alaria crassifolia</i>	39.429609	142.043319	1990	Environment Agency Japan 1994	BISMaL
99	<i>Alaria crassifolia</i>	39.422073	142.038012	1990	Environment Agency Japan 1994	BISMaL
100	<i>Alaria crassifolia</i>	39.417618	142.025494	1990	Environment Agency Japan 1994	BISMaL
101	<i>Alaria crassifolia</i>	39.248369	141.965878	1990	Environment Agency Japan 1994	BISMaL
102	<i>Alaria crassifolia</i>	38.940105	141.710587	1990	Environment Agency Japan 1994	BISMaL
103	<i>Arthrothamnus bifidus</i>	43.364004	145.820635	1990	Environment Agency Japan 1994	BISMaL
104	<i>Arthrothamnus bifidus</i>	43.357649	145.797515	1990	Environment Agency Japan 1994	BISMaL
105	<i>Arthrothamnus bifidus</i>	43.358971	145.790820	1990	Environment Agency Japan 1994	BISMaL
106	<i>Arthrothamnus bifidus</i>	43.330256	145.733174	1990	Environment Agency Japan 1994	BISMaL
107	<i>Arthrothamnus bifidus</i>	43.332784	145.725260	1990	Environment Agency Japan 1994	BISMaL
108	<i>Arthrothamnus bifidus</i>	43.299238	145.609043	1990	Environment Agency Japan 1994	BISMaL
109	<i>Arthrothamnus bifidus</i>	43.289191	145.599406	1990	Environment Agency Japan 1994	BISMaL
110	<i>Arthrothamnus bifidus</i>	43.279004	145.590169	1990	Environment Agency Japan 1994	BISMaL
111	<i>Arthrothamnus bifidus</i>	43.190356	145.530717	1990	Environment Agency Japan 1994	BISMaL
112	<i>Arthrothamnus bifidus</i>	43.163244	145.493492	1990	Environment Agency Japan 1994	BISMaL
113	<i>Arthrothamnus bifidus</i>	43.218492	145.600968	1990	Environment Agency Japan 1994	BISMaL
114	<i>Arthrothamnus bifidus</i>	43.166461	145.312531	1990	Environment Agency Japan 1994	BISMaL
115	<i>Arthrothamnus bifidus</i>	43.148829	145.238842	1990	Environment Agency Japan 1994	BISMaL
116	<i>Arthrothamnus bifidus</i>	43.069332	145.148016	1990	Environment Agency Japan 1994	BISMaL
117	<i>Arthrothamnus bifidus</i>	43.047842	145.106357	1990	Environment Agency Japan 1994	BISMaL
118	<i>Arthrothamnus bifidus</i>	43.034664	145.065273	1990	Environment Agency Japan 1994	BISMaL
119	<i>Arthrothamnus bifidus</i>	42.985205	144.951358	1990	Environment Agency Japan 1994	BISMaL
120	<i>Arthrothamnus bifidus</i>	42.934964	144.722374	1990	Environment Agency Japan 1994	BISMaL
121	<i>Arthrothamnus bifidus</i>	42.942086	144.669512	1990	Environment Agency Japan 1994	BISMaL
122	<i>Arthrothamnus bifidus</i>	42.949900	144.622001	1990	Environment Agency Japan 1994	BISMaL
123	<i>Arthrothamnus bifidus</i>	42.949451	144.583166	1990	Environment Agency Japan 1994	BISMaL
124	<i>Arthrothamnus bifidus</i>	42.949201	144.542386	1990	Environment Agency Japan 1994	BISMaL
125	<i>Arthrothamnus bifidus</i>	42.940480	144.491234	1990	Environment Agency Japan 1994	BISMaL
126	<i>Costaria costata</i>	44.336967	145.343476	1990	Environment Agency Japan 1994	BISMaL
127	<i>Costaria costata</i>	44.315877	145.350534	1990	Environment Agency Japan 1994	BISMaL
128	<i>Costaria costata</i>	44.249579	145.358562	1990	Environment Agency Japan 1994	BISMaL
129	<i>Costaria costata</i>	44.205429	145.336246	1990	Environment Agency Japan 1994	BISMaL
130	<i>Costaria costata</i>	44.146097	145.279194	1990	Environment Agency Japan 1994	BISMaL
131	<i>Costaria costata</i>	44.091425	145.246165	1990	Environment Agency Japan 1994	BISMaL
132	<i>Costaria costata</i>	44.037485	145.219988	1990	Environment Agency Japan 1994	BISMaL
133	<i>Costaria costata</i>	43.972286	145.151943	1990	Environment Agency Japan 1994	BISMaL
134	<i>Costaria costata</i>	43.339609	145.575108	1990	Environment Agency Japan 1994	BISMaL
135	<i>Costaria costata</i>	43.351754	145.589838	1990	Environment Agency Japan 1994	BISMaL
136	<i>Costaria costata</i>	43.271258	145.566216	1990	Environment Agency Japan 1994	BISMaL
137	<i>Costaria costata</i>	42.028797	143.288052	1990	Environment Agency Japan 1994	BISMaL
138	<i>Costaria costata</i>	41.953889	143.248521	1990	Environment Agency Japan 1994	BISMaL
139	<i>Costaria costata</i>	41.999947	143.157215	1990	Environment Agency Japan 1994	BISMaL
140	<i>Costaria costata</i>	42.024817	143.132682	1990	Environment Agency Japan 1994	BISMaL
141	<i>Costaria costata</i>	42.213334	142.637914	1990	Environment Agency Japan 1994	BISMaL
142	<i>Costaria costata</i>	42.231278	142.602864	1990	Environment Agency Japan 1994	BISMaL
143	<i>Costaria costata</i>	42.253021	142.539264	1990	Environment Agency Japan 1994	BISMaL
144	<i>Costaria costata</i>	42.275412	142.475043	1990	Environment Agency Japan 1994	BISMaL
145	<i>Costaria costata</i>	42.289340	142.457159	1990	Environment Agency Japan 1994	BISMaL
146	<i>Costaria costata</i>	42.302659	142.424897	1990	Environment Agency Japan 1994	BISMaL
147	<i>Costaria costata</i>	41.787594	141.123023	1990	Environment Agency Japan 1994	BISMaL
148	<i>Costaria costata</i>	40.439330	141.696867	1990	Environment Agency Japan 1994	BISMaL
149	<i>Costaria costata</i>	40.429615	141.702684	1990	Environment Agency Japan 1994	BISMaL
150	<i>Costaria costata</i>	40.415217	141.718700	1990	Environment Agency Japan 1994	BISMaL
151	<i>Costaria costata</i>	40.395391	141.727146	1990	Environment Agency Japan 1994	BISMaL
152	<i>Costaria costata</i>	40.377085	141.747898	1990	Environment Agency Japan 1994	BISMaL
153	<i>Costaria costata</i>	40.368155	141.756342	1990	Environment Agency Japan 1994	BISMaL
154	<i>Costaria costata</i>	40.353358	141.763576	1990	Environment Agency Japan 1994	BISMaL
155	<i>Costaria costata</i>	40.342571	141.772720	1990	Environment Agency Japan 1994	BISMaL
156	<i>Costaria costata</i>	40.284402	141.806476	1990	Environment Agency Japan 1994	BISMaL
157	<i>Costaria costata</i>	40.255584	141.822151	1990	Environment Agency Japan 1994	BISMaL
158	<i>Costaria costata</i>	40.246026	141.826105	1990	Environment Agency Japan 1994	BISMaL
159	<i>Costaria costata</i>	40.230829	141.832760	1990	Environment Agency Japan 1994	BISMaL
160	<i>Costaria costata</i>	40.220063	141.824836	1990	Environment Agency Japan 1994	BISMaL
161	<i>Costaria costata</i>	40.182244	141.815386	1990	Environment Agency Japan 1994	BISMaL
162	<i>Costaria costata</i>	40.178949	141.833288	1990	Environment Agency Japan 1994	BISMaL
163	<i>Costaria costata</i>	40.157088	141.865470	1990	Environment Agency Japan 1994	BISMaL
164	<i>Costaria costata</i>	40.143429	141.879887	1990	Environment Agency Japan 1994	BISMaL
165	<i>Costaria costata</i>	40.132959	141.866329	1990	Environment Agency Japan 1994	BISMaL
166	<i>Costaria costata</i>	40.062994	141.846190	1990	Environment Agency Japan 1994	BISMaL
167	<i>Costaria costata</i>	40.009060	141.919181	1990	Environment Agency Japan 1994	BISMaL
168	<i>Costaria costata</i>	39.973730	141.955306	1990	Environment Agency Japan 1994	BISMaL
169	<i>Costaria costata</i>	39.954240	141.958870	1990	Environment Agency Japan 1994	BISMaL
170	<i>Costaria costata</i>	39.948434	141.960392	1990	Environment Agency Japan 1994	BISMaL
171	<i>Costaria costata</i>	39.927444	141.942496	1990	Environment Agency Japan 1994	BISMaL
172	<i>Costaria costata</i>	39.914770	141.948691	1990	Environment Agency Japan 1994	BISMaL
173	<i>Costaria costata</i>	39.904186	141.952362	1990	Environment Agency Japan 1994	BISMaL
174	<i>Costaria costata</i>	39.893994	141.955051	1990	Environment Agency Japan 1994	BISMaL
175	<i>Costaria costata</i>	39.889490	141.958409	1990	Environment Agency Japan 1994	BISMaL
176	<i>Costaria costata</i>	39.886350	141.966028	1990	Environment Agency Japan 1994	BISMaL
177	<i>Costaria costata</i>	39.865307	141.978313	1990	Environment Agency Japan 1994	BISMaL
178	<i>Costaria costata</i>	39.856533	141.976704	1990	Environment Agency Japan 1994	BISMaL
179	<i>Costaria costata</i>	39.834255	141.980069	1990	Environment Agency Japan 1994	BISMaL
180	<i>Costaria costata</i>	39.829275	141.981413	1990	Environment Agency Japan 1994	BISMaL
181	<i>Costaria costata</i>	39.825707	141.989271	1990	Environment Agency Japan 1994	BISMaL
182	<i>Costaria costata</i>	39.802951	141.986295	1990	Environment Agency Japan 1994	BISMaL

183	<i>Costaria costata</i>	39.784070	141.992453	1990	Environment Agency Japan 1994	BISMaL
184	<i>Costaria costata</i>	39.771408	141.997978	1990	Environment Agency Japan 1994	BISMaL
185	<i>Costaria costata</i>	39.760563	141.990214	1990	Environment Agency Japan 1994	BISMaL
186	<i>Costaria costata</i>	39.752702	141.994269	1990	Environment Agency Japan 1994	BISMaL
187	<i>Costaria costata</i>	39.752880	142.001849	1990	Environment Agency Japan 1994	BISMaL
188	<i>Costaria costata</i>	39.747599	141.996307	1990	Environment Agency Japan 1994	BISMaL
189	<i>Costaria costata</i>	39.726212	141.983033	1990	Environment Agency Japan 1994	BISMaL
190	<i>Costaria costata</i>	39.717648	141.985294	1990	Environment Agency Japan 1994	BISMaL
191	<i>Costaria costata</i>	39.709316	141.985632	1990	Environment Agency Japan 1994	BISMaL
192	<i>Costaria costata</i>	39.703740	141.975557	1990	Environment Agency Japan 1994	BISMaL
193	<i>Costaria costata</i>	39.528748	142.057154	1990	Environment Agency Japan 1994	BISMaL
194	<i>Costaria costata</i>	39.525182	142.052461	1990	Environment Agency Japan 1994	BISMaL
195	<i>Costaria costata</i>	39.525289	142.032669	1990	Environment Agency Japan 1994	BISMaL
196	<i>Costaria costata</i>	39.515659	142.031102	1990	Environment Agency Japan 1994	BISMaL
197	<i>Costaria costata</i>	39.500627	142.018820	1990	Environment Agency Japan 1994	BISMaL
198	<i>Costaria costata</i>	39.494231	142.010518	1990	Environment Agency Japan 1994	BISMaL
199	<i>Costaria costata</i>	39.484446	142.011897	1990	Environment Agency Japan 1994	BISMaL
200	<i>Costaria costata</i>	39.472406	142.022777	1990	Environment Agency Japan 1994	BISMaL
201	<i>Costaria costata</i>	39.481524	142.035430	1990	Environment Agency Japan 1994	BISMaL
202	<i>Costaria costata</i>	39.483231	142.046826	1990	Environment Agency Japan 1994	BISMaL
203	<i>Costaria costata</i>	39.446371	142.042267	1990	Environment Agency Japan 1994	BISMaL
204	<i>Costaria costata</i>	39.408554	141.985557	1990	Environment Agency Japan 1994	BISMaL
205	<i>Costaria costata</i>	39.415916	141.969029	1990	Environment Agency Japan 1994	BISMaL
206	<i>Costaria costata</i>	39.403056	141.957433	1990	Environment Agency Japan 1994	BISMaL
207	<i>Costaria costata</i>	39.235103	141.950888	1990	Environment Agency Japan 1994	BISMaL
208	<i>Costaria costata</i>	39.219975	141.952731	1990	Environment Agency Japan 1994	BISMaL
209	<i>Costaria costata</i>	39.220130	141.937811	1990	Environment Agency Japan 1994	BISMaL
210	<i>Costaria costata</i>	39.211986	141.918077	1990	Environment Agency Japan 1994	BISMaL
211	<i>Costaria costata</i>	39.087681	141.884947	1990	Environment Agency Japan 1994	BISMaL
212	<i>Costaria costata</i>	38.987381	141.733009	1990	Environment Agency Japan 1994	BISMaL
213	<i>Costaria costata</i>	38.693992	141.516869	1990	Environment Agency Japan 1994	BISMaL
214	<i>Costaria costata</i>	38.399948	141.537167	1990	Environment Agency Japan 1994	BISMaL
215	<i>Costaria costata</i>	38.390708	141.539643	1990	Environment Agency Japan 1994	BISMaL
216	<i>Costaria costata</i>	38.384726	141.534818	1990	Environment Agency Japan 1994	BISMaL
217	<i>Costaria costata</i>	38.383063	141.527822	1990	Environment Agency Japan 1994	BISMaL
218	<i>Costaria costata</i>	38.404278	141.551909	1990	Environment Agency Japan 1994	BISMaL
219	<i>Saccharina angustata</i>	42.807205	143.823486	1990	Environment Agency Japan 1994	BISMaL
220	<i>Saccharina angustata</i>	42.791475	143.805781	1990	Environment Agency Japan 1994	BISMaL
221	<i>Saccharina angustata</i>	42.764668	143.776643	1990	Environment Agency Japan 1994	BISMaL
222	<i>Saccharina angustata</i>	42.764414	143.767100	1990	Environment Agency Japan 1994	BISMaL
223	<i>Saccharina angustata</i>	42.354731	143.353019	1990	Environment Agency Japan 1994	BISMaL
224	<i>Saccharina angustata</i>	42.271471	143.315894	1990	Environment Agency Japan 1994	BISMaL
225	<i>Saccharina angustata</i>	42.262057	143.312786	1990	Environment Agency Japan 1994	BISMaL
226	<i>Saccharina angustata</i>	42.241553	143.312061	1990	Environment Agency Japan 1994	BISMaL
227	<i>Saccharina angustata</i>	42.215239	143.321906	1990	Environment Agency Japan 1994	BISMaL
228	<i>Saccharina angustata</i>	42.201340	143.335468	1990	Environment Agency Japan 1994	BISMaL
229	<i>Saccharina angustata</i>	42.181160	143.335206	1990	Environment Agency Japan 1994	BISMaL
230	<i>Saccharina angustata</i>	42.166141	143.329881	1990	Environment Agency Japan 1994	BISMaL
231	<i>Saccharina angustata</i>	41.792755	141.169658	1990	Environment Agency Japan 1994	BISMaL
232	<i>Saccharina angustata</i>	41.787065	141.162948	1990	Environment Agency Japan 1994	BISMaL
233	<i>Saccharina angustata</i>	41.781545	141.156369	1990	Environment Agency Japan 1994	BISMaL
234	<i>Saccharina angustata</i>	41.782740	141.151435	1990	Environment Agency Japan 1994	BISMaL
235	<i>Saccharina angustata</i>	41.782704	141.143926	1990	Environment Agency Japan 1994	BISMaL
236	<i>Saccharina angustata</i>	41.782555	141.133454	1990	Environment Agency Japan 1994	BISMaL
237	<i>Saccharina angustata</i>	41.787594	141.123023	1990	Environment Agency Japan 1994	BISMaL
238	<i>Saccharina angustata</i>	41.786958	141.116160	1990	Environment Agency Japan 1994	BISMaL
239	<i>Saccharina cichorioides</i>	45.310329	141.613072	1990	Environment Agency Japan 1994	BISMaL
240	<i>Saccharina cichorioides</i>	45.409156	141.634809	1990	Environment Agency Japan 1994	BISMaL
241	<i>Saccharina cichorioides</i>	45.435206	141.670405	1990	Environment Agency Japan 1994	BISMaL
242	<i>Saccharina cichorioides</i>	45.521356	141.917215	1990	Environment Agency Japan 1994	BISMaL
243	<i>Saccharina cichorioides</i>	45.494587	141.971059	1990	Environment Agency Japan 1994	BISMaL
244	<i>Saccharina cichorioides</i>	45.450056	142.024902	1990	Environment Agency Japan 1994	BISMaL
245	<i>Saccharina cichorioides</i>	45.320260	142.193099	1990	Environment Agency Japan 1994	BISMaL
246	<i>Saccharina cichorioides</i>	44.491589	143.124182	1990	Environment Agency Japan 1994	BISMaL
247	<i>Saccharina cichorioides</i>	44.373777	143.341913	1990	Environment Agency Japan 1994	BISMaL
248	<i>Saccharina cichorioides</i>	44.052643	144.262185	1990	Environment Agency Japan 1994	BISMaL
249	<i>Saccharina cichorioides</i>	44.012299	144.284342	1990	Environment Agency Japan 1994	BISMaL
250	<i>Saccharina cichorioides</i>	43.999936	144.295627	1990	Environment Agency Japan 1994	BISMaL
251	<i>Saccharina cichorioides</i>	43.958942	144.829109	1990	Environment Agency Japan 1994	BISMaL
252	<i>Saccharina cichorioides</i>	43.979765	144.856650	1990	Environment Agency Japan 1994	BISMaL
253	<i>Saccharina cichorioides</i>	44.068692	144.985806	1990	Environment Agency Japan 1994	BISMaL
254	<i>Saccharina cichorioides</i>	44.345822	145.329586	1990	Environment Agency Japan 1994	BISMaL
255	<i>Saccharina cichorioides</i>	43.327473	145.560144	1990	Environment Agency Japan 1994	BISMaL
256	<i>Saccharina coriacea</i>	43.364004	145.820635	1990	Environment Agency Japan 1994	BISMaL
257	<i>Saccharina coriacea</i>	43.360873	145.807993	1990	Environment Agency Japan 1994	BISMaL
258	<i>Saccharina coriacea</i>	43.357649	145.797515	1990	Environment Agency Japan 1994	BISMaL
259	<i>Saccharina coriacea</i>	43.358971	145.790820	1990	Environment Agency Japan 1994	BISMaL
260	<i>Saccharina coriacea</i>	43.347466	145.775876	1990	Environment Agency Japan 1994	BISMaL
261	<i>Saccharina coriacea</i>	43.341691	145.769480	1990	Environment Agency Japan 1994	BISMaL
262	<i>Saccharina coriacea</i>	43.335308	145.775079	1990	Environment Agency Japan 1994	BISMaL
263	<i>Saccharina coriacea</i>	43.330256	145.733174	1990	Environment Agency Japan 1994	BISMaL
264	<i>Saccharina coriacea</i>	43.332784	145.725260	1990	Environment Agency Japan 1994	BISMaL
265	<i>Saccharina coriacea</i>	43.328003	145.701616	1990	Environment Agency Japan 1994	BISMaL
266	<i>Saccharina coriacea</i>	43.323310	145.682761	1990	Environment Agency Japan 1994	BISMaL
267	<i>Saccharina coriacea</i>	43.307445	145.676377	1990	Environment Agency Japan 1994	BISMaL
268	<i>Saccharina coriacea</i>	43.297356	145.670309	1990	Environment Agency Japan 1994	BISMaL
269	<i>Saccharina coriacea</i>	43.299238	145.609043	1990	Environment Agency Japan 1994	BISMaL
270	<i>Saccharina coriacea</i>	43.289191	145.599406	1990	Environment Agency Japan 1994	BISMaL
271	<i>Saccharina coriacea</i>	43.279004	145.590169	1990	Environment Agency Japan 1994	BISMaL
272	<i>Saccharina coriacea</i>	43.271258	145.566216	1990	Environment Agency Japan 1994	BISMaL
273	<i>Saccharina coriacea</i>	43.210083	145.549839	1990	Environment Agency Japan 1994	BISMaL
274	<i>Saccharina coriacea</i>	43.190356	145.530717	1990	Environment Agency Japan 1994	BISMaL
275	<i>Saccharina coriacea</i>	43.163244	145.493492	1990	Environment Agency Japan 1994	BISMaL

276	<i>Saccharina coriacea</i>	43.218492	145.600968	1990	Environment Agency Japan 1994	BISMaL
277	<i>Saccharina coriacea</i>	43.166461	145.312531	1990	Environment Agency Japan 1994	BISMaL
278	<i>Saccharina coriacea</i>	43.155081	145.251461	1990	Environment Agency Japan 1994	BISMaL
279	<i>Saccharina coriacea</i>	43.148829	145.238842	1990	Environment Agency Japan 1994	BISMaL
280	<i>Saccharina coriacea</i>	43.145618	145.177277	1990	Environment Agency Japan 1994	BISMaL
281	<i>Saccharina coriacea</i>	43.122838	145.128327	1990	Environment Agency Japan 1994	BISMaL
282	<i>Saccharina coriacea</i>	43.088850	145.200345	1990	Environment Agency Japan 1994	BISMaL
283	<i>Saccharina coriacea</i>	43.069332	145.148016	1990	Environment Agency Japan 1994	BISMaL
284	<i>Saccharina coriacea</i>	43.047842	145.106357	1990	Environment Agency Japan 1994	BISMaL
285	<i>Saccharina coriacea</i>	43.034664	145.065273	1990	Environment Agency Japan 1994	BISMaL
286	<i>Saccharina coriacea</i>	43.007791	145.023841	1990	Environment Agency Japan 1994	BISMaL
287	<i>Saccharina coriacea</i>	42.985205	144.951358	1990	Environment Agency Japan 1994	BISMaL
288	<i>Saccharina coriacea</i>	42.968312	144.878338	1990	Environment Agency Japan 1994	BISMaL
289	<i>Saccharina coriacea</i>	42.980066	144.728765	1990	Environment Agency Japan 1994	BISMaL
290	<i>Saccharina coriacea</i>	42.947443	144.767130	1990	Environment Agency Japan 1994	BISMaL
291	<i>Saccharina coriacea</i>	42.942086	144.669512	1990	Environment Agency Japan 1994	BISMaL
292	<i>Saccharina coriacea</i>	42.949451	144.583166	1990	Environment Agency Japan 1994	BISMaL
293	<i>Saccharina coriacea</i>	42.949201	144.542386	1990	Environment Agency Japan 1994	BISMaL
294	<i>Saccharina coriacea</i>	42.940480	144.491234	1990	Environment Agency Japan 1994	BISMaL
295	<i>Saccharina coriacea</i>	42.949604	144.439202	1990	Environment Agency Japan 1994	BISMaL
296	<i>Saccharina gyrate</i>	44.146097	145.279194	1990	Environment Agency Japan 1994	BISMaL
297	<i>Saccharina gyrate</i>	44.011074	145.189009	1990	Environment Agency Japan 1994	BISMaL
298	<i>Saccharina gyrate</i>	43.972286	145.151943	1990	Environment Agency Japan 1994	BISMaL
299	<i>Saccharina gyrate</i>	43.947267	145.131587	1990	Environment Agency Japan 1994	BISMaL
300	<i>Saccharina gyrate</i>	43.918741	145.115940	1990	Environment Agency Japan 1994	BISMaL
301	<i>Saccharina gyrate</i>	43.327473	145.560144	1990	Environment Agency Japan 1994	BISMaL
302	<i>Saccharina gyrate</i>	43.218492	145.600968	1990	Environment Agency Japan 1994	BISMaL
303	<i>Saccharina japonica</i>	44.345822	145.329586	1990	Environment Agency Japan 1994	BISMaL
304	<i>Saccharina japonica</i>	44.336967	145.343476	1990	Environment Agency Japan 1994	BISMaL
305	<i>Saccharina japonica</i>	44.315877	145.350534	1990	Environment Agency Japan 1994	BISMaL
306	<i>Saccharina japonica</i>	44.289219	145.355479	1990	Environment Agency Japan 1994	BISMaL
307	<i>Saccharina japonica</i>	44.249579	145.358562	1990	Environment Agency Japan 1994	BISMaL
308	<i>Saccharina japonica</i>	44.205429	145.336246	1990	Environment Agency Japan 1994	BISMaL
309	<i>Saccharina japonica</i>	44.146097	145.279194	1990	Environment Agency Japan 1994	BISMaL
310	<i>Saccharina japonica</i>	44.091425	145.246165	1990	Environment Agency Japan 1994	BISMaL
311	<i>Saccharina japonica</i>	44.037485	145.219988	1990	Environment Agency Japan 1994	BISMaL
312	<i>Saccharina japonica</i>	44.011074	145.189009	1990	Environment Agency Japan 1994	BISMaL
313	<i>Saccharina japonica</i>	43.972286	145.151943	1990	Environment Agency Japan 1994	BISMaL
314	<i>Saccharina japonica</i>	43.947267	145.131587	1990	Environment Agency Japan 1994	BISMaL
315	<i>Saccharina japonica</i>	43.918741	145.115940	1990	Environment Agency Japan 1994	BISMaL
316	<i>Saccharina japonica</i>	43.327473	145.560144	1990	Environment Agency Japan 1994	BISMaL
317	<i>Saccharina japonica</i>	43.339609	145.575108	1990	Environment Agency Japan 1994	BISMaL
318	<i>Saccharina japonica</i>	43.351754	145.589838	1990	Environment Agency Japan 1994	BISMaL
319	<i>Saccharina japonica</i>	43.399369	145.757454	1990	Environment Agency Japan 1994	BISMaL
320	<i>Saccharina japonica</i>	43.393119	145.782051	1990	Environment Agency Japan 1994	BISMaL
321	<i>Saccharina japonica</i>	43.389085	145.802690	1990	Environment Agency Japan 1994	BISMaL
322	<i>Saccharina japonica</i>	43.188757	145.514311	1990	Environment Agency Japan 1994	BISMaL
323	<i>Saccharina japonica</i>	43.218492	145.600968	1990	Environment Agency Japan 1994	BISMaL
324	<i>Saccharina japonica</i>	42.968312	144.878338	1990	Environment Agency Japan 1994	BISMaL
325	<i>Saccharina japonica</i>	42.248938	140.301042	1990	Environment Agency Japan 1994	BISMaL
326	<i>Saccharina japonica</i>	42.246009	140.312910	1990	Environment Agency Japan 1994	BISMaL
327	<i>Saccharina japonica</i>	42.238924	140.323841	1990	Environment Agency Japan 1994	BISMaL
328	<i>Saccharina japonica</i>	42.234109	140.339807	1990	Environment Agency Japan 1994	BISMaL
329	<i>Saccharina japonica</i>	42.232438	140.355104	1990	Environment Agency Japan 1994	BISMaL
330	<i>Saccharina japonica</i>	42.230116	140.375617	1990	Environment Agency Japan 1994	BISMaL
331	<i>Saccharina japonica</i>	42.224873	140.401671	1990	Environment Agency Japan 1994	BISMaL
332	<i>Saccharina japonica</i>	42.212427	140.413102	1990	Environment Agency Japan 1994	BISMaL
333	<i>Saccharina japonica</i>	42.214844	140.422555	1990	Environment Agency Japan 1994	BISMaL
334	<i>Saccharina japonica</i>	42.207267	140.421665	1990	Environment Agency Japan 1994	BISMaL
335	<i>Saccharina japonica</i>	42.202472	140.414885	1990	Environment Agency Japan 1994	BISMaL
336	<i>Saccharina japonica</i>	42.197415	140.424611	1990	Environment Agency Japan 1994	BISMaL
337	<i>Saccharina japonica</i>	42.206330	140.431605	1990	Environment Agency Japan 1994	BISMaL
338	<i>Saccharina japonica</i>	42.191784	140.439943	1990	Environment Agency Japan 1994	BISMaL
339	<i>Saccharina japonica</i>	42.185631	140.448947	1990	Environment Agency Japan 1994	BISMaL
340	<i>Saccharina japonica</i>	42.186280	140.439480	1990	Environment Agency Japan 1994	BISMaL
341	<i>Saccharina japonica</i>	42.183189	140.442468	1990	Environment Agency Japan 1994	BISMaL
342	<i>Saccharina japonica</i>	42.180469	140.446130	1990	Environment Agency Japan 1994	BISMaL
343	<i>Saccharina japonica</i>	42.179267	140.451738	1990	Environment Agency Japan 1994	BISMaL
344	<i>Saccharina japonica</i>	42.090156	140.787170	1990	Environment Agency Japan 1994	BISMaL
345	<i>Saccharina japonica</i>	42.076008	140.810203	1990	Environment Agency Japan 1994	BISMaL
346	<i>Saccharina japonica</i>	42.065162	140.812738	1990	Environment Agency Japan 1994	BISMaL
347	<i>Saccharina japonica</i>	42.054800	140.815891	1990	Environment Agency Japan 1994	BISMaL
348	<i>Saccharina japonica</i>	42.042075	140.826308	1990	Environment Agency Japan 1994	BISMaL
349	<i>Saccharina japonica</i>	42.030049	140.838355	1990	Environment Agency Japan 1994	BISMaL
350	<i>Saccharina japonica</i>	42.023606	140.848364	1990	Environment Agency Japan 1994	BISMaL
351	<i>Saccharina japonica</i>	42.016106	140.860509	1990	Environment Agency Japan 1994	BISMaL
352	<i>Saccharina japonica</i>	41.787539	141.128240	1990	Environment Agency Japan 1994	BISMaL
353	<i>Saccharina japonica</i>	41.763619	141.092238	1990	Environment Agency Japan 1994	BISMaL
354	<i>Saccharina japonica</i>	41.758267	141.086821	1990	Environment Agency Japan 1994	BISMaL
355	<i>Saccharina japonica</i>	41.756487	141.088051	1990	Environment Agency Japan 1994	BISMaL
356	<i>Saccharina japonica</i>	41.746009	141.079037	1990	Environment Agency Japan 1994	BISMaL
357	<i>Saccharina japonica</i>	41.742710	141.079873	1990	Environment Agency Japan 1994	BISMaL
358	<i>Saccharina japonica</i>	41.740314	141.073032	1990	Environment Agency Japan 1994	BISMaL
359	<i>Saccharina japonica</i>	41.738172	141.072425	1990	Environment Agency Japan 1994	BISMaL
360	<i>Saccharina japonica</i>	41.735292	141.062525	1990	Environment Agency Japan 1994	BISMaL
361	<i>Saccharina japonica</i>	41.737152	141.061311	1990	Environment Agency Japan 1994	BISMaL
362	<i>Saccharina japonica</i>	41.730518	141.052684	1990	Environment Agency Japan 1994	BISMaL
363	<i>Saccharina japonica</i>	41.728185	141.054429	1990	Environment Agency Japan 1994	BISMaL
364	<i>Saccharina japonica</i>	40.453166	141.682401	1990	Environment Agency Japan 1994	BISMaL
365	<i>Saccharina japonica</i>	40.454000	141.683234	1990	Environment Agency Japan 1994	BISMaL
366	<i>Saccharina japonica</i>	40.461610	141.666236	1990	Environment Agency Japan 1994	BISMaL
367	<i>Saccharina japonica</i>	40.462245	141.666997	1990	Environment Agency Japan 1994	BISMaL
368	<i>Saccharina japonica</i>	40.469533	141.655029	1990	Environment Agency Japan 1994	BISMaL

369	<i>Saccharina japonica</i>	40.470202	141.655958	1990	Environment Agency Japan 1994	BISMaL
370	<i>Saccharina japonica</i>	40.474441	141.650237	1990	Environment Agency Japan 1994	BISMaL
371	<i>Saccharina japonica</i>	40.478683	141.645217	1990	Environment Agency Japan 1994	BISMaL
372	<i>Saccharina japonica</i>	40.489182	141.635433	1990	Environment Agency Japan 1994	BISMaL
373	<i>Saccharina japonica</i>	40.497575	141.628095	1990	Environment Agency Japan 1994	BISMaL
374	<i>Saccharina japonica</i>	41.494044	141.035092	1990	Environment Agency Japan 1994	BISMaL
375	<i>Saccharina japonica</i>	41.497813	140.990195	1990	Environment Agency Japan 1994	BISMaL
376	<i>Saccharina japonica</i>	45.484124	140.967181	1990	Environment Agency Japan 1994	BISMaL
377	<i>Saccharina japonica</i>	45.465888	140.970401	1990	Environment Agency Japan 1994	BISMaL
378	<i>Saccharina japonica</i>	45.435366	141.015428	1990	Environment Agency Japan 1994	BISMaL
379	<i>Saccharina japonica</i>	45.434075	141.016369	1990	Environment Agency Japan 1994	BISMaL
380	<i>Saccharina japonica</i>	45.439477	141.030717	1990	Environment Agency Japan 1994	BISMaL
381	<i>Saccharina japonica</i>	45.447948	141.048786	1990	Environment Agency Japan 1994	BISMaL
382	<i>Saccharina japonica</i>	45.458393	141.038426	1990	Environment Agency Japan 1994	BISMaL
383	<i>Saccharina japonica</i>	45.439267	141.056439	1990	Environment Agency Japan 1994	BISMaL
384	<i>Saccharina japonica</i>	45.408624	141.061544	1990	Environment Agency Japan 1994	BISMaL
385	<i>Saccharina japonica</i>	45.380050	141.060469	1990	Environment Agency Japan 1994	BISMaL
386	<i>Saccharina japonica</i>	45.354548	141.059368	1990	Environment Agency Japan 1994	BISMaL
387	<i>Saccharina japonica</i>	45.334148	141.053676	1990	Environment Agency Japan 1994	BISMaL
388	<i>Saccharina japonica</i>	45.317516	141.055913	1990	Environment Agency Japan 1994	BISMaL
389	<i>Saccharina japonica</i>	45.297692	141.044929	1990	Environment Agency Japan 1994	BISMaL
390	<i>Saccharina japonica</i>	45.281264	141.045594	1990	Environment Agency Japan 1994	BISMaL
391	<i>Saccharina japonica</i>	45.276699	141.021344	1990	Environment Agency Japan 1994	BISMaL
392	<i>Saccharina japonica</i>	45.277185	141.022292	1990	Environment Agency Japan 1994	BISMaL
393	<i>Saccharina japonica</i>	45.303643	141.020297	1990	Environment Agency Japan 1994	BISMaL
394	<i>Saccharina japonica</i>	45.327198	141.004037	1990	Environment Agency Japan 1994	BISMaL
395	<i>Saccharina japonica</i>	45.369835	140.987831	1990	Environment Agency Japan 1994	BISMaL
396	<i>Saccharina japonica</i>	45.400119	140.985748	1990	Environment Agency Japan 1994	BISMaL
397	<i>Saccharina japonica</i>	45.412918	140.983277	1990	Environment Agency Japan 1994	BISMaL
398	<i>Saccharina japonica</i>	45.433324	140.977787	1990	Environment Agency Japan 1994	BISMaL
399	<i>Saccharina japonica</i>	45.257293	141.200611	1990	Environment Agency Japan 1994	BISMaL
400	<i>Saccharina japonica</i>	45.235894	141.245511	1990	Environment Agency Japan 1994	BISMaL
401	<i>Saccharina japonica</i>	45.231263	141.278694	1990	Environment Agency Japan 1994	BISMaL
402	<i>Saccharina japonica</i>	45.206263	141.310886	1990	Environment Agency Japan 1994	BISMaL
403	<i>Saccharina japonica</i>	45.162480	141.329605	1990	Environment Agency Japan 1994	BISMaL
404	<i>Saccharina japonica</i>	45.122842	141.299326	1990	Environment Agency Japan 1994	BISMaL
405	<i>Saccharina japonica</i>	45.105625	141.268590	1990	Environment Agency Japan 1994	BISMaL
406	<i>Saccharina japonica</i>	45.100486	141.229840	1990	Environment Agency Japan 1994	BISMaL
407	<i>Saccharina japonica</i>	45.118419	141.196336	1990	Environment Agency Japan 1994	BISMaL
408	<i>Saccharina japonica</i>	45.137743	141.165744	1990	Environment Agency Japan 1994	BISMaL
409	<i>Saccharina japonica</i>	45.174606	141.134975	1990	Environment Agency Japan 1994	BISMaL
410	<i>Saccharina japonica</i>	45.213499	141.135083	1990	Environment Agency Japan 1994	BISMaL
411	<i>Saccharina japonica</i>	45.239348	141.163658	1990	Environment Agency Japan 1994	BISMaL
412	<i>Saccharina japonica</i>	45.310329	141.613072	1990	Environment Agency Japan 1994	BISMaL
413	<i>Saccharina japonica</i>	45.409156	141.634809	1990	Environment Agency Japan 1994	BISMaL
414	<i>Saccharina japonica</i>	45.435206	141.670405	1990	Environment Agency Japan 1994	BISMaL
415	<i>Saccharina japonica</i>	45.407440	141.737784	1990	Environment Agency Japan 1994	BISMaL
416	<i>Saccharina japonica</i>	45.423587	141.744907	1990	Environment Agency Japan 1994	BISMaL
417	<i>Saccharina japonica</i>	45.446539	141.865598	1990	Environment Agency Japan 1994	BISMaL
418	<i>Saccharina japonica</i>	45.499199	141.878571	1990	Environment Agency Japan 1994	BISMaL
419	<i>Saccharina japonica</i>	45.521356	141.917215	1990	Environment Agency Japan 1994	BISMaL
420	<i>Saccharina japonica</i>	45.494587	141.971059	1990	Environment Agency Japan 1994	BISMaL
421	<i>Saccharina japonica</i>	45.450056	142.024902	1990	Environment Agency Japan 1994	BISMaL
422	<i>Saccharina japonica</i>	45.426298	142.036709	1990	Environment Agency Japan 1994	BISMaL
423	<i>Saccharina japonica</i>	45.392460	142.075962	1990	Environment Agency Japan 1994	BISMaL
424	<i>Saccharina japonica</i>	45.364865	142.129109	1990	Environment Agency Japan 1994	BISMaL
425	<i>Saccharina japonica</i>	45.320260	142.193099	1990	Environment Agency Japan 1994	BISMaL
426	<i>Saccharina japonica</i>	44.597113	142.963699	1990	Environment Agency Japan 1994	BISMaL
427	<i>Saccharina japonica</i>	44.588478	142.973352	1990	Environment Agency Japan 1994	BISMaL
428	<i>Saccharina japonica</i>	44.578667	142.979227	1990	Environment Agency Japan 1994	BISMaL
429	<i>Saccharina japonica</i>	44.525398	143.062855	1990	Environment Agency Japan 1994	BISMaL
430	<i>Saccharina japonica</i>	44.436850	143.228817	1990	Environment Agency Japan 1994	BISMaL
431	<i>Saccharina japonica</i>	44.414696	143.253741	1990	Environment Agency Japan 1994	BISMaL
432	<i>Saccharina japonica</i>	44.373777	143.341913	1990	Environment Agency Japan 1994	BISMaL
433	<i>Saccharina japonica</i>	44.171631	143.798652	1990	Environment Agency Japan 1994	BISMaL
434	<i>Saccharina japonica</i>	44.130220	144.099346	1990	Environment Agency Japan 1994	BISMaL
435	<i>Saccharina japonica</i>	44.105201	144.224714	1990	Environment Agency Japan 1994	BISMaL
436	<i>Saccharina japonica</i>	44.052643	144.262185	1990	Environment Agency Japan 1994	BISMaL
437	<i>Saccharina japonica</i>	44.012299	144.284342	1990	Environment Agency Japan 1994	BISMaL
438	<i>Saccharina japonica</i>	43.999936	144.295627	1990	Environment Agency Japan 1994	BISMaL
439	<i>Saccharina japonica</i>	44.240954	145.222483	1990	Environment Agency Japan 1994	BISMaL
440	<i>Saccharina japonica</i>	44.345822	145.329586	1990	Environment Agency Japan 1994	BISMaL
441	<i>Saccharina japonica</i>	41.402432	140.204545	1990	Environment Agency Japan 1994	BISMaL
442	<i>Saccharina japonica</i>	41.398427	140.190173	1990	Environment Agency Japan 1994	BISMaL
443	<i>Saccharina japonica</i>	41.402978	140.181356	1990	Environment Agency Japan 1994	BISMaL
444	<i>Saccharina japonica</i>	41.408921	140.174543	1990	Environment Agency Japan 1994	BISMaL
445	<i>Saccharina japonica</i>	41.413551	140.169794	1990	Environment Agency Japan 1994	BISMaL
446	<i>Saccharina japonica</i>	41.417208	140.163788	1990	Environment Agency Japan 1994	BISMaL
447	<i>Saccharina japonica</i>	41.421996	140.156921	1990	Environment Agency Japan 1994	BISMaL
448	<i>Saccharina japonica</i>	41.424801	140.149425	1990	Environment Agency Japan 1994	BISMaL
449	<i>Saccharina japonica</i>	41.424009	140.109495	1990	Environment Agency Japan 1994	BISMaL
450	<i>Saccharina japonica</i>	41.415332	140.088713	1990	Environment Agency Japan 1994	BISMaL
451	<i>Saccharina japonica</i>	41.425867	140.071910	1990	Environment Agency Japan 1994	BISMaL
452	<i>Saccharina japonica</i>	41.439493	140.053989	1990	Environment Agency Japan 1994	BISMaL
453	<i>Saccharina japonica</i>	41.447044	140.038787	1990	Environment Agency Japan 1994	BISMaL
454	<i>Saccharina japonica</i>	41.457174	140.030999	1990	Environment Agency Japan 1994	BISMaL
455	<i>Saccharina japonica</i>	41.464966	140.026586	1990	Environment Agency Japan 1994	BISMaL
456	<i>Saccharina japonica</i>	41.474159	140.026287	1990	Environment Agency Japan 1994	BISMaL
457	<i>Saccharina japonica</i>	41.480191	140.024509	1990	Environment Agency Japan 1994	BISMaL
458	<i>Saccharina japonica</i>	41.487934	140.015766	1990	Environment Agency Japan 1994	BISMaL
459	<i>Saccharina japonica</i>	41.509792	140.005615	1990	Environment Agency Japan 1994	BISMaL
460	<i>Saccharina japonica</i>	41.515313	140.004564	1990	Environment Agency Japan 1994	BISMaL
461	<i>Saccharina japonica</i>	41.522712	140.000376	1990	Environment Agency Japan 1994	BISMaL

462	<i>Saccharina japonica</i>	41.528641	140.000309	1990	Environment Agency Japan 1994	BISMaL
463	<i>Saccharina japonica</i>	41.556202	139.984236	1990	Environment Agency Japan 1994	BISMaL
464	<i>Saccharina japonica</i>	41.567565	139.984323	1990	Environment Agency Japan 1994	BISMaL
465	<i>Saccharina japonica</i>	41.574270	139.983644	1990	Environment Agency Japan 1994	BISMaL
466	<i>Saccharina japonica</i>	41.586349	139.980649	1990	Environment Agency Japan 1994	BISMaL
467	<i>Saccharina japonica</i>	41.595518	139.982207	1990	Environment Agency Japan 1994	BISMaL
468	<i>Saccharina japonica</i>	41.614740	139.984618	1990	Environment Agency Japan 1994	BISMaL
469	<i>Saccharina japonica</i>	41.623232	139.989375	1990	Environment Agency Japan 1994	BISMaL
470	<i>Saccharina japonica</i>	42.687480	140.003830	1990	Environment Agency Japan 1994	BISMaL
471	<i>Saccharina japonica</i>	42.691179	140.021234	1990	Environment Agency Japan 1994	BISMaL
472	<i>Saccharina japonica</i>	42.716055	140.065959	1990	Environment Agency Japan 1994	BISMaL
473	<i>Saccharina japonica</i>	42.986174	140.503081	1990	Environment Agency Japan 1994	BISMaL
474	<i>Saccharina japonica</i>	43.358393	140.519778	1990	Environment Agency Japan 1994	BISMaL
475	<i>Saccharina japonica</i>	43.317484	140.575044	1990	Environment Agency Japan 1994	BISMaL
476	<i>Saccharina japonica</i>	43.286864	140.640063	1990	Environment Agency Japan 1994	BISMaL
477	<i>Saccharina japonica</i>	43.252416	140.699837	1990	Environment Agency Japan 1994	BISMaL
478	<i>Saccharina japonica</i>	43.252129	140.703421	1990	Environment Agency Japan 1994	BISMaL
479	<i>Saccharina japonica</i>	43.226996	140.763857	1990	Environment Agency Japan 1994	BISMaL
480	<i>Saccharina japonica</i>	43.211285	140.908044	1990	Environment Agency Japan 1994	BISMaL
481	<i>Saccharina japonica</i>	43.224527	141.020610	1990	Environment Agency Japan 1994	BISMaL
482	<i>Saccharina japonica</i>	43.182050	141.037027	1990	Environment Agency Japan 1994	BISMaL
483	<i>Saccharina japonica</i>	43.180017	141.044778	1990	Environment Agency Japan 1994	BISMaL
484	<i>Saccharina japonica</i>	43.174999	141.072813	1990	Environment Agency Japan 1994	BISMaL
485	<i>Saccharina japonica</i>	43.156386	141.126307	1990	Environment Agency Japan 1994	BISMaL
486	<i>Saccharina japonica</i>	43.148257	141.151182	1990	Environment Agency Japan 1994	BISMaL
487	<i>Saccharina japonica</i>	43.438801	141.413122	1990	Environment Agency Japan 1994	BISMaL
488	<i>Saccharina japonica</i>	43.488669	141.377955	1990	Environment Agency Japan 1994	BISMaL
489	<i>Saccharina japonica</i>	43.528678	141.362069	1990	Environment Agency Japan 1994	BISMaL
490	<i>Saccharina japonica</i>	43.593632	141.383650	1990	Environment Agency Japan 1994	BISMaL
491	<i>Saccharina japonica</i>	43.611705	141.372757	1990	Environment Agency Japan 1994	BISMaL
492	<i>Saccharina japonica</i>	43.635477	141.356672	1990	Environment Agency Japan 1994	BISMaL
493	<i>Saccharina japonica</i>	43.643079	141.350875	1990	Environment Agency Japan 1994	BISMaL
494	<i>Saccharina japonica</i>	43.650443	141.350640	1990	Environment Agency Japan 1994	BISMaL
495	<i>Saccharina japonica</i>	43.663549	141.348912	1990	Environment Agency Japan 1994	BISMaL
496	<i>Saccharina japonica</i>	43.678779	141.341859	1990	Environment Agency Japan 1994	BISMaL
497	<i>Saccharina japonica</i>	43.711367	141.331074	1990	Environment Agency Japan 1994	BISMaL
498	<i>Saccharina japonica</i>	43.734823	141.336074	1990	Environment Agency Japan 1994	BISMaL
499	<i>Saccharina japonica</i>	38.319365	141.534745	1990	Environment Agency Japan 1994	BISMaL
500	<i>Saccharina japonica</i>	36.953565	140.948496	1990	Environment Agency Japan 1994	BISMaL
501	<i>Saccharina japonica</i>	36.953999	140.944319	1990	Environment Agency Japan 1994	BISMaL
502	<i>Saccharina japonica</i>	36.952548	140.939034	1990	Environment Agency Japan 1994	BISMaL
503	<i>Saccharina japonica</i>	36.935159	140.929027	1990	Environment Agency Japan 1994	BISMaL
504	<i>Saccharina longissima</i>	43.389085	145.802690	1990	Environment Agency Japan 1994	BISMaL
505	<i>Saccharina longissima</i>	43.375777	145.811533	1990	Environment Agency Japan 1994	BISMaL
506	<i>Saccharina longissima</i>	43.364004	145.820635	1990	Environment Agency Japan 1994	BISMaL
507	<i>Saccharina longissima</i>	43.360873	145.807993	1990	Environment Agency Japan 1994	BISMaL
508	<i>Saccharina longissima</i>	43.357649	145.797515	1990	Environment Agency Japan 1994	BISMaL
509	<i>Saccharina longissima</i>	43.358971	145.790820	1990	Environment Agency Japan 1994	BISMaL
510	<i>Saccharina longissima</i>	43.347466	145.775876	1990	Environment Agency Japan 1994	BISMaL
511	<i>Saccharina longissima</i>	43.341691	145.769480	1990	Environment Agency Japan 1994	BISMaL
512	<i>Saccharina longissima</i>	43.335308	145.775079	1990	Environment Agency Japan 1994	BISMaL
513	<i>Saccharina longissima</i>	43.330256	145.733174	1990	Environment Agency Japan 1994	BISMaL
514	<i>Saccharina longissima</i>	43.332784	145.725260	1990	Environment Agency Japan 1994	BISMaL
515	<i>Saccharina longissima</i>	43.328003	145.701616	1990	Environment Agency Japan 1994	BISMaL
516	<i>Saccharina longissima</i>	43.323310	145.682761	1990	Environment Agency Japan 1994	BISMaL
517	<i>Saccharina longissima</i>	43.307445	145.676377	1990	Environment Agency Japan 1994	BISMaL
518	<i>Saccharina longissima</i>	43.297356	145.670309	1990	Environment Agency Japan 1994	BISMaL
519	<i>Saccharina longissima</i>	43.299238	145.609043	1990	Environment Agency Japan 1994	BISMaL
520	<i>Saccharina longissima</i>	43.289191	145.599406	1990	Environment Agency Japan 1994	BISMaL
521	<i>Saccharina longissima</i>	43.279004	145.590169	1990	Environment Agency Japan 1994	BISMaL
522	<i>Saccharina longissima</i>	43.271258	145.566216	1990	Environment Agency Japan 1994	BISMaL
523	<i>Saccharina longissima</i>	43.234273	145.555320	1990	Environment Agency Japan 1994	BISMaL
524	<i>Saccharina longissima</i>	43.210083	145.549839	1990	Environment Agency Japan 1994	BISMaL
525	<i>Saccharina longissima</i>	43.190356	145.530717	1990	Environment Agency Japan 1994	BISMaL
526	<i>Saccharina longissima</i>	43.163244	145.493492	1990	Environment Agency Japan 1994	BISMaL
527	<i>Saccharina longissima</i>	43.218492	145.600968	1990	Environment Agency Japan 1994	BISMaL
528	<i>Saccharina longissima</i>	43.186529	145.436614	1990	Environment Agency Japan 1994	BISMaL
529	<i>Saccharina longissima</i>	43.181808	145.378415	1990	Environment Agency Japan 1994	BISMaL
530	<i>Saccharina longissima</i>	43.178000	145.359128	1990	Environment Agency Japan 1994	BISMaL
531	<i>Saccharina longissima</i>	43.172981	145.334757	1990	Environment Agency Japan 1994	BISMaL
532	<i>Saccharina longissima</i>	43.166461	145.312531	1990	Environment Agency Japan 1994	BISMaL
533	<i>Saccharina longissima</i>	43.148829	145.238842	1990	Environment Agency Japan 1994	BISMaL
534	<i>Saccharina longissima</i>	43.145618	145.177277	1990	Environment Agency Japan 1994	BISMaL
535	<i>Saccharina longissima</i>	43.122838	145.128327	1990	Environment Agency Japan 1994	BISMaL
536	<i>Saccharina longissima</i>	43.088850	145.200345	1990	Environment Agency Japan 1994	BISMaL
537	<i>Saccharina longissima</i>	43.069332	145.148016	1990	Environment Agency Japan 1994	BISMaL
538	<i>Saccharina longissima</i>	43.047842	145.106357	1990	Environment Agency Japan 1994	BISMaL
539	<i>Saccharina longissima</i>	43.034664	145.065273	1990	Environment Agency Japan 1994	BISMaL
540	<i>Saccharina longissima</i>	43.007791	145.023841	1990	Environment Agency Japan 1994	BISMaL
541	<i>Saccharina longissima</i>	42.985205	144.951358	1990	Environment Agency Japan 1994	BISMaL
542	<i>Saccharina longissima</i>	42.985294	144.876922	1990	Environment Agency Japan 1994	BISMaL
543	<i>Saccharina longissima</i>	42.968312	144.878338	1990	Environment Agency Japan 1994	BISMaL
544	<i>Saccharina longissima</i>	42.980066	144.728765	1990	Environment Agency Japan 1994	BISMaL
545	<i>Saccharina longissima</i>	42.947443	144.767130	1990	Environment Agency Japan 1994	BISMaL
546	<i>Saccharina longissima</i>	42.934964	144.722374	1990	Environment Agency Japan 1994	BISMaL
547	<i>Saccharina longissima</i>	42.942086	144.689512	1990	Environment Agency Japan 1994	BISMaL
548	<i>Saccharina longissima</i>	42.949900	144.622001	1990	Environment Agency Japan 1994	BISMaL
549	<i>Saccharina longissima</i>	42.949451	144.583166	1990	Environment Agency Japan 1994	BISMaL
550	<i>Saccharina longissima</i>	42.940480	144.491234	1990	Environment Agency Japan 1994	BISMaL
551	<i>Saccharina longissima</i>	42.949604	144.439202	1990	Environment Agency Japan 1994	BISMaL
552	<i>Saccharina longissima</i>	42.968508	144.372563	1990	Environment Agency Japan 1994	BISMaL
553	<i>Saccharina sculpera</i>	42.083980	140.788295	1990	Environment Agency Japan 1994	BISMaL
554	<i>Saccharina sculpera</i>	41.855469	141.148291	1990	Environment Agency Japan 1994	BISMaL

555	<i>Saccharina sculpera</i>	41.853669	141.150693	1990	Environment Agency Japan 1994	BISMaL
556	<i>Saccharina sculpera</i>	41.826390	141.160994	1990	Environment Agency Japan 1994	BISMaL
557	<i>Saccharina sculpera</i>	41.818546	141.183170	1990	Environment Agency Japan 1994	BISMaL
558	<i>Saccharina sculpera</i>	41.811683	141.185817	1990	Environment Agency Japan 1994	BISMaL
559	<i>Saccharina sculpera</i>	41.805380	141.188344	1990	Environment Agency Japan 1994	BISMaL
560	<i>Saccharina sculpera</i>	41.788373	141.168368	1990	Environment Agency Japan 1994	BISMaL
561	<i>Saccharina sculpera</i>	41.792755	141.169658	1990	Environment Agency Japan 1994	BISMaL
562	<i>Saccharina sculpera</i>	41.781545	141.156369	1990	Environment Agency Japan 1994	BISMaL
563	<i>Saccharina sculpera</i>	41.779825	141.136768	1990	Environment Agency Japan 1994	BISMaL
564	<i>Saccharina sculpera</i>	41.782555	141.133454	1990	Environment Agency Japan 1994	BISMaL
565	<i>Saccharina sculpera</i>	41.781082	141.128365	1990	Environment Agency Japan 1994	BISMaL
566	<i>Saccharina sculpera</i>	41.787539	141.128240	1990	Environment Agency Japan 1994	BISMaL
567	<i>Saccharina sculpera</i>	41.787594	141.123023	1990	Environment Agency Japan 1994	BISMaL
568	<i>Saccharina sculpera</i>	41.768836	141.097578	1990	Environment Agency Japan 1994	BISMaL
569	<i>Saccharina sculpera</i>	41.766508	141.096178	1990	Environment Agency Japan 1994	BISMaL
570	<i>Saccharina sculpera</i>	41.763619	141.092238	1990	Environment Agency Japan 1994	BISMaL
571	<i>Saccharina sculpera</i>	41.756487	141.088051	1990	Environment Agency Japan 1994	BISMaL
572	<i>Saccharina sculpera</i>	41.740314	141.073032	1990	Environment Agency Japan 1994	BISMaL
573	<i>Saccharina sculpera</i>	41.738172	141.072425	1990	Environment Agency Japan 1994	BISMaL
574	<i>Saccharina sculpera</i>	41.737152	141.061311	1990	Environment Agency Japan 1994	BISMaL
575	<i>Saccharina sculpera</i>	41.728185	141.054429	1990	Environment Agency Japan 1994	BISMaL
576	<i>Saccharina sculpera</i>	41.494044	141.035092	1990	Environment Agency Japan 1994	BISMaL
577	<i>Saccharina sculpera</i>	41.497813	140.990195	1990	Environment Agency Japan 1994	BISMaL
578	<i>Saccharina sculpera</i>	41.533755	140.934464	1990	Environment Agency Japan 1994	BISMaL
579	<i>Saccharina sculpera</i>	41.546085	140.929652	1990	Environment Agency Japan 1994	BISMaL
580	<i>Saccharina sculpera</i>	41.521059	140.897908	1990	Environment Agency Japan 1994	BISMaL
581	<i>Saccharina sculpera</i>	41.507275	140.890286	1990	Environment Agency Japan 1994	BISMaL
582	<i>Saccharina sculpera</i>	41.487022	140.883016	1990	Environment Agency Japan 1994	BISMaL
583	<i>Saccharina sculpera</i>	41.456717	140.864722	1990	Environment Agency Japan 1994	BISMaL
584	<i>Saccharina sculpera</i>	41.463757	140.862721	1990	Environment Agency Japan 1994	BISMaL
585	<i>Saccharina sculpera</i>	41.431186	140.844337	1990	Environment Agency Japan 1994	BISMaL
586	<i>Saccharina sculpera</i>	41.405874	140.826560	1990	Environment Agency Japan 1994	BISMaL
587	<i>Saccharina sculpera</i>	41.401228	140.820820	1990	Environment Agency Japan 1994	BISMaL
588	<i>Saccharina sculpera</i>	41.333410	140.803065	1990	Environment Agency Japan 1994	BISMaL
589	<i>Agarum clathratum</i>	42.300000	140.970000	1951	Hokkaido university SAP Specimen	BISMaL
590	<i>Agarum clathratum</i>	45.330000	141.030000	1953	Hokkaido university SAP Specimen	BISMaL
591	<i>Agarum clathratum</i>	43.000000	144.820000	1955	Hokkaido university SAP Specimen	BISMaL
592	<i>Agarum clathratum</i>	42.300000	140.950000	1957	Hokkaido university SAP Specimen	BISMaL
593	<i>Agarum clathratum</i>	42.170000	142.720000	1957	Hokkaido university SAP Specimen	BISMaL
594	<i>Agarum clathratum</i>	42.070000	143.000000	1957	Hokkaido university SAP Specimen	BISMaL
595	<i>Agarum clathratum</i>	43.380000	145.820000	1960	Hokkaido university SAP Specimen	BISMaL
596	<i>Agarum clathratum</i>	43.270000	145.480000	1960	Hokkaido university SAP Specimen	BISMaL
597	<i>Agarum clathratum</i>	43.070000	145.120000	1961	Hokkaido university SAP Specimen	BISMaL
598	<i>Agarum clathratum</i>	42.930000	144.870000	1961	Hokkaido university SAP Specimen	BISMaL
599	<i>Agarum clathratum</i>	44.020000	144.270000	1961	Hokkaido university SAP Specimen	BISMaL
600	<i>Agarum clathratum</i>	42.300000	140.980000	1963	Hokkaido university SAP Specimen	BISMaL
601	<i>Agarum clathratum</i>	42.300000	140.980000	1963	Hokkaido university SAP Specimen	BISMaL
602	<i>Agarum clathratum</i>	42.300000	140.980000	1963	Hokkaido university SAP Specimen	BISMaL
603	<i>Agarum clathratum</i>	42.300000	140.970000	1966	Hokkaido university SAP Specimen	BISMaL
604	<i>Agarum clathratum</i>	42.300000	140.980000	1966	Hokkaido university SAP Specimen	BISMaL
605	<i>Agarum clathratum</i>	42.930000	144.870000	1966	Hokkaido university SAP Specimen	BISMaL
606	<i>Agarum clathratum</i>	42.300000	140.970000	1967	Hokkaido university SAP Specimen	BISMaL
607	<i>Agarum clathratum</i>	42.320000	140.930000	1967	Hokkaido university SAP Specimen	BISMaL
608	<i>Agarum clathratum</i>	44.250000	145.350000	1968	Hokkaido university SAP Specimen	BISMaL
609	<i>Agarum clathratum</i>	44.250000	145.350000	1968	Hokkaido university SAP Specimen	BISMaL
610	<i>Agarum clathratum</i>	44.050000	145.230000	1968	Hokkaido university SAP Specimen	BISMaL
611	<i>Agarum clathratum</i>	44.330000	145.330000	1968	Hokkaido university SAP Specimen	BISMaL
612	<i>Agarum clathratum</i>	44.250000	145.350000	1968	Hokkaido university SAP Specimen	BISMaL
613	<i>Agarum clathratum</i>	45.470000	140.950000	1969	Hokkaido university SAP Specimen	BISMaL
614	<i>Agarum clathratum</i>	42.570000	140.680000	1969	Hokkaido university SAP Specimen	BISMaL
615	<i>Agarum clathratum</i>	44.030000	145.220000	1969	Hokkaido university SAP Specimen	BISMaL
616	<i>Agarum clathratum</i>	44.050000	145.230000	1969	Hokkaido university SAP Specimen	BISMaL
617	<i>Agarum clathratum</i>	43.380000	145.770000	1969	Hokkaido university SAP Specimen	BISMaL
618	<i>Agarum clathratum</i>	43.380000	145.820000	1969	Hokkaido university SAP Specimen	BISMaL
619	<i>Agarum clathratum</i>	43.300000	145.530000	1969	Hokkaido university SAP Specimen	BISMaL
620	<i>Agarum clathratum</i>	45.450000	140.950000	1970	Hokkaido university SAP Specimen	BISMaL
621	<i>Agarum clathratum</i>	45.250000	141.200000	1970	Hokkaido university SAP Specimen	BISMaL
622	<i>Agarum clathratum</i>	44.030000	145.220000	1970	Hokkaido university SAP Specimen	BISMaL
623	<i>Agarum clathratum</i>	43.330000	145.570000	1970	Hokkaido university SAP Specimen	BISMaL
624	<i>Agarum clathratum</i>	43.330000	145.570000	1970	Hokkaido university SAP Specimen	BISMaL
625	<i>Agarum clathratum</i>	43.330000	145.570000	1970	Hokkaido university SAP Specimen	BISMaL
626	<i>Agarum clathratum</i>	43.380000	145.820000	1970	Hokkaido university SAP Specimen	BISMaL
627	<i>Agarum clathratum</i>	43.330000	145.570000	1970	Hokkaido university SAP Specimen	BISMaL
628	<i>Agarum clathratum</i>	43.000000	144.850000	1971	Hokkaido university SAP Specimen	BISMaL
629	<i>Agarum clathratum</i>	43.020000	144.830000	1971	Hokkaido university SAP Specimen	BISMaL
630	<i>Agarum clathratum</i>	41.420000	141.450000	1973	Hokkaido university SAP Specimen	BISMaL
631	<i>Agarum clathratum</i>	43.020000	144.830000	1974	Hokkaido university SAP Specimen	BISMaL
632	<i>Agarum clathratum</i>	42.030000	140.800000	1978	Hokkaido university SAP Specimen	BISMaL
633	<i>Agarum clathratum</i>	45.520000	141.930000	1980	Hokkaido university SAP Specimen	BISMaL
634	<i>Agarum clathratum</i>	45.520000	141.930000	1980	Hokkaido university SAP Specimen	BISMaL
635	<i>Agarum clathratum</i>	41.420000	141.150000	1982	Hokkaido university SAP Specimen	BISMaL
636	<i>Agarum clathratum</i>	43.280000	145.670000	1987	Hokkaido university SAP Specimen	BISMaL
637	<i>Agarum clathratum</i>	41.680000	140.520000	1988	Hokkaido university SAP Specimen	BISMaL
638	<i>Agarum clathratum</i>	42.220000	142.620000	1988	Hokkaido university SAP Specimen	BISMaL
639	<i>Agarum clathratum</i>	43.380000	145.820000	1988	Hokkaido university SAP Specimen	BISMaL
640	<i>Alaria crassifolia</i>	40.320000	141.770000	1951	Hokkaido university SAP Specimen	BISMaL
641	<i>Alaria crassifolia</i>	38.380000	141.580000	1951	Hokkaido university SAP Specimen	BISMaL
642	<i>Alaria crassifolia</i>	40.170000	141.820000	1952	Hokkaido university SAP Specimen	BISMaL
643	<i>Alaria crassifolia</i>	40.170000	141.820000	1952	Hokkaido university SAP Specimen	BISMaL
644	<i>Alaria crassifolia</i>	41.470000	141.080000	1955	Hokkaido university SAP Specimen	BISMaL
645	<i>Alaria crassifolia</i>	42.300000	140.970000	1960	Hokkaido university SAP Specimen	BISMaL
646	<i>Alaria crassifolia</i>	42.300000	140.950000	1963	Hokkaido university SAP Specimen	BISMaL
647	<i>Alaria crassifolia</i>	42.300000	140.970000	1966	Hokkaido university SAP Specimen	BISMaL

834	<i>Saccharina sculpera</i>	42.030000	140.800000	1985	Hokkaido university SAP Specimen	BISMaL
835	<i>Saccharina sculpera</i>	41.500000	140.900000	1987	Hokkaido university SAP Specimen	BISMaL
836	<i>Saccharina longissima</i>	42.950000	144.400000	1963	Hokusuikenpo (10)1-42	BISMaL
837	<i>Saccharina japonica</i>	43.200000	140.850000	1966	Hokusuikenpo (10)43-50	BISMaL
838	<i>Saccharina japonica</i>	41.766667	140.683333	1969	Hokusuikenpo (12)47-62	BISMaL
839	<i>Saccharina japonica</i>	44.350000	143.350000	1968	Hokusuikenpo (13)1-18	BISMaL
840	<i>Costaria costata</i>	42.516667	140.766667	1970	Hokusuikenpo (14)31-44	BISMaL
841	<i>Saccharina japonica</i>	42.516667	140.766667	1970	Hokusuikenpo (14)31-44	BISMaL
842	<i>Saccharina japonica</i>	45.400000	141.733333	1970	Hokusuikenpo (14)45-54	BISMaL
843	<i>Saccharina japonica</i>	45.416667	141.666667	1972	Hokusuikenpo (15)1-8	BISMaL
844	<i>Saccharina japonica</i>	45.100000	141.283333	1972	Hokusuikenpo (15)1-8	BISMaL
845	<i>Saccharina japonica</i>	45.233333	141.166667	1972	Hokusuikenpo (15)1-8	BISMaL
846	<i>Saccharina japonica</i>	45.433333	141.000000	1971	Hokusuikenpo (17)11-18	BISMaL
847	<i>Saccharina japonica</i>	45.250000	141.200000	1972	Hokusuikenpo (17)11-18	BISMaL
848	<i>Saccharina japonica</i>	43.200000	140.850000	1962	Hokusuikenpo (2)1-6	BISMaL
849	<i>Saccharina japonica</i>	42.483333	140.816667	1966	Hokusuikenpo (22)17-71	BISMaL
850	<i>Saccharina japonica</i>	42.450000	140.866667	1966	Hokusuikenpo (22)17-71	BISMaL
851	<i>Saccharina japonica</i>	42.400000	140.900000	1966	Hokusuikenpo (22)17-71	BISMaL
852	<i>Saccharina japonica</i>	42.500000	140.766667	1966	Hokusuikenpo (22)17-71	BISMaL
853	<i>Saccharina japonica</i>	45.083333	141.216667	1978	Hokusuikenpo (22)7-16	BISMaL
854	<i>Saccharina japonica</i>	43.200000	140.850000	1974	Hokusuikenpo (24)41-50	BISMaL
855	<i>Saccharina japonica</i>	43.133333	140.416667	1980	Hokusuikenpo (25)35-46	BISMaL
856	<i>Saccharina japonica</i>	43.200000	140.850000	1981	Hokusuikenpo (25)47-60	BISMaL
857	<i>Saccharina japonica</i>	43.200000	140.850000	1978	Hokusuikenpo (26)25-37	BISMaL
858	<i>Saccharina japonica</i>	43.200000	140.850000	1983	Hokusuikenpo (27)101-110	BISMaL
859	<i>Alaria crassifolia</i>	41.783333	141.150000	1984	Hokusuikenpo (29)37-49	BISMaL
860	<i>Saccharina angustata</i>	41.783333	141.150000	1984	Hokusuikenpo (29)37-49	BISMaL
861	<i>Saccharina japonica</i>	43.200000	140.850000	1963	Hokusuikenpo (3)39-50	BISMaL
862	<i>Saccharina japonica</i>	41.900000	140.983333	1986	Hokusuikenpo (31)55-61	BISMaL
863	<i>Saccharina japonica</i>	45.416667	141.666667	1983	Hokusuikenpo (32)11-17	BISMaL
864	<i>Saccharina japonica</i>	43.200000	140.850000	1986	Hokusuikenpo (32)11-17	BISMaL
865	<i>Saccharina japonica</i>	43.200000	140.850000	1986	Hokusuikenpo (35)37-60	BISMaL
866	<i>Saccharina japonica</i>	42.133333	139.916667	1985	Hokusuikenpo (38)1-14	BISMaL
867	<i>Saccharina japonica</i>	43.200000	140.850000	1964	Hokusuikenpo (8)1-37	BISMaL
868	<i>Alaria crassifolia</i>	41.783333	141.150000	1953	Hokusuishi Geppo 10(9):18-25	BISMaL
869	<i>Saccharina angustata</i>	41.783333	141.150000	1953	Hokusuishi Geppo 10(9):18-25	BISMaL
870	<i>Saccharina japonica</i>	41.783333	141.150000	1953	Hokusuishi Geppo 10(9):18-25	BISMaL
871	<i>Alaria crassifolia</i>	42.050000	143.016667	1954	Hokusuishi Geppo 12(10):13-19	BISMaL
872	<i>Saccharina angustata</i>	42.050000	143.016667	1954	Hokusuishi Geppo 12(10):13-19	BISMaL
873	<i>Saccharina angustata</i>	42.133333	142.816667	1955	Hokusuishi Geppo 12(11)32-36	BISMaL
874	<i>Saccharina angustata</i>	42.233333	142.583333	1955	Hokusuishi Geppo 13(10)4-18	BISMaL
875	<i>Saccharina japonica</i>	41.166667	140.466667	1952	Hokusuishi Geppo 13(2)19-20	BISMaL
876	<i>Saccharina japonica</i>	42.100000	140.550000	1956	Hokusuishi Geppo 13(9)26-29	BISMaL
877	<i>Saccharina japonica</i>	43.216667	140.766667	1958	Hokusuishi Geppo 15(10)15-20	BISMaL
878	<i>Saccharina angustata</i>	42.233333	142.583333	1956	Hokusuishi Geppo 15(2)19-26	BISMaL
879	<i>Saccharina angustata</i>	42.233333	142.583333	1958	Hokusuishi Geppo 15(9)29-30	BISMaL
880	<i>Saccharina japonica</i>	43.200000	140.766667	1961	Hokusuishi Geppo 18(10)13-26	BISMaL
881	<i>Saccharina japonica</i>	45.133333	141.316667	1962	Hokusuishi Geppo 20(7)18-20	BISMaL
882	<i>Saccharina japonica</i>	45.400000	141.733333	1962	Hokusuishi Geppo 20(7)18-20	BISMaL
883	<i>Saccharina longissima</i>	42.950000	144.400000	1961	Hokusuishi Geppo 20(7)18-20	BISMaL
884	<i>Saccharina longissima</i>	42.950000	144.400000	1962	Hokusuishi Geppo 21(2)12-29	BISMaL
885	<i>Saccharina japonica</i>	42.550000	140.750000	1965	Hokusuishi Geppo 22(12)29-37	BISMaL
886	<i>Saccharina coriacea</i>	43.050000	145.116667	1966	Hokusuishi Geppo 23(10)26-37	BISMaL
887	<i>Saccharina japonica</i>	43.050000	145.116667	1964	Hokusuishi Geppo 23(10)26-37	BISMaL
888	<i>Saccharina longissima</i>	43.100000	145.100000	1964	Hokusuishi Geppo 23(10)26-37	BISMaL
889	<i>Saccharina japonica</i>	45.400000	141.683333	1963	Hokusuishi Geppo 24(11)2-16	BISMaL
890	<i>Saccharina japonica</i>	45.133333	141.316667	1963	Hokusuishi Geppo 24(11)2-16	BISMaL
891	<i>Saccharina japonica</i>	45.383333	141.633333	1965	Hokusuishi Geppo 24(3)46-55	BISMaL
892	<i>Saccharina longissima</i>	42.950000	144.400000	1965	Hokusuishi Geppo 24(4)12-23	BISMaL
893	<i>Saccharina japonica</i>	42.400000	140.900000	1966	Hokusuishi Geppo 24(9)10-19	BISMaL
894	<i>Saccharina japonica</i>	44.350000	143.350000	1967	Hokusuishi Geppo 25(3)8-14	BISMaL
895	<i>Saccharina japonica</i>	42.400000	140.900000	1968	Hokusuishi Geppo 26(7)13-20	BISMaL
896	<i>Saccharina japonica</i>	42.483333	140.816667	1968	Hokusuishi Geppo 26(7)13-20	BISMaL
897	<i>Saccharina angustata</i>	42.233333	142.583333	1962	Hokusuishi Geppo 26(9)20-26	BISMaL
898	<i>Costaria costata</i>	42.400000	140.900000	1968	Hokusuishi Geppo 26(9)27-36	BISMaL
899	<i>Saccharina japonica</i>	42.400000	140.900000	1968	Hokusuishi Geppo 26(9)27-36	BISMaL
900	<i>Saccharina japonica</i>	42.416667	140.883333	1969	Hokusuishi Geppo 27(3)6-22	BISMaL
901	<i>Costaria costata</i>	43.216667	141.016667	1970	Hokusuishi Geppo 28(1)2-11	BISMaL
902	<i>Saccharina japonica</i>	43.216667	141.016667	1970	Hokusuishi Geppo 28(1)2-11	BISMaL
903	<i>Saccharina japonica</i>	41.550000	140.433333	1970	Hokusuishi Geppo 28(12)20-36	BISMaL
904	<i>Saccharina japonica</i>	41.533333	140.433333	1970	Hokusuishi Geppo 28(12)20-36	BISMaL
905	<i>Saccharina japonica</i>	45.233333	141.166667	1968	Hokusuishi Geppo 28(2)10-26	BISMaL
906	<i>Saccharina japonica</i>	41.766667	140.766667	1971	Hokusuishi Geppo 29(9)23-29	BISMaL
907	<i>Costaria costata</i>	43.200000	140.850000	1971	Hokusuishi Geppo 30(1)25-33	BISMaL
908	<i>Saccharina japonica</i>	43.200000	140.850000	1971	Hokusuishi Geppo 30(1)25-33	BISMaL
909	<i>Costaria costata</i>	43.200000	140.850000	1971	Hokusuishi Geppo 30(12)1-16	BISMaL
910	<i>Saccharina japonica</i>	43.200000	140.850000	1971	Hokusuishi Geppo 30(12)1-16	BISMaL
911	<i>Saccharina angustata</i>	42.200000	143.316667	1971	Hokusuishi Geppo 30(3)5-21	BISMaL
912	<i>Agarum clathratum</i>	42.066667	140.783333	1972	Hokusuishi Geppo 31(5)1-6	BISMaL
913	<i>Alaria crassifolia</i>	42.066667	140.783333	1972	Hokusuishi Geppo 31(5)1-6	BISMaL
914	<i>Costaria costata</i>	42.066667	140.783333	1972	Hokusuishi Geppo 31(5)1-6	BISMaL
915	<i>Saccharina angustata</i>	42.066667	140.783333	1972	Hokusuishi Geppo 31(5)1-6	BISMaL
916	<i>Saccharina japonica</i>	42.066667	140.783333	1972	Hokusuishi Geppo 31(5)1-6	BISMaL
917	<i>Saccharina japonica</i>	41.350000	139.783333	1970	Hokusuishi Geppo 31(5)7-20	BISMaL
918	<i>Saccharina japonica</i>	41.350000	139.800000	1970	Hokusuishi Geppo 31(5)7-20	BISMaL
919	<i>Saccharina japonica</i>	41.350000	139.800000	1970	Hokusuishi Geppo 31(5)7-20	BISMaL
920	<i>Saccharina japonica</i>	41.350000	139.800000	1970	Hokusuishi Geppo 31(5)7-20	BISMaL
921	<i>Saccharina japonica</i>	41.350000	139.800000	1970	Hokusuishi Geppo 31(5)7-20	BISMaL
922	<i>Saccharina japonica</i>	41.350000	139.783333	1970	Hokusuishi Geppo 31(5)7-20	BISMaL
923	<i>Saccharina japonica</i>	41.516667	139.366667	1970	Hokusuishi Geppo 31(5)7-20	BISMaL
924	<i>Saccharina japonica</i>	41.516667	139.366667	1970	Hokusuishi Geppo 31(5)7-20	BISMaL
925	<i>Saccharina japonica</i>	41.483333	139.350000	1970	Hokusuishi Geppo 31(5)7-20	BISMaL
926	<i>Saccharina japonica</i>	41.483333	139.350000	1970	Hokusuishi Geppo 31(5)7-20	BISMaL

927	<i>Saccharina japonica</i>	41.483333	139.350000	1970	Hokusuishi Geppo 31(5)7-20	BISMaL
928	<i>Saccharina japonica</i>	41.500000	139.316667	1970	Hokusuishi Geppo 31(5)7-20	BISMaL
929	<i>Saccharina japonica</i>	41.516667	139.333333	1970	Hokusuishi Geppo 31(5)7-20	BISMaL
930	<i>Saccharina japonica</i>	41.883333	141.016667	1973	Hokusuishi Geppo 31(9)1-2	BISMaL
931	<i>Saccharina japonica</i>	42.033333	140.800000	1974	Hokusuishi Geppo 31(9)1-2	BISMaL
932	<i>Saccharina japonica</i>	42.033333	140.800000	1968	Hokusuishi Geppo 32(11)24-37	BISMaL
933	<i>Saccharina sculpera</i>	42.033333	140.800000	1968	Hokusuishi Geppo 32(11)24-37	BISMaL
934	<i>Saccharina sculpera</i>	42.033333	140.800000	1968	Hokusuishi Geppo 32(11)24-37	BISMaL
935	<i>Costaria costata</i>	44.016667	145.200000	1970	Hokusuishi Geppo 35(11, 12)1-10	BISMaL
936	<i>Saccharina japonica</i>	44.316667	143.400000	1976	Hokusuishi Geppo 38(2)17-30	BISMaL
937	<i>Saccharina japonica</i>	45.416667	141.666667	1979	Hokusuishi Geppo 38(9)287-295	BISMaL
938	<i>Saccharina japonica</i>	45.083333	141.216667	1979	Hokusuishi Geppo 38(9)287-295	BISMaL
939	<i>Saccharina cichorioides</i>	43.383330	141.416670	1981	Hokusuishi Geppo 40(1)1-21	BISMaL
940	<i>Saccharina japonica</i>	43.383333	141.416667	1981	Hokusuishi Geppo 40(1)1-21	BISMaL
941	<i>Saccharina japonica</i>	45.183333	141.133333	1982	Hokusuishi Geppo 40(11)249-270	BISMaL
942	<i>Saccharina japonica</i>	45.250000	141.183333	1982	Hokusuishi Geppo 40(11)249-270	BISMaL
943	<i>Saccharina japonica</i>	45.100000	141.266667	1982	Hokusuishi Geppo 40(11)249-270	BISMaL
944	<i>Costaria costata</i>	45.083333	141.216667	1981	Hokusuishi Geppo 40(11)249-271	BISMaL
945	<i>Saccharina japonica</i>	45.083333	141.216667	1981	Hokusuishi Geppo 40(11)249-271	BISMaL
946	<i>Saccharina japonica</i>	45.100000	141.280000	1964	Hokusuishihou (5)31-35	BISMaL
947	<i>Saccharina japonica</i>	45.250000	141.200000	1965	Hokusuishihou (5)31-35	BISMaL
948	<i>Saccharina japonica</i>	45.420000	141.670000	1965	Hokusuishihou (5)31-35	BISMaL
949	<i>Saccharina japonica</i>	45.420000	141.670000	1964	Hokusuishihou (5)36-44	BISMaL
950	<i>Saccharina japonica</i>	45.400000	141.750000	1964	Hokusuishihou (5)36-44	BISMaL
951	<i>Saccharina japonica</i>	45.300000	141.600000	1964	Hokusuishihou (5)36-44	BISMaL
952	<i>Saccharina japonica</i>	44.580000	142.950000	1989	Hokusuishikenpou (45)45-56	BISMaL
953	<i>Saccharina japonica</i>	44.430000	143.220000	1989	Hokusuishikenpou (45)45-56	BISMaL
954	<i>Agarum clathratum</i>	41.480000	140.300000	1983	Hokusuishikenpou (51)1-66	BISMaL
955	<i>Agarum clathratum</i>	41.530000	140.420000	1985	Hokusuishikenpou (51)1-66	BISMaL
956	<i>Alaria crassifolia</i>	41.730000	141.050000	1983	Hokusuishikenpou (51)1-66	BISMaL
957	<i>Alaria crassifolia</i>	41.530000	140.420000	1985	Hokusuishikenpou (51)1-66	BISMaL
958	<i>Costaria costata</i>	41.730000	141.050000	1983	Hokusuishikenpou (51)1-66	BISMaL
959	<i>Costaria costata</i>	41.530000	140.420000	1985	Hokusuishikenpou (51)1-66	BISMaL
960	<i>Saccharina japonica</i>	41.480000	140.300000	1983	Hokusuishikenpou (51)1-66	BISMaL
961	<i>Saccharina japonica</i>	41.730000	141.050000	1983	Hokusuishikenpou (51)1-66	BISMaL
962	<i>Saccharina japonica</i>	41.530000	140.420000	1985	Hokusuishikenpou (51)1-66	BISMaL
963	<i>Saccharina japonica</i>	42.000000	140.100000	1983	Hokusuishikenpou (51)1-66	BISMaL
964	<i>Saccharina sculpera</i>	41.730000	141.050000	1983	Hokusuishikenpou (51)1-66	BISMaL
965	<i>Saccharina japonica</i>	44.583330	142.966670	1990	Isoyake no kikou to mobasyuuhuku 84-93	BISMaL
966	<i>Saccharina japonica</i>	44.416667	141.416667	1965	Japanese Journal of Phycology 14(3):1-7	BISMaL
967	<i>Alaria crassifolia</i>	41.716667	141.016667	1968	Japanese Journal of Phycology 17(3):18-23	BISMaL
968	<i>Alaria crassifolia</i>	41.733333	140.716667	1968	Japanese Journal of Phycology 17(3):18-23	BISMaL
969	<i>Saccharina angustata</i>	41.716667	141.016667	1968	Japanese Journal of Phycology 17(3):18-23	BISMaL
970	<i>Saccharina japonica</i>	40.650000	139.933333	1968	Japanese Journal of Phycology 19(1):15-20	BISMaL
971	<i>Agarum clathratum</i>	41.433333	141.150000	1969	Japanese Journal of Phycology 22(1):29-38	BISMaL
972	<i>Agarum clathratum</i>	41.250000	141.416667	1969	Japanese Journal of Phycology 22(1):29-38	BISMaL
973	<i>Alaria crassifolia</i>	41.433333	141.150000	1969	Japanese Journal of Phycology 22(1):29-38	BISMaL
974	<i>Alaria crassifolia</i>	41.250000	141.416667	1969	Japanese Journal of Phycology 22(1):29-38	BISMaL
975	<i>Alaria crassifolia</i>	40.500000	141.600000	1969	Japanese Journal of Phycology 22(1):29-38	BISMaL
976	<i>Alaria crassifolia</i>	41.350000	140.816667	1970	Japanese Journal of Phycology 22(1):29-38	BISMaL
977	<i>Costaria costata</i>	41.200000	140.516667	1968	Japanese Journal of Phycology 22(1):29-38	BISMaL
978	<i>Costaria costata</i>	41.433333	141.150000	1969	Japanese Journal of Phycology 22(1):29-38	BISMaL
979	<i>Costaria costata</i>	40.500000	141.600000	1969	Japanese Journal of Phycology 22(1):29-38	BISMaL
980	<i>Costaria costata</i>	41.350000	140.816667	1970	Japanese Journal of Phycology 22(1):29-38	BISMaL
981	<i>Saccharina japonica</i>	41.166667	140.316667	1965	Japanese Journal of Phycology 22(1):29-38	BISMaL
982	<i>Saccharina japonica</i>	41.200000	140.516667	1968	Japanese Journal of Phycology 22(1):29-38	BISMaL
983	<i>Saccharina japonica</i>	41.433333	141.150000	1969	Japanese Journal of Phycology 22(1):29-38	BISMaL
984	<i>Saccharina japonica</i>	41.433333	141.150000	1969	Japanese Journal of Phycology 22(1):29-38	BISMaL
985	<i>Saccharina japonica</i>	41.250000	141.416667	1969	Japanese Journal of Phycology 22(1):29-38	BISMaL
986	<i>Saccharina japonica</i>	40.500000	141.600000	1969	Japanese Journal of Phycology 22(1):29-38	BISMaL
987	<i>Saccharina japonica</i>	41.116667	140.700000	1969	Japanese Journal of Phycology 22(1):29-38	BISMaL
988	<i>Saccharina japonica</i>	41.350000	140.816667	1970	Japanese Journal of Phycology 22(1):29-38	BISMaL
989	<i>Saccharina japonica</i>	41.166667	140.316667	1965	Japanese Journal of Phycology 22(1):29-38	BISMaL
990	<i>Saccharina japonica</i>	41.200000	140.516667	1968	Japanese Journal of Phycology 22(1):29-38	BISMaL
991	<i>Saccharina japonica</i>	41.433333	141.150000	1969	Japanese Journal of Phycology 22(1):29-38	BISMaL
992	<i>Saccharina japonica</i>	41.250000	141.416667	1969	Japanese Journal of Phycology 22(1):29-38	BISMaL
993	<i>Saccharina japonica</i>	40.500000	141.600000	1969	Japanese Journal of Phycology 22(1):29-38	BISMaL
994	<i>Saccharina sculpera</i>	41.433333	141.150000	1969	Japanese Journal of Phycology 22(1):29-38	BISMaL
995	<i>Saccharina japonica</i>	42.300000	140.983333	1974	Japanese Journal of Phycology 25(suppl):297-301	BISMaL
996	<i>Agarum clathratum</i>	42.933333	144.866667	1969	Japanese Journal of Phycology 25(suppl):403-412	BISMaL
997	<i>Agarum clathratum</i>	42.083333	142.883333	1969	Japanese Journal of Phycology 25(suppl):403-412	BISMaL
998	<i>Agarum clathratum</i>	43.283333	145.583333	1971	Japanese Journal of Phycology 25(suppl):403-412	BISMaL
999	<i>Saccharina japonica</i>	43.200000	140.850000	1976	Japanese Journal of Phycology 30(2):134-138	BISMaL
1000	<i>Costaria costata</i>	45.166667	141.116667	1981	Japanese Journal of Phycology 31(2):107-127	BISMaL
1001	<i>Saccharina angustata</i>	41.983333	143.150000	1977	Japanese Journal of Phycology 31(3):208-216	BISMaL
1002	<i>Saccharina angustata</i>	42.166667	142.750000	1977	Japanese Journal of Phycology 31(3):208-216	BISMaL
1003	<i>Saccharina angustata</i>	42.100000	142.966667	1977	Japanese Journal of Phycology 31(3):208-216	BISMaL
1004	<i>Saccharina angustata</i>	42.233333	142.583333	1977	Japanese Journal of Phycology 31(3):208-216	BISMaL
1005	<i>Alaria crassifolia</i>	37.033333	140.966667	1984	Japanese Journal of Phycology 35(1):22-33	BISMaL
1006	<i>Saccharina japonica</i>	37.033333	140.966667	1984	Japanese Journal of Phycology 35(1):22-33	BISMaL
1007	<i>Saccharina japonica</i>	37.033333	140.966667	1984	Japanese Journal of Phycology 35(1):22-33	BISMaL
1008	<i>Saccharina japonica</i>	42.833333	140.316667	1986	Japanese Journal of Phycology 37(1):65-86	BISMaL
1009	<i>Saccharina angustata</i>	42.300000	140.983333	1985	Japanese Journal of Phycology 37(2):105-116	BISMaL
1010	<i>Arthrothamnus bifidus</i>	42.933333	144.866667	1989	Japanese Journal of Phycology 38(1):83-102	BISMaL
1011	<i>Saccharina japonica</i>	41.500000	140.900000	1988	Japanese Journal of Phycology 38(1):83-102	BISMaL
1012	<i>Saccharina longissima</i>	42.933333	144.433333	1988	Japanese Journal of Phycology 38(2):147-153	BISMaL
1013	<i>Saccharina angustata</i>	42.300000	140.983333	1988	Japanese Journal of Phycology 39(2):185-187	BISMaL
1014	<i>Saccharina angustata</i>	42.033333	140.800000	1988	Japanese Journal of Phycology 39(2):185-187	BISMaL
1015	<i>Saccharina angustata</i>	42.233333	142.583333	1988	Japanese Journal of Phycology 39(2):185-187	BISMaL
1016	<i>Saccharina angustata</i>	41.933333	140.933333	1988	Japanese Journal of Phycology 39(2):185-187	BISMaL
1017	<i>Saccharina japonica</i>	42.300000	140.983333	1988	Japanese Journal of Phycology 39(2):185-187	BISMaL
1018	<i>Saccharina japonica</i>	42.033333	140.800000	1988	Japanese Journal of Phycology 39(2):185-187	BISMaL
1019	<i>Saccharina japonica</i>	41.933333	140.933333	1988	Japanese Journal of Phycology 39(2):185-187	BISMaL

1020	<i>Saccharina japonica</i>	45.400000	141.733333	1988	Japanese Journal of Phycology 39(2):185-187	BISMaL
1021	<i>Saccharina japonica</i>	45.300000	141.050000	1988	Japanese Journal of Phycology 39(2):185-187	BISMaL
1022	<i>Saccharina japonica</i>	43.200000	140.850000	1988	Japanese Journal of Phycology 39(2):185-187	BISMaL
1023	<i>Saccharina japonica</i>	43.016667	144.833333	1990	Japanese Journal of Phycology 40(1):87-107	BISMaL
1024	<i>Costaria costata</i>	41.883333	141.016667	1990	Japanese Journal of Phycology 40(2):173-175	BISMaL
1025	<i>Costaria costata</i>	44.050000	144.333333	1987	Japanese Journal of Phycology 42(1):79-81	BISMaL
1026	<i>Saccharina japonica</i>	43.016667	144.833333	1956	Japanese Journal of Phycology 6(2):57-58	BISMaL
1027	<i>Saccharina japonica</i>	41.750000	140.716667	1958	Japanese Journal of Phycology 8(1):16-21	BISMaL
1028	<i>Saccharina japonica</i>	41.766667	140.783333	1958	Japanese Journal of Phycology 8(1):16-21	BISMaL
1029	<i>Saccharina japonica</i>	44.050000	144.266667	1958	Japanese Journal of Phycology 8(1):16-21	BISMaL
1030	<i>Saccharina japonica</i>	43.200000	140.850000	1958	Japanese Journal of Phycology 8(1):16-21	BISMaL
1031	<i>Saccharina japonica</i>	42.000000	140.083333	1958	Japanese Journal of Phycology 8(1):16-21	BISMaL
1032	<i>Saccharina sculpera</i>	41.750000	140.816667	1958	Japanese Journal of Phycology 8(1):16-21	BISMaL
1033	<i>Saccharina japonica</i>	41.800000	140.700000	1958	Japanese Journal of Phycology 8(2):15-21	BISMaL
1034	<i>Saccharina japonica</i>	45.350000	141.050000	1958	Japanese Journal of Phycology 8(2):15-21	BISMaL
1035	<i>Agarum clathratum</i>	43.033060	144.832780	1974	Japanese Journal of Phycology 25(suppl):403-412	BISMaL
1036	<i>Saccharina japonica</i>	42.433330	139.830000	1989	Kaigan Kougaku Ronbunshuu Dai37kan	BISMaL
1037	<i>Agarum clathratum</i>	43.383330	145.816670	1983	Kakenhi houkousyo Shouwa58nendo	BISMaL
1038	<i>Saccharina angustata</i>	42.300000	143.330000	1966	Kushiro Suishidayori (4)11	BISMaL
1039	<i>Saccharina coriacea</i>	43.050000	145.120000	1966	Kushiro Suishidayori (4)11	BISMaL
1040	<i>Saccharina coriacea</i>	43.330000	145.750000	1966	Kushiro Suishidayori (4)11	BISMaL
1041	<i>Agarum clathratum</i>	43.330000	145.770000	1977	Kushiro Suishidayori (45) 6-28	BISMaL
1042	<i>Agarum clathratum</i>	43.220000	145.580000	1977	Kushiro Suishidayori (45) 6-28	BISMaL
1043	<i>Arthrothamnus bifidus</i>	43.330000	145.770000	1977	Kushiro Suishidayori (45) 6-28	BISMaL
1044	<i>Costaria costata</i>	43.330000	145.770000	1977	Kushiro Suishidayori (45) 6-28	BISMaL
1045	<i>Costaria costata</i>	43.220000	145.580000	1977	Kushiro Suishidayori (45) 6-28	BISMaL
1046	<i>Saccharina coriacea</i>	43.330000	145.770000	1977	Kushiro Suishidayori (45) 6-28	BISMaL
1047	<i>Saccharina coriacea</i>	43.220000	145.580000	1977	Kushiro Suishidayori (45) 6-28	BISMaL
1048	<i>Saccharina gyrate</i>	43.330000	145.770000	1977	Kushiro Suishidayori (45) 6-28	BISMaL
1049	<i>Saccharina japonica</i>	43.220000	145.580000	1977	Kushiro Suishidayori (45) 6-28	BISMaL
1050	<i>Saccharina longissima</i>	43.330000	145.770000	1977	Kushiro Suishidayori (45) 6-28	BISMaL
1051	<i>Saccharina longissima</i>	43.220000	145.580000	1977	Kushiro Suishidayori (45) 6-28	BISMaL
1052	<i>Saccharina japonica</i>	45.380000	141.050000	1990	Marine net HokkaidoNo.289	BISMaL
1053	<i>Agarum clathratum</i>	43.066667	145.116667	1969	Nihonsan Konbu Zukan	BISMaL
1054	<i>Alaria crassifolia</i>	41.700000	141.000000	1987	Nihonsan Konbu Zukan	BISMaL
1055	<i>Alaria crassifolia</i>	41.933333	140.933333	1987	Nihonsan Konbu Zukan	BISMaL
1056	<i>Alaria crassifolia</i>	41.733333	141.066667	1987	Nihonsan Konbu Zukan	BISMaL
1057	<i>Arthrothamnus bifidus</i>	43.333333	145.750000	1963	Nihonsan Konbu Zukan	BISMaL
1058	<i>Arthrothamnus bifidus</i>	43.033333	145.083333	1972	Nihonsan Konbu Zukan	BISMaL
1059	<i>Arthrothamnus bifidus</i>	43.066667	145.116667	1972	Nihonsan Konbu Zukan	BISMaL
1060	<i>Arthrothamnus bifidus</i>	43.066667	145.116667	1972	Nihonsan Konbu Zukan	BISMaL
1061	<i>Arthrothamnus bifidus</i>	42.933333	144.866667	1987	Nihonsan Konbu Zukan	BISMaL
1062	<i>Costaria costata</i>	44.100000	145.233333	1969	Nihonsan Konbu Zukan	BISMaL
1063	<i>Costaria costata</i>	41.950000	140.916667	1987	Nihonsan Konbu Zukan	BISMaL
1064	<i>Saccharina angustata</i>	41.783333	141.133333	1986	Nihonsan Konbu Zukan	BISMaL
1065	<i>Saccharina angustata</i>	42.250000	142.533333	1987	Nihonsan Konbu Zukan	BISMaL
1066	<i>Saccharina angustata</i>	42.083333	142.983333	1988	Nihonsan Konbu Zukan	BISMaL
1067	<i>Saccharina cichorioides</i>	44.766670	142.716670	1984	Nihonsan Konbu Zukan	BISMaL
1068	<i>Saccharina cichorioides</i>	44.700000	142.800000	1984	Nihonsan Konbu Zukan	BISMaL
1069	<i>Saccharina cichorioides</i>	44.033330	144.250000	1987	Nihonsan Konbu Zukan	BISMaL
1070	<i>Saccharina coriacea</i>	43.000000	144.833333	1986	Nihonsan Konbu Zukan	BISMaL
1071	<i>Saccharina coriacea</i>	42.983333	144.900000	1986	Nihonsan Konbu Zukan	BISMaL
1072	<i>Saccharina coriacea</i>	42.966667	144.866667	1987	Nihonsan Konbu Zukan	BISMaL
1073	<i>Saccharina gyrate</i>	43.333333	145.566667	1986	Nihonsan Konbu Zukan	BISMaL
1074	<i>Saccharina gyrate</i>	43.333333	145.566667	1986	Nihonsan Konbu Zukan	BISMaL
1075	<i>Saccharina gyrate</i>	42.933333	144.866667	1989	Nihonsan Konbu Zukan	BISMaL
1076	<i>Saccharina japonica</i>	44.333333	145.333333	1967	Nihonsan Konbu Zukan	BISMaL
1077	<i>Saccharina japonica</i>	44.000000	145.183333	1985	Nihonsan Konbu Zukan	BISMaL
1078	<i>Saccharina japonica</i>	43.333333	145.566667	1986	Nihonsan Konbu Zukan	BISMaL
1079	<i>Saccharina japonica</i>	43.016667	144.816667	1987	Nihonsan Konbu Zukan	BISMaL
1080	<i>Saccharina japonica</i>	43.016667	144.816667	1987	Nihonsan Konbu Zukan	BISMaL
1081	<i>Saccharina japonica</i>	41.750000	140.866667	1984	Nihonsan Konbu Zukan	BISMaL
1082	<i>Saccharina japonica</i>	41.700000	140.966667	1986	Nihonsan Konbu Zukan	BISMaL
1083	<i>Saccharina japonica</i>	41.700000	140.966667	1986	Nihonsan Konbu Zukan	BISMaL
1084	<i>Saccharina japonica</i>	41.900000	140.950000	1987	Nihonsan Konbu Zukan	BISMaL
1085	<i>Saccharina japonica</i>	41.933333	140.933333	1987	Nihonsan Konbu Zukan	BISMaL
1086	<i>Saccharina japonica</i>	43.916667	144.650000	1983	Nihonsan Konbu Zukan	BISMaL
1087	<i>Saccharina japonica</i>	44.583333	142.966667	1984	Nihonsan Konbu Zukan	BISMaL
1088	<i>Saccharina japonica</i>	44.033333	144.250000	1984	Nihonsan Konbu Zukan	BISMaL
1089	<i>Saccharina japonica</i>	42.216667	139.833333	1984	Nihonsan Konbu Zukan	BISMaL
1090	<i>Saccharina japonica</i>	41.416667	140.100000	1987	Nihonsan Konbu Zukan	BISMaL
1091	<i>Saccharina longissima</i>	43.000000	144.833333	1986	Nihonsan Konbu Zukan	BISMaL
1092	<i>Saccharina longissima</i>	42.966667	144.866667	1987	Nihonsan Konbu Zukan	BISMaL
1093	<i>Saccharina longissima</i>	42.933333	144.866667	1987	Nihonsan Konbu Zukan	BISMaL
1094	<i>Saccharina longissima</i>	42.966667	144.866667	1987	Nihonsan Konbu Zukan	BISMaL
1095	<i>Saccharina sculpera</i>	41.950000	140.916667	1987	Nihonsan Konbu Zukan	BISMaL
1096	<i>Saccharina sculpera</i>	41.950000	140.916667	1987	Nihonsan Konbu Zukan	BISMaL
1097	<i>Saccharina sculpera</i>	41.950000	140.916667	1987	Nihonsan Konbu Zukan	BISMaL
1098	<i>Alaria crassifolia</i>	39.600000	142.066667	1951	Nippon Suisan Gakkaishi 20(3):189-192	BISMaL
1099	<i>Saccharina japonica</i>	41.783333	141.116667	1965	Nippon Suisan Gakkaishi 33(1):41-46	BISMaL
1100	<i>Saccharina japonica</i>	41.750000	140.716667	1966	Nippon Suisan Gakkaishi 33(11):1038-1043	BISMaL
1101	<i>Saccharina japonica</i>	41.900000	140.966667	1966	Nippon Suisan Gakkaishi 33(11):1038-1043	BISMaL
1102	<i>Saccharina japonica</i>	45.116667	141.283333	1967	Nippon Suisan Gakkaishi 35(12):1189-1192	BISMaL
1103	<i>Saccharina japonica</i>	41.900000	140.966667	1968	Nippon Suisan Gakkaishi 36(11):1181-1185	BISMaL
1104	<i>Saccharina japonica</i>	41.750000	140.716667	1966	Nippon Suisan Gakkaishi 39(3):317-321	BISMaL
1105	<i>Alaria crassifolia</i>	41.733333	140.900000	1970	Nippon Suisan Gakkaishi 40(6):609-617	BISMaL
1106	<i>Saccharina japonica</i>	41.733333	140.900000	1970	Nippon Suisan Gakkaishi 40(6):609-617	BISMaL
1107	<i>Saccharina sculpera</i>	41.733333	140.900000	1970	Nippon Suisan Gakkaishi 40(6):609-617	BISMaL
1108	<i>Saccharina longissima</i>	42.950000	144.400000	1971	Nippon Suisan Gakkaishi 41(7):739-742	BISMaL
1109	<i>Saccharina longissima</i>	42.950000	144.400000	1977	Nippon Suisan Gakkaishi 45(2):163-165	BISMaL
1110	<i>Saccharina japonica</i>	45.133333	141.316667	1979	Nippon Suisan Gakkaishi 47(2):251-254	BISMaL
1111	<i>Saccharina japonica</i>	45.416667	141.666667	1979	Nippon Suisan Gakkaishi 47(2):251-254	BISMaL
1112	<i>Saccharina japonica</i>	45.300000	141.050000	1979	Nippon Suisan Gakkaishi 47(2):251-254	BISMaL

1113	<i>Saccharina sculpera</i>	41.700000	141.000000	1979	Nippon Suisan Gakkaishi 47(2):251-254	BISMaL
1114	<i>Saccharina japonica</i>	42.450000	140.833333	1986	Nippon Suisan Gakkaishi 59(2):295-299	BISMaL
1115	<i>Agarum clathratum</i>	43.900000	145.100000	1967	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1116	<i>Agarum clathratum</i>	44.333333	145.316667	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1117	<i>Agarum clathratum</i>	44.316667	145.350000	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1118	<i>Agarum clathratum</i>	44.250000	145.366667	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1119	<i>Agarum clathratum</i>	44.050000	145.233333	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1120	<i>Agarum clathratum</i>	44.033333	145.216667	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1121	<i>Costaria costata</i>	44.333333	145.316667	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1122	<i>Costaria costata</i>	44.316667	145.350000	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1123	<i>Costaria costata</i>	44.250000	145.366667	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1124	<i>Costaria costata</i>	44.150000	145.300000	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1125	<i>Costaria costata</i>	44.116667	145.250000	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1126	<i>Costaria costata</i>	44.050000	145.233333	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1127	<i>Costaria costata</i>	44.033333	145.216667	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1128	<i>Costaria costata</i>	44.000000	145.183333	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1129	<i>Saccharina japonica</i>	44.116667	145.250000	1967	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1130	<i>Saccharina japonica</i>	43.900000	145.100000	1967	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1131	<i>Saccharina japonica</i>	44.250000	145.366667	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1132	<i>Saccharina japonica</i>	44.150000	145.300000	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1133	<i>Saccharina japonica</i>	44.116667	145.250000	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1134	<i>Saccharina japonica</i>	44.050000	145.233333	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1135	<i>Saccharina japonica</i>	44.033333	145.216667	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1136	<i>Saccharina japonica</i>	44.000000	145.183333	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1137	<i>Saccharina japonica</i>	43.966667	145.150000	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1138	<i>Saccharina japonica</i>	44.016667	145.200000	1969	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1139	<i>Saccharina japonica</i>	44.333333	145.316667	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1140	<i>Saccharina japonica</i>	44.316667	145.350000	1968	Rausu Kaiiki no konbu ni kansuru sougouchousa houkokusho	BISMaL
1141	<i>Saccharina japonica</i>	43.200000	140.850000	1975	Suisan zousyoku 39(1)83-89	BISMaL
1142	<i>Saccharina japonica</i>	43.200000	140.850000	1980	Suisan zousyoku 39(1)83-89	BISMaL
1143	<i>Saccharina japonica</i>	42.930000	140.420000	1980	Suisan zousyoku 39(1)83-89	BISMaL
1144	<i>Saccharina japonica</i>	42.830000	140.320000	1982	Suisan zousyoku 39(1)91-95	BISMaL
1145	<i>Saccharina japonica</i>	43.480000	141.370000	1977	Suisan zousyoku 39(1)91-95	BISMaL
1146	<i>Saccharina japonica</i>	43.480000	141.370000	1982	Suisan zousyoku 39(1)91-95	BISMaL
1147	<i>Saccharina japonica</i>	43.200000	140.850000	1977	Suisan zousyoku 39(1)91-95	BISMaL
1148	<i>Saccharina japonica</i>	43.200000	140.850000	1982	Suisan zousyoku 39(1)91-95	BISMaL
1149	<i>Saccharina angustata</i>	42.230000	142.580000	1957	Suisancho Hokkaidouku Suisannkenkyujo Kenkyuuhoukoku 23(43-49)	BISMaL
1150	<i>Saccharina angustata</i>	42.450000	142.100000	1957	Suisancho Hokkaidouku Suisannkenkyujo Kenkyuuhoukoku 24(116-138)	BISMaL
1151	<i>Saccharina japonica</i>	42.050000	140.820000	1970	Suisancho Hokkaidouku Suisannkenkyujo Kenkyuuhoukoku 39(61-82)	BISMaL
1152	<i>Saccharina japonica</i>	42.480000	140.780000	1970	Suisancho Hokkaidouku Suisannkenkyujo Kenkyuuhoukoku 39(61-82)	BISMaL
1153	<i>Saccharina japonica</i>	42.050000	140.820000	1973	Suisancho Hokkaidouku Suisannkenkyujo Kenkyuuhoukoku 40(48-59)	BISMaL
1154	<i>Saccharina japonica</i>	42.480000	140.780000	1973	Suisancho Hokkaidouku Suisannkenkyujo Kenkyuuhoukoku 40(48-59)	BISMaL
1155	<i>Saccharina japonica</i>	41.900000	140.980000	1969	Suisancho Hokkaidouku Suisannkenkyujo Kenkyuuhoukoku 43(79-88)	BISMaL
1156	<i>Saccharina japonica</i>	45.400000	141.730000	1969	Suisancho Hokkaidouku Suisannkenkyujo Kenkyuuhoukoku 43(79-88)	BISMaL
1157	<i>Saccharina angustata</i>	42.170000	142.750000	1978	Suisancho Hokkaidouku Suisannkenkyujo Kenkyuuhoukoku 44(67-72)	BISMaL
1158	<i>Saccharina japonica</i>	42.450000	140.850000	1978	Suisancho Hokkaidouku Suisannkenkyujo Kenkyuuhoukoku 44(67-72)	BISMaL
1159	<i>Saccharina japonica</i>	41.900000	140.980000	1978	Suisancho Hokkaidouku Suisannkenkyujo Kenkyuuhoukoku 44(67-72)	BISMaL
1160	<i>Saccharina japonica</i>	41.750000	140.680000	1978	Suisancho Hokkaidouku Suisannkenkyujo Kenkyuuhoukoku 44(67-72)	BISMaL
1161	<i>Saccharina japonica</i>	41.883333	140.120000	1978	Suisancho Hokkaidouku Suisannkenkyujo Kenkyuuhoukoku 44(67-72)	BISMaL
1162	<i>Saccharina angustata</i>	42.930000	144.550000	1979	Suisancho Hokkaidouku Suisannkenkyujo Kenkyuuhoukoku 50(27-44)	BISMaL
1163	<i>Saccharina japonica</i>	44.100000	145.250000	1979	Suisancho Hokkaidouku Suisannkenkyujo Kenkyuuhoukoku 50(27-44)	BISMaL
1164	<i>Saccharina japonica</i>	41.900000	140.980000	1979	Suisancho Hokkaidouku Suisannkenkyujo Kenkyuuhoukoku 50(27-44)	BISMaL
1165	<i>Saccharina japonica</i>	45.380000	141.050000	1979	Suisancho Hokkaidouku Suisannkenkyujo Kenkyuuhoukoku 50(27-44)	BISMaL
1166	<i>Saccharina japonica</i>	43.220000	140.770000	1979	Suisancho Hokkaidouku Suisannkenkyujo Kenkyuuhoukoku 50(27-44)	BISMaL
1167	<i>Saccharina longissima</i>	42.930000	144.430000	1984	Suisancho Hokkaidouku Suisannkenkyujo Kenkyuuhoukoku 50(45-62)	BISMaL
1168	<i>Arthrothamnus bifidus</i>	42.966667	144.866667	1987	Yuyokaisoushi (kaisou no sigen kaihatsu to ikusei ni mukete)	BISMaL
1169	<i>Saccharina coriacea</i>	42.966667	144.866667	1987	Yuyokaisoushi (kaisou no sigen kaihatsu to ikusei ni mukete)	BISMaL
1170	<i>Saccharina gyrate</i>	42.966667	144.866667	1987	Yuyokaisoushi (kaisou no sigen kaihatsu to ikusei ni mukete)	BISMaL
1171	<i>Saccharina japonica</i>	43.066667	145.116667	1990	Yuyokaisoushi (kaisou no sigen kaihatsu to ikusei ni mukete)	BISMaL
1172	<i>Saccharina japonica</i>	41.700000	140.966667	1990	Yuyokaisoushi (kaisou no sigen kaihatsu to ikusei ni mukete)	BISMaL
1173	<i>Saccharina longissima</i>	42.966667	144.866667	1987	Yuyokaisoushi (kaisou no sigen kaihatsu to ikusei ni mukete)	BISMaL
1174	<i>Agarum clathratum</i>	42.282897	140.966156	1956	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1175	<i>Agarum clathratum</i>	41.446474	140.239123	1958	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1176	<i>Agarum clathratum</i>	42.282897	140.966156	1963	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1177	<i>Agarum clathratum</i>	42.957051	144.407080	1965	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1178	<i>Agarum clathratum</i>	42.984056	144.869446	1965	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1179	<i>Agarum clathratum</i>	45.474803	140.966495	1969	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1180	<i>Agarum clathratum</i>	41.945096	143.219251	1970	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1181	<i>Agarum clathratum</i>	42.031891	143.288970	1970	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1182	<i>Agarum clathratum</i>	42.031891	143.288970	1970	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1183	<i>Agarum clathratum</i>	42.009117	142.997595	1970	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1184	<i>Agarum clathratum</i>	41.945096	143.219251	1970	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1185	<i>Agarum clathratum</i>	45.464540	140.967440	1970	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1186	<i>Agarum clathratum</i>	45.464540	140.967440	1970	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1187	<i>Agarum clathratum</i>	41.945096	143.219251	1970	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1188	<i>Agarum clathratum</i>	41.945096	143.219251	1970	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1189	<i>Agarum clathratum</i>	42.084844	143.004657	1970	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1190	<i>Agarum clathratum</i>	41.945096	143.219251	1970	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1191	<i>Agarum clathratum</i>	41.945096	143.219251	1970	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1192	<i>Agarum clathratum</i>	41.945096	143.219251	1970	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1193	<i>Agarum clathratum</i>	41.945096	143.219251	1970	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1194	<i>Agarum clathratum</i>	42.031891	143.288970	1970	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1195	<i>Agarum clathratum</i>	41.958852	143.244869	1970	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1196	<i>Agarum clathratum</i>	41.958852	143.244869	1970	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1197	<i>Agarum clathratum</i>	42.956297	144.867175	1971	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1198	<i>Agarum clathratum</i>	43.031545	144.834715	1971	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1199	<i>Agarum clathratum</i>	43.385651	145.819080	1971	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1200	<i>Agarum clathratum</i>	41.945096	143.219251	1971	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1201	<i>Agarum clathratum</i>	41.945096	143.219251	1971	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1202	<i>Agarum clathratum</i>	43.001430	144.853724	1971	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1203	<i>Agarum clathratum</i>	41.945096	143.219251	1971	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1204	<i>Agarum clathratum</i>	41.945096	143.219251	1971	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/
1205	<i>Agarum clathratum</i>	41.945096	143.219251	1971	National Museum of Nature and Science Specimens	http://db.kahaku.go.jp/webmuseum/

1950	<i>Saccharina japonica</i>	41.415000	140.836100	1971	Saito 1972	Kumagai et al. 2016
1951	<i>Saccharina japonica</i>	41.553300	140.910100	1971	Saito 1972	Kumagai et al. 2016
1952	<i>Saccharina japonica</i>	38.456800	141.518700	1967	Shinzaki 1968	Kumagai et al. 2016
1953	<i>Saccharina japonica</i>	38.495700	141.534500	1967	Shinzaki 1968	Kumagai et al. 2016
1954	<i>Saccharina japonica</i>	38.890200	141.664900	1967	Shinzaki 1968	Kumagai et al. 2016
1955	<i>Saccharina japonica</i>	43.214700	140.853400	1966	Yamada 1980	Kumagai et al. 2016
1956	<i>Saccharina japonica</i>	44.427300	141.425500	1966	Yamada 1980	Kumagai et al. 2016
1957	<i>Saccharina japonica</i>	41.361200	139.815500	1968	Yamada 1980	Kumagai et al. 2016
1958	<i>Saccharina japonica</i>	43.333900	140.345700	1970	Yamada 1980	Kumagai et al. 2016

Note: *Saccharina coriacea* treated as *Saccharina cichorioides* f. *coriacea*

Saccharina sculpera treated as *Kjellmaniella crassifolia*

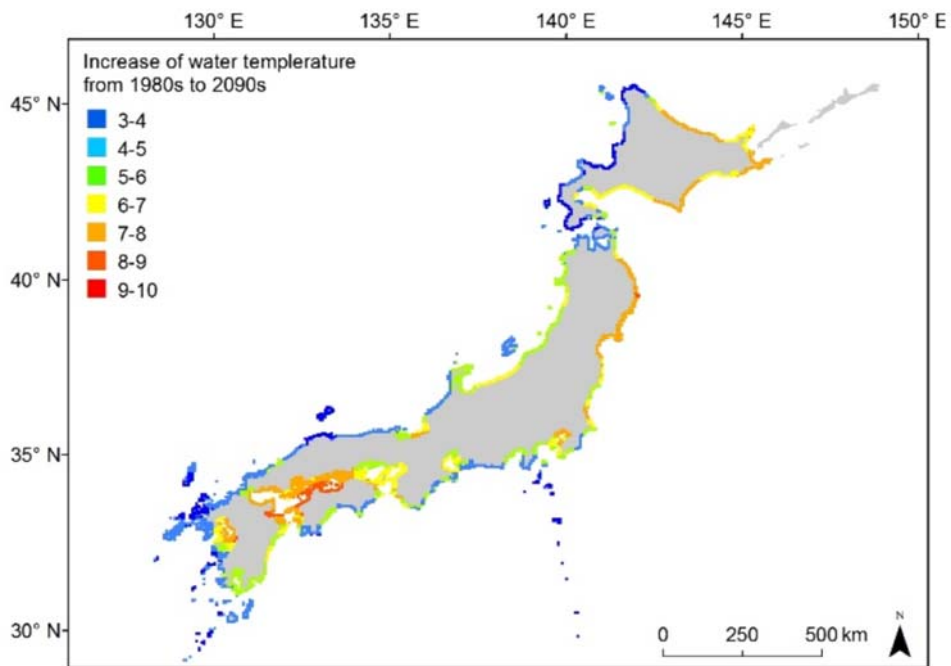


Fig. 2-S1-1 Increase in the coldest month SST from 1980s to 2090s based on the CMIP5 with RCP 8.5 scenario

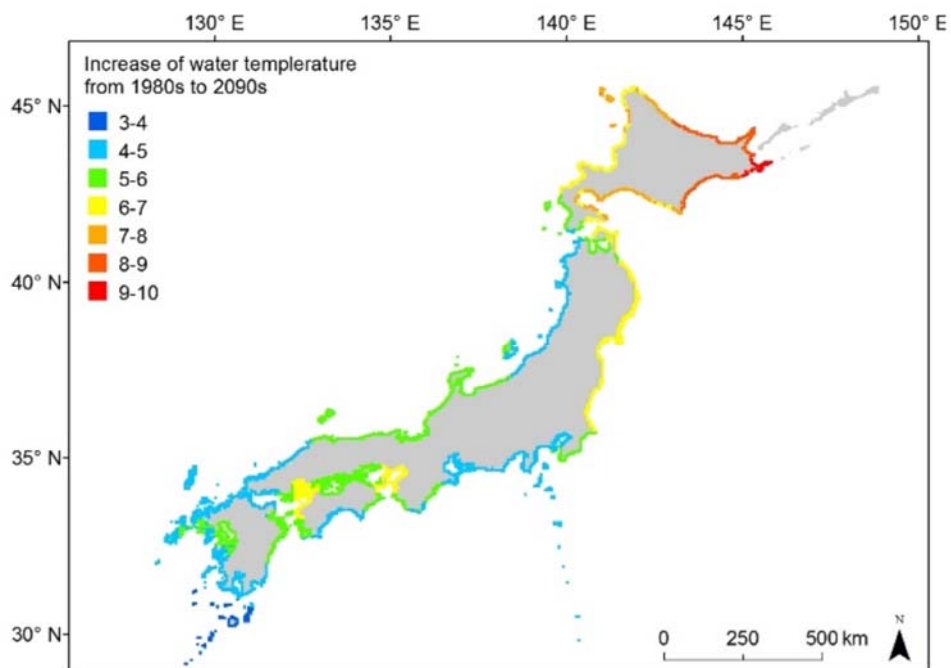


Fig.2-S1-2 Increase in the warmest moth SST from 1980s to 2090s based on the CMIP5 with RCP 8.5 scenario

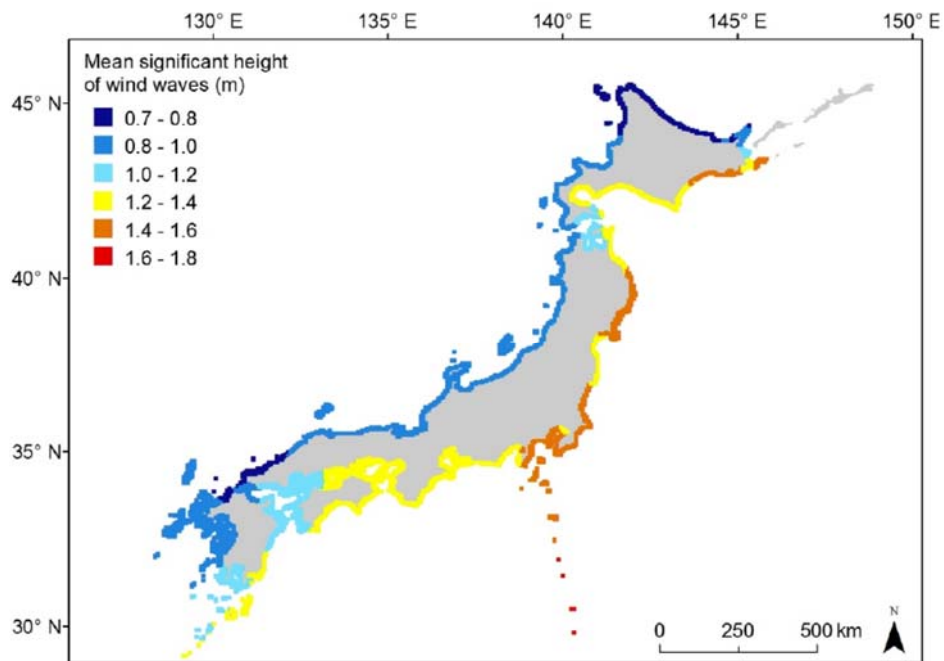


Fig.2-S1-3 Mean significant height of wind waves

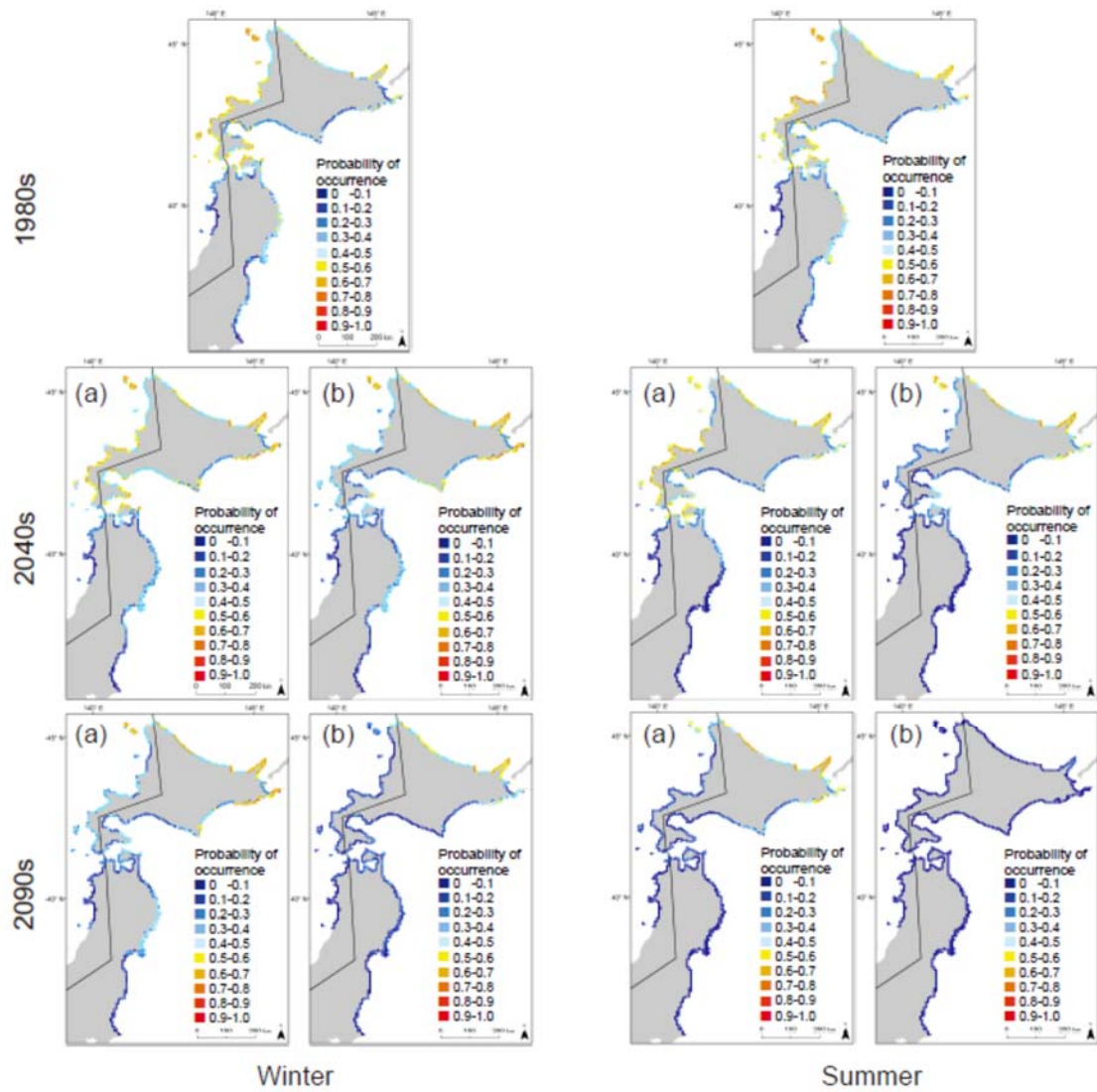


Fig. 2-S2a Estimated distribution of *Saccharina japonica* in the 1980s and projected distribution using winter(left) and summer(right) model based on based on different climate scenarios (a);RCP4.5 scenario, (b);RCP8.5 scenario

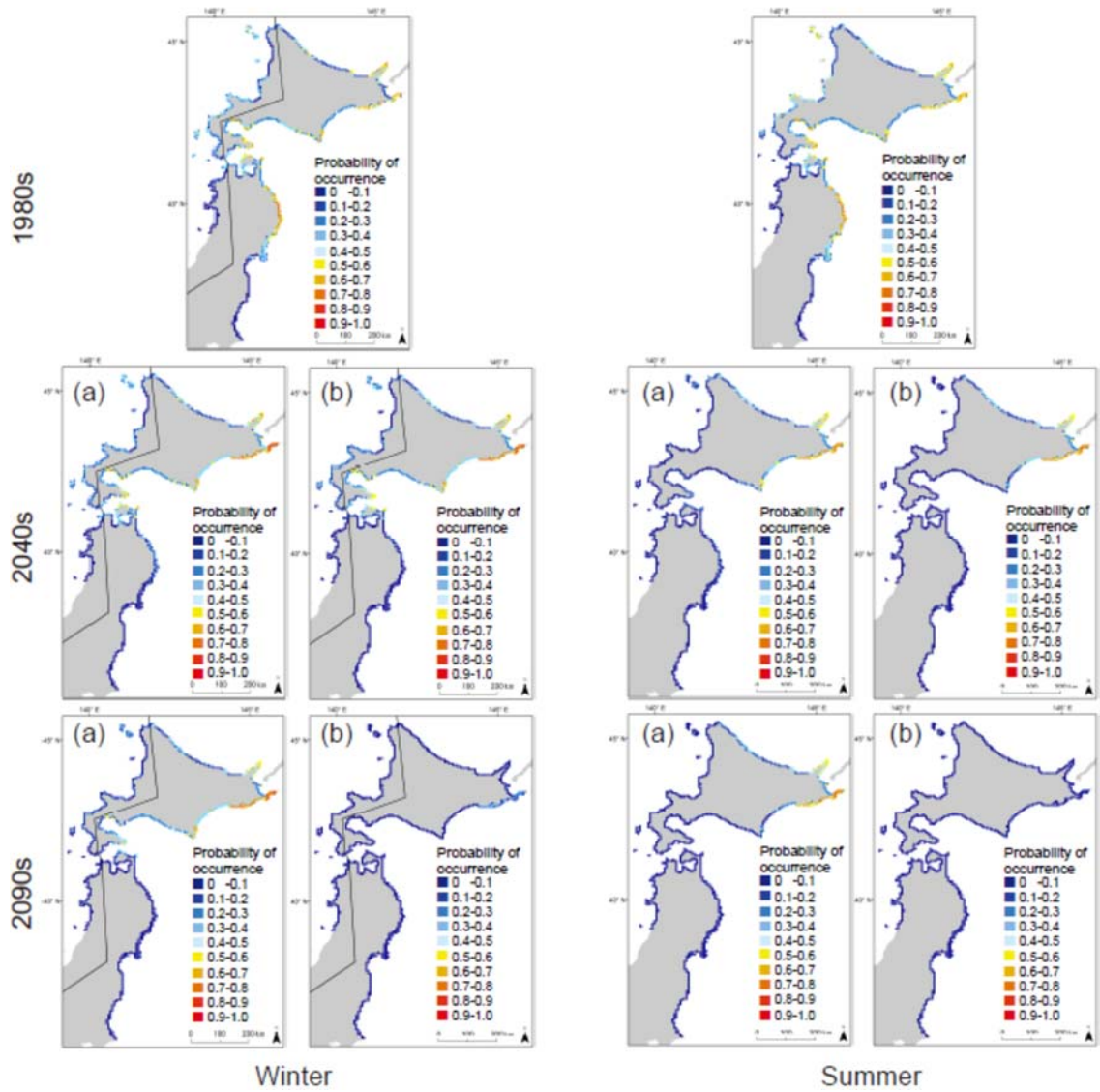


Fig. 2-S2b Estimated distribution of *Costaria costata* in the 1980s and projected distribution using winter(left) and summer(right) model based on based on different climate scenarios (a);RCP4.5 scenario, (b);RCP8.5 scenario

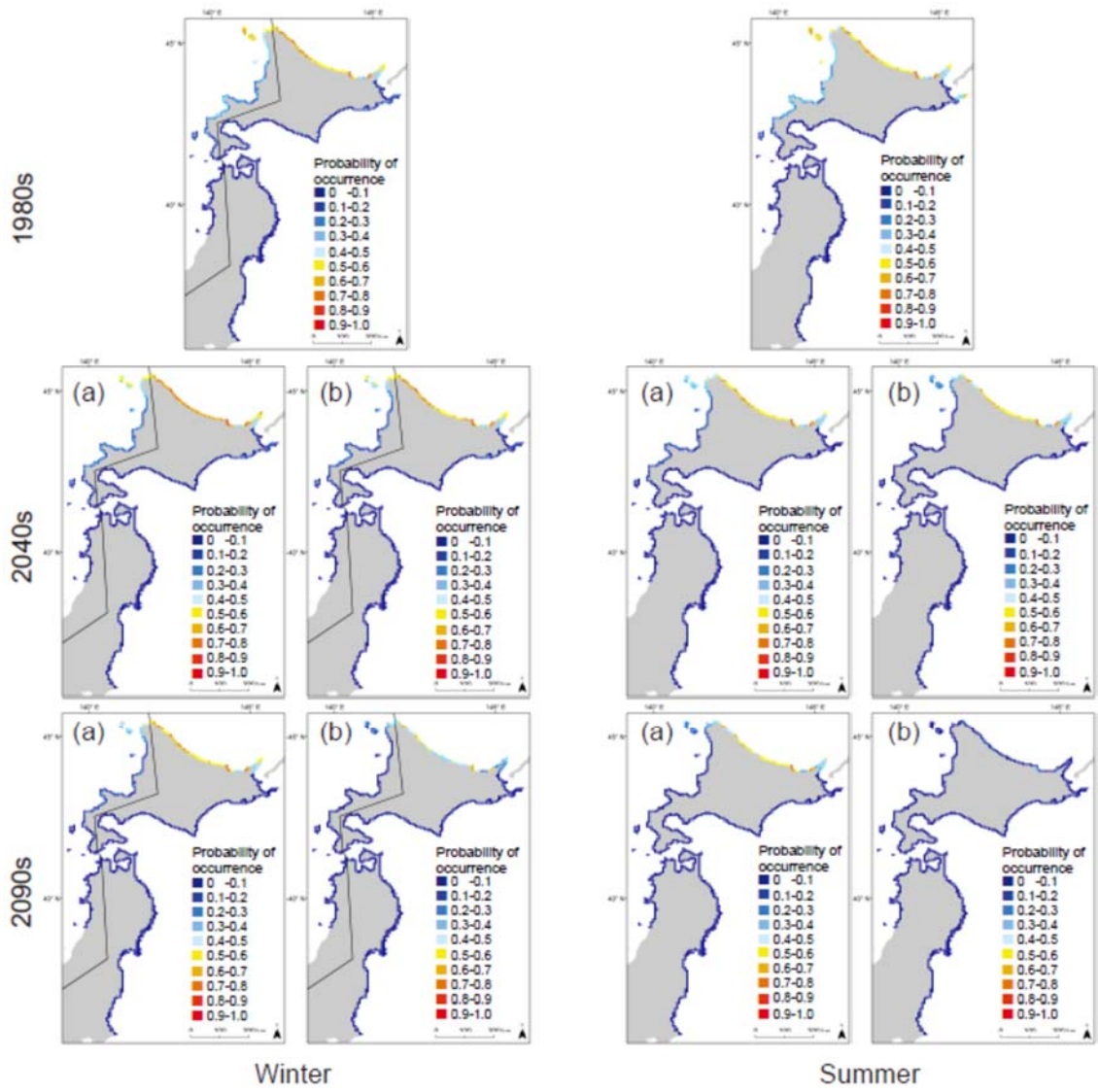


Fig. 2-S2c Estimated distribution of *Saccharina cichorioides* in the 1980s and projected distribution using winter(left) and summer(right) model based on based on different climate scenarios (a);RCP4.5 scenario, (b);RCP8.5 scenario

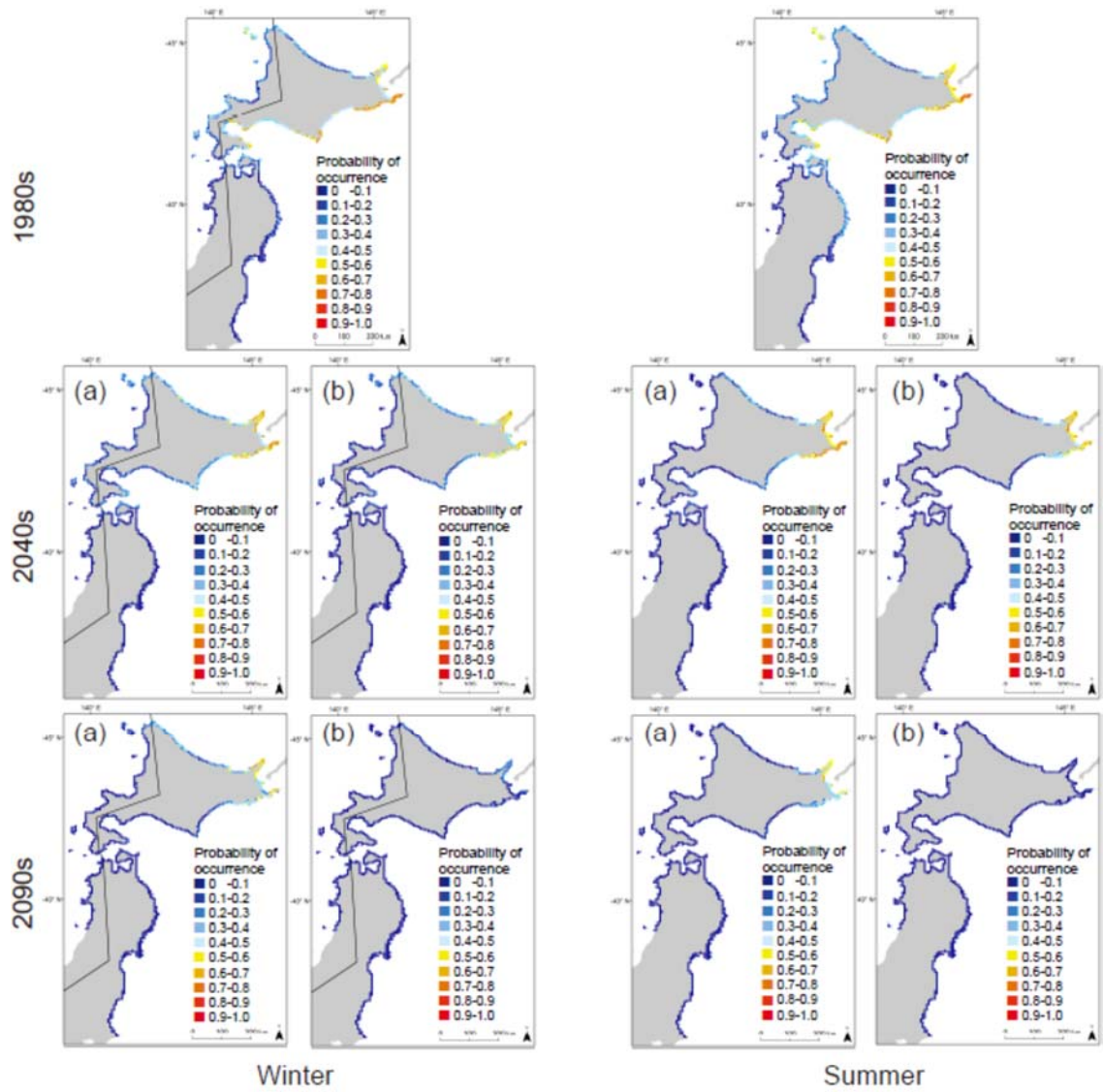


Fig. 2-S2d Estimated distribution of *Agarum clathratum* in the 1980s and projected distribution using winter(left) and summer(right) model based on based on different climate scenarios (a);RCP4.5 scenario, (b);RCP8.5 scenario

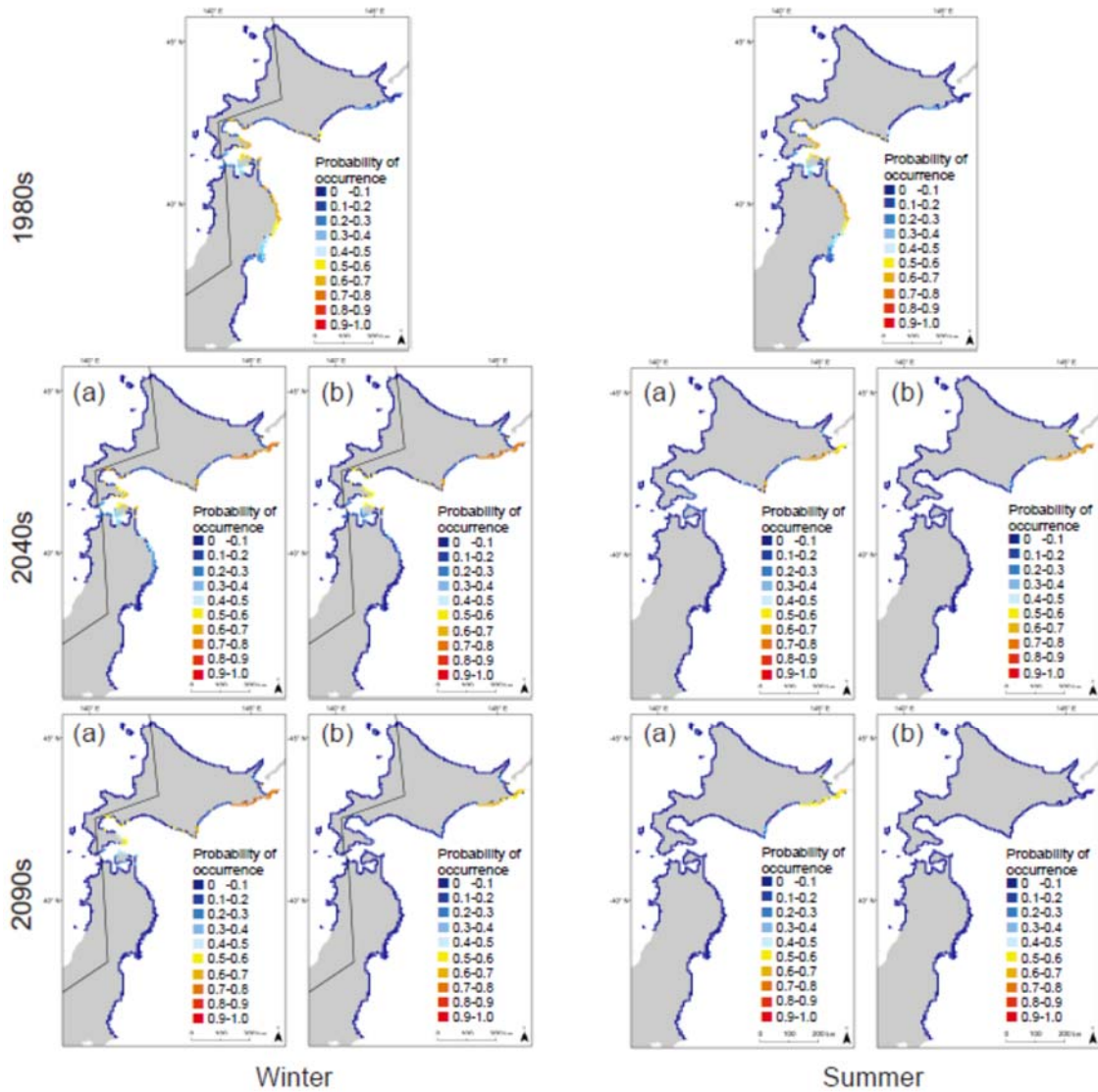


Fig. 2-S3a Estimated distribution of *Alaria crassifolia* in the 1980s and projected distribution using winter(left) and summer(right) model based on based on different climate scenarios (a);RCP4.5 scenario, (b);RCP8.5 scenario

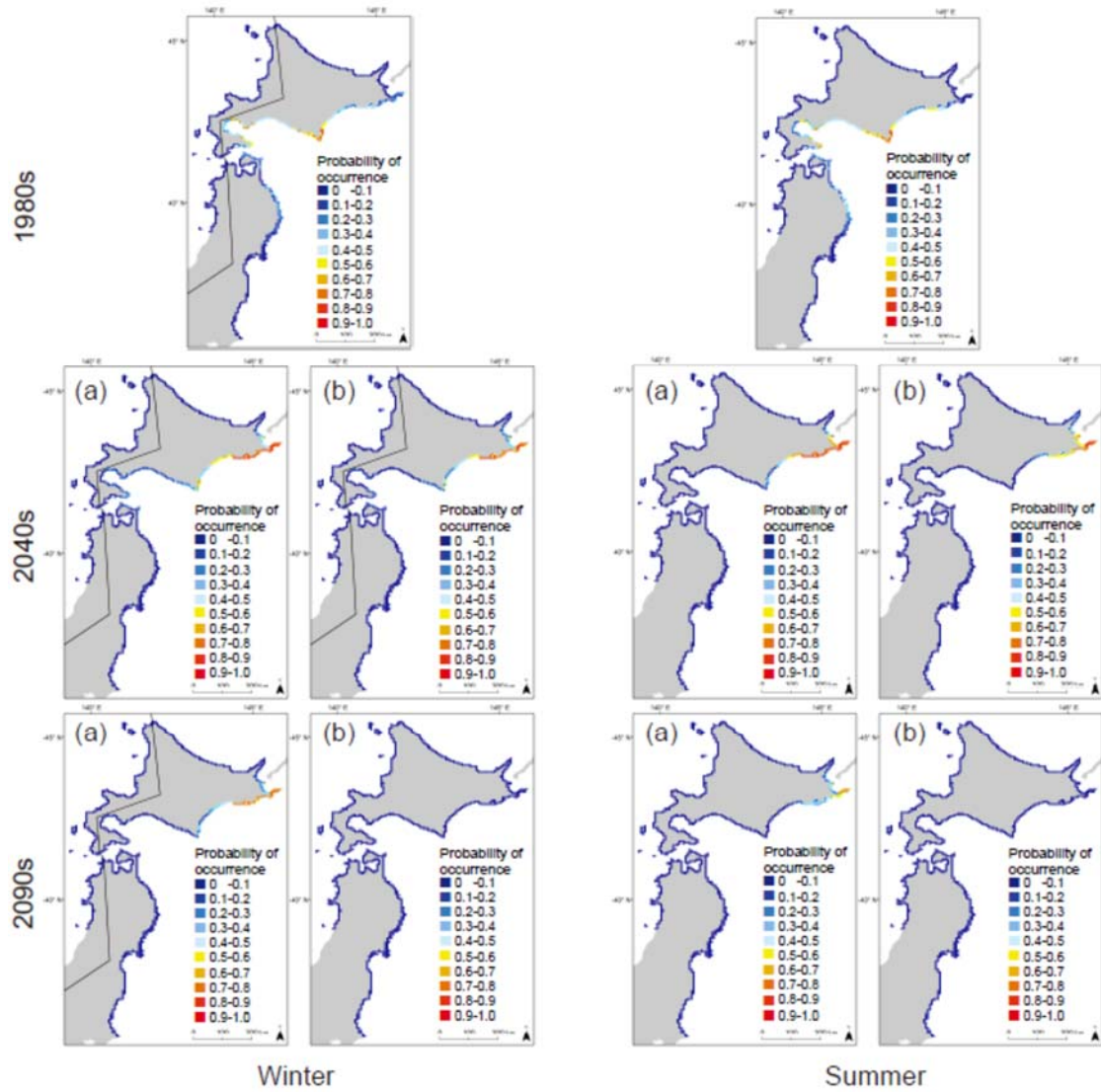


Fig. 2-S3b Estimated distribution of *Saccharina angustata* in the 1980s and projected distribution using winter(left) and summer(right) model based on based on different climate scenarios (a);RCP4.5 scenario, (b);RCP8.5 scenario

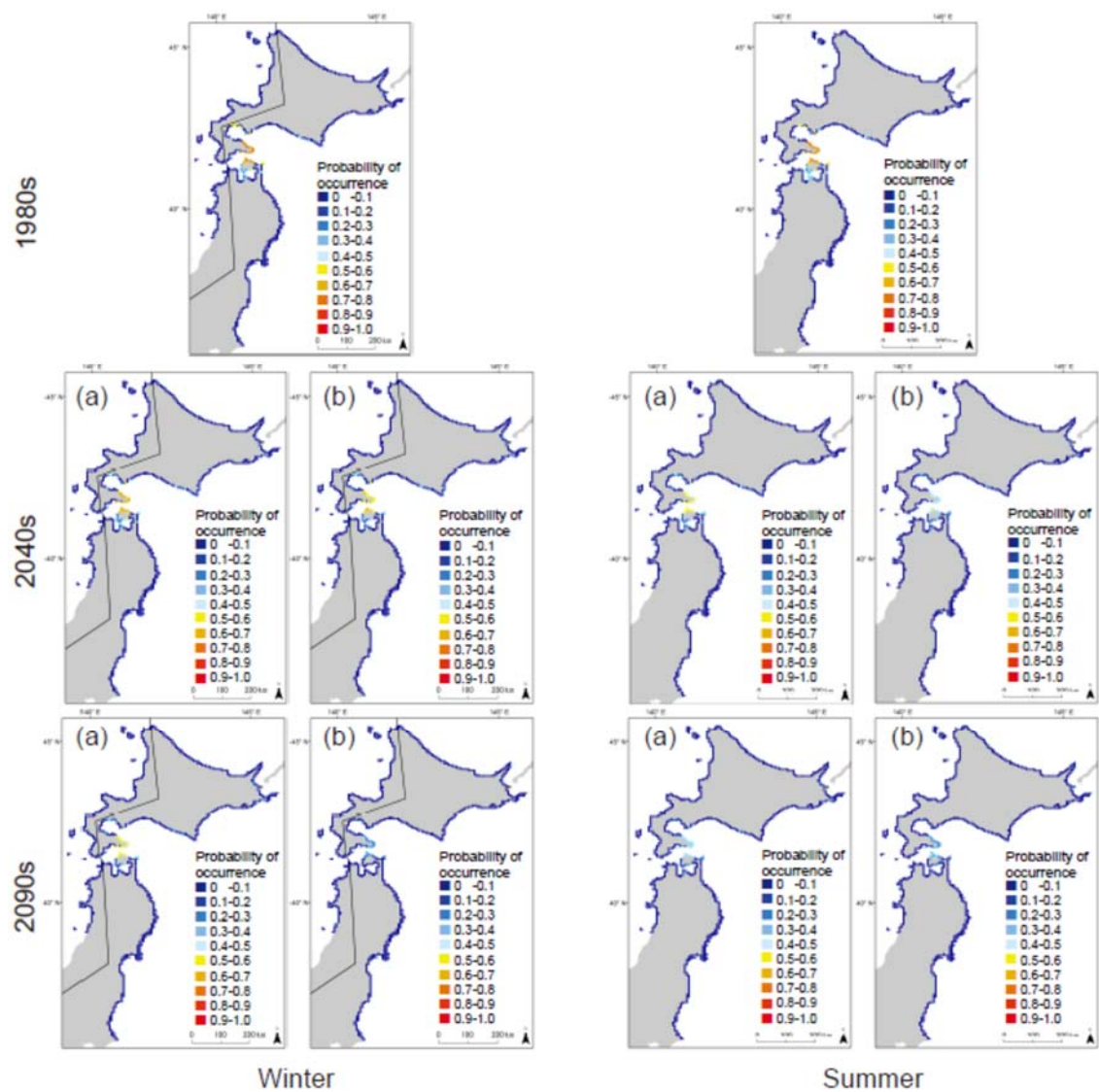


Fig. 2-S3c Estimated distribution of *Kjellmaniella sculpera* in the 1980s and projected distribution using winter(left) and summer(right) model based on based on different climate scenarios (a);RCP4.5 scenario, (b);RCP8.5 scenario

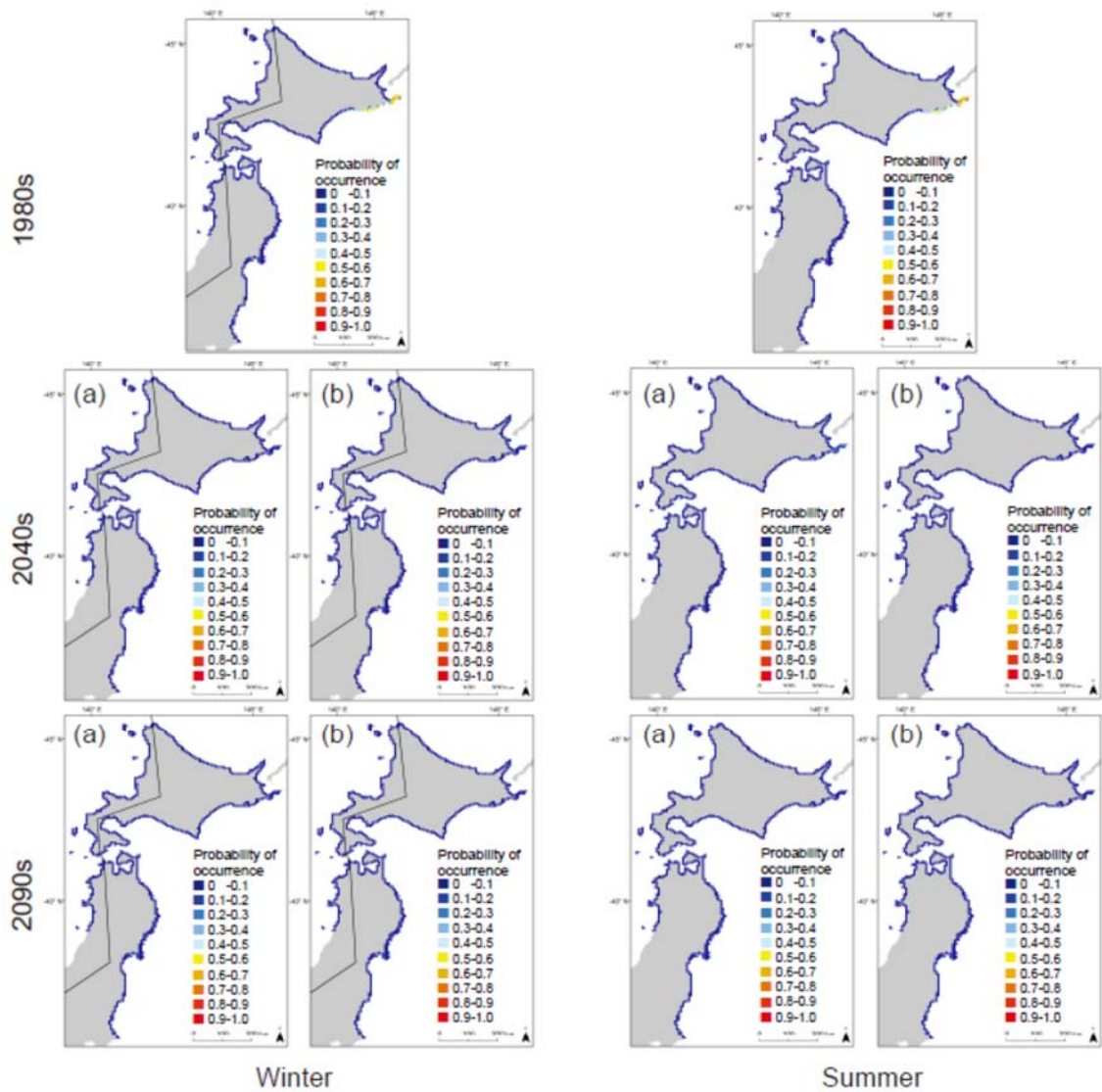


Fig. 2-S3d Estimated distribution of *Arthrothamnus bifidus* in the 1980s and projected distribution using winter(left) and summer(right) model based on based on different climate scenarios (a);RCP4.5 scenario, (b);RCP8.5 scenario

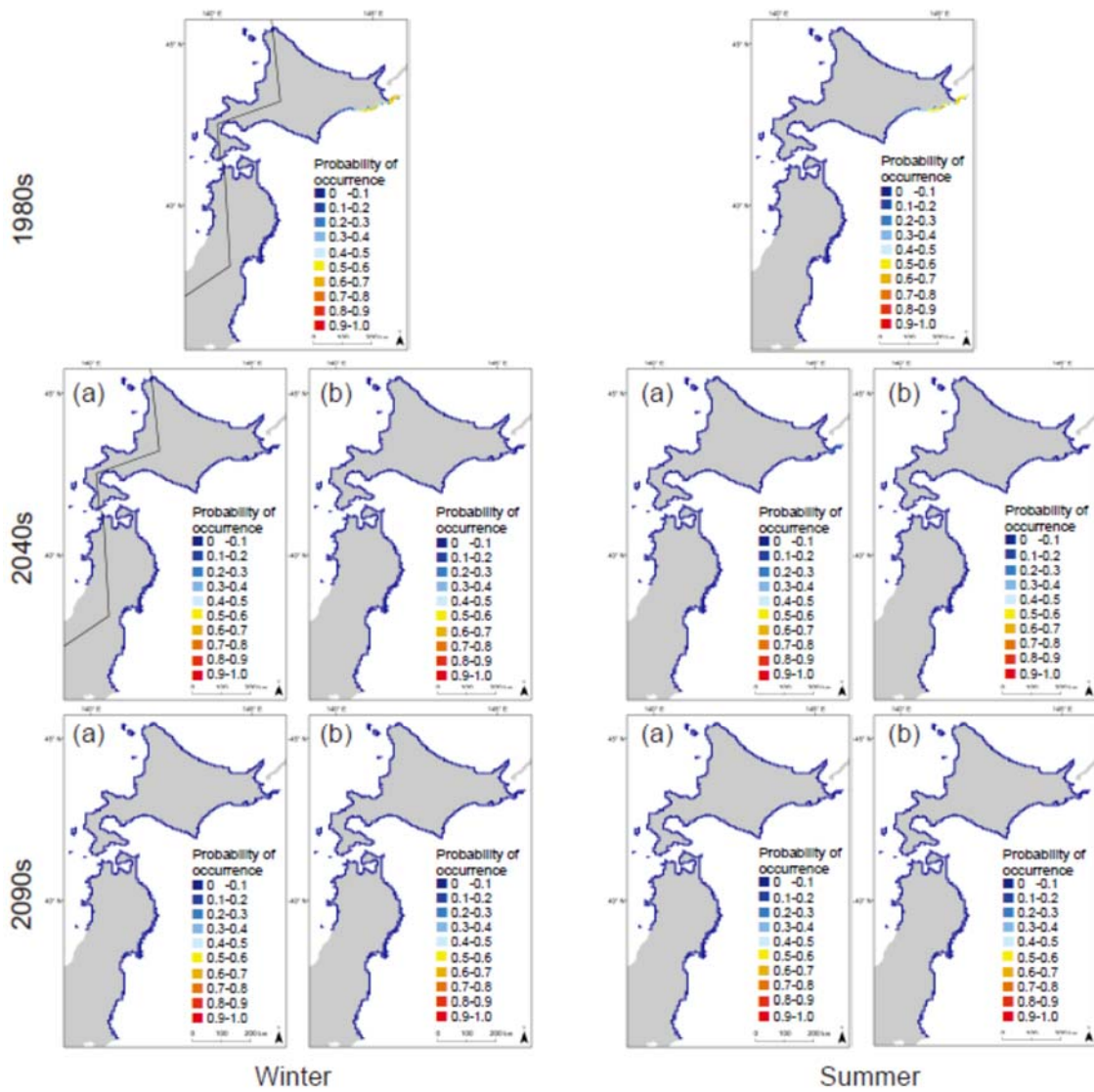


Fig. 2-S3e Estimated distribution of *Saccharina cichorioides f. coriaceain* in the 1980s and projected distribution using winter(left) and summer(right) model based on based on different climate scenarios (a);RCP4.5 scenario, (b);RCP8.5 scenario

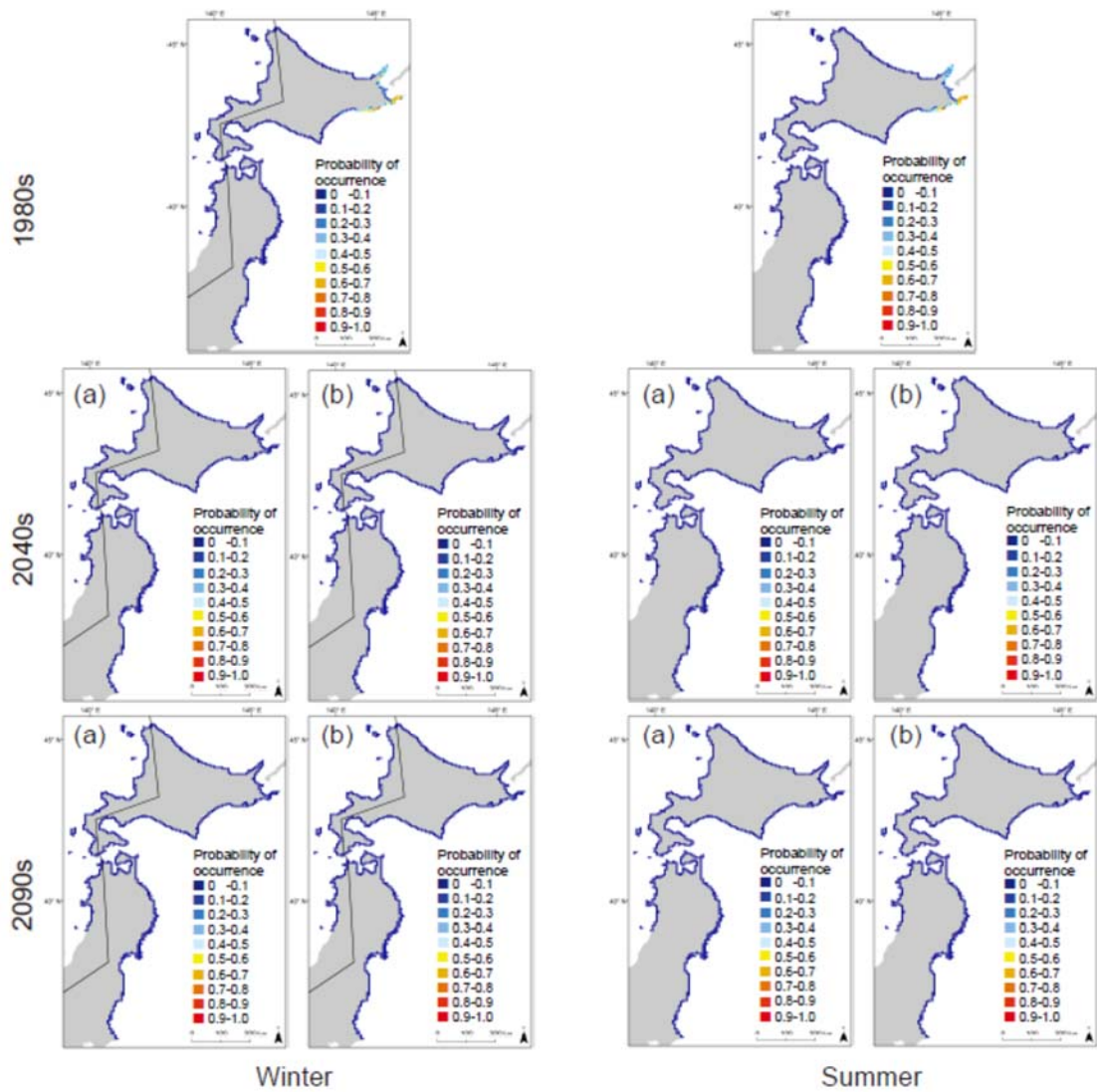


Fig. 2-S3f Estimated distribution of *Saccharina gyrata* in the 1980s and projected distribution using winter(left) and summer(right) model based on based on different climate scenarios (a);RCP4.5 scenario, (b);RCP8.5 scenario

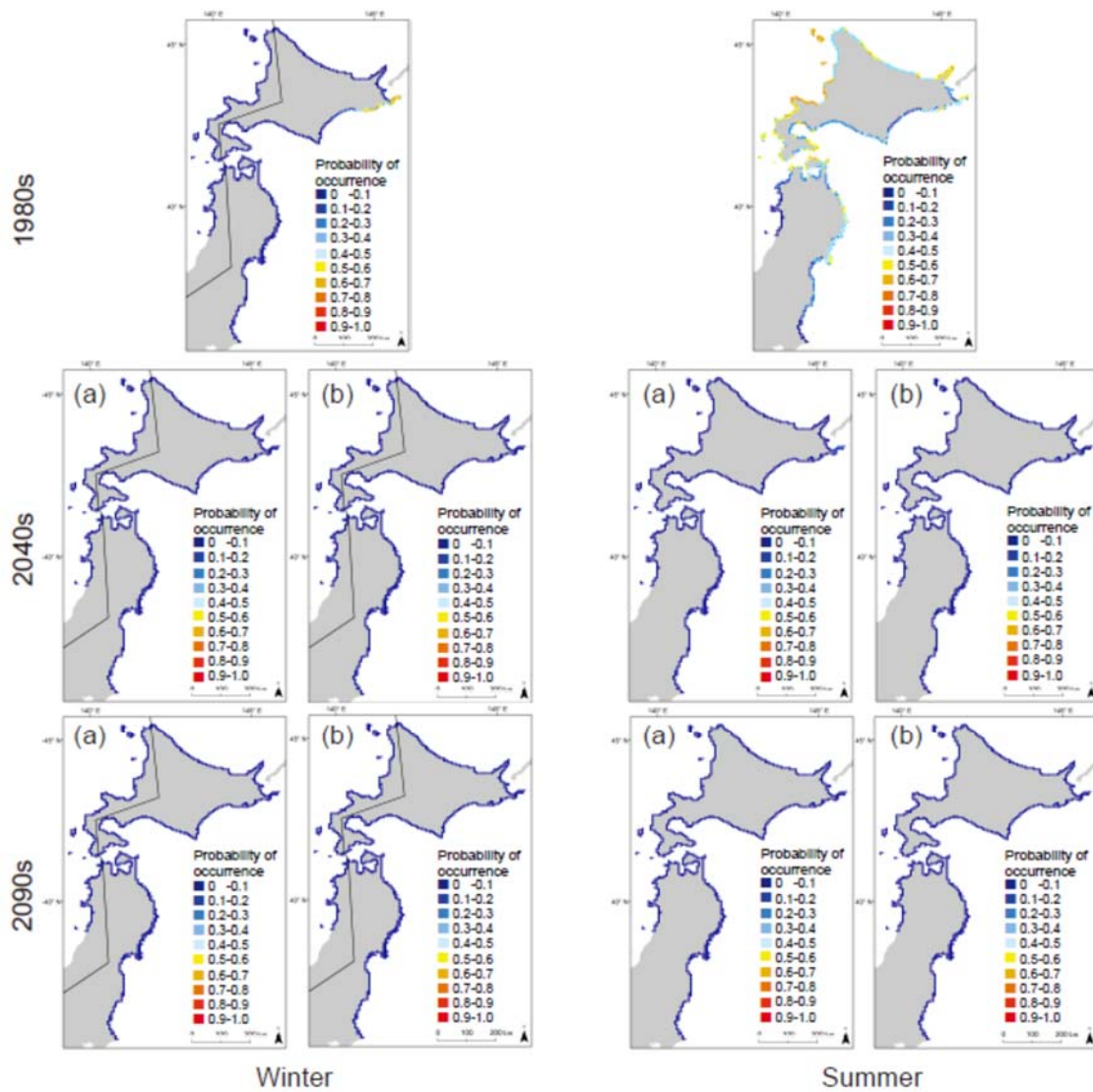


Fig.2-S3g Estimated distribution of *Saccarina longissima* in the 1980s and projected distribution using winter(left) and summer(right) model based on based on different climate scenarios (a);RCP4.5 scenario, (b);RCP8.5 scenario

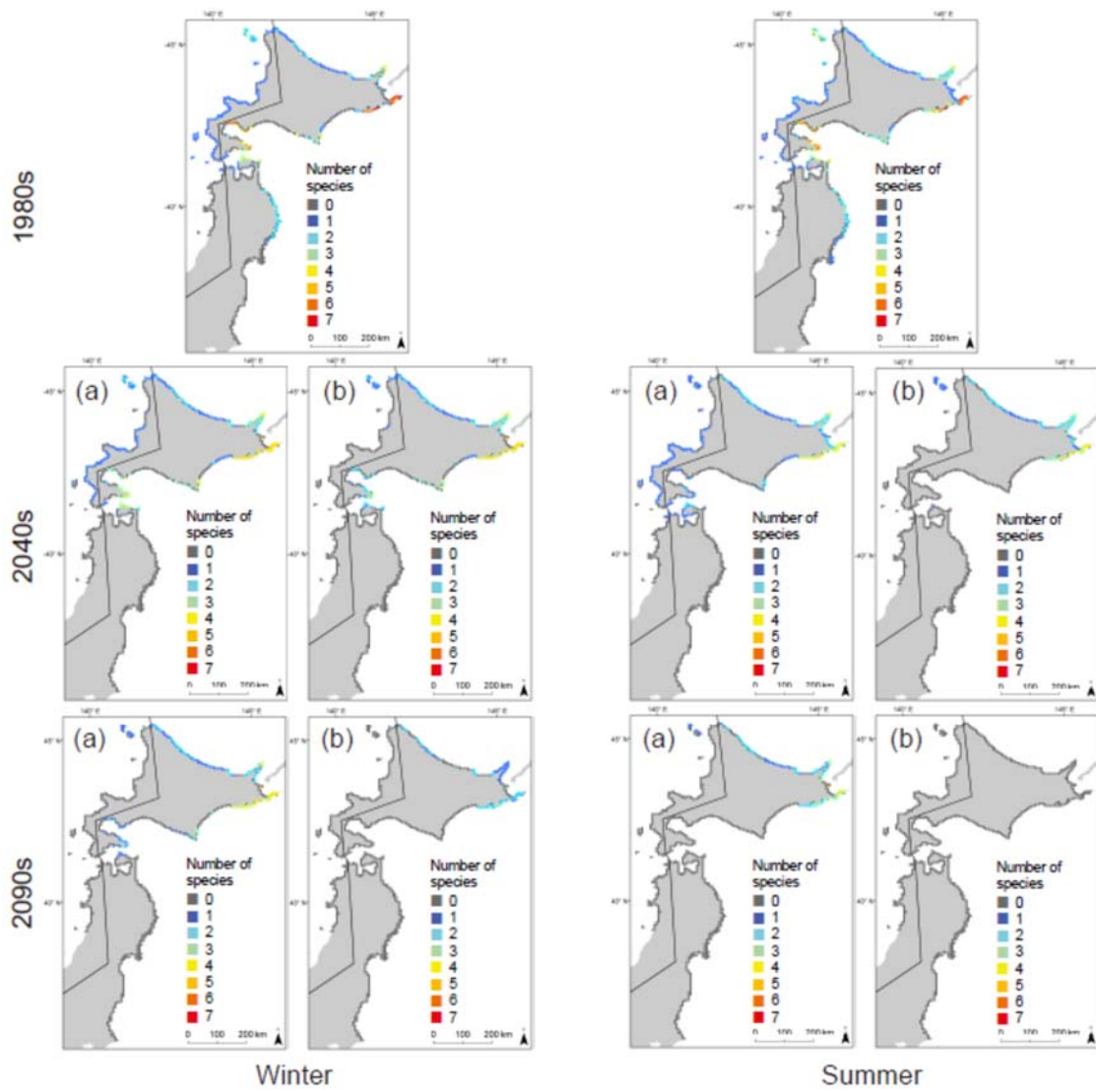


Fig. 2-S4 Estimated species richness of the cold temperate kelps in the 1980s and projected species richness using winter(left) and summer(right) model based on based on different climate scenarios (a);RCP4.5 scenario, (b);RCP8.5 scenario

Chapter 3 Fine-scale distribution of tropical seagrass beds in

Southeast Asia

Supporting information

Seagrass point DB.csv

Seagrass polygon DB.csv

Reference DB.csv

Seagrass point DB.csv

ID	No.	Locality	Station	Lat	Long	Reference	Source	Country	Area (ha)	Remarks	CR	CS	HP	HU	SI	EA	HB	HD	HM	HO	HS	TH	TC	ZJ	RM
BRNp101	1	Pulau Muara Besar		5.014428	115.090914	Lamit et al. 2017	Figure 1	BRN		Area is PMB and PB tota	1	0	1	0	0	0	1	0	0	1	0	0	0	0	0
BRNp102	2	Pulau Bedukang		4.980809	115.059756	Lamit et al. 2017	Figure 1	BRN	150	Area is PMB and PB tota	1	0	0	0	0	1	1	0	0	1	0	1	0	0	0
CHNp101	1	Hainan	Qiaolong Bay, Wenchang	19.336262	110.821942	Zheng et al. 2013	Figure 1 and Appendix I	CHN	3158	Wenchang except Yelin Bay	0	0	0	1	0	1	0	0	0	1	0	1	0	0	0
CHNp102	2	Hainan	Qiaolong Village, Wenchang	19.474454	110.792474	Zheng et al. 2013	Figure 1 and Appendix I	CHN		Wenchang except Yelin Bay	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0
CHNp103	3	Hainan	Changpi Harbor, Wenchang	19.455000	110.771919	Zheng et al. 2013	Figure 1 and Appendix I	CHN		Wenchang except Yelin Bay	0	0	0	1	0	1	0	0	1	1	0	1	0	0	0
CHNp104	4	Hainan	Baoshi Village, Wenchang	19.434084	110.763877	Zheng et al. 2013	Figure 1 and Appendix I	CHN		Wenchang except Yelin Bay	1	1	0	1	1	0	0	0	0	1	1	0	1	0	0
CHNp105	5	Hainan	Fengjia Bay, Wenchang	19.405575	110.728729	Zheng et al. 2013	Figure 1 and Appendix I	CHN		Wenchang except Yelin Bay	0	1	0	1	0	1	0	0	0	1	0	1	0	0	0
CHNp106	6	Hainan	Yelin Bay, Wenchang	19.545082	110.836222	Zheng et al. 2013	Figure 1 and Appendix I	CHN	101.2		1	0	0	0	0	0	0	0	0	1	0	1	0	0	0
CHNp107	7	Hainan	Qingge, Qionghai	19.317800	110.675372	Zheng et al. 2013	Figure 1 and Appendix I	CHN	1596	Qionghai	1	0	0	1	0	1	0	0	0	1	0	1	0	0	0
CHNp108	8	Hainan	Long Bay, Qionghai	19.308506	110.655874	Zheng et al. 2013	Figure 1 and Appendix I	CHN		Qionghai	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0
CHNp109	9	Hainan	Tanmen, Qionghai	19.540260	110.623387	Zheng et al. 2013	Figure 1 and Appendix I	CHN		Qionghai	1	0	0	1	0	0	0	0	0	1	0	1	0	0	0
CHNp110	10	Hainan	Houhai Bay, Sanya	18.268802	109.721089	Zheng et al. 2013	Figure 1 and Appendix I	CHN	164	Sanya	1	0	0	0	0	1	0	0	0	1	0	1	0	0	0
CHNp111	11	Hainan	Tielu Harbor, Sanya	18.267671	109.685546	Zheng et al. 2013	Figure 1 and Appendix I	CHN		Sanya	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
CHNp112	12	Hainan	Huachang Bay, Chengmai	18.922076	109.843339	Zheng et al. 2013	Figure 1 and Appendix I	CHN	40		0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
CHNp113	13	Hainan	Li'an Lagoon, Lingshui	18.403404	110.046909	Zheng et al. 2013	Figure 1 and Appendix I	CHN	57.4	Lingshui	1	0	0	0	0	1	0	0	0	1	0	1	0	0	0
CHNp114	14	Hainan	Xincun Lagoon, Lingshui	18.397938	109.955553	Zheng et al. 2013	Figure 1 and Appendix I	CHN		Lingshui	1	0	0	0	1	0	0	0	1	1	0	1	0	0	0
CHNp115	15	Hainan	Wanning	18.688955	110.380021	Zheng et al. 2013	Figure 1 and Appendix I	CHN	1		0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
CHNp116	16	Hainan	Dongfang	19.203118	108.835752	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear	Original source is old (den Hartog & Yano, 1990)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
CHNp117	17	Hainan	Xusha Islands (Jinqing Island)	16.465065	111.740267	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear	Original source is old (den Hartog & Yano, 1990)	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
CHNp118	18	Hainan	Nansha Islands (Taiping Island, etc.)	10.739077	114.365104	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHNp119	19	Guangxi	Beimu, Tieshangang, Beihai	21.527413	109.561496	Zheng et al. 2013	Figure 1 and Appendix I	CHN	170.1		0	0	0	0	0	0	1	0	1	1	0	0	0	1	0
CHNp120	20	Guangxi	Chuanjiang, Tieshangang, Beihai	21.513699	109.550546	Zheng et al. 2013	Figure 1 and Appendix I	CHN	73.3		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CHNp121	21	Guangxi	Jiaodong, Fangchenggang (Pearl Bay)	21.601851	108.199829	Zheng et al. 2013	Figure 1 and Appendix I	CHN	41.6		0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
CHNp122	22	Guangxi	Shanliao, Shatian, Beihai	21.483821	109.702969	Zheng et al. 2013	Figure 1 and Appendix I	CHN	14.3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
CHNp123	23	Guangxi	Zhibaojing, Qinzhou	21.851214	108.601823	Zheng et al. 2013	Figure 1 and Appendix I	CHN	10.7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHNp124	24	Guangxi	Diondu, Shankou, Beihai	21.455204	109.365244	Zheng et al. 2013	Figure 1 and Appendix I	CHN	10.7		0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
CHNp125	25	Guangdong	Luohu Bay, Zhuanjiang	20.487969	109.881248	Zheng et al. 2013	Figure 1 and Appendix I	CHN	900		0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
CHNp126	26	Guangdong	Zhuilin Bay, Raoping, Chaozhou	23.509971	116.912935	Zheng et al. 2013	Figure 1 and Appendix I	CHN	40		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CHNp127	27	Guangdong	Donghai Island, Zhanjiang	21.038065	110.281363	Zheng et al. 2013	Figure 1 and Appendix I	CHN	9		0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
CHNp128	28	Guangdong	Tangjia Bay, Zhuhai	22.343781	113.594097	Zheng et al. 2013	Figure 1 and Appendix I	CHN	7.5		0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
CHNp129	29	Guangdong	Shangchuan Island, Taishan	21.680832	112.778350	Zheng et al. 2013	Figure 1 and Appendix I	CHN	7		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
CHNp130	30	Guangdong	Kaohoyang, Huadong	22.739787	114.866868	Zheng et al. 2013	Figure 1 and Appendix I	CHN	6.95		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CHNp131	31	Guangdong	Hailing Island, Yangjiang	21.650460	111.938412	Zheng et al. 2013	Figure 1 and Appendix I	CHN	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHNp132	32	Guangdong	Xiaochuan Island, Taishan	21.668482	112.632989	Zheng et al. 2013	Figure 1 and Appendix I	CHN	1		0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
CHNp133	33	Guangdong	Beihaihu, Shanwei	22.732303	115.540304	Zheng et al. 2013	Figure 1 and Appendix I	CHN	<1		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CHNp134	34	Guangdong	Ouya Bay, Shenzhen	22.491276	114.582274	Zheng et al. 2013	Figure 1 and Appendix I	CHN	<1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHNp135	35	Guangdong	Qilhai Bay, Leizhou	20.780072	109.732579	Zheng et al. 2013	Figure 1 and Appendix I	CHN	<1		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CHNp136	36	Guangdong	Naozhou Island, Zhanjiang	20.883341	110.547426	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear	Original source is old (den Hartog & Yano, 1990)	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CHNp137	37	Guangdong	Hailu, Shanwei	22.787599	115.083887	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear	Original source is old (den Hartog & Yano, 1990)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
CHNp138	38	Hong Kong	Ha Pak Nai, Yuen Long District	22.426071	113.938421	Zheng et al. 2013	Figure 1 and Appendix I	CHN	4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHNp139	39	Hong Kong	Lai Chi Wo	22.526981	114.263275	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear		0	0	0	0	0	0	1	0	1	1	0	0	0	1	0
CHNp140	40	Hong Kong	Yan Chau Tong	22.516652	114.288883	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear		0	0	0	0	0	0	1	0	1	1	0	0	1	0	0
CHNp141	41	Hong Kong	Shan A Chung	22.599742	114.277657	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
CHNp142	42	Hong Kong	Tai Tam Bay	22.218753	114.230204	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear		0	0	0	0	0	0	1	0	1	1	0	0	1	0	0
CHNp143	43	Hong Kong	San Tau	22.286538	113.925215	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear		0	0	0	0	0	0	1	0	1	1	0	0	1	0	0
CHNp144	44	Fujian	Jinjiang	24.601506	118.539201	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear	Original source is old (den Hartog & Yano, 1990)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
CHNp145	45	Fujian	Shimen	24.336892	118.183142	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear	Original source is old (den Hartog & Yano, 1990)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHNp146	46	Fujian	Dongshan Island, Zhangzhou	23.658941	117.436427	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear	Original source is old (den Hartog & Yano, 1990)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHNp147	47	Taiwan	Tongsha Island	20.708182	116.720995	Zheng et al. 2013	Figure 1 and Appendix I	CHN	820		1	1	0	1	1	0	0	0	0	1	0	1	1	0	0
CHNp148	48	Taiwan	Nanwan, Hengchun Peninsular, Pingtung	21.568850	120.766293	Zheng et al. 2013	Figure 1 and Appendix I	CHN	0.4		0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
CHNp149	49	Taiwan	Dakwan, Hengchun Peninsular, Pingtung	21.546890	120.747387	Zheng et al. 2013	Figure 1 and Appendix I	CHN	0.3		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
CHNp150	50	Taiwan	Penghu Islands (Chinhu)	23.649277	119.612511	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear		0	0	0	1	0	0	0	0	0	1	0	0	0	1	0
CHNp151	51	Taiwan	Penghu Islands (Chenhu)	23.637392	119.599334	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear		0	0	0	1	0	0	0	0	0	1	0	0	0	1	0
CHNp152	52	Taiwan	Penghu Islands (Shikou)	23.620275	119.620634	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear		0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
CHNp153	53	Taiwan	Penghu Islands (Chiangmei)	23.636861	119.599737	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear		0	0	0	1	0	0	0	0	0	1	0	0	0	1	0
CHNp154	54	Taiwan	Luto Island	22.649056	121.500318	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
CHNp155	55	Taiwan	Hsiaoichu Island	22.348451	120.363602	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear		0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
CHNp156	56	Taiwan	Kinmen Island (Yu river mouth)	24.427387	118.312437	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
CHNp157	57	Taiwan	Kinmen Island (Cihu)	24.470009	118.305997	Zheng et al. 2013	Figure 1 and Appendix I	CHN	Unclear</																

ID	No.	Locality	Station	Lat	Long	Reference	Source	Country	Area (ha)	Remarks	CR	CS	HP	HU	SI	EA	HB	HD	HM	HO	HS	TH	TC	ZJ	RM
CHNp008	8	Dongsha Island	8b	20.707129	116.715119	Lin et al. 2015	Figure 1	CHN			1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
CHNp701		Hong Kong	HK1c1	22.289900	113.924900	Nguyen et al. 2014	Table 1	CHN	N.R.		0	0	0	0	0	0	0	0	0	1	0	0	0	0	
CHNp801	1	Shabel		21.516667	109.516667	Xu et al. 2011	Table 1	CHN	N.R.		0	0	0	0	0	0	0	0	0	1	0	0	0	0	
CHNp802	2	Xialongwei		21.483333	109.516667	Xu et al. 2011	Table 1	CHN	N.R.		0	0	0	0	0	0	0	0	0	1	0	0	0	0	
CHNp803	3	Beimu		21.533333	109.583333	Xu et al. 2011	Table 1	CHN	N.R.		0	0	0	0	0	0	0	0	0	1	0	0	0	0	
CHNp804	4	Yingluo		21.450000	109.750000	Xu et al. 2011	Table 1	CHN	N.R.		0	0	0	0	0	0	0	0	0	1	0	0	0	0	
CHNp901	1	Xincun Bay, Hainan		18.397552	109.995247	Yang and Yang 2009	Figure 7	CHN	N.R.		0	0	0	0	0	0	0	0	0	1	0	0	0	0	
IDNp10101	1	Blak	Paray	-1.188554	136.162318	Aji and Widayastuti 2017	Figure 1	IDN			SH 2	0	0	0	0	0	0	0	0	0	0	1	0	0	
IDNp10102	2	Blak	Yemures	-1.183068	136.068959	Aji and Widayastuti 2017	Figure 1	IDN			SH 5	0	0	0	0	0	0	0	0	0	0	0	0	0	
IDNp10201	1	Gusung Talang		-5.062607	119.458289	Ambo-Rappe 2014	Figure 1	IDN				0	0	0	0	1	0	0	0	0	0	0	0	0	
IDNp10202	2	Las Lee Island		-5.336913	119.381806	Ambo-Rappe 2014	Figure 1	IDN				0	0	0	0	1	0	0	0	0	0	0	0	0	
IDNp10203	3	Barrang Caddi Island		-5.084314	119.318130	Ambo-Rappe 2014	Figure 1	IDN				0	0	0	0	1	0	0	0	0	0	0	0	0	
IDNp10204	4	Barrang Lombo Island		-5.053001	119.326091	Ambo-Rappe 2014	Figure 1	IDN				0	0	0	0	1	0	0	0	0	0	0	0	0	
IDNp10205	5	Bone Tambung Island		-5.045047	119.273208	Ambo-Rappe 2014	Figure 1	IDN				0	0	0	0	1	0	0	0	0	0	0	0	0	
IDNp10206	6	Kodingarang Lombo Island		-5.157413	119.259012	Ambo-Rappe 2014	Figure 1	IDN				0	0	0	0	1	0	0	0	0	0	0	0	0	
IDNp10207	7	Bone Batang Island		-5.053517	119.355050	Ambo-Rappe 2014	Figure 1	IDN				0	0	0	0	1	0	0	0	0	0	0	0	0	
IDNp10208	8	Kapoppoang Island		-4.698279	118.951425	Ambo-Rappe 2014	Figure 1	IDN				0	0	0	0	1	0	0	0	0	0	0	0	0	
IDNp10301	1	Ambon	Tanjung Tiram	-3.655172	128.199880	Ambo-Rappe et al. 2013	Figure 1	IDN				0	0	0	0	1	0	0	0	0	0	0	0	0	
IDNp10302	2	Ambon	Latir	-3.647504	128.234222	Ambo-Rappe et al. 2013	Figure 1	IDN				0	0	0	0	1	0	0	0	0	0	0	0	0	
IDNp10303	3	Ambon	Walheru	-3.635617	128.223937	Ambo-Rappe et al. 2013	Figure 1	IDN				0	0	0	0	1	0	0	0	0	0	0	0	0	
IDNp10401	1	Sulawesi Island	Bahoi village	1.719849	125.019902	Fahrudin et al. 2017	Method	IDN				1	0	0	1	1	0	0	0	1	0	0	0	0	
IDNp10501	1	Tavando-Tam Island	Tavando	-5.649929	132.392938	Fitrian et al. 2017	Figure 1	IDN				1	1	0	0	0	0	0	0	0	0	1	0	0	
IDNp10502	2	Tavando-Tam Island	Vat	-5.628275	132.284127	Fitrian et al. 2017	Figure 1	IDN				1	1	0	0	0	0	0	0	0	0	1	0	0	
IDNp10503	3	Tavando-Tam Island	Reer	-5.615777	132.250182	Fitrian et al. 2017	Figure 1	IDN				1	0	0	0	0	0	0	0	0	1	0	0	0	
IDNp10504	4	Tavando-Tam Island	Tam	-5.715320	132.198521	Fitrian et al. 2017	Figure 1	IDN				1	0	0	0	0	0	0	0	0	1	0	0	0	
IDNp10505	5	Tavando-Tam Island	Wair	-5.580550	132.275578	Fitrian et al. 2017	Figure 1	IDN				1	0	0	0	0	0	0	0	0	1	0	0	0	
IDNp10601	1	Mentawai Island	Karangmadjati Island	-1.907267	99.307006	Garcia 2016	Figure 3	IDN				0	0	0	0	0	0	0	0	0	0	1	0	0	
IDNp10701	1	Blak		-1.158127	136.047244	Hernawan et al. 2017	Figure S1	IDN				0	0	0	0	0	0	0	0	0	0	1	0	0	
IDNp10702	2	Tual		-5.605847	132.149868	Hernawan et al. 2017	Figure S1	IDN				0	0	0	0	0	0	0	0	0	0	1	0	0	
IDNp10703	3	Kendari		-3.982893	122.620252	Hernawan et al. 2017	Figure S1	IDN				0	0	0	0	0	0	0	0	0	0	1	0	0	
IDNp10704	4	Bitung		1.412508	125.123145	Hernawan et al. 2017	Figure S1	IDN				0	0	0	0	0	0	0	0	0	0	1	0	0	
IDNp10705	5	Palu		-0.722564	119.857924	Hernawan et al. 2017	Figure S1	IDN				0	0	0	0	0	0	0	0	0	0	0	1	0	
IDNp10706	6	Jepara		-6.463312	110.629969	Hernawan et al. 2017	Figure S1	IDN				0	0	0	0	0	0	0	0	0	0	0	1	0	
IDNp10707	7	Pari Is.		-5.856719	106.623987	Hernawan et al. 2017	Figure S1	IDN				0	0	0	0	0	0	0	0	0	0	0	1	0	
IDNp10708	8	Natuna		-4.157222	108.163812	Hernawan et al. 2017	Figure S1	IDN				0	0	0	0	0	0	0	0	0	0	0	0	0	
IDNp10709	9	Kupang		-10.132693	123.860958	Hernawan et al. 2017	Figure S1	IDN				0	0	0	0	0	0	0	0	0	0	0	1	0	
IDNp10710	10	Dini		-8.138682	110.578225	Hernawan et al. 2017	Figure S1	IDN				0	0	0	0	0	0	0	0	0	0	0	1	0	
IDNp10711	11	Padang		-1.021756	100.387329	Hernawan et al. 2017	Figure S1	IDN				0	0	0	0	0	0	0	0	0	0	0	1	0	
IDNp10801	1	Teluk Bakau Station		1.050363	104.654391	Indriani et al. 2017	Figure 1	IDN				0	0	0	0	0	1	0	0.00	0	0	1	0	0	
IDNp10902	2	Pengudang Station		1.182088	104.507804	Indriani et al. 2017	Figure 1	IDN				0	0	0	0	0	1	0	0	0	0	0	1	0	
IDNp10901	1	Pengudang		1.170619	104.499338	Irawan 2017	Figure 1	IDN				1	1	0	0	1	1	0	0	0	0	0	1	0	
IDNp10902	2	Teluk Bakau		1.050363	104.654391	Irawan 2017	Figure 1	IDN				0	1	0	0	0	1	0	0	0	1	0	1	0	
IDNp1001	1	Pulau Pramuka	site1	-5.746037	106.514604	Ismet et al. 2016	Figure 1	IDN				1	0	0	0	0	1	0	0	0	0	0	0	0	
IDNp1002	2	Pulau Pramuka	site2	-5.749888	106.612855	Ismet et al. 2016	Figure 1	IDN				1	0	0	0	0	1	0	0	0	0	0	0	0	
IDNp1101	1	Air Bangis Archipelago	Pulau Panjang	0.189639	99.314361	Kamal et al. 2008	Materials and methods	IDN				0	0	0	1	0	0	0	0	0	0	0	1	0	
IDNp1102	2	Air Bangis Archipelago	Pulau Unggas	0.222278	99.301639	Kamal et al. 2008	Materials and methods	IDN				0	0	0	0	0	1	0	0	0	0	0	1	0	
IDNp1103	3	Air Bangis Archipelago	Pulau Taming	0.186750	99.285615	Kamal et al. 2008	Materials and methods	IDN				0	0	0	0	0	0	0	0	0	0	0	0	0	
IDNp1104	4	Air Bangis Archipelago	Teluk Tapang	0.220444	99.267611	Kamal et al. 2008	Materials and methods	IDN				0	0	0	1	0	0	0	0	0	0	0	1	0	
IDNp1201	1	Pulau Sumbawa	Madasanger	-9.020699	116.770970	Kharunnisa et al. 2019	Figure 1	IDN				C. sp. C. sp. H. sp. H. sp.	0	0	0	0	0	0	0	0	0	0	0	0	
IDNp1301	1	Traveller lodge to Sei Kawai		1.070770	104.647280	Kuriandewa and Supriadi 2006	Table 1	IDN				0	0	1	0	0	0	0	0	0	0	1	0	0	
IDNp1302	2	Traveller lodge to Sei Kawai		1.063980	104.651770	Kuriandewa and Supriadi 2006	Table 1	IDN				0	0	0	0	1	0	0	0	0	0	0	1	0	
IDNp1303	3	Traveller lodge to Sei Kawai		1.060280	104.652980	Kuriandewa and Supriadi 2006	Table 1	IDN				1	0	1	0	0	0	0	0	0	0	1	0	0	
IDNp1304	4	Traveller lodge to Sei Kawai		1.057040	104.653250	Kuriandewa and Supriadi 2006	Table 1	IDN				1	0	0	0	1	0	0	0	0	0	1	0	0	
IDNp1305	5	Traveller lodge to Sei Kawai		1.053240	104.653070	Kuriandewa and Supriadi 2006	Table 1	IDN				0	1	0	0	0	0	0	0	0	0	0	0	0	
IDNp1306	6	Traveller lodge to Sei Kawai		1.053110	104.655390	Kuriandewa and Supriadi 2006	Table 1	IDN				0	0	0	0	1	0	0	0	0	0	0	0	0	
IDNp1307	7	Traveller lodge to Sei Kawai		1.050230	104.656860	Kuriandewa and Supriadi 2006	Table 1	IDN				0	1	0	0	1	0	0	0	0	0	1	0	0	
IDNp1308	8	Traveller lodge to Sei Kawai		1.047230	104.657290	Kuriandewa and Supriadi 2006	Table 1	IDN				1	1	0	0	1	0	0	0	0	0	1	0	0	
IDNp1309	9	Teluk Bakau		1.045350	104.661190	Kuriandewa and Supriadi 2006	Table 1	IDN				0	0	0	0	0	1	0	0	0	0	0	1	0	
IDNp1310	10	Teluk Bakau		1.041370	104.659170	Kuriandewa and Supriadi 2006	Table 1	IDN				0	1	0	0	0	1	0	0	0	0	0	1	0	
IDNp1311	11	Teluk Bakau		1.036000	104.664980	Kuriandewa and Supriadi 2006	Table 1	IDN				0	0	0	0	0	0	0	0	0	0	0	1	0	
IDNp1312	12	Teluk Bakau		1.032820	104.659860	Kuriandewa and Supriadi 2006	Table 1	IDN				1	0	0	0	0	1	0	0	0	0	0	1	0	
IDNp1313	13	Teluk Bakau		1.030800	104.660310	Kuriandewa and Supriadi 2006	Table 1	IDN				0	0	0	0	1	0	0	0	0	0	0	1	0	
IDNp1314	14	Teluk Bakau		1.027910	104.657650	Kuriandewa and Supriadi 2006	Table 1	IDN				1	1	0	0	0	0	0	0	0	0	0	0	0	
IDNp1315	15	Teluk Bakau		1.027390	104.660580	Kuriandewa and Supriadi 2006	Table 1	IDN				0	0	0	0	1	0	0	0	0	0	0	1	0	
IDNp1316	16	Teluk Bakau		1.022590	104.659980	Kuriandewa and Supriadi 2006	Table 1	IDN				1	1	0	0	1	0	0	0	0	0	0	1	0	
IDNp1317	17	Teluk Bakau		1.004610	104.655240	Kuriandewa and Supriadi 2006	Table 1	IDN				0	1	0	0	1	0	0	0	0	0				

ID	No.	Locality	Station	Lat	Long	Reference	Source	Country	Area (ha)	Remarks	CR	CS	HP	HU	SI	EA	HB	HD	HM	HO	HS	TH	TC	ZJ	RM
IDNpt1502	2	Kapoposang Island	B	-4.696889	118.949361	Nadiarti 2012	Table 2, Appendix 1	IDN			0	0	0	0	1	1	0	0	0	0	0	1	0	0	0
IDNpt1503	3	Kapoposang Island	C	-4.697917	118.950083	Nadiarti 2012	Table 2, Appendix 1	IDN			1	0	0	0	1	1	0	0	0	0	0	0	1	0	0
IDNpt1504	4	Kapoposang Island	D	-4.699083	118.955639	Nadiarti 2012	Table 2, Appendix 1	IDN			0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
IDNpt1505	5	Kapoposang Island	E	-4.699232	118.962737	Nadiarti 2012	Table 2, Appendix 1	IDN			1	0	0	0	1	1	0	0	0	0	0	0	1	0	0
IDNpt1601	11	Hiri Island	Tafakra	0.882320	127.326860	Patly 2016	Table 2	IDN	10.98	Area is total of Hiri Island	1	1	1	1	1	1	0	0	0	1	0	1	0	0	0
IDNpt1602	2	Ternate Island	Sasa	0.754390	127.326400	Patly 2016	Table 2	IDN	166.41	Area is total of Ternate Island	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0
IDNpt1603	3	Ternate Island	Kastela	0.752610	127.309490	Patly 2016	Table 2	IDN			1	1	1	1	1	0	0	0	0	1	0	1	0	0	0
IDNpt1604	4	Mallara Island	Akibui	0.741600	127.366560	Patly 2016	Table 2	IDN	25.56	Area is total of Mallara Island	1	1	1	1	1	0	0	0	0	1	0	1	0	0	0
IDNpt1605	5	Mallara Island	Pasimanyou	0.729910	127.379520	Patly 2016	Table 2	IDN			1	1	0	0	1	1	0	0	0	1	0	1	0	0	0
IDNpt1606	6	Tidore Island	Rum Ballibunga	0.732860	127.384830	Patly 2016	Table 2	IDN	199.62	Area is total of Tidore Island	1	0	1	0	1	0	0	0	0	1	0	1	0	0	0
IDNpt1607	7	Tidore Island	Dowora	0.739390	127.453320	Patly 2016	Table 2	IDN			1	1	1	1	0	1	0	0	0	1	0	1	0	0	0
IDNpt1701	11	Bone Batang East		-5.013978	119.327015	Pogoreutz et al. 2012	Figure 1	IDN			1	0	0	0	1	0	0	0	0	0	1	0	1	0	0
IDNpt1702	2	Bone Batang North		-5.009391	119.325626	Pogoreutz et al. 2012	Figure 1	IDN			1	0	0	1	0	0	0	0	0	0	1	0	1	0	0
IDNpt1703	3	Bone Batang South		-5.016538	119.328132	Pogoreutz et al. 2012	Figure 1	IDN			1	0	0	1	1	1	0	0	0	1	0	1	0	0	0
IDNpt1704	4	Bone Batang West		-5.013978	119.325606	Pogoreutz et al. 2012	Figure 1	IDN			1	0	0	0	1	1	0	0	0	1	0	1	0	0	0
IDNpt1705	5	Barrang Lompo South		-5.053216	119.327863	Pogoreutz et al. 2012	Figure 1	IDN			1	0	0	1	0	1	0	0	0	1	0	1	0	0	0
IDNpt1801	1	Awerange Bay	AWR1	-4.238111	119.612333	Sarinia and Priosambodo 2006	Figure 1 and method	IDN			0	0	0	0	1	1	0	0	0	0	0	1	0	0	0
IDNpt1802	2	Awerange Bay	AWR2	-4.232528	119.604611	Sarinia and Priosambodo 2006	Figure 1 and method	IDN			0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
IDNpt1803	3	Awerange Bay	AWR3	-4.235757	119.600483	Sarinia and Priosambodo 2006	Figure 1 and method	IDN			1	1	0	0	1	0	0	0	0	0	0	1	0	0	0
IDNpt1804	4	Lubauang Bay	LAB1	-4.110254	119.617828	Sarinia and Priosambodo 2006	Figure 1 and method	IDN			1	1	0	0	1	0	0	0	1	1	0	1	0	0	0
IDNpt1805	5	Lubauang Bay	LAB2	-4.107250	119.615417	Sarinia and Priosambodo 2006	Figure 1 and method	IDN			1	1	0	0	1	0	0	0	0	0	0	0	0	0	0
IDNpt1806	6	Lubauang Bay	LAB3	-4.108861	119.608869	Sarinia and Priosambodo 2006	Figure 1 and method	IDN			1	1	0	0	0	1	0	0	0	0	0	0	0	0	0
IDNpt1901	11	Komodo/Seraya Kecil	IK16.1	-8.411667	119.867500	Short et al. 2016	Table 1	IDN			1	1	0	0	1	1	0	0	0	1	0	1	0	0	0
IDNpt2001	1	Makassar	Barranglompo Island	-5.053001	119.326991	Supriadi et al. 2014	Figure 1	IDN			1	1	1	1	0	1	0	0	0	1	0	1	0	0	0
IDNpt2101	11	Tanjung Merah	220000	-1.418111	125.124944	Syahalatus and Nurani 2010	Table 1	IDN			0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
IDNpt2102	2	Tanjung Merah	220000	-1.403657	125.120511	Syahalatus and Nurani 2010	Table 1	IDN			0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
IDNpt2201	1	Lati Island (north)		-8.170529	127.676005	Tanigan and Salam 2011	UNEP/CMS (2011) Southeast Asia	IDN	214.06		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
IDNpt2202	2	Moa Island		-8.108408	127.819391	Tanigan and Salam 2011	UNEP/CMS (2011) Southeast Asia	IDN	63.05		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
IDNpt2203	3	Lakor Island		-8.213966	128.146734	Tanigan and Salam 2011	UNEP/CMS (2011) Southeast Asia	IDN	171.42		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
IDNpt2301	11	Wakatobi Marine National Park	Hoga Beach	-5.457427	123.761507	Unsworth et al. 2007	Figure 1	IDN			1	0	0	0	0	1	0	0	0	1	0	1	0	0	0
IDNpt2401	11	Sumatra	Mentawai Islands	-1.676656	99.203611	Unsworth et al. 2018	Figure 2	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2402	2	Banten Bay		-6.825632	105.855652	Unsworth et al. 2018	Figure 2	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2403	3	Pari Islands	Tengah, Pari, Qudus Johns	-8.858119	106.62987	Unsworth et al. 2018	Figure 2	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2404	4	Bali		-8.715274	115.255273	Unsworth et al. 2018	Figure 2	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2405	5	Southern Lombok	Gerupuk Bay	-8.899405	116.283795	Unsworth et al. 2018	Figure 2	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2406	6	Lombok		-8.361808	115.125823	Unsworth et al. 2018	Figure 2	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2407	7	Rote Island	Nembarala	-10.890067	122.821229	Unsworth et al. 2018	Figure 2	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2408	8	Tual		-5.521905	132.804008	Unsworth et al. 2018	Figure 2, Supplement 3	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2409	9	West Papua	Jayapura Bay	-2.590478	140.702096	Unsworth et al. 2018	Figure 2	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2410	10	Manobo		-0.874027	134.080051	Unsworth et al. 2018	Figure 2	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2411	11	Ambon		-3.667330	128.196326	Unsworth et al. 2018	Figure 2, Supplement 3	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2412	12	Wakatobi		-5.457427	123.761507	Unsworth et al. 2018	Figure 2	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2413	13	Selayar		-5.132831	120.449603	Unsworth et al. 2018	Figure 2	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2414	14	Lae Loe Island		-5.36909	119.389475	Unsworth et al. 2018	Figure 2, Supplement 3	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2415	15	Barranglompo		-5.045273	119.329400	Unsworth et al. 2018	Figure 2, Supplement 3	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2416	16	Bangka Selatan	Tukak	-2.972081	106.653573	Unsworth et al. 2018	Figure 2, Supplement 3	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2417	17	Sintan		-1.043350	104.681190	Unsworth et al. 2018	Figure 2	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2418	18	Derawan		-2.281057	118.243492	Unsworth et al. 2018	Figure 2, Supplement 3	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2419	19	Kalamantan	Kota Bontang	-0.137756	117.522607	Unsworth et al. 2018	Figure 2	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2420	20	South Kalimantan		-3.218937	116.281161	Unsworth et al. 2018	Figure 2	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2421	21	Pulu Bay		-0.722564	119.657924	Unsworth et al. 2018	Figure 2	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2422	22	Manado		-1.421778	124.714353	Unsworth et al. 2018	Figure 2	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2423	23	Bitung, North Sulawesi	Tasikoko Beach	-1.390285	125.103572	Unsworth et al. 2018	Figure 2	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2501	1	Arakan		-1.376570	124.551195	Wagey et al. 2016	Figure 1	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2502	2	Manado Bay		-1.421778	124.714353	Wagey et al. 2016	Figure 1	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2503	3	Tongkeina		-1.577972	124.810705	Wagey et al. 2016	Figure 1	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2504	4	Siladen		-1.633465	124.800165	Wagey et al. 2016	Figure 1	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2505	5	Manihage		-1.704695	124.769884	Wagey et al. 2016	Figure 1	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2506	6	Ukupang		-1.672838	125.066457	Wagey et al. 2016	Figure 1	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2507	7	Tanjung Merah		-1.401614	125.119864	Wagey et al. 2016	Figure 1	IDN			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IDNpt2601	1	Panggang Island	St. East	-5.738706	106.604364	Wahab et al. 2017	Figure 1	IDN			0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
IDNpt2602	2	Panggang Island	St. South	-5.743455	106.604699	Wahab et al. 2017	Figure 1	IDN			1	1	0	0	0	1	0	0	0	0	1	0	0	0	0
IDNpt2603	3	Panggang Island	St. West	-5.739580	106.597254	Wahab et al. 2017	Figure 1	IDN			1	0	0												

ID	No.	Locality	Station	Lat	Long	Reference	Source	Country	Area (ha)	Remarks	CR	CS	HP	HU	SI	EA	HB	HD	HM	HO	HS	TH	TC	ZJ	RM
IDNpt3004	4	Derawan archipelago	Derawan north	2.281057	118.243492	Zon 2010	Figure 2	IDN			0	0	0	1	1	0	0	0	0	1	0	1	0	0	0
IDNpt3005	5	Derawan archipelago	Derawan south	2.278516	118.242180	Zon 2010	Figure 2	IDN			0	0	0	1	1	0	0	0	0	1	0	1	0	0	0
IDNpt3006	6	Derawan archipelago	Semama	2.130658	118.327158	Zon 2010	Figure 2	IDN			0	0	0	1	1	0	0	0	0	1	0	1	0	0	0
IDNpt3007	7	Derawan archipelago	Pulu Sengalaki	2.085542	118.395541	Zon 2010	Figure 2	IDN			0	0	0	1	1	0	0	0	0	1	0	1	0	0	0
IDNpt3008	8	Derawan archipelago	Kakaban	2.140076	118.519275	Zon 2010	Figure 2	IDN			1	1	0	1	1	0	0	0	0	1	0	1	0	0	0
IDNpt3009	9	Derawan archipelago	Maratus(Payung Payung)	2.195550	118.595697	Zon 2010	Figure 2	IDN			1	1	0	1	1	0	0	0	0	1	0	1	0	0	0
IDNpt3010	10	Derawan archipelago	Maratus(Payung Payung)	2.195550	118.510284	Zon 2010	Figure 2	IDN			1	1	0	1	1	0	0	0	0	1	0	1	0	0	0
IDNpt3011	11	Derawan archipelago	Maratus(Faluku bay)	2.254297	118.620476	Zon 2010	Figure 2	IDN			1	1	0	1	1	0	0	0	0	1	0	1	0	0	0
IDNpt3101	12	Lombok	Ela-ela Beach	-8.735167	115.966394	Zurron et al. 2015	Materials and methods	IDN			0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
JPNpt101	1	Okinawa island	Kayo	26.548552	128.108678	Hirayama et al. 2005	Table 1	JPN			1	0	0	1	1	0	0	0	0	1	0	1	0	0	0
JPNpt102	2	Amami Oshima island	Akagi	28.417446	129.531534	Hirayama et al. 2005	Table 1	JPN			0	1	0	1	0	0	0	0	0	1	0	0	0	0	0
JPNpt201	1	Tanegashima island	Hirota	30.424096	130.970816	Kawano et al. 2012	Result	JPN			0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
JPNpt202	2	Tokunoshima island	Yonama	27.861085	128.890693	Kawano et al. 2012	Result	JPN			0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
JPNpt203	3	Yoron island		27.038677	128.403707	Kawano et al. 2012	Figure 4.5	JPN			0	0	0	0	1	0	0	0	0	1	0	1	0	0	0
JPNpt204	4	Yoron island		27.055702	128.449704	Kawano et al. 2012	Figure 3	JPN			0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
JPNpt205	5	Amami Oshima island	Kasari	28.458236	129.659349	Kawano et al. 2012	Table 2	JPN			0	0	0	1	0	0	0	0	0	1	0	0	0	1	0
JPNpt206	6	Amami Oshima island	Setouchi	28.124146	129.362526	Kawano et al. 2012	Table 3	JPN			0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
JPNpt301	1	Okinawa island	Kn	26.453442	127.948015	Ministry of the Environment 2008	No118	JPN			1	0	1	1	1	0	0	0	0	0	1	0	1	0	0
JPNpt302	2	Okinawa island	Yabuchi island	26.316366	127.923663	Ministry of the Environment 2008	No117	JPN			1	0	1	1	0	0	0	0	0	0	0	1	0	0	0
JPNpt303	3	Okinawa island	Bise	26.706900	127.878960	Ministry of the Environment 2008	No120	JPN	25		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
JPNpt304	4	Miyako island	Gusukube	24.771360	125.407230	Ministry of the Environment 2008	No122	JPN			1	1	0	0	0	0	0	0	0	0	0	1	0	0	0
JPNpt305	5	Miyako island	Yonaha	24.783377	125.258964	Ministry of the Environment 2008	No123	JPN			1	0	0	0	1	0	0	0	0	0	0	1	0	0	0
JPNpt306	6	Ishigaki island	Fukudou river	24.488050	124.229440	Ministry of the Environment 2008	No124	JPN			1	1	1	1	1	0	0	0	0	1	0	1	0	1	0
JPNpt307	7	Ishigaki island	Kabira bay,Yonehara	24.454130	124.156610	Ministry of the Environment 2008	No125	JPN			0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
JPNpt308	8	Ishigaki island	Nakura bay	24.419720	124.089050	Ministry of the Environment 2008	No126	JPN			1	1	1	1	1	0	0	0	0	0	0	1	0	1	0
JPNpt309	9	Ishigaki island	Shiraho	24.383979	124.256532	Ministry of the Environment 2008	No127	JPN			0	0	0	1	1	0	0	0	0	0	0	1	0	0	0
JPNpt310	10	Iriomote island	Saikiyama bay	24.311980	123.681510	Ministry of the Environment 2008	No128	JPN	37.5		0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
JPNpt311	11	Iriomote island	Amitori bay	24.325797	123.700843	Ministry of the Environment 2008	No129	JPN			1	1	1	1	1	0	0	0	0	1	0	1	0	0	0
JPNpt401	1	Iriomote island		24.333662	123.702123	Nakamura and Tsuchiya 2008	Table 1	JPN	7		0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
JPNpt402	2	Ishigaki island	Itota	24.483993	124.223572	Nakamura and Tsuchiya 2008	Table 1	JPN	11		0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
JPNpt403	3	Okinawa island	Onna	26.484769	127.839748	Nakamura and Tsuchiya 2008	Table 1	JPN	8		0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
JPNpt404	4	Okinawa island	Bise	26.709779	127.878963	Nakamura and Tsuchiya 2008	Table 1	JPN	5.8		0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
JPNpt405	5	Amami Oshima island	Akagi	28.417446	129.631634	Nakamura and Tsuchiya 2008	Table 1	JPN	2.3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JPNpt406	6	Amami island	Akagina	28.461136	129.670255	Nakamura and Tsuchiya 2008	Table 1	JPN	2.3		0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
JPNpt501	1	Okinawa island	Chinen	26.130308	127.793986	Okinawa prefecture 2017-2019	Table 2-4	JPN			0	0	1	1	0	0	0	0	0	1	0	1	0	0	0
JPNpt502	2	Okinawa island	Hamaohira island	26.323697	128.048128	Okinawa prefecture 2017-2019	Table 2-5	JPN			0	0	0	0	0	0	0	0	0	0	2	0	0	0	
JPNpt503	3	Okinawa island	Cape Kanna	26.293432	127.918674	Okinawa prefecture 2017-2019	Table 2-7	JPN			1	1	0	1	0	0	0	0	0	0	0	1	0	0	0
JPNpt504	4	Okinawa island	Tsukien island	26.265939	127.941186	Okinawa prefecture 2017-2019	Table 2-8	JPN			1	1	1	1	1	0	0	0	0	1	0	1	0	0	0
JPNpt505	5	Okinawa island	Yonastiro	26.342735	127.840983	Okinawa prefecture 2017-2019	Table 2-9	JPN			1	1	1	1	1	0	0	0	0	1	0	1	0	0	0
JPNpt506	6	Okinawa island	Nakijin	26.692015	127.959201	Okinawa prefecture 2017-2019	Table 2-10	JPN			1	0	1	1	0	0	0	0	0	0	0	1	0	0	0
JPNpt507	7	Okinawa island	Kouri island	26.686437	128.019528	Okinawa prefecture 2017-2019	Table 2-11	JPN			1	0	1	1	1	0	0	0	0	1	0	1	0	0	0
JPNpt508	8	Okinawa island	Yagaji island	26.679224	128.017098	Okinawa prefecture 2017-2019	Table 2-12	JPN			1	0	1	1	1	0	0	0	0	1	0	1	0	1	0
JPNpt509	9	Okinawa island	Yagaji island	26.689156	128.026958	Okinawa prefecture 2017-2019	Table 2-13	JPN			1	0	1	1	0	0	0	0	0	1	0	1	0	0	0
JPNpt510	10	Okinawa island	Nakijin	26.692353	127.966362	Okinawa prefecture 2017-2019	Table 2-14	JPN			1	0	1	1	0	0	0	0	0	0	1	0	1	0	0
JPNpt601	1	Ishigaki island	Ibaruma	24.514436	124.277324	Takada and Abe 2002	Table 1	JPN			1	1	0	0	0	0	0	0	0	0	0	1	0	0	0
JPNpt602	2	Ishigaki island	Urasoko	24.455220	124.217953	Takada and Abe 2002	Table 1	JPN			1	1	0	1	0	0	0	0	0	0	0	0	1	0	0
JPNpt603	3	Iriomote island	Nagahama	24.376546	123.762641	Takada and Abe 2002	Table 1	JPN			1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
JPNpt701	4	Iriomote island	Thakahama	24.284642	123.746699	Takada and Abe 2002	Table 1	JPN			1	0	1	0	0	0	0	0	0	1	0	1	0	0	0
JPNpt702	1	Ishigaki island	Kuura	24.552213	124.287475	Tanaka and Kayanne 2007	Figure 1, 2	JPN			1	1	1	1	0	0	0	0	0	1	0	1	0	0	0
JPNpt703	2	Ishigaki island	Fukudo	24.467679	124.227751	Tanaka and Kayanne 2007	Figure 1, 2	JPN			1	1	1	0	1	0	0	0	0	0	1	0	1	0	0
JPNpt704	3	Ishigaki island	Nagura	24.395522	124.136509	Tanaka and Kayanne 2007	Figure 1, 2	JPN			1	1	1	1	0	0	0	0	0	0	0	1	0	0	0
JPNpt705	4	Ishigaki island	Miyara	24.343759	124.205199	Tanaka and Kayanne 2007	Figure 1, 2	JPN			1	1	0	1	1	0	0	0	0	0	0	1	0	0	0
JPNpt706	5	Ishigaki island	Shiraho	24.366488	124.206675	Tanaka and Kayanne 2007	Figure 1, 2	JPN			1	1	0	1	1	0	0	0	0	1	0	1	0	0	0
JPNpt707	6	Ishigaki island	Karadake	24.396704	124.251811	Tanaka and Kayanne 2007	Figure 1, 2	JPN			1	1	1	1	0	0	0	0	0	0	0	1	0	0	0
MMRpt101	1	Buabty		11.405000	96.118000	Novak et al. 2009	Table 1	MMR	12		1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
MMRpt102	2	Anne		11.322000	96.012333	Novak et al. 2009	Table 1	MMR	-0.0005		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MMRpt103	3	Lampi		10.683167	96.239167	Novak et al. 2009	Table 1	MMR	-0.0005		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MMRpt104	4	Lampi		10.633000	96.195500	Novak et al. 2009	Table 1	MMR	-0.0005		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MMRpt105	5	Lampi		10.887333	96.203333	Novak et al. 2009	Table 1	MMR	22		1	0	0	1	1	0	0	0	0	0	1	0	1	0	0
MMRpt106	6	Lampi		10.896000	96.190000	Novak et al. 2009	Table 1	MMR	-0.0005		0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MMRpt107	7	Lampi		10.880333	96.074000	Novak et al. 2009	Table 1	MMR			1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MMRpt108	8	Kyau Pila		10.673000	96.027000	Novak et al. 2009	Table 1	MMR	-0.0005		0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
MMRpt109	9	Buda		10.478667	96.219833	Novak et al. 2009	Table 1	MMR	-0.0005		0														

ID	No	Locality	Station	Lat	Long	Reference	Source	Country	Area (ha)	Remarks	CR	CS	HP	HU	SI	EA	HB	HD	HM	HO	HS	TH	TC	ZJ	RM
MMRpt402	2	Ko Phawt Island		10.860698	98.183297	Tun and Barry 2011	Figure 1-4	MMR			1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
MMRpt403	3	Ko Phawt Island		10.863821	98.189715	Tun and Barry 2011	Figure 1-4	MMR			1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MMRpt404	4	Ko Phawt Island		10.860025	98.196131	Tun and Barry 2011	Figure 1-4	MMR			0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
MMRpt405	5	Ko Phawt Island		10.835257	98.200653	Tun and Barry 2011	Figure 1-4	MMR			0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
MMRpt406	6	Ko Phawt Island		10.830063	98.192903	Tun and Barry 2011	Figure 1-4	MMR			0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
MMRpt407	7	Ko Phawt Island		10.830438	98.196410	Tun and Barry 2011	Figure 1-4	MMR			0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
MMRpt408	8	Hombill Island		10.829108	98.204238	Tun and Barry 2011	Figure 1-4	MMR			0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
MMRpt409	9	Lampi Island		10.783090	98.232602	Tun and Barry 2011	Figure 1-4	MMR			0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
MMRpt410	10	Lampi Island		10.747915	98.283330	Tun and Barry 2011	Figure 1-4	MMR			0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
MMRpt411	11	Lampi Island		10.727813	98.285145	Tun and Barry 2011	Figure 1-4	MMR			1	1	0	1	0	0	1	0	1	0	1	0	0	0	0
MMRpt412	12	Lampi Island		10.712777	98.288180	Tun and Barry 2011	Figure 1-4	MMR			1	0	1	0	0	0	0	0	1	0	1	0	0	0	0
MMRpt413	13	Lampi Island		10.701905	98.291777	Tun and Barry 2011	Figure 1-4	MMR			1	0	1	0	0	0	0	0	1	0	1	0	0	0	0
MMRpt414	14	Bo Cho Island		10.669317	98.259857	Tun and Barry 2011	Figure 1-4	MMR			1	0	0	1	0	0	0	0	0	1	0	1	0	0	0
MMRpt415	15	Than Dar Phyu Island		10.664712	98.345351	Tun and Barry 2011	Figure 1-4	MMR			1	0	0	0	0	0	0	0	1	0	1	0	0	0	0
MMRpt416	16	Nyaung Wee (Bada) Island		10.487537	98.195044	Tun and Barry 2011	Figure 1-4	MMR			1	0	1	0	0	0	0	0	0	1	0	1	0	0	0
MMRpt417	17	Nyaung Wee (Bada) Island		10.505524	98.195855	Tun and Barry 2011	Figure 1-4	MMR			0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MMRpt418	18	Nyaung Wee (Bada) Island		10.523831	98.233202	Tun and Barry 2011	Figure 1-4	MMR			1	0	0	1	0	0	0	0	1	0	1	0	0	0	0
MMRpt419	19	Nyaung Wee (Bada) Island		10.519122	98.234988	Tun and Barry 2011	Figure 1-4	MMR			1	0	0	1	0	0	0	0	1	0	1	0	0	0	0
MMRpt420	20	Nyaung Wee (Bada) Island		10.507196	98.233004	Tun and Barry 2011	Figure 1-4	MMR			1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MMRpt421	21	Nyaung Wee (Bada) Island		10.490053	98.236001	Tun and Barry 2011	Figure 1-4	MMR			0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MMRpt422	22	Pony Island		10.461063	98.221096	Tun and Barry 2011	Figure 1-4	MMR			0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MMRpt423	23	Pony Island		10.466484	98.224498	Tun and Barry 2011	Figure 1-4	MMR			0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
MYSp01001	1	Lewas	Sg. Bangkult	4.984306	115.451222	Ahmad-Kamil et al. 2013	Figure 1	MYA			1	0	1	1	0	1	0	0	1	1	0	1	0	0	0
MYSp01002	2	Lewas	Awat-awat	4.933278	115.423861	Ahmad-Kamil et al. 2013	Figure 1	MYA			1	0	1	1	0	1	0	0	1	1	0	1	0	0	0
MYSp02001	1	Spratly archipelago	Swallow Reef	7.374929	113.821115	Aener et al. 2017	Table 1, Appendix 2	MYA			0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
MYSp03001	1	Malay Peninsula	Pengkalan Nangka	5.834755	102.556040	Buang et al. 2006	Figure 1	MYA																	
MYSp03002	2	Malay Peninsula	Gong Batu	5.688783	102.705290	Buang et al. 2006	Figure 1	MYA																	
MYSp03003	3	Malay Peninsula	Setiout	5.533715	102.936370	Buang et al. 2006	Figure 1	MYA																	
MYSp03004	4	Malay Peninsula	Perhentian Island	5.902938	102.129180	Buang et al. 2006	Figure 1	MYA																	
MYSp03005	5	Malay Peninsula	Perhentian Island	5.923685	102.716905	Buang et al. 2006	Figure 1	MYA																	
MYSp03006	6	Malay Peninsula	Redang Island	5.786956	103.021404	Buang et al. 2006	Figure 1	MYA																	
MYSp03007	7	Malay Peninsula	Redang Island	5.771867	103.035387	Buang et al. 2006	Figure 1	MYA																	
MYSp03008	8	Malay Peninsula	Redang Island	5.769688	103.021199	Buang et al. 2006	Figure 1	MYA																	
MYSp03009	9	Malay Peninsula	Redang Island	5.813194	103.007117	Buang et al. 2006	Figure 1	MYA																	
MYSp03010	10	Malay Peninsula	Merchang	5.038437	103.299798	Buang et al. 2006	Figure 1	MYA																	
MYSp03011	11	Malay Peninsula	Paka	4.646576	103.490129	Buang et al. 2006	Figure 1	MYA																	
MYSp03012	12	Malay Peninsula	Kemasik	4.416471	103.457362	Buang et al. 2006	Figure 1	MYA																	
MYSp03013	13	Malay Peninsula	Telaga Simpul	4.241011	103.446405	Buang et al. 2006	Figure 1	MYA																	
MYSp03014	14	Malay Peninsula	Toman Island	4.283948	104.159862	Buang et al. 2006	Figure 1	MYA																	
MYSp03015	15	Malay Peninsula	Tengah Island	2.479518	103.975115	Buang et al. 2006	Figure 1	MYA																	
MYSp03016	16	Malay Peninsula	Besar Island	2.241967	103.975131	Buang et al. 2006	Figure 1	MYA																	
MYSp03017	17	Malay Peninsula	Sibu Island	2.220989	104.060289	Buang et al. 2006	Figure 1	MYA																	
MYSp03018	18	Malay Peninsula	Sembilan Island	2.121028	102.116028	Buang et al. 2006	Figure 1	MYA																	
MYSp03019	19	Malay Peninsula	Teluk Kemang	2.442625	101.854688	Buang et al. 2006	Figure 1	MYA																	
MYSp03020	20	Malay Peninsula	Penang	5.385887	100.319057	Buang et al. 2006	Figure 1	MYA																	
MYSp03021	21	Malay Peninsula	Tanjung Rhu	4.685343	99.818352	Buang et al. 2006	Figure 1	MYA																	
MYSp03022	22	Sarawak	Pungang	1.894374	115.348130	Buang et al. 2006	Figure 1	MYA																	
MYSp03023	23	Sabah	Tuan Abdul Rahman Park Sapi Island	6.007761	116.006893	Buang et al. 2006	Figure 1	MYA																	
MYSp03024	24	Sabah	Tuan Abdul Rahman Park Manukan Island	5.974373	116.002437	Buang et al. 2006	Figure 1	MYA																	
MYSp03025	25	Sabah	Tuan Abdul Rahman Park Mamuk Island	5.967558	116.014377	Buang et al. 2006	Figure 1	MYA																	
MYSp03026	26	Sabah	Bakungan Keel Island	6.107102	118.109504	Buang et al. 2006	Figure 1	MYA																	
MYSp04001	1	Sarawak	Pungang-Sari Lewas	4.985173	115.451971	Hossain et al. 2015	Figure 4	MYA			1	0	1	0	0	0	0	0	1	1	0	1	0	0	0
MYSp04002	2	Sarawak	Pungang-Sari Lewas	4.912426	115.384415	Hossain et al. 2015	Figure 4	MYA	120		1	0	1	0	0	0	0	0	1	1	0	1	0	0	0
MYSp04003	3	Kelantan	Pengkalan Nangka	6.203034	102.142262	Hossain et al. 2015	Figure B.1	MYA	37		0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
MYSp04004	4	Terengganu	Paka	4.648526	103.436085	Hossain et al. 2015	Figure 8	MYA	27		0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
MYSp05001	1	Sabah	Sibuan	4.652833	118.658000	Hossain et al. 2016	Table 1	MYA																	
MYSp05002	2	Sabah	Maga	4.609000	118.686750	Hossain et al. 2016	Table 1	MYA																	
MYSp05003	3	Sabah	Sebangkat	4.554611	118.662339	Hossain et al. 2016	Table 1	MYA																	
MYSp05004	4	Sabah	Bodgaya	4.601639	118.720833	Hossain et al. 2016	Table 1	MYA																	
MYSp05005	5	Sabah	BohayDulang	4.589639	118.750861	Hossain et al. 2016	Table 1	MYA																	
MYSp05006	6	Sabah	Selakan	4.576056	118.694444	Hossain et al. 2016	Table 1	MYA																	
MYSp05007	7	Sabah	Bum-Bum	4.489689	118.686667	Hossain et al. 2016	Table 1	MYA																	
MYSp05008	8	Sabah	Tiga-I	4.374972	118.600583	Hossain et al. 2016	Table 1	MYA																	
MYSp05009	9	Sabah	Tiga-II	4.367917	118.591778	Hossain et al. 2016	Table 1	MYA																	
MYSp05010	10	Sabah	Tiga-III	4.357972	118.582389	Hossain et al. 2016	Table 1	MYA																	
MYSp05011	11	Sabah	Manampik	4.344778	118.568014	Hossain et al. 2016	Table 1	MYA																	
MYSp05012	12	Sabah	Gusungan-I	4.316111	118.545833	Hossain et al. 2016	Table 1	MYA																	
MYSp05013	13	Sabah	Gusungan-II	4.315111	118.545389	Hossain et al. 2016	Table 1	MYA																	
MYSp05014	14	Sabah	Mabul-I	4.248548	118.631081	Hossain et al. 2016	Table 1	MYA																	

ID	No.	Locality	Station	Lat	Long	Reference	Source	Country	Area (ha)	Remarks	CR	CS	HP	HU	SI	EA	HB	HD	HM	HO	HS	TH	TC	ZJ	RM	
MYSp1101	1	Sarawak	Sematani	1.827528	109.773966	UNEP 2004	Figure 1	MY		Identified using site name and UNEP 2004	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
MYSp1102	2	Sarawak	Lewas	4.968888	115.410548	UNEP 2004	Figure 1	MY		Identified using site name and UNEP 2004	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0	
MYSp1103	3	Sabah	Labuan Island	5.331402	115.190190	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	
MYSp1104	4	Sabah	Tuan Abdul Rahman Park Gaya Island	6.012029	116.028607	UNEP 2004	Figure 2	MY		Identified using site name	1	1	1	1	1	0	1	1	1	1	1	1	0	0	0	
MYSp1105	5	Sabah	Sepanggar bay	6.078921	116.126997	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	1	1	1	1	0	1	1	0	1	1	1	1	0	0	0	
MYSp1106	6	Sabah	Tanjung Kaitan	6.116975	116.097518	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	
MYSp1107	7	Sabah	Matanani island	6.717035	116.347466	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	
MYSp1108	8	Sabah	Tanjung Mengayau	7.036082	116.746831	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
MYSp1109	9	Sabah	Bak-Bak, Kudat	6.948250	116.836624	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	1	1	1	1	1	1	0	0	1	0	1	1	0	0	0	
MYSp1110	10	Sabah	Bangi island	7.105807	117.082574	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	1	1	0	0	1	1	1	0	1	1	0	1	0	0	0	
MYSp1111	11	Sabah	Cribongan island	6.750317	117.456190	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	
MYSp1112	12	Sabah	Selingsaan island	6.174682	118.059035	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	
MYSp1113	13	Sabah	Nunuyan Laut	5.925223	118.103834	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
MYSp1114	14	Sabah	Sandakan	5.864119	118.123054	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
MYSp1115	15	Sabah	Bai island	5.751563	118.105603	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
MYSp1116	16	Sabah	Bagahak	4.928008	118.521152	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	
MYSp1117	17	Sabah	Maganing island	4.819638	118.282036	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	0	0	0	1	0	0	0	0	1	1	0	1	0	0	0	
MYSp1118	18	Sabah	Tabawan island	4.790189	118.355855	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	1	0	0	1	0	0	0	0	0	1	1	0	0	0	0	
MYSp1119	19	Sabah	Sibuan island	4.653346	118.659115	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
MYSp1120	20	Sabah	Bohay Dukang island	4.593742	118.791481	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	0	0	0	1	0	1	0	0	0	1	1	0	0	0	0	
MYSp1121	21	Sabah	Bum Bum island	4.450434	118.750725	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	
MYSp1122	22	Sabah	Mabul island	4.246833	118.633589	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	
MYSp1123	23	Sabah	Spidan island	4.114773	118.626828	UNEP 2004	Figure 2	MY		Identified using site name and UNEP 2004	1	0	1	1	0	0	0	0	0	1	0	1	1	0	0	
PHLp0101	1	San Sebastian, Sorsogon	SSE	12.626639	124.095056	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0102	2	Bacon, Sorsogon	BAC	13.036778	124.030828	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0103	3	Lumang Bayan, Oriental Mindoro	LMB	13.416444	121.040222	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0104	4	Dulangan, Oriental Mindoro	DLG	13.467611	120.975472	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0105	5	Hondura Bay, Oriental Mindoro	HNR	13.495917	120.955250	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0106	6	Capalete It., Quezon	CQB	14.253194	121.830889	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0107	7	Camayan Beach, Zamboela	CMY	14.764889	120.248811	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0108	8	NE Anda Island, Pangasinan	AND	16.323028	120.023611	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0109	9	East Santiago Island, Pangasinan	ESA	16.403836	119.967403	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0110	10	Puerto Princesa Bay, Palawan	PPB	9.773361	118.728742	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0111	11	Ulugan Bay, Palawan	ULG	10.012139	118.784028	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0112	12	Bantayan, Negros Oriental	BAN	9.330667	123.309944	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0113	13	Unawa, Negros Occidental	UNO	9.966917	122.969178	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0114	14	Sabang, Guimaras	SAB	10.477444	122.665167	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0115	15	Nadulao, Guimaras	NAD	10.505639	122.741056	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0116	16	Guluan, Eastern Samar	GUL	10.971611	125.807306	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0117	17	UP Botanical Garden, Leyte	BOG	11.248417	125.087150	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0118	18	Kota Park, Madrigales	KOT	11.300750	123.727861	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0119	19	Look Tutohoan, Iloilo	LOT	11.302750	123.174278	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0120	20	Apo Beach, Davao del Sur	APD	6.746839	125.366839	Arnesgado et al. 2015	Table 1	PHL			0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0201	1	San Sebastian, Sorsogon	SSE	12.626639	124.095056	Arnesgado et al. 2016	Table 1	PHL			1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0202	2	Bacon, Sorsogon	BAC	13.036778	124.030828	Arnesgado et al. 2016	Table 1	PHL			1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0203	3	Bahao Loman, Camarines Sur	BAL	13.632389	122.834194	Arnesgado et al. 2016	Table 1	PHL			1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0204	4	Capit, Cagayan Valley	CTL	18.366250	122.027867	Arnesgado et al. 2016	Table 1	PHL			1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0205	5	Chanarian, Batanes Island	CHN	20.434861	121.960528	Arnesgado et al. 2016	Table 1	PHL			1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0206	6	Nalipang, Batanes Island	NLP	20.320750	121.882528	Arnesgado et al. 2016	Table 1	PHL			1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0207	7	Capalete Island, Quezon	CQB	14.253194	121.830889	Arnesgado et al. 2016	Table 1	PHL			1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0208	8	Puritan, Aurora	PUN	15.758511	121.594000	Arnesgado et al. 2016	Table 1	PHL			1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0209	9	SE Verde Island, Oriental	SEV	13.526811	121.085472	Arnesgado et al. 2016	Table 1	PHL			1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0210	10	Manila Channel, Oriental	MCH	13.517139	120.952111	Arnesgado et al. 2016	Table 1	PHL			1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0211	11	Balete, Oriental Mindoro	BLT	13.507156	120.931500	Arnesgado et al. 2016	Table 1	PHL			1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0212	12	Morong, Zambales	MRO	14.696667	120.268583	Arnesgado et al. 2016	Table 1	PHL			1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0213	13	Camayan Beach, Central Luzon	CMY	14.764889	120.248611	Arnesgado et al. 2016	Table 1	PHL			1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0214	14	NE Anda Island, Pangasinan	AND	16.323028	120.023611	Arnesgado et al. 2016	Table 1	PHL			1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0215	15	NE Santiago Island, Pangasinan	NES	16.428917	119.953167	Arnesgado et al. 2016	Table 1	PHL			1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0216	16	Ilog-Marino, Pangasinan	ILM	16.355583	119.812056	Arnesgado et al. 2016	Table 1	PHL			1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLp0217	17	Ulugan Bay, Palawan	ULG	10.012139	118.784028	Arnesgado et al. 2016	Table 1	PHL			1	0	0	0												

46

ID	No.	Locality	Station	Lat	Long	Reference	Source	Country	Area (ha)	Remarks	CR	CS	HP	HU	SI	EA	HB	HD	HM	HO	HS	TH	TC	ZJ	RM
PHLpt0405	105	No information		16.243986	120.402465	Fortes 2013	Figure 1	PHL		Position is low accuracy															
PHLpt0406	106	No information		16.428571	119.911136	Fortes 2013	Figure 1	PHL		Position is low accuracy															
PHLpt0407	107	No information		16.415447	120.291394	Fortes 2013	Figure 1	PHL		Position is low accuracy															
PHLpt0408	108	No information		17.120223	122.620093	Fortes 2013	Figure 1	PHL		Position is low accuracy															
PHLpt0409	109	No information		17.200038	122.437621	Fortes 2013	Figure 1	PHL		Position is low accuracy															
PHLpt0410	110	No information		18.263111	122.325454	Fortes 2013	Figure 1	PHL		Position is low accuracy															
PHLpt0411	111	No information		18.329767	122.052220	Fortes 2013	Figure 1	PHL		Position is low accuracy															
PHLpt0412	112	No information		18.417575	122.276182	Fortes 2013	Figure 1	PHL		Position is low accuracy															
PHLpt0413	113	No information		18.533550	120.701247	Fortes 2013	Figure 1	PHL		Position is low accuracy															
PHLpt0414	114	No information		18.600705	120.776867	Fortes 2013	Figure 1	PHL		Position is low accuracy															
PHLpt0415	115	No information		18.610362	121.032550	Fortes 2013	Figure 1	PHL		Position is low accuracy															
PHLpt0416	116	No information		18.870887	121.280901	Fortes 2013	Figure 1	PHL		Position is low accuracy															
PHLpt0417	117	No information		19.320855	121.525263	Fortes 2013	Figure 1	PHL		Position is low accuracy															
PHLpt0418	118	No information		19.489558	121.301097	Fortes 2013	Figure 1	PHL		Position is low accuracy															
PHLpt0501	1	Cagbalete island	CGB	14.250056	121.816917	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0502	2	Sawanga Bacon	BAC	13.037156	124.052772	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0503	3	San Sebastian	SSB	12.617607	124.097725	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0504	4	Guisan	GUJ	10.966750	125.800111	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0505	5	Chanarian	CNR	20.433361	121.950167	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0506	6	Sabtang island	NLP	20.320424	121.884088	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0507	7	Santiago island	SAN	16.416806	119.950111	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0508	8	Anda island	AND	16.161778	120.016178	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0509	9	Camayan	CMY	14.756453	120.245608	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0510	10	Morong	MOR	14.666894	120.266694	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0511	11	Puerto Galera	PHR	13.493830	120.957802	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0512	12	Dulangan	DLG	13.466874	120.974011	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0513	13	Catican	UNB	11.933333	121.950194	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0514	14	Alegria	PAB	10.250139	123.369917	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0515	15	Danao	ALB	9.544622	123.762880	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0516	16	Dumaguete	BAN	9.319648	123.313396	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0517	17	Lotuban	SII	9.065572	123.143819	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0518	18	Mabunao	RIZ	8.625493	123.544824	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0519	19	Laguindingan	SLW	8.622999	124.469845	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0520	20	Pobiciacion	OPL	8.522187	124.574783	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0521	21	San Agustin	SAG	6.579611	125.480833	Kurokuchi et al. 2016	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0601	1	San-Men Gang	H-M	19.253333	119.253333	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0602	2	Li-An Gang	H-LA	18.434167	110.043889	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0603	3	Xin-Cun Gang	H-XC	18.412500	109.970278	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0604	4	Anda Island	W-Ad	16.320000	120.012222	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0605	5	Santiago Island	W-SI	16.428889	119.953056	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0606	6	Ilog-Marino	W-Im	16.355556	119.811944	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0607	7	Camayan Beach	W-Cm	14.755000	120.248611	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0608	8	Morong	W-M	14.666811	120.266811	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0609	9	Balsiero	D-B	13.507500	120.931389	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0610	10	Manila Channel	D-Mc	13.517222	120.952222	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0611	11	Boquete	D-Bq	13.510833	120.948611	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0612	12	Donutara Bay	D-Hr	13.495833	120.958333	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0613	13	Cagbalete Island	E-Cg	14.253333	121.830833	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0614	14	Bacon	E-Bc	13.036667	124.053056	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0615	15	San Sebastian	E-Ss	12.626156	124.095738	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0616	16	Magallanes	E-Mg	12.530088	123.534444	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0617	17	Bahao Libmanan	E-Bh	13.632500	122.834167	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0618	18	Bulwang	P-Ba	12.264444	119.888333	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0619	19	Salvacion	P-Sl	12.265278	119.895833	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0620	20	Decabobo	P-Dc	12.134626	119.930572	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0621	21	Jendi Sea Front	P-Js	12.000833	120.227778	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0622	22	Ulugan Bay	P-Ul	10.025666	118.785046	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0623	23	Honda Bay	P-Hd	9.814107	118.767411	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0624	24	Puerto Purisness Bay	P-Pp	9.773333	118.730000	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0625	25	Union Beach	V-Un	11.934202	121.962003	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0626	26	Tago Island	V-Tg	11.281389	123.144167	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PHLpt0627	27	Iakong	V-Ih	10.413337	122.504540	Nakajima et al. 2014	Table 1	PHL		Revised lat & long from satellite map	0	0	0	0	1	0	0	0	0						

ID	No.	Locality	Station	Lat	Long	Reference	Source	Country	Area (ha)	Remarks	CR	CS	HP	HU	SI	EA	HB	HD	HM	HO	HS	TH	TC	ZJ	RM
PHLpt0907	7	Luzon	CAL_PAG	13.797069	120.673969	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0908	8	Luzon	CAL_PAG	13.812361	120.665819	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0909	9	Camantilis	CAM_S1	16.190136	120.046303	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0910	10	Camantilis	CAM_S2	16.190329	120.049289	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0911	11	Gapas gapas	Cebu_S1	10.258381	123.914781	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0912	12	Hilutungan	Hilutungan	10.210319	123.987919	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0913	13	Nalusuan	Nalusuan	10.190389	123.999861	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0914	14	Hilutungan	Hilutungan/VII	10.209539	123.990189	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0915	15	Sangat	Sangat	11.978361	120.062111	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0916	16	Busuanga	Decalve	11.994086	120.084919	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0917	17	Malcatop East	MalcatopE	12.015960	119.917519	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0918	18	Malcatop West	MalcatopW	12.034911	119.909650	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0919	19	Bugur	BugurMPA	11.915561	120.037511	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0920	20	Ditayayan	Ditayayan	11.732681	120.104800	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0921	21	Bulalacao	Tanjilaw	11.765381	120.135531	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0922	22	Bulalacao	Bulalacao	11.745400	120.161850	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0923	23	Culon	MonteMar	11.805031	120.053089	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0924	24	Danjugan	BambocB	9.875400	122.380250	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0925	25	Danjugan	ThudLagom	9.871425	122.379414	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0926	26	Danjugan	TurtleBeach	9.874014	122.377108	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0927	27	Danjugan	TaborBeach	9.869956	122.375550	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0928	28	Dewey	DEW_S1	16.408244	119.959883	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0929	29	Dewey	DEW_S2	16.408356	119.963989	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0930	30	Governor	Governor	16.204425	120.039531	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0931	31	M Daku	MDA	10.953969	123.362372	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0932	32	M Dityay	MDI	10.962078	123.546083	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0933	33	Medio	Medio	13.620744	120.955144	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0934	34	Olympia	OLY_S1	9.617481	123.148422	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0935	35	Olympia	OLY_S2	9.613872	123.143444	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0936	36	Pulong Daku	PD	9.586144	123.156358	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0937	37	Boquete	Boquete	13.512194	120.947986	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0938	38	Medio	NMedio	13.527561	120.955839	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0939	39	Boquete	WBoquete	13.509631	120.945600	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0940	40	Mindoro	PiratesCove	13.607331	120.961331	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0941	41	Medio	SMedio	13.517031	120.957789	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0942	42	Medio	SchoolMedio	13.517219	120.959119	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0943	43	Mindoro	LittleLaLaguna	13.524583	120.970244	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0944	44	Mindoro	Gulid	13.512953	120.963800	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0945	45	Quezon	Quezon	16.222608	120.046700	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0946	46	Mindoro	Sabang	13.620894	120.975378	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0947	47	Shell	Shell	16.194789	120.046411	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0948	48	Siapar	SIA_S1	16.367811	119.961939	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0949	49	Silaqui	SIL_GC	16.443886	119.923183	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0950	50	Silaqui	SIL_S1	16.440331	119.923728	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0951	51	Silaqui	SIL_S2	16.440733	119.922097	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0952	52	Silaqui	SIL_S3	16.443119	119.925069	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0953	53	Suyac	Suyac	10.948967	123.454028	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt0954	54	Turtle	Turtle	9.829692	122.366300	Quiros et al. 2017	Appendix 1	PHL																	
PHLpt1001	1	Lagundingan	T1	8.623286	124.468245	Sharma et al. 2017	Figure 1	PHL																	
PHLpt1002	2	Lagundingan	T2	8.624066	124.465817	Sharma et al. 2017	Figure 1	PHL																	
PHLpt1003	3	Lagundingan	T3	8.624299	124.455466	Sharma et al. 2017	Figure 1	PHL																	
PHLpt1004	4	Lagundingan	T4	8.623590	124.449957	Sharma et al. 2017	Figure 1	PHL																	
PHLpt1101	1	MindoroPaniquian		13.518333	120.951167	Short et al. 2014	Table 1	PHL			1	0	0	1	0	1	0	0	0	1	0	1	0	0	0
PHLpt1102	2	MindoroSabang		13.521390	120.977390	Short et al. 2014	Table 1	PHL			1	0	0	0	0	0	0	0	0	1	0	1	0	0	0
PHLpt1201	1	Silaqui Island	Site 1	16.441142	119.925492	Tanaka et al. 2014	Materials and methods	PHL			1	0	0	1	1	0	0	0	0	1	0	1	0	0	0
PHLpt1202	2	Binabalian Loo	Site 2	16.384528	119.912197	Tanaka et al. 2014	Materials and methods	PHL			1	0	0	1	0	1	0	0	0	0	0	1	0	0	0
PHLpt1203	3	Palatan	Site 3	16.367631	119.962369	Tanaka et al. 2014	Materials and methods	PHL			1	0	0	0	1	0	0	0	0	0	0	1	0	0	0
PHLpt1301	1	Quang Quang		6.930703	126.248270	Troch et al. 2008	Materials and methods	PHL			0	0	0	1	1	0	0	0	1	0	0	1	0	0	0
PHLpt1401	1	SW of Tabangao Is.	St. 1	9.833259	124.561624	Tuyogon 2008	Table 1	PHL			0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
PHLpt1402	2	Galangaman Is.	St. 2	9.830916	124.561240	Tuyogon 2008	Table 1	PHL			0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
PHLpt1403	3	North of Kawasihan Is.	St. 3	9.832397	124.569628	Tuyogon 2008	Table 1	PHL			1	1	0	0	0	1	0	0	0	0	0	0	0	0	0
PHLpt1404	4	NW of Kawasihan Is.	St. 4	9.832483	124.567162	Tuyogon 2008	Table 1	PHL			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLpt1501	1	Capayas		8.579382	123.765509	Venus et al. 2014	Figure 1	PHL			1	0	0	0	0	1	0	0	0	0	0	1	0	0	0
PHLpt1502	2	Danlugan		8.557271	123.764875	Venus et al. 2014	Figure 1	PHL			0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
PHLpt1503	3	Manababay		8.528764	123.780105	Venus et al. 2014	Figure 1	PHL			1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SGPpt101	1	Tuas		1.327121	103.628728	McKenzie et al. 2016	Figure 1	SGP			0	0	0	0	0	1	0	0	0	1	1	0	0	0	0
SGPpt102	2	Lim Chu Kang Mangroves		1.446681	103.708856	McKenzie et al. 2016	Figure 1	SGP			0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SGPpt103	3	Sungei Buloh+ Kranji		1.445482	103.733637	McKenzie et al. 2016	Figure 1	SGP			0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SGPpt104	4	Mandai		1.441941	103.763198	McKenzie et al. 2016	Figure 1	SGP			0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SGPpt105	5	Pulau Pergam		1.398073	103.660678	McKenzie et al. 2016	Figure 1	SGP			0	0	0	0	0	1	0	1	1	1	1	0	0	0	0
SGPpt106	6	Punggol		1.421674	10																				

ID	No.	Locality	Station	Lat	Long	Reference	Source	Country	Area (ha)	Remarks	CR	CS	HP	HU	SI	EA	HB	HD	HM	HO	HS	TH	TC	ZJ	RM
SGPp126	26	Pulau Hantu		1.224331	103.751978	McKenzie et al. 2016	Figure 1	SGP			0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
SGPp127	27	Pulau Semakau		1.210055	103.756419	McKenzie et al. 2016	Figure 1	SGP			0	1	0	1	1	1	0	1	0	1	0	1	0	0	0
SGPp128	28	Pulau Jong		1.214818	103.786780	McKenzie et al. 2016	Figure 1	SGP			0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
SGPp129	29	Pulau Sudong		1.208151	103.728342	McKenzie et al. 2016	Figure 1	SGP			0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
SGPp130	30	Pulau Salu		1.217352	103.707561	McKenzie et al. 2016	Figure 1	SGP			0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SGPp131	31	Pulau Pawai		1.187981	103.721839	McKenzie et al. 2016	Figure 1	SGP			1	1	1	1	1	1	0	0	1	0	1	1	0	0	0
SGPp132	32	Pulau Senang		1.175004	103.736107	McKenzie et al. 2016	Figure 1	SGP			0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
SGPp133	33	Pulau Bida		1.164808	103.742350	McKenzie et al. 2016	Figure 1	SGP			0	0	0	1	0	0	0	0	0	1	0	1	0	0	0
SGPp134	34	Pulau Satumu(Raffles Lighthouse)		1.159961	103.741099	McKenzie et al. 2016	Figure 1	SGP			0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SGPp135	35	Terumbu Pandan (Cyrene Reef)		1.258629	103.754615	McKenzie et al. 2016	Figure 1	SGP			1	1	0	1	1	1	0	1	0	1	0	1	0	0	0
SGPp136	36	Terumbu Pempang Darat		1.226711	103.737542	McKenzie et al. 2016	Figure 1	SGP			0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
SGPp137	37	Terumbu Pempang Laut		1.232263	103.721362	McKenzie et al. 2016	Figure 1	SGP			0	0	0	0	1	1	0	0	0	1	0	1	0	0	0
SGPp138	38	Terumbu Pempang Tengah		1.227609	103.730621	McKenzie et al. 2016	Figure 1	SGP			0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
SGPp139	39	Terumbu bemban		1.208896	103.741191	McKenzie et al. 2016	Figure 1	SGP			1	1	0	0	1	1	0	0	0	1	0	1	0	0	0
SGPp140	40	Beting Bemban Besar		1.208247	103.747538	McKenzie et al. 2016	Figure 1	SGP			1	1	0	0	1	1	0	0	0	1	0	1	0	0	0
SGPp141	41	Terumbu Raya		1.214338	103.753247	McKenzie et al. 2016	Figure 1	SGP			1	1	0	0	0	1	0	0	0	1	0	1	0	0	0
SGPp142	42	Terumbu Semakau		1.212243	103.768615	McKenzie et al. 2016	Table 4	SGP			0	1	0	0	0	1	0	0	0	1	0	0	0	0	0
SGPp201	1	Changi		1.363288	104.020871	Yasuk et al. 2013	Figure 1	SGP																	
VNMP101	1	Gia Luan		20.850333	106.962697	Huang et al. 2003	2.1. Study site	VNM	N.D.																
VNMP201	1	Nha Mac Warp		20.838841	106.796417	Luong et al. 2012	Figure 4	VNM	500		0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
VNMP202	2	Tien Beach(Nha Tran bay)		12.168310	109.206283	Luong et al. 2012	Figure 4	VNM	100		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
VNMP203	3	Bach Long Vy Island		20.135871	107.724204	Luong et al. 2012	Figure 4	VNM	10		0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
VNMP204	4	Cam Ranh Gulf		11.915094	109.204852	Luong et al. 2012	Figure 4	VNM	300		0	0	0	1	0	0	0	0	1	0	0	1	0	0	0
VNMP205	5	Con Dao Island		8.687953	106.635432	Luong et al. 2012	Figure 4	VNM	200		0	1	1	1	1	1	0	0	1	1	0	1	0	0	0
VNMP206	6	Cua Dai Estuary		15.871337	108.396192	Luong et al. 2012	Figure 4	VNM	162		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNMP207	7	Cu Mong Lagoon		13.837384	109.263040	Luong et al. 2012	Figure 4	VNM	250		1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
VNMP208	8	Thuy Trieu Lagoon		12.103877	109.165016	Luong et al. 2012	Figure 4	VNM	800		0	0	0	1	0	1	1	0	1	1	0	1	0	0	1
VNMP209	9	Thuy Trieu Lagoon		12.048453	109.183912	Luong et al. 2012	Figure 4	VNM	N.D.		0	0	0	1	0	1	0	1	1	0	1	0	0	0	1
VNMP210	10	Ha Lagoon		21.200094	107.611609	Luong et al. 2012	Figure 4	VNM	80		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
VNMP211	11	Nha Phu Lagoon		12.433611	109.172922	Luong et al. 2012	Figure 4	VNM	30		0	0	0	1	0	1	1	0	1	1	0	1	0	0	1
VNMP212	12	De Gi Lagoon		14.128067	109.190112	Luong et al. 2012	Figure 4	VNM	50		0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
VNMP213	13	Dinh Vu		20.826530	106.791504	Luong et al. 2012	Figure 4	VNM	120		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
VNMP214	14	Dong Hoi(Nhat Le Estuary)		17.404046	108.651326	Luong et al. 2012	Figure 4	VNM	200		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
VNMP215	15	Gia Luan		20.852103	106.983121	Luong et al. 2012	Figure 4	VNM	100		0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
VNMP216	16	Ha Coi		21.444386	107.906849	Luong et al. 2012	Figure 4	VNM	150		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
VNMP217	17	Hon Rwar		16.094053	108.094068	Luong et al. 2012	Figure 4	VNM	200		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNMP218	18	Hon Khoi		12.563325	109.209470	Luong et al. 2012	Figure 4	VNM	100		1	0	0	1	0	0	0	0	1	0	1	0	0	0	0
VNMP219	19	Lach Huyen		20.813345	106.914273	Luong et al. 2012	Figure 4	VNM	60		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
VNMP220	20	Lana Co		16.230973	108.079604	Luong et al. 2012	Figure 4	VNM	120		0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
VNMP221	21	Long Chau		20.625228	107.162277	Luong et al. 2012	Figure 4	VNM	10		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
VNMP222	22	My Hoa - My Tuong		11.610143	109.153464	Luong et al. 2012	Figure 4	VNM	15		1	0	0	1	0	1	0	0	0	0	0	1	0	0	0
VNMP223	23	My Giang - Ninh THUY	My Giang	12.485278	109.296343	Luong et al. 2012	Figure 4	VNM	80		1	0	0	1	0	1	0	0	1	1	0	1	0	0	0
VNMP224	24	My Giang - Ninh THUY	Ninh THUY	12.507836	109.243376	Luong et al. 2012	Figure 4	VNM			0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
VNMP225	25	Ranh River		17.706121	108.471181	Luong et al. 2012	Figure 4	VNM	500		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
VNMP226	26	Tam Giang - Cau Hai Lago	Cau Hai Lagoon	16.345274	107.858813	Luong et al. 2012	Figure 4	VNM	1000		0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
VNMP227	27	Thi Nai Lagoon	TNMR5	13.858779	109.234773	Luong et al. 2012	Figure 4	VNM	200		0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
VNMP228	28	Van Phong Bay		12.722538	109.306861	Luong et al. 2012	Figure 4	VNM	200		1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
VNMP229	29	Van Phong Bay	Hon bib	12.716942	109.306683	Luong et al. 2012	Figure 4	VNM	N.D.		1	0	0	1	0	1	0	0	1	1	0	1	0	0	0
VNMP230	30	Van Phong Bay	Xuan Tu	12.697330	109.235286	Luong et al. 2012	Figure 4	VNM	N.D.		1	0	0	1	0	1	0	0	1	1	0	1	0	0	0
VNMP231	31	Van Phong Bay	Xuan Ha	12.639714	109.197216	Luong et al. 2012	Figure 4	VNM	N.D.		1	0	0	1	0	0	0	0	1	1	0	1	0	0	0
VNMP232	32	Ha Long Bay		20.877055	107.209765	Luong et al. 2012	Figure 4	VNM	30		0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
VNMP233	33	Phu Quoc Island		10.309041	104.089192	Luong et al. 2012	Figure 4	VNM	10063		1	1	1	1	1	1	0	0	1	1	0	1	0	0	0
VNMP301	1	Quang Ninh		20.735992	107.017364	Luong et al. 2014	Figure 1	VNM	N.D.																
VNMP302	2	Quang Ninh		20.905245	106.891091	Luong et al. 2014	Figure 1	VNM	N.D.																
VNMP303	3	Quang Ninh		20.947340	107.026444	Luong et al. 2014	Figure 1	VNM	N.D.																
VNMP304	4	Quang Ninh		21.083434	107.381917	Luong et al. 2014	Figure 1	VNM	N.D.																
VNMP305	5	Quang Ninh		21.294304	107.455325	Luong et al. 2014	Figure 1	VNM	N.D.																
VNMP306	6	Quang Ninh		21.108945	107.810595	Luong et al. 2014	Figure 1	VNM	N.D.																
VNMP307	7	Quang Ninh		21.388937	107.699464	Luong et al. 2014	Figure 1	VNM	N.D.																
VNMP308	8	Quang Ninh		21.510062	107.910399	Luong et al. 2014	Figure 1	VNM	N.D.																
VNMP309	9	Quang Ninh		20.841120	106.780597	Luong et al. 2014	Figure 1	VNM	N.D.																
VNMP310	10	Ha Phong		20.627325	106.680794	Luong et al. 2014	Figure 1	VNM	N.D.																
VNMP311	11	Thai Binh		20.516932	106.588008	Luong et al. 2014	Figure 1	VNM	N.D.																
VNMP312	12	Ninh Binh		20.023478	106.200073	Luong et al. 2014	Figure 1	VNM	N.D.																
VNMP313	13	Nam Dinh		20.292705	106.605770	Luong et al. 2014	Figure 1	VNM	N.D.																
VNMP314	14	Thanh Hoa		19.331222	1																				

ID	No.	Locality	Station	Lat	Long	Reference	Source	Country	Area (ha)	Remarks	CR	CS	HP	HU	SI	EA	HB	HD	HM	HO	HS	TH	TC	TJ	RM
VNMp410	10	Thi Nai lagoon	TNMR18	13.798040	109.274032	Luong and Nga 2017	Figure 1	VNM	1		0	0	1	1	0	0	0	0	0	1	0	0	0	0	0
VNMp411	11	Thi Nai lagoon	TNMR19	13.772100	109.252999	Luong and Nga 2017	Figure 1	VNM	N.D.		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
VNMp501	1	Tuan le		12.770599	109.351200	Pham et al 2006	Figure 1	VNM	100		1	0	0	1	0	1	0	0	1	1	0	1	0	0	0
VNMp502	2	Hon bib		12.714027	109.309262	Pham et al 2006	Figure 1	VNM	10		0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
VNMp503	3	Xuan Tu		12.700018	109.241870	Pham et al 2006	Figure 1	VNM	30	Area is VNMp078 and 079 value	1	0	0	0	0	1	0	0	1	1	0	1	0	0	0
VNMp504	4	Xuan Ha		12.640966	109.203400	Pham et al 2006	Figure 1	VNM	40																
VNMp505	5	Hon Khoi		12.570323	109.208373	Pham et al 2006	Figure 1	VNM	40		1	0	0	1	0	1	0	0	0	1	0	1	0	0	0
VNMp506	6	My Giang		12.488072	109.290741	Pham et al 2006	Figure 1	VNM	20	Area is VNMp081 and 082 value	1	1	0	1	0	1	0	0	1	1	0	1	0	0	0
VNMp507	7	Ninh Phuoc		12.466538	109.295278	Pham et al 2006	Figure 1	VNM	20																
VNMp508	8	Nha Phu		12.400260	109.220128	Pham et al 2006	Figure 1	VNM	20		0	0	0	1	0	1	1	0	1	1	0	1	0	0	1
VNMp509	9	Bai Tien, HonChong		12.278823	109.204020	Pham et al 2006	Figure 1	VNM	8		0	0	0	0	0	0	0	0	1	1	0	1	0	0	0
VNMp510	10	Dam Gia		12.228057	109.260474	Pham et al 2006	Figure 1	VNM	10		1	0	0	1	0	1	1	0	1	0	0	1	0	0	0
VNMp511	11	Que Be		12.194186	109.207775	Pham et al 2006	Figure 1	VNM	6		1	0	0	1	0	1	0	0	0	1	0	1	0	0	0
VNMp512	12	Thuy Trieu		12.106751	109.166987	Pham et al 2006	Figure 1	VNM	350		0	0	0	1	0	1	0	0	1	1	0	1	0	0	0
VNMp513	13	Dong Ba Thin		12.030711	109.194639	Pham et al 2006	Figure 1	VNM	N.D.																
VNMp514	14	My Ca		11.977355	109.211446	Pham et al 2006	Figure 1	VNM	N.D.																
VNMp515	15	Cam Ranh		11.904266	109.155046	Pham et al 2006	Figure 1	VNM	200		0	0	0	1	0	1	0	0	0	1	0	1	0	0	0

Seagrass polygon DB.csv

ID	No.	Locality	Site	Lat	Long	Reference	Source	Country	Area GIS	Area literature	Remarks	CR	CS	HP	HU	SI	EA	HB	HD	HM	HO	HS	PH	FC	EJ	RM
KHMpy101	1	Koh Kong		11.391548	103.063895	Hines et al. 2008	Figure 2	KHM	4116																	
KHMpy102	2	Kaoh Rong		10.747148	103.275955	Hines et al. 2008	Figure 2	KHM	1769																	
KHMpy103	3	Kampom Som Bay		10.913188	103.685177	Hines et al. 2008	Figure 2	KHM	4677																	
KHMpy104	4	Koh Kong		11.182624	103.077612	Hines et al. 2008	Figure 2	KHM	3516																	
KHMpy105	5	Sihanouk Vile		10.487024	103.614310	Hines et al. 2008	Figure 2	KHM	316																	
KHMpy201	1	Kaoh Rong		10.702961	103.300063	Leng et al. 2014	Figure 1	KHM	19																	
KHMpy202	2	Kaoh Rong		10.667684	103.277404	Leng et al. 2014	Figure 1	KHM	0.1																	
KHMpy203	3	Kaoh Rong Sanlem		10.572622	103.324367	Leng et al. 2014	Figure 1	KHM	1																	
KHMpy301	1	Koh Kong		11.303523	103.105879	Mangroves for the Future 2013	Map 2.3	KHM	79																	
KHMpy302	2	Koh Kong		11.323640	103.040738	Mangroves for the Future 2013	Map 2.3	KHM	22																	
KHMpy303	3	Koh Kong		11.306819	103.028567	Mangroves for the Future 2013	Map 2.3	KHM	22																	
KHMpy401	1	Kampot	Preaek Traot commune	10.583141	103.946394	Supkong and Bourne 2014	Map 7	KHM	1278	1320.5 A		1	1	1	1	1	1	1	0	0	1	0	1	0	0	0
KHMpy402	2	Kampot	Kaoh Touch commune	10.546108	104.046050	Supkong and Bourne 2014	Map 7	KHM	927	976.5 B		0	1	0	1	1	1	0	0	0	0	0	0	1	0	0
KHMpy403	3	Kampot	Boeng Tok commune	10.536128	104.113677	Supkong and Bourne 2014	Map 7	KHM	2480	2581.8 C		1	1	1	1	1	1	0	0	1	1	0	1	0	0	0
KHMpy404	4	Kampot	Trasey Kaoh commune to Koun Satv commune	10.547571	104.180680	Supkong and Bourne 2014	Map 7	KHM	2274	2384.6 D		1	1	1	1	1	1	1	0	1	0	1	0	1	0	0
KHMpy405	5	Kampot	Kampong Trach district	10.427582	104.411326	Supkong and Bourne 2014	Map 7	KHM	1137	1117.6 E		1	1	1	1	1	1	0	1	0	0	0	1	0	0	0
KHMpy406	6	Kampot	Kaoh Ses	10.432323	103.806716	Supkong and Bourne 2014	Map 7	KHM	47	54.7 F		0	1	0	0	0	1	0	0	0	0	0	0	1	0	0
IDNpy101	1	Panjang		-5.920791	106.157349	Douven et al. 2003	Figure 5	IDN	12																	
IDNpy102	2	Panjang		-5.929043	106.167152	Douven et al. 2003	Figure 5	IDN	9																	
IDNpy103	3	Panjang		-5.938486	106.169269	Douven et al. 2003	Figure 5	IDN	7																	
IDNpy104	4	Panjang		-5.939698	106.153618	Douven et al. 2003	Figure 5	IDN	61																	
IDNpy105	5	Besar		-5.943441	106.218959	Douven et al. 2003	Figure 5	IDN	7																	
IDNpy106	6	Kecil		-5.964343	106.192319	Douven et al. 2003	Figure 5	IDN	1																	
IDNpy107	7	Dua		-6.016261	106.190467	Douven et al. 2003	Figure 5	IDN	1																	
IDNpy108	8	Dua		-6.015139	106.184846	Douven et al. 2003	Figure 5	IDN	5																	
IDNpy109	9	Piang		-6.000332	106.155633	Douven et al. 2003	Figure 5	IDN	20																	
IDNpy110	10	Lima		-5.95623	106.150686	Douven et al. 2003	Figure 5	IDN	28																	
IDNpy111	11	Tanjung Gundul		-5.988647	106.148545	Douven et al. 2003	Figure 5	IDN	5																	
IDNpy112	12	Kubur		-5.980031	106.150208	Douven et al. 2003	Figure 5	IDN	17																	
IDNpy113	13	Gosong Dadapan		-5.989182	106.121124	Douven et al. 2003	Figure 5	IDN	8																	
IDNpy114	14	Bojongara		-5.985508	106.104164	Douven et al. 2003	Figure 5	IDN	35																	
IDNpy115	15	Bojongara		-5.962737	106.109928	Douven et al. 2003	Figure 5	IDN	17																	
IDNpy116	16	Bojongara		-5.968893	106.109669	Douven et al. 2003	Figure 5	IDN	25																	
IDNpy117	17	Bojongara		-5.968570	106.108394	Douven et al. 2003	Figure 5	IDN	13																	
IDNpy118	18	Bojongara		-5.954525	106.110012	Douven et al. 2003	Figure 5	IDN	5																	
IDNpy119	19	Tanahan		-5.949187	106.115084	Douven et al. 2003	Figure 5	IDN	8																	
IDNpy201	1	SE Maluku		-7.580343	127.606080	Torres-Pulliza et al. 2013	Figure 5	IDN	8440		Low accuracy															
IDNpy202	2	SE Maluku		-7.518272	127.296576	Torres-Pulliza et al. 2013	Figure 5	IDN	2212		Low accuracy															
IDNpy203	3	SE Maluku		-7.519702	127.431741	Torres-Pulliza et al. 2013	Figure 5	IDN	2827		Low accuracy															
IDNpy204	4	SE Maluku		-7.522133	127.440218	Torres-Pulliza et al. 2013	Figure 5	IDN	6836		Low accuracy															
IDNpy205	5	SE Maluku		-7.588018	127.360477	Torres-Pulliza et al. 2013	Figure 5	IDN	758		Low accuracy															
IDNpy206	6	SE Maluku		-8.066984	127.221189	Torres-Pulliza et al. 2013	Figure 5	IDN	3122		Low accuracy															
IDNpy207	7	SE Maluku		-8.058333	127.145891	Torres-Pulliza et al. 2013	Figure 5	IDN	2660		Low accuracy															
IDNpy208	8	SE Maluku		-8.194726	127.684501	Torres-Pulliza et al. 2013	Figure 5	IDN	6336		Low accuracy															
IDNpy209	9	SE Maluku		-8.174882	127.967903	Torres-Pulliza et al. 2013	Figure 5	IDN	29696		Low accuracy															
IDNpy210	10	SE Maluku		-8.231053	128.157162	Torres-Pulliza et al. 2013	Figure 5	IDN	10312		Low accuracy															
IDNpy211	11	Savu		-10.639245	121.616447	Torres-Pulliza et al. 2013	Figure 5	IDN	3181		Low accuracy															
IDNpy212	12	Savu		-10.462117	121.854900	Torres-Pulliza et al. 2013	Figure 5	IDN	2176		Low accuracy															
IDNpy213	13	Savu		-10.476925	122.005342	Torres-Pulliza et al. 2013	Figure 5	IDN	4629		Low accuracy															
IDNpy214	14	Savu		-10.561133	121.917061	Torres-Pulliza et al. 2013	Figure 5	IDN	3594		Low accuracy															
IDNpy215	15	Savu		-10.597221	121.722840	Torres-Pulliza et al. 2013	Figure 5	IDN	3870		Low accuracy															
IDNpy216	16	Rote		-10.819240	123.227223	Torres-Pulliza et al. 2013	Figure 5	IDN	2336		Low accuracy															
IDNpy217	17	Rote		-10.526283	123.394196	Torres-Pulliza et al. 2013	Figure 5	IDN	13251		Low accuracy															
IDNpy218	18	Rote		-10.551393	123.248614	Torres-Pulliza et al. 2013	Figure 5	IDN	7681		Low accuracy															
IDNpy219	19	Rote		-10.729495	123.299219	Torres-Pulliza et al. 2013	Figure 5	IDN	612		Low accuracy															
IDNpy220	20	Timor		-10.168873	123.560550	Torres-Pulliza et al. 2013	Figure 5	IDN	611		Low accuracy															
IDNpy221	21	Timor		-10.088906	123.549136	Torres-Pulliza et al. 2013	Figure 5	IDN	1571		Low accuracy															
IDNpy222	22	Timor		-10.042098	123.591303	Torres-Pulliza et al. 2013	Figure 5	IDN	1523		Low accuracy															
IDNpy223	23	Timor		-10.291012	123.489941	Torres-Pulliza et al. 2013	Figure 5	IDN	8019		Low accuracy															
IDNpy224	24	Timor		-10.302076	123.407412	Torres-Pulliza et al. 2013	Figure 5	IDN	629		Low accuracy															
IDNpy225	25	Timor		-10.239023	123.424299	Torres-Pulliza et al. 2013	Figure 5	IDN	894		Low accuracy															
IDNpy226	26	Timor		-10.166446	123.491450	Torres-Pulliza et al. 2013	Figure 5	IDN	3308		Low accuracy															
IDNpy227	27	Wetar		-7.983682	125.855137	Torres-Pulliza et al. 2013	Figure 5	IDN	948		Low accuracy															
IDNpy228	28	Wetar		-7.897887	125.812974	Torres-Pulliza et al. 2013	Figure 5	IDN	3104		Low accuracy															
IDNpy229	29	Wetar		-7.935224	125.380544	Torres-Pulliza et al. 2013	Figure 5	IDN	721		Low accuracy															
IDNpy230	30	Wetar		-7.944489	126.433180	Torres-Pulliza et al. 2013	Figure 5	IDN	720		Low accuracy															
IDNpy231	31	Wetar		-7.636580	126.388423	Torres-Pulliza et al. 2013	Figure 5	IDN	727		Low accuracy															
IDNpy232	32	Wetar		-7.590624	126.471478	Torres-Pulliza et al. 2013	Figure 5	IDN	1423		Low accuracy															
IDNpy233	33	Wetar		-7.676881	125.954096	Torres-Pulliza et al. 2013	Figure 5	IDN	6034		Low accuracy															
IDNpy234	34	Wetar		-7.677243	126.810878	Torres-Pulliza et al. 2013	Figure 5	IDN	4288		Low accuracy															
IDNpy235	35	Wetar		-7.744542																						

ID	No.	Locality	Site	Lat	Long	Reference	Source	Country	Area GIS	Area literature	Remarks	CR	CS	HP	HU	SI	EA	HB	HD	HM	HO	HS	PH	TC	EJ	KM
IDNpy255	55	Lembata		-8.239417	123.860445	Torres-Pulliza et al. 2013	Figure 5	IDN		7816	Low accuracy															
IDNpy256	56	Lembata		-8.208966	123.727416	Torres-Pulliza et al. 2013	Figure 5	IDN		480	Low accuracy															
IDNpy257	57	Lembata		-8.182429	123.756710	Torres-Pulliza et al. 2013	Figure 5	IDN		607	Low accuracy															
IDNpy258	58	Lembata		-8.255098	123.622243	Torres-Pulliza et al. 2013	Figure 5	IDN		10915	Low accuracy															
IDNpy259	59	Lembata		-8.345013	123.501128	Torres-Pulliza et al. 2013	Figure 5	IDN		2277	Low accuracy															
IDNpy260	60	Lembata		-8.247850	123.541230	Torres-Pulliza et al. 2013	Figure 5	IDN		2894	Low accuracy															
IDNpy261	61	Lembata		-8.417109	123.316525	Torres-Pulliza et al. 2013	Figure 5	IDN		966	Low accuracy															
IDNpy262	62	Lembata		-8.273601	123.318606	Torres-Pulliza et al. 2013	Figure 5	IDN		22141	Low accuracy															
IDNpy263	63	Lembata		-8.485113	123.260469	Torres-Pulliza et al. 2013	Figure 5	IDN		954	Low accuracy															
IDNpy264	64	Lembata		-8.548759	123.226666	Torres-Pulliza et al. 2013	Figure 5	IDN		1005	Low accuracy															
IDNpy265	65	Lembata		-8.438433	123.090049	Torres-Pulliza et al. 2013	Figure 5	IDN		783	Low accuracy															
IDNpy266	66	Flores		-8.214720	122.988836	Torres-Pulliza et al. 2013	Figure 5	IDN		8859	Low accuracy															
IDNpy267	67	Flores		-8.091906	122.823704	Torres-Pulliza et al. 2013	Figure 5	IDN		2325	Low accuracy															
IDNpy268	68	Flores		-8.152649	122.775707	Torres-Pulliza et al. 2013	Figure 5	IDN		1078	Low accuracy															
IDNpy269	69	Flores		-8.197280	122.811295	Torres-Pulliza et al. 2013	Figure 5	IDN		1034	Low accuracy															
IDNpy270	70	Flores		-8.217230	122.903140	Torres-Pulliza et al. 2013	Figure 5	IDN		1564	Low accuracy															
IDNpy271	71	Flores		-8.220046	122.729281	Torres-Pulliza et al. 2013	Figure 5	IDN		1369	Low accuracy															
IDNpy272	72	Flores		-8.241334	122.771444	Torres-Pulliza et al. 2013	Figure 5	IDN		679	Low accuracy															
IDNpy273	73	Flores		-8.301307	122.602451	Torres-Pulliza et al. 2013	Figure 5	IDN		945	Low accuracy															
IDNpy274	74	Flores		-8.371414	122.716052	Torres-Pulliza et al. 2013	Figure 5	IDN		4450	Low accuracy															
IDNpy275	75	Flores		-8.635139	122.703557	Torres-Pulliza et al. 2013	Figure 5	IDN		805	Low accuracy															
IDNpy276	76	Flores		-8.446254	122.634700	Torres-Pulliza et al. 2013	Figure 5	IDN		10830	Low accuracy															
IDNpy277	77	Flores		-8.628350	122.323610	Torres-Pulliza et al. 2013	Figure 5	IDN		842	Low accuracy															
IDNpy278	78	Flores		-8.746138	122.392623	Torres-Pulliza et al. 2013	Figure 5	IDN		288	Low accuracy															
IDNpy279	79	Flores		-8.791647	122.036710	Torres-Pulliza et al. 2013	Figure 5	IDN		786	Low accuracy															
IDNpy280	80	Flores		-8.515526	122.064099	Torres-Pulliza et al. 2013	Figure 5	IDN		11577	Low accuracy															
IDNpy281	81	Flores		-8.540218	121.582630	Torres-Pulliza et al. 2013	Figure 5	IDN		20995	Low accuracy															
IDNpy282	82	Flores		-8.898393	121.5119870	Torres-Pulliza et al. 2013	Figure 5	IDN		2380	Low accuracy															
IDNpy283	83	Flores		-8.405763	121.063655	Torres-Pulliza et al. 2013	Figure 5	IDN		12729	Low accuracy															
IDNpy284	84	Bali		-8.159415	114.445777	Torres-Pulliza et al. 2013	Figure 5	IDN		2499	Low accuracy															
IDNpy285	85	Bali		-8.101154	114.510747	Torres-Pulliza et al. 2013	Figure 5	IDN		757	Low accuracy															
IDNpy286	86	Bali		-8.133604	114.585438	Torres-Pulliza et al. 2013	Figure 5	IDN		4370	Low accuracy															
IDNpy287	87	Bali		-8.188644	114.824651	Torres-Pulliza et al. 2013	Figure 5	IDN		833	Low accuracy															
IDNpy288	88	Bali		-8.166493	115.009381	Torres-Pulliza et al. 2013	Figure 5	IDN		652	Low accuracy															
IDNpy289	89	Bali		-8.688110	115.451676	Torres-Pulliza et al. 2013	Figure 5	IDN		3364	Low accuracy															
IDNpy290	90	Bali		-8.770365	115.165109	Torres-Pulliza et al. 2013	Figure 5	IDN		651	Low accuracy															
IDNpy291	91	Bali		-8.763480	115.236746	Torres-Pulliza et al. 2013	Figure 5	IDN		4342	Low accuracy															
IDNpy292	92	Bali		-8.537445	115.508670	Torres-Pulliza et al. 2013	Figure 5	IDN		193	Low accuracy															
IDNpy293	93	Lombok		-8.742952	116.952442	Torres-Pulliza et al. 2013	Figure 5	IDN		10442	Low accuracy															
IDNpy294	94	Lombok		-8.873812	116.071740	Torres-Pulliza et al. 2013	Figure 5	IDN		6566	Low accuracy															
IDNpy295	95	Lombok		-8.908050	116.254507	Torres-Pulliza et al. 2013	Figure 5	IDN		2718	Low accuracy															
IDNpy296	96	Lombok		-8.368843	116.087453	Torres-Pulliza et al. 2013	Figure 5	IDN		6570	Low accuracy															
IDNpy297	97	Lombok		-8.315805	116.180784	Torres-Pulliza et al. 2013	Figure 5	IDN		775	Low accuracy															
IDNpy298	98	Lombok		-8.321976	116.714653	Torres-Pulliza et al. 2013	Figure 5	IDN		4158	Low accuracy															
IDNpy299	99	Lombok		-8.449842	116.718453	Torres-Pulliza et al. 2013	Figure 5	IDN		3733	Low accuracy															
IDNpy300	100	Sumbawa		-8.426138	116.969607	Torres-Pulliza et al. 2013	Figure 5	IDN		17198	Low accuracy															
IDNpy301	101	Sumbawa		-8.517117	116.853281	Torres-Pulliza et al. 2013	Figure 5	IDN		3330	Low accuracy															
IDNpy302	102	Sumbawa		-8.541196	116.776281	Torres-Pulliza et al. 2013	Figure 5	IDN		1416	Low accuracy															
IDNpy303	103	Sumbawa		-8.436594	117.393486	Torres-Pulliza et al. 2013	Figure 5	IDN		5101	Low accuracy															
IDNpy304	104	Sumbawa		-8.148904	117.567986	Torres-Pulliza et al. 2013	Figure 5	IDN		286	Low accuracy															
IDNpy305	105	Sumbawa		-8.151439	117.635529	Torres-Pulliza et al. 2013	Figure 5	IDN		976	Low accuracy															
IDNpy306	106	Sumbawa		-8.200397	117.658219	Torres-Pulliza et al. 2013	Figure 5	IDN		262	Low accuracy															
IDNpy307	107	Sumbawa		-8.298641	117.497568	Torres-Pulliza et al. 2013	Figure 5	IDN		1050	Low accuracy															
IDNpy308	108	Sumbawa		-8.425109	117.613204	Torres-Pulliza et al. 2013	Figure 5	IDN		4339	Low accuracy															
IDNpy309	109	Sumbawa		-8.552256	117.668731	Torres-Pulliza et al. 2013	Figure 5	IDN		2807	Low accuracy															
IDNpy310	110	Sumbawa		-8.620266	117.760763	Torres-Pulliza et al. 2013	Figure 5	IDN		1088	Low accuracy															
IDNpy311	111	Sumbawa		-8.514378	117.740231	Torres-Pulliza et al. 2013	Figure 5	IDN		3885	Low accuracy															
IDNpy312	112	Sumbawa		-8.687695	117.837327	Torres-Pulliza et al. 2013	Figure 5	IDN		529	Low accuracy															
IDNpy313	113	Sumbawa		-8.225665	117.704555	Torres-Pulliza et al. 2013	Figure 5	IDN		406	Low accuracy															
IDNpy314	114	Sumbawa		-8.456544	117.978451	Torres-Pulliza et al. 2013	Figure 5	IDN		478	Low accuracy															
IDNpy315	115	Sumbawa		-8.498496	118.135170	Torres-Pulliza et al. 2013	Figure 5	IDN		620	Low accuracy															
IDNpy316	116	Sumbawa		-8.349577	118.301450	Torres-Pulliza et al. 2013	Figure 5	IDN		2584	Low accuracy															
IDNpy317	117	Sumbawa		-8.276774	118.212311	Torres-Pulliza et al. 2013	Figure 5	IDN		220	Low accuracy															
IDNpy318	118	Sumbawa		-8.278906	118.429640	Torres-Pulliza et al. 2013	Figure 5	IDN		2558	Low accuracy															
IDNpy319	119	Sumbawa		-8.297532	118.655873	Torres-Pulliza et al. 2013	Figure 5	IDN		643	Low accuracy															
IDNpy320	120	Sumbawa		-8.345720	118.732613	Torres-Pulliza et al. 2013	Figure 5	IDN		951	Low accuracy															
IDNpy321	121	Sumbawa		-8.388247	118.700736	Torres-Pulliza et al. 2013	Figure 5	IDN		1292	Low accuracy															
IDNpy322	122	Sumbawa		-8.455797	119.041820	Torres-Pulliza et al. 2013	Figure 5	IDN		1203	Low accuracy															
IDNpy323	123	Sumbawa		-8.678603	119.037509	Torres-Pulliza et al. 2013	Figure 5	IDN		5476	Low accuracy															
IDNpy324	124	Sumbawa		-8.637769	119.095739	Torres-Pulliza et al. 2013	Figure 5	IDN		840	Low accuracy															
IDNpy325	125	Sumbawa		-8.581390	119.160599	Torres-Pulliza et al. 2013	Figure 5																			

53

ID	No.	Locality	Site	Lat	Long	Reference	Source	Country	Area GIS	Area literature	Remarks	CR	CS	HP	HU	SI	EA	HB	HD	HM	HO	HS	PH	TC	EJ	RM
IDNpy435	235	Komodo National Park		-8.444393	119.578041	Torres-Pulliza et al. 2013	Figure 5	IDN	8		Low accuracy															
IDNpy436	236	Komodo National Park		-8.451139	119.585493	Torres-Pulliza et al. 2013	Figure 5	IDN	10		Low accuracy															
IDNpy437	237	Komodo National Park		-8.484706	119.526526	Torres-Pulliza et al. 2013	Figure 5	IDN	11		Low accuracy															
IDNpy438	238	Komodo National Park		-8.488783	119.516228	Torres-Pulliza et al. 2013	Figure 5	IDN	16		Low accuracy															
IDNpy439	239	Komodo National Park		-8.485314	119.485188	Torres-Pulliza et al. 2013	Figure 5	IDN	4		Low accuracy															
IDNpy440	240	Komodo National Park		-8.481519	119.475089	Torres-Pulliza et al. 2013	Figure 5	IDN	30		Low accuracy															
IDNpy441	241	Komodo National Park		-8.472922	119.472906	Torres-Pulliza et al. 2013	Figure 5	IDN	18		Low accuracy															
IDNpy442	242	Komodo National Park		-8.465730	119.468008	Torres-Pulliza et al. 2013	Figure 5	IDN	18		Low accuracy															
IDNpy443	243	Komodo National Park		-8.454693	119.471719	Torres-Pulliza et al. 2013	Figure 5	IDN	19		Low accuracy															
IDNpy444	244	Komodo National Park		-8.444588	119.467035	Torres-Pulliza et al. 2013	Figure 5	IDN	32		Low accuracy															
IDNpy445	245	Komodo National Park		-8.442837	119.453153	Torres-Pulliza et al. 2013	Figure 5	IDN	71		Low accuracy															
IDNpy446	246	Komodo National Park		-8.448999	119.443536	Torres-Pulliza et al. 2013	Figure 5	IDN	35		Low accuracy															
IDNpy447	247	Komodo National Park		-8.446121	119.433042	Torres-Pulliza et al. 2013	Figure 5	IDN	9		Low accuracy															
IDNpy448	248	Komodo National Park		-8.484262	119.443638	Torres-Pulliza et al. 2013	Figure 5	IDN	69		Low accuracy															
IDNpy449	249	Komodo National Park		-8.450823	119.442216	Torres-Pulliza et al. 2013	Figure 5	IDN	12		Low accuracy															
IDNpy450	250	Komodo National Park		-8.557845	119.405533	Torres-Pulliza et al. 2013	Figure 5	IDN	150		Low accuracy															
IDNpy451	251	Rote		-10.859593	123.079587	Torres-Pulliza et al. 2013	Figure 5	IDN	72		Low accuracy															
IDNpy452	252	Rote		-10.851847	123.071120	Torres-Pulliza et al. 2013	Figure 5	IDN	38		Low accuracy															
IDNpy453	253	Rote		-10.875286	123.064107	Torres-Pulliza et al. 2013	Figure 5	IDN	38		Low accuracy															
IDNpy454	254	Rote		-10.858097	123.038710	Torres-Pulliza et al. 2013	Figure 5	IDN	64		Low accuracy															
IDNpy455	255	Rote		-10.923313	122.982512	Torres-Pulliza et al. 2013	Figure 5	IDN	18		Low accuracy															
IDNpy456	256	Rote		-10.910445	122.997760	Torres-Pulliza et al. 2013	Figure 5	IDN	239		Low accuracy															
IDNpy457	257	Rote		-10.901710	122.964244	Torres-Pulliza et al. 2013	Figure 5	IDN	50		Low accuracy															
IDNpy458	258	Rote		-10.912321	122.971867	Torres-Pulliza et al. 2013	Figure 5	IDN	46		Low accuracy															
IDNpy459	259	Rote		-10.923986	122.967158	Torres-Pulliza et al. 2013	Figure 5	IDN	34		Low accuracy															
IDNpy460	260	Rote		-10.906791	122.960708	Torres-Pulliza et al. 2013	Figure 5	IDN	63		Low accuracy															
IDNpy461	261	Rote		-10.917441	122.950237	Torres-Pulliza et al. 2013	Figure 5	IDN	122		Low accuracy															
IDNpy462	262	Rote		-10.921736	122.928327	Torres-Pulliza et al. 2013	Figure 5	IDN	229		Low accuracy															
IDNpy463	263	Rote		-10.914539	122.894165	Torres-Pulliza et al. 2013	Figure 5	IDN	187		Low accuracy															
IDNpy464	264	Rote		-10.924887	122.907842	Torres-Pulliza et al. 2013	Figure 5	IDN	11		Low accuracy															
IDNpy465	265	Rote		-10.923603	122.861359	Torres-Pulliza et al. 2013	Figure 5	IDN	45		Low accuracy															
IDNpy466	266	Rote		-10.940155	122.844227	Torres-Pulliza et al. 2013	Figure 5	IDN	79		Low accuracy															
IDNpy467	267	Rote		-10.927104	122.828912	Torres-Pulliza et al. 2013	Figure 5	IDN	17		Low accuracy															
IDNpy468	268	Rote		-10.909636	122.819525	Torres-Pulliza et al. 2013	Figure 5	IDN	97		Low accuracy															
IDNpy469	269	Rote		-10.896299	122.817821	Torres-Pulliza et al. 2013	Figure 5	IDN	26		Low accuracy															
IDNpy470	270	Rote		-10.940414	122.818629	Torres-Pulliza et al. 2013	Figure 5	IDN	987		Low accuracy															
IDNpy471	271	Rote		-10.785589	122.804195	Torres-Pulliza et al. 2013	Figure 5	IDN	195		Low accuracy															
IDNpy472	272	Rote		-10.767722	122.822582	Torres-Pulliza et al. 2013	Figure 5	IDN	122		Low accuracy															
IDNpy473	273	Rote		-10.764545	122.850850	Torres-Pulliza et al. 2013	Figure 5	IDN	135		Low accuracy															
IDNpy474	274	Rote		-10.755233	122.875919	Torres-Pulliza et al. 2013	Figure 5	IDN	99		Low accuracy															
IDNpy475	275	Rote		-10.748099	122.903275	Torres-Pulliza et al. 2013	Figure 5	IDN	170		Low accuracy															
IDNpy476	276	Rote		-10.732697	122.961519	Torres-Pulliza et al. 2013	Figure 5	IDN	117		Low accuracy															
IDNpy477	277	Rote		-10.729686	122.940327	Torres-Pulliza et al. 2013	Figure 5	IDN	88		Low accuracy															
IDNpy478	278	Rote		-10.732009	122.988675	Torres-Pulliza et al. 2013	Figure 5	IDN	64		Low accuracy															
IDNpy479	279	Rote		-10.719682	123.049709	Torres-Pulliza et al. 2013	Figure 5	IDN	44		Low accuracy															
IDNpy480	280	Rote		-10.682025	123.074772	Torres-Pulliza et al. 2013	Figure 5	IDN	34		Low accuracy															
IDNpy481	281	Rote		-10.685112	123.089738	Torres-Pulliza et al. 2013	Figure 5	IDN	24		Low accuracy															
IDNpy482	282	Rote		-10.674124	123.098718	Torres-Pulliza et al. 2013	Figure 5	IDN	25		Low accuracy															
IDNpy483	283	Rote		-10.647387	123.127815	Torres-Pulliza et al. 2013	Figure 5	IDN	113		Low accuracy															
IDNpy484	284	Rote		-11.007776	122.876706	Torres-Pulliza et al. 2013	Figure 5	IDN	30		Low accuracy															
IDNpy485	285	Rote		-10.988329	122.845408	Torres-Pulliza et al. 2013	Figure 5	IDN	91		Low accuracy															
IDNpy486	286	Rote		-10.975383	122.845217	Torres-Pulliza et al. 2013	Figure 5	IDN	31		Low accuracy															
IDNpy487	287	Rote		-10.834549	122.735700	Torres-Pulliza et al. 2013	Figure 5	IDN	225		Low accuracy															
IDNpy488	288	Rote		-10.782180	122.765038	Torres-Pulliza et al. 2013	Figure 5	IDN	577		Low accuracy															
IDNpy489	289	Rote		-10.772117	122.734863	Torres-Pulliza et al. 2013	Figure 5	IDN	6		Low accuracy															
IDNpy490	290	Rote		-10.799723	122.659673	Torres-Pulliza et al. 2013	Figure 5	IDN	141		Low accuracy															
IDNpy491	291	Rote		-10.817894	122.651682	Torres-Pulliza et al. 2013	Figure 5	IDN	131		Low accuracy															
IDNpy492	292	Rote		-10.834107	122.681381	Torres-Pulliza et al. 2013	Figure 5	IDN	127		Low accuracy															
IDNpy493	293	Lombok		-8.916256	116.481776	Torres-Pulliza et al. 2013	Figure 5	IDN	491		Low accuracy															
IDNpy494	294	Lombok		-8.902787	116.514198	Torres-Pulliza et al. 2013	Figure 5	IDN	139		Low accuracy															
IDNpy495	295	Lombok		-8.898751	116.447286	Torres-Pulliza et al. 2013	Figure 5	IDN	31		Low accuracy															
IDNpy496	296	Lombok		-8.849460	116.453199	Torres-Pulliza et al. 2013	Figure 5	IDN	86		Low accuracy															
IDNpy497	297	Lombok		-8.859126	116.458136	Torres-Pulliza et al. 2013	Figure 5	IDN	68		Low accuracy															
IDNpy498	298	Lombok		-8.845597	116.440061	Torres-Pulliza et al. 2013	Figure 5	IDN	142		Low accuracy															
IDNpy499	299	Lombok		-8.849305	116.414472	Torres-Pulliza et al. 2013	Figure 5	IDN	118		Low accuracy															
IDNpy500	300	Lombok		-8.862106	116.410900	Torres-Pulliza et al. 2013	Figure 5	IDN	134		Low accuracy															
IDNpy501	301	Lombok		-8.909016	116.352098	Torres-Pulliza et al. 2013	Figure 5	IDN	400		Low accuracy															
IDNpy502	302	Lombok		-8.919122	116.334096	Torres-Pulliza et al. 2013	Figure 5	IDN	125		Low accuracy															
IDNpy503	303	Lombok		-8.913176	116.321428	Torres-Pulliza et al. 2013	Figure 5	IDN	30		Low accuracy															
IDNpy504	304	Lombok		-8.857897	116.561534	Torres-Pulliza et al. 2013	Figure 5	IDN	287		Low accuracy															
IDNpy505	305	Lombok		-8.860930	116.538739	Torres-Pulliza et al. 2013	Figure 5	IDN	15		Low															

ID	No.	Locality	Site	Lat	Long	Reference	Source	Country	Area GIS	Area literature	Remarks	CR	CS	HP	HU	SI	EA	HB	HD	HM	HO	HS	PH	TC	EJ	RM
PHLpy101	1	Surigao del Sur		9.448949	125.940903	Japitana and Bermoy 2015	Figure 10	PHL	25.0																	
PHLpy102	2	Surigao del Sur		9.438230	125.936565	Japitana and Bermoy 2015	Figure 10	PHL	68.5																	
PHLpy103	3	Surigao del Sur		9.436856	125.929492	Japitana and Bermoy 2015	Figure 10	PHL	75.7																	
PHLpy104	4	Surigao del Sur		9.428075	125.917198	Japitana and Bermoy 2015	Figure 10	PHL	37.0																	
PHLpy105	5	Surigao del Sur		9.431196	125.907900	Japitana and Bermoy 2015	Figure 10	PHL	0.4																	
PHLpy106	6	Surigao del Sur		9.414691	125.906087	Japitana and Bermoy 2015	Figure 10	PHL	220.1																	
PHLpy107	7	Surigao del Sur		9.419440	125.921863	Japitana and Bermoy 2015	Figure 10	PHL	11.0																	
PHLpy108	8	Surigao del Sur		9.405051	125.918257	Japitana and Bermoy 2015	Figure 10	PHL	38.9																	
PHLpy109	9	Surigao del Sur		9.394730	125.919951	Japitana and Bermoy 2015	Figure 10	PHL	5.4																	
PHLpy110	10	Surigao del Sur		9.403953	125.927355	Japitana and Bermoy 2015	Figure 10	PHL	77.1																	
PHLpy111	11	Surigao del Sur		9.391599	125.928922	Japitana and Bermoy 2015	Figure 10	PHL	38.0																	
PHLpy112	12	Surigao del Sur		9.399199	125.934212	Japitana and Bermoy 2015	Figure 10	PHL	72.7																	
PHLpy113	13	Surigao del Sur		9.397819	125.942976	Japitana and Bermoy 2015	Figure 10	PHL	68.9																	
PHLpy114	14	Surigao del Sur		9.274846	126.202291	Japitana and Bermoy 2015	Figure 10	PHL	15.0																	
PHLpy115	15	Surigao del Sur		9.274222	126.183311	Japitana and Bermoy 2015	Figure 10	PHL	1.2																	
PHLpy116	16	Surigao del Sur		9.262888	126.192607	Japitana and Bermoy 2015	Figure 10	PHL	11.4																	
PHLpy117	17	Surigao del Sur		9.257209	126.193532	Japitana and Bermoy 2015	Figure 10	PHL	4.3																	
PHLpy118	18	Surigao del Sur		9.253336	126.189455	Japitana and Bermoy 2015	Figure 10	PHL	11.8																	
PHLpy119	19	Surigao del Sur		9.247436	126.186197	Japitana and Bermoy 2015	Figure 10	PHL	38.5																	
PHLpy120	20	Surigao del Sur		9.242736	126.184552	Japitana and Bermoy 2015	Figure 10	PHL	3.1																	
PHLpy121	21	Surigao del Sur		9.240973	126.186444	Japitana and Bermoy 2015	Figure 10	PHL	1.3																	
PHLpy122	22	Surigao del Sur		9.236746	126.190765	Japitana and Bermoy 2015	Figure 10	PHL	7.6																	
PHLpy123	23	Surigao del Sur		9.234971	126.181114	Japitana and Bermoy 2015	Figure 10	PHL	3.5																	
PHLpy124	24	Surigao del Sur		9.229759	126.183317	Japitana and Bermoy 2015	Figure 10	PHL	5.7																	
PHLpy125	25	Surigao del Sur		9.227631	126.186361	Japitana and Bermoy 2015	Figure 10	PHL	4.7																	
PHLpy126	26	Surigao del Sur		9.692141	126.223234	Japitana and Bermoy 2015	Figure 10	PHL	2.6																	
PHLpy127	27	Surigao del Sur		8.691027	126.222957	Japitana and Bermoy 2015	Figure 10	PHL	1.8																	
PHLpy128	28	Surigao del Sur		8.690397	126.221865	Japitana and Bermoy 2015	Figure 10	PHL	2.5																	
PHLpy129	29	Surigao del Sur		8.690754	126.218692	Japitana and Bermoy 2015	Figure 10	PHL	2.0																	
PHLpy130	30	Surigao del Sur		8.690000	126.217360	Japitana and Bermoy 2015	Figure 10	PHL	5.8																	
PHLpy131	31	Surigao del Sur		8.688437	126.213509	Japitana and Bermoy 2015	Figure 10	PHL	4.8																	
PHLpy132	32	Surigao del Sur		8.687200	126.218756	Japitana and Bermoy 2015	Figure 10	PHL	2.1																	
PHLpy133	33	Surigao del Sur		8.690481	126.210549	Japitana and Bermoy 2015	Figure 10	PHL	6.6																	
PHLpy134	34	Surigao del Sur		8.694572	126.192960	Japitana and Bermoy 2015	Figure 10	PHL	130.8																	
PHLpy135	35	Surigao del Sur		8.691165	126.206392	Japitana and Bermoy 2015	Figure 10	PHL	1.9																	
PHLpy136	36	Surigao del Sur		8.691599	126.189333	Japitana and Bermoy 2015	Figure 10	PHL	1.2																	
PHLpy137	37	Surigao del Sur		8.692021	126.196354	Japitana and Bermoy 2015	Figure 10	PHL	4.6																	
PHLpy138	38	Surigao del Sur		8.689541	126.193672	Japitana and Bermoy 2015	Figure 10	PHL	1.6																	
PHLpy139	39	Surigao del Sur		8.689694	126.191470	Japitana and Bermoy 2015	Figure 10	PHL	1.5																	
PHLpy140	40	Surigao del Sur		8.691013	126.190088	Japitana and Bermoy 2015	Figure 10	PHL	0.3																	
PHLpy141	41	Surigao del Sur		8.689158	126.188331	Japitana and Bermoy 2015	Figure 10	PHL	0.7																	
PHLpy142	42	Surigao del Sur		8.687154	126.179070	Japitana and Bermoy 2015	Figure 10	PHL	7.1																	
PHLpy143	43	Surigao del Sur		8.682768	126.175589	Japitana and Bermoy 2015	Figure 10	PHL	99.9																	
PHLpy144	44	Surigao del Sur		8.676329	126.165576	Japitana and Bermoy 2015	Figure 10	PHL	34.9																	
PHLpy145	45	Surigao del Sur		8.674076	126.151310	Japitana and Bermoy 2015	Figure 10	PHL	41.2																	
PHLpy146	46	Surigao del Sur		8.650006	126.137168	Japitana and Bermoy 2015	Figure 10	PHL	1021.9																	
PHLpy147	47	Surigao del Sur		8.533948	126.203981	Japitana and Bermoy 2015	Figure 10	PHL	659.8																	
PHLpy148	48	Surigao del Sur		8.521404	126.354111	Japitana and Bermoy 2015	Figure 10	PHL	11.6																	
PHLpy149	49	Surigao del Sur		8.519996	126.357416	Japitana and Bermoy 2015	Figure 10	PHL	11.0																	
PHLpy150	50	Surigao del Sur		8.519111	126.364195	Japitana and Bermoy 2015	Figure 10	PHL	85.5																	
PHLpy151	51	Surigao del Sur		8.488308	126.385840	Japitana and Bermoy 2015	Figure 10	PHL	4.5																	
PHLpy152	52	Surigao del Sur		8.465782	126.380980	Japitana and Bermoy 2015	Figure 10	PHL	15.5																	
PHLpy153	53	Surigao del Sur		8.469963	126.368178	Japitana and Bermoy 2015	Figure 10	PHL	36.7																	
PHLpy154	54	Surigao del Sur		8.472417	126.348845	Japitana and Bermoy 2015	Figure 10	PHL	81.4																	
PHLpy155	55	Surigao del Sur		8.464374	126.362301	Japitana and Bermoy 2015	Figure 10	PHL	14.4																	
PHLpy156	56	Surigao del Sur		8.450540	126.364399	Japitana and Bermoy 2015	Figure 10	PHL	241.9																	
PHLpy157	57	Surigao del Sur		8.419251	126.375979	Japitana and Bermoy 2015	Figure 10	PHL	8.2																	
PHLpy158	58	Surigao del Sur		8.406504	126.385732	Japitana and Bermoy 2015	Figure 10	PHL	1.4																	
PHLpy159	59	Surigao del Sur		8.400932	126.383981	Japitana and Bermoy 2015	Figure 10	PHL	16.1																	
PHLpy160	60	Surigao del Sur		8.399421	126.379852	Japitana and Bermoy 2015	Figure 10	PHL	16.5																	
PHLpy161	61	Surigao del Sur		8.394503	126.371862	Japitana and Bermoy 2015	Figure 10	PHL	90.9																	
PHLpy162	62	Surigao del Sur		8.379700	126.368602	Japitana and Bermoy 2015	Figure 10	PHL	25.3																	
PHLpy163	63	Surigao del Sur		8.378595	126.373005	Japitana and Bermoy 2015	Figure 10	PHL	3.2																	
PHLpy164	64	Surigao del Sur		8.377879	126.365054	Japitana and Bermoy 2015	Figure 10	PHL	10.9																	
PHLpy165	65	Surigao del Sur		8.376553	126.360463	Japitana and Bermoy 2015	Figure 10	PHL	4.9																	
PHLpy166	66	Surigao del Sur		8.372885	126.361097	Japitana and Bermoy 2015	Figure 10	PHL	7.4																	
PHLpy167	67	Surigao del Sur		8.374306	126.357682	Japitana and Bermoy 2015	Figure 10	PHL	10.7																	
PHLpy168	68	Surigao del Sur		8.366661	126.351614	Japitana and Bermoy 2015	Figure 10	PHL	17.2																	
PHLpy169	69	Surigao del Sur		8.366143	126.347715	Japitana and Bermoy 2015	Figure 10	PHL	1.3																	
PHLpy170	70	Surigao del Sur		8.361372	126.350212	Japitana and Bermoy 2015	Figure 10	PHL	14.4																	
PHLpy171	71	Surigao del Sur		8.362																						

ID	No.	Locality	Site	Lat	Long	Reference	Source	Country	Area GIS	Area literature	Remarks	CR	CS	HP	HU	SI	EA	HB	HD	HM	HO	HS	PH	TC	EJ	KM
PHLpy301	1	Pangasinan	Bolinao	16.394149	119.886701	Tamondong et al. 2013	Figure 4	PHL	196.1																	
PHLpy302	2	Pangasinan	Bolinao	16.431226	119.926283	Tamondong et al. 2013	Figure 4	PHL	1358.2																	
PHLpy303	3	Pangasinan	Bolinao	16.408947	119.971921	Tamondong et al. 2013	Figure 4	PHL	107.1																	
PHLpy304	4	Pangasinan	Bolinao	16.392770	119.972150	Tamondong et al. 2013	Figure 4	PHL	37.3																	
PHLpy305	5	Pangasinan	Bolinao	16.383706	119.974214	Tamondong et al. 2013	Figure 4	PHL	52.4																	
PHLpy306	6	Pangasinan	Bolinao	16.383276	119.966939	Tamondong et al. 2013	Figure 4	PHL	16.5																	
PHLpy307	7	Pangasinan	Bolinao	16.374102	119.968459	Tamondong et al. 2013	Figure 4	PHL	2.8																	
PHLpy308	8	Pangasinan	Bolinao	16.370525	119.958521	Tamondong et al. 2013	Figure 4	PHL	25.0																	
PHLpy309	9	Pangasinan	Bolinao	16.355603	119.987022	Tamondong et al. 2013	Figure 4	PHL	12.1																	
PHLpy310	10	Pangasinan	Bolinao	16.349550	119.984607	Tamondong et al. 2013	Figure 4	PHL	9.5																	
PHLpy311	11	Pangasinan	Bolinao	16.350107	119.977058	Tamondong et al. 2013	Figure 4	PHL	14.3																	
PHLpy312	12	Pangasinan	Bolinao	16.354259	119.972474	Tamondong et al. 2013	Figure 4	PHL	18.5																	
SGPpy101	1	Cyrene Reef		1.258568	103.754629	Yaakub et al. 2013	Figure 2	SGP	40.3	14.0																
SGPpy102	2	Pulau Semakau		1.211477	103.763196	Yaakub et al. 2013	Figure 2	SGP	0.2																	
SGPpy103	3	Pulau Semakau		1.198810	103.760024	Yaakub et al. 2013	Figure 2	SGP	0.2																	
SGPpy104	4	Pulau Semakau		1.199448	103.759525	Yaakub et al. 2013	Figure 2	SGP	0.4																	
SGPpy105	5	Pulau Semakau		1.198823	103.758679	Yaakub et al. 2013	Figure 2	SGP	0.3																	
SGPpy106	6	Pulau Semakau		1.214597	103.757904	Yaakub et al. 2013	Figure 2	SGP	0.2																	
SGPpy107	7	Pulau Semakau		1.205824	103.756911	Yaakub et al. 2013	Figure 2	SGP	13.1		13.7 Total area of Pulau Semakau SGPpy002-008															
SGPpy108	8	Pulau Semakau		1.204920	103.755599	Yaakub et al. 2013	Figure 2	SGP	0.0																	
SGPpy109	9	Chek Jawa		1.411743	103.992377	Yaakub et al. 2013	Figure 2	SGP	14.5	6.5																
JPNpy101	1	Okinawa island	Yagaji	26.635477	128.047118	Okinawa prefecture 2017-2019	Figure 2	JPN	1.0																	
JPNpy102	2	Okinawa island	Yagaji	26.635790	128.048599	Okinawa prefecture 2017-2019	Figure 2	JPN	0.3																	
JPNpy103	3	Okinawa island	Yagaji	26.638666	128.052041	Okinawa prefecture 2017-2019	Figure 2	JPN	2.1																	
JPNpy104	4	Okinawa island	Yagaji	26.637255	128.044061	Okinawa prefecture 2017-2019	Figure 2	JPN	3.5																	
JPNpy105	5	Okinawa island	Yagaji	26.641615	128.042351	Okinawa prefecture 2017-2019	Figure 2	JPN	33.9																	
JPNpy106	6	Okinawa island	Yagaji	26.639322	128.037440	Okinawa prefecture 2017-2019	Figure 2	JPN	3.1																	
JPNpy107	7	Okinawa island	Yagaji	26.651571	128.046607	Okinawa prefecture 2017-2019	Figure 2	JPN	0.6																	
JPNpy108	8	Okinawa island	Yagaji	26.649761	128.042650	Okinawa prefecture 2017-2019	Figure 2	JPN	1.0																	
JPNpy109	9	Okinawa island	Yagaji	26.659508	128.032356	Okinawa prefecture 2017-2019	Figure 2	JPN	128.9																	
JPNpy110	10	Okinawa island	Yagaji	26.665715	128.044974	Okinawa prefecture 2017-2019	Figure 2	JPN	2.1																	
JPNpy111	11	Okinawa island	Yagaji	26.671401	128.039185	Okinawa prefecture 2017-2019	Figure 2	JPN	2.6																	
JPNpy112	12	Okinawa island	Yagaji	26.676149	128.023262	Okinawa prefecture 2017-2019	Figure 2	JPN	17.2																	
JPNpy113	13	Okinawa island	Yagaji	26.679525	128.017149	Okinawa prefecture 2017-2019	Figure 2	JPN	8.4																	
JPNpy114	14	Okinawa island	Kouri	26.683854	128.025327	Okinawa prefecture 2017-2019	Figure 2	JPN	8.3																	
JPNpy115	15	Okinawa island	Kouri	26.684594	128.017537	Okinawa prefecture 2017-2019	Figure 2	JPN	1.6																	
JPNpy116	16	Okinawa island	Kouri	26.687712	128.020816	Okinawa prefecture 2017-2019	Figure 2	JPN	22.7																	
JPNpy117	17	Okinawa island	Kouri	26.693539	128.025514	Okinawa prefecture 2017-2019	Figure 2	JPN	48.4																	
JPNpy118	18	Okinawa island	Nakijin	26.692630	127.993191	Okinawa prefecture 2017-2019	Figure 2	JPN	12.4																	
JPNpy119	19	Okinawa island	Yagaji	26.649783	128.015265	Okinawa prefecture 2017-2019	Figure 2	JPN	4.1																	
JPNpy120	20	Okinawa island	Yagaji	26.651009	128.003826	Okinawa prefecture 2017-2019	Figure 2	JPN	8.7																	
JPNpy121	21	Okinawa island	Shikoya	26.136192	127.807397	Okinawa prefecture 2017-2019	Figure 2	JPN	109.8																	
JPNpy122	22	Okinawa island	Shikoya	26.138342	127.799172	Okinawa prefecture 2017-2019	Figure 2	JPN	3.5																	
JPNpy123	23	Okinawa island	Shikoya	26.132383	127.794859	Okinawa prefecture 2017-2019	Figure 2	JPN	46.3																	
JPNpy124	24	Okinawa island	Shikoya	26.150251	127.813625	Okinawa prefecture 2017-2019	Figure 2	JPN	1.9																	
JPNpy125	25	Okinawa island	Shikoya	26.150913	127.814506	Okinawa prefecture 2017-2019	Figure 2	JPN	0.1																	
JPNpy126	26	Okinawa island	Shikoya	26.147144	127.811203	Okinawa prefecture 2017-2019	Figure 2	JPN	0.9																	
JPNpy127	27	Okinawa island	Shikoya	26.152613	127.815560	Okinawa prefecture 2017-2019	Figure 2	JPN	1.1																	
JPNpy128	28	Okinawa island	Shikoya	26.137887	127.820847	Okinawa prefecture 2017-2019	Figure 2	JPN	27.7																	
JPNpy129	29	Okinawa island	Shikoya	26.158352	127.823570	Okinawa prefecture 2017-2019	Figure 2	JPN	0.6																	
JPNpy130	30	Okinawa island	Kayo	26.550330	128.113518	Okinawa prefecture 2017-2019	Figure 2	JPN	5.2																	
JPNpy131	31	Okinawa island	Kayo	26.548002	128.108705	Okinawa prefecture 2017-2019	Figure 2	JPN	4.5																	
JPNpy132	32	Okinawa island	Kayo	26.545863	128.106796	Okinawa prefecture 2017-2019	Figure 2	JPN	0.6																	
JPNpy133	33	Okinawa island	Kayo	26.543602	128.103259	Okinawa prefecture 2017-2019	Figure 2	JPN	10.8																	
JPNpy134	34	Okinawa island	Abu	26.538976	128.095100	Okinawa prefecture 2017-2019	Figure 2	JPN	12.5																	
JPNpy135	35	Okinawa island	Henoko	26.509992	128.026881	Okinawa prefecture 2017-2019	Figure 2	JPN	330.5																	
JPNpy136	36	Okinawa island	Bise	26.697401	127.876581	Okinawa prefecture 2017-2019	Figure 2	JPN	2.0																	
JPNpy137	37	Okinawa island	Bise	26.704407	127.877080	Okinawa prefecture 2017-2019	Figure 2	JPN	46.7																	
JPNpy138	38	Okinawa island	Bise	26.702464	127.869601	Okinawa prefecture 2017-2019	Figure 2	JPN	1.6																	
JPNpy139	39	Okinawa island	Bise	26.705239	127.932443	Okinawa prefecture 2017-2019	Figure 2	JPN	22.2																	
JPNpy140	40	Okinawa island	Yonasio Henza	26.360013	127.877901	Okinawa prefecture 2017-2019	Figure 2	JPN	14.4																	
JPNpy141	41	Okinawa island	Yonasio Henza	26.348747	127.865333	Okinawa prefecture 2017-2019	Figure 2	JPN	31.0																	
JPNpy142	42	Okinawa island	Yonasio Henza	26.343149	127.869604	Okinawa prefecture 2017-2019	Figure 2	JPN	4.4																	
JPNpy143	43	Okinawa island	Yonasio Henza	26.339426	127.894145	Okinawa prefecture 2017-2019	Figure 2	JPN	4.4																	
JPNpy144	44	Okinawa island	Yonasio Henza	26.348598	127.915728	Okinawa prefecture 2017-2019	Figure 2	JPN	1224.8																	
JPNpy145	45	Okinawa island	Yonasio Henza	26.332694	127.901363	Okinawa prefecture 2017-2019	Figure 2	JPN	2.0																	
JPNpy146	46	Okinawa island	Yonasio Henza	26.347881	127.943818	Okinawa prefecture 2017-2019	Figure 2	JPN	0.4																	
JPNpy147	47	Okinawa island	Yonasio Henza	26.351049	127.944408	Okinawa prefecture 2017-2019	Figure 2	JPN	6.6																	
JPNpy148	48	Okinawa island	Katsuren	26.328683	127.913273	Okinawa prefecture 2017-2019	Figure 2	JPN	26.6																	
JPNpy149	49	Okinawa island	Katsuren	26.331041	127.919095	Okinawa prefecture 2017-201																				

57

ID	No.	Locality	Site	Lat	Long	Reference	Source	Country	Area GIS	Area literature	Remarks	CR	CS	HP	HU	SI	EA	HB	HD	HM	HO	HS	PH	TC	EJ	RM
TLSpy103	3	Viqueque		-8.933754	126.479378	Torres-Pulliza et al. 2013	Figure 5	TLS		342																
TLSpy104	4	Lautem		-8.670104	127.010904	Torres-Pulliza et al. 2013	Figure 5	TLS		233																
TLSpy105	5	Lautem		-8.479137	127.235617	Torres-Pulliza et al. 2013	Figure 5	TLS		45																
TLSpy106	6	Lautem		-8.363357	127.218442	Torres-Pulliza et al. 2013	Figure 5	TLS		50																
TLSpy107	7	Manatuto		-8.511961	126.074285	Torres-Pulliza et al. 2013	Figure 5	TLS		210																
TLSpy108	8	Lautem		-8.365270	127.094108	Torres-Pulliza et al. 2013	Figure 5	TLS		94																
TLSpy109	9	Lautem		-8.351292	127.084368	Torres-Pulliza et al. 2013	Figure 5	TLS		65																
TLSpy110	10	Lautem		-8.333443	127.019356	Torres-Pulliza et al. 2013	Figure 5	TLS		64																
TLSpy111	11	Lautem		-8.442377	127.338344	Torres-Pulliza et al. 2013	Figure 5	TLS		31																
TLSpy112	12	Lautem		-8.439627	127.313965	Torres-Pulliza et al. 2013	Figure 5	TLS		6																
TLSpy113	13	Lautem		-8.418918	126.712341	Torres-Pulliza et al. 2013	Figure 5	TLS		51																
TLSpy114	14	Lautem		-8.414740	126.712256	Torres-Pulliza et al. 2013	Figure 5	TLS		33																
TLSpy115	15	Baucau		-8.437730	126.659405	Torres-Pulliza et al. 2013	Figure 5	TLS		80																
TLSpy116	16	Baucau		-8.439640	126.471683	Torres-Pulliza et al. 2013	Figure 5	TLS		128																
TLSpy117	17	Liquica		-8.659948	125.455034	Torres-Pulliza et al. 2013	Figure 5	TLS		353																
TLSpy118	18	Manatuto		-8.478136	125.913656	Torres-Pulliza et al. 2013	Figure 5	TLS		6																
TLSpy119	19	Manatuto		-8.475280	125.868054	Torres-Pulliza et al. 2013	Figure 5	TLS		44																
TLSpy120	20	Manatuto		-8.756995	125.388011	Torres-Pulliza et al. 2013	Figure 5	TLS		5																
TLSpy121	21	Manatuto		-8.477215	125.846766	Torres-Pulliza et al. 2013	Figure 5	TLS		4																
TLSpy122	22	Manatuto		-8.480476	125.841378	Torres-Pulliza et al. 2013	Figure 5	TLS		4																
TLSpy123	23	Manatuto		-8.484082	125.836035	Torres-Pulliza et al. 2013	Figure 5	TLS		11																
TLSpy124	24	Dili		-8.501756	125.789997	Torres-Pulliza et al. 2013	Figure 5	TLS		314																
TLSpy125	25	Dili		-8.520941	125.722361	Torres-Pulliza et al. 2013	Figure 5	TLS		539																
TLSpy126	26	Dili		-8.521300	125.614566	Torres-Pulliza et al. 2013	Figure 5	TLS		5																
TLSpy127	27	Dili		-8.523774	125.634117	Torres-Pulliza et al. 2013	Figure 5	TLS		137																
TLSpy128	28	Dili		-8.526232	125.667353	Torres-Pulliza et al. 2013	Figure 5	TLS		136																
TLSpy129	29	Dili		-8.537566	125.609477	Torres-Pulliza et al. 2013	Figure 5	TLS		109																
TLSpy130	30	Dili		-8.201770	125.625096	Torres-Pulliza et al. 2013	Figure 5	TLS		615																
VNMpy101	1	Ly Son Islands		15.389170	109.106766	Ca et al. 2011	Figure 3	VNM		17.1																
VNMpy102	2	Ly Son Islands		15.388843	109.135461	Ca et al. 2011	Figure 3	VNM		9.6																
VNMpy103	3	Ly Son Islands		15.373324	109.117488	Ca et al. 2011	Figure 3	VNM		63.4																
VNMpy104	4	Ly Son Islands		15.429621	109.081789	Ca et al. 2011	Figure 3	VNM		11.1																
VNMpy201	1	Cam Ranh Bay	B	11.964162	109.211003	Chen et al. 2016	Figure 13	VNM		66.0	195.3 Total area of Cam Ranh Bay in 2015 VNMpy201-220															
VNMpy202	2	Cam Ranh Bay	B	11.955424	109.207548	Chen et al. 2016	Figure 13	VNM		33.1																
VNMpy203	3	Cam Ranh Bay	B	11.950510	109.202617	Chen et al. 2016	Figure 13	VNM		1.6																
VNMpy204	4	Cam Ranh Bay	B	11.936184	109.215262	Chen et al. 2016	Figure 13	VNM		68.4																
VNMpy205	5	Cam Ranh Bay	B	11.933734	109.212765	Chen et al. 2016	Figure 13	VNM		2.3																
VNMpy206	6	Cam Ranh Bay	B	11.921562	109.207772	Chen et al. 2016	Figure 13	VNM		2.3																
VNMpy207	7	Cam Ranh Bay	B	11.918045	109.206286	Chen et al. 2016	Figure 13	VNM		33.7																
VNMpy208	8	Cam Ranh Bay	B	11.915737	109.212875	Chen et al. 2016	Figure 13	VNM		0.7																
VNMpy209	9	Cam Ranh Bay	A1	11.965631	109.204005	Chen et al. 2016	Figure 13	VNM		1.1																
VNMpy210	10	Cam Ranh Bay	A1	11.964618	109.202647	Chen et al. 2016	Figure 13	VNM		1.4																
VNMpy211	11	Cam Ranh Bay	A1	11.963878	109.203365	Chen et al. 2016	Figure 13	VNM		0.7																
VNMpy212	12	Cam Ranh Bay	A1	11.962911	109.203888	Chen et al. 2016	Figure 13	VNM		0.4																
VNMpy213	13	Cam Ranh Bay	A1	11.968268	109.200858	Chen et al. 2016	Figure 13	VNM		0.2																
VNMpy214	14	Cam Ranh Bay	A1	11.965709	109.199405	Chen et al. 2016	Figure 13	VNM		0.2																
VNMpy215	15	Cam Ranh Bay	A1	11.955951	109.191781	Chen et al. 2016	Figure 13	VNM		1.4																
VNMpy216	16	Cam Ranh Bay	A2	11.947524	109.188555	Chen et al. 2016	Figure 13	VNM		2.6																
VNMpy217	17	Cam Ranh Bay	A2	11.942652	109.189959	Chen et al. 2016	Figure 13	VNM		8.4																
VNMpy218	18	Cam Ranh Bay	A2	11.844564	109.118276	Chen et al. 2016	Figure 13	VNM		0.6																
VNMpy219	19	Cam Ranh Bay	A4	11.852927	109.117602	Chen et al. 2016	Figure 13	VNM		1.8																
VNMpy220	20	Cam Ranh Bay	A4	11.856840	109.118814	Chen et al. 2016	Figure 13	VNM		3.3																
VNMpy301	1	Phu Quy Island		10.553560	108.947641	Dai et al. 2009	Figure 2	VNM		166.4																
VNMpy302	2	Phu Quy Island		10.522360	108.960615	Dai et al. 2009	Figure 2	VNM		23.6																
VNMpy303	3	Phu Quy Island		10.503663	108.961449	Dai et al. 2009	Figure 2	VNM		45.2																
VNMpy304	4	Phu Quy Island		10.520892	108.930453	Dai et al. 2009	Figure 2	VNM		132.1																
VNMpy401	1	Tam Giang - Cau Hai lagoon		16.574742	107.593713	Luong et al. 2012	Figure 6	VNM		14.0																
VNMpy402	2	Tam Giang - Cau Hai lagoon		16.562465	107.614533	Luong et al. 2012	Figure 6	VNM		6.8																
VNMpy403	3	Tam Giang - Cau Hai lagoon		16.528096	107.648142	Luong et al. 2012	Figure 6	VNM		23.3																
VNMpy404	4	Tam Giang - Cau Hai lagoon		16.525493	107.658514	Luong et al. 2012	Figure 6	VNM		159.7																
VNMpy405	5	Tam Giang - Cau Hai lagoon		16.506139	107.661607	Luong et al. 2012	Figure 6	VNM		168.1																
VNMpy406	6	Tam Giang - Cau Hai lagoon		16.512522	107.688143	Luong et al. 2012	Figure 6	VNM		17.7																
VNMpy407	7	Tam Giang - Cau Hai lagoon		16.509223	107.714267	Luong et al. 2012	Figure 6	VNM		16.2																
VNMpy408	8	Tam Giang - Cau Hai lagoon		16.500708	107.719592	Luong et al. 2012	Figure 6	VNM		21.0																
VNMpy409	9	Tam Giang - Cau Hai lagoon		16.480566	107.738852	Luong et al. 2012	Figure 6	VNM		100.0																
VNMpy410	10	Tam Giang - Cau Hai lagoon		16.465671	107.735525	Luong et al. 2012	Figure 6	VNM		24.0																
VNMpy411	11	Tam Giang - Cau Hai lagoon		16.429427	107.781687	Luong et al. 2012	Figure 6	VNM		20.6																
VNMpy412	12	Tam Giang - Cau Hai lagoon		16.404980	107.796260	Luong et al. 2012	Figure 6	VNM		35.4																
VNMpy413	13	Tam Giang - Cau Hai lagoon		16.371157	107.825569	Luong et al. 2012	Figure 6	VNM		5.2																
VNMpy414	14	Tam Giang - Cau Hai lagoon		16.361385	107.839654	Luong et al. 2012	Figure 6	VNM		7.0																
VNMpy415	15	Tam Giang - Cau Hai lagoon		16.344057	107.824868	Luong et al. 2012	Figure 6	VNM		19.6																
VNMpy416	16	Tam Giang - Cau Hai lagoon		16.331920	107.831474	Luong et al. 2012	Figure 6	VNM		273.0																

Reference DB.csv

ID	Reference
BRN1	Lamit N, Tanaka Y, Majid HMBA, Link GB, 2017. Seagrass diversity in Brunei Darussalam: first records of three species. <i>Scientia Bruneiana</i> , 16(2), 48-52.
KHM1	Hines E, Adulyanukosol K, Somany P, Ath LS, Cox N, Boonyanate P, Hoa NX, 2008. Conservation needs of the dugong <i>Dugong dugon</i> in Cambodia and Phu Quoc Island, Vietnam. <i>ORYX</i> 42:113– 121. https://doi.org/10.1017/S0030605308000094
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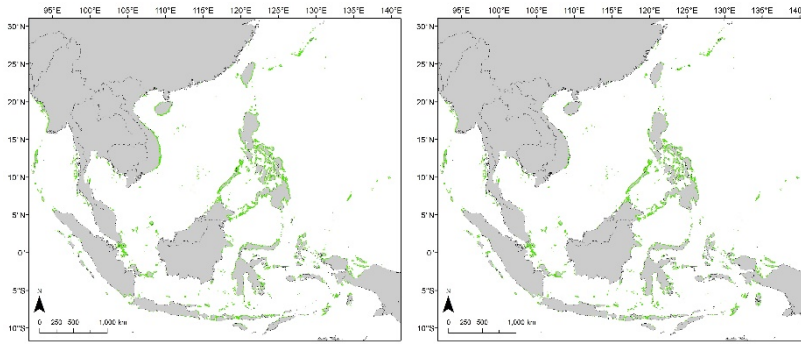
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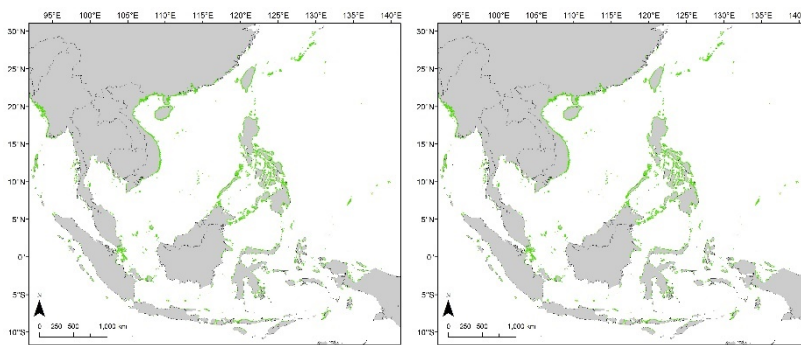
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VNM07	Pham HT, Nguyen HD, Nguyen XH, Nguyen TL, 2006. Study on the variation of seagrass population in coastal waters of Khanh Hoa Province, Vietnam. Coast. Mar. Sci. 30(1): 167-173.
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VNM09	Ca VT, Pham VH, Cao VL, Dam DT, 2011. The conservation potential of the seagrass ecosystem in a pilot study at Ly Son islands, Quang ngai. Tạp chí Khoa học và công nghệ Biển T11. Số 4. Tr 47 - 56.

**Chapter 4 Estimated distribution of tropical seagrasses species
in Southeast Asia and their conservation status
Supporting information**



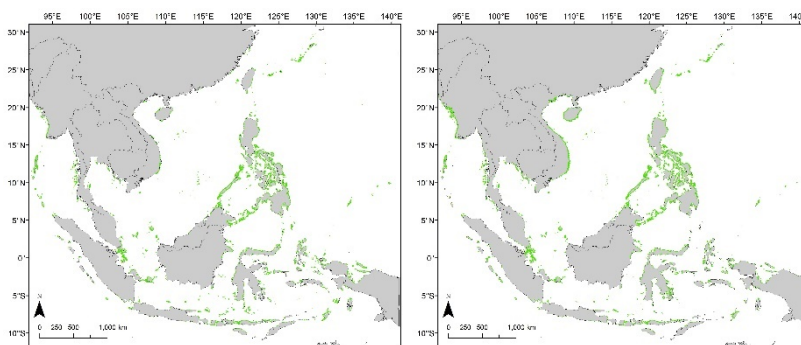
Cymodocea rotundata

Cymodocea serrulate



Halodule pinifolia

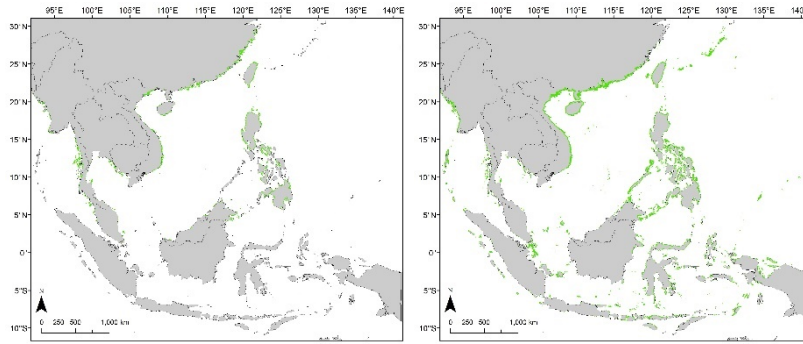
Halodule uninervis



Syringodium isoetifolium

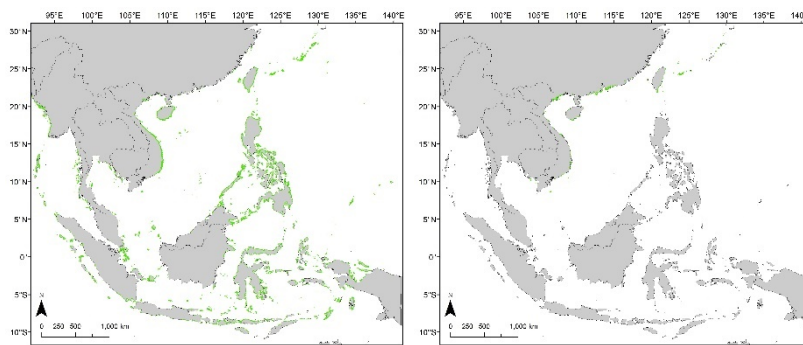
Enhalus acoroides

Fig 4-S1-1 Estimated distribution of each seagrass species using SDMs in the February models



Halophila beccarii

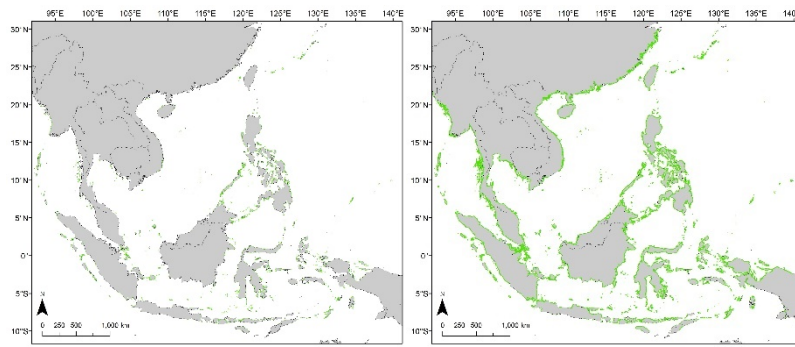
Halophila ovalis



Thalassia hemprichii

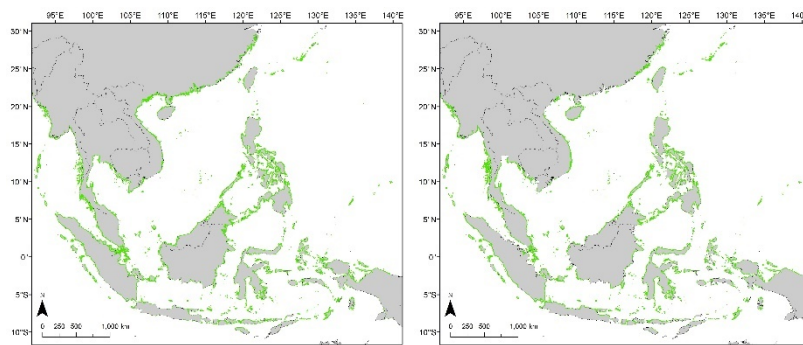
Zostera japonica

Fig 4-S1-1 Estimated distribution of each seagrass species using SDMs in the February models



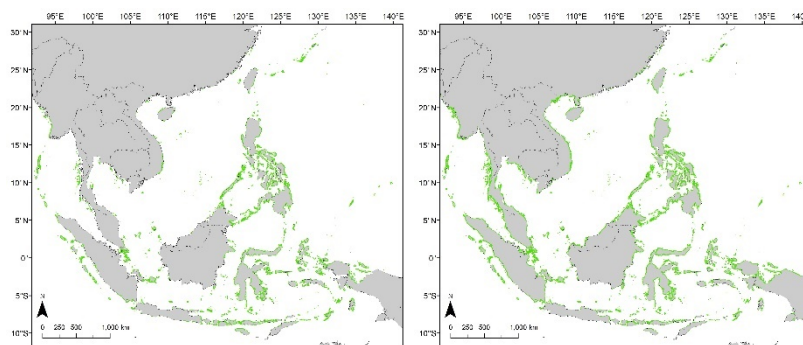
Cymodocea rotundata

Cymodocea serrulate



Halodule pinifolia

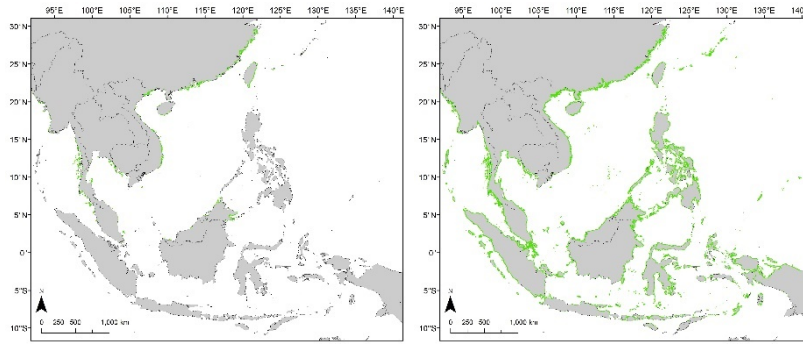
Halodule uninervis



Syringodium isoetifolium

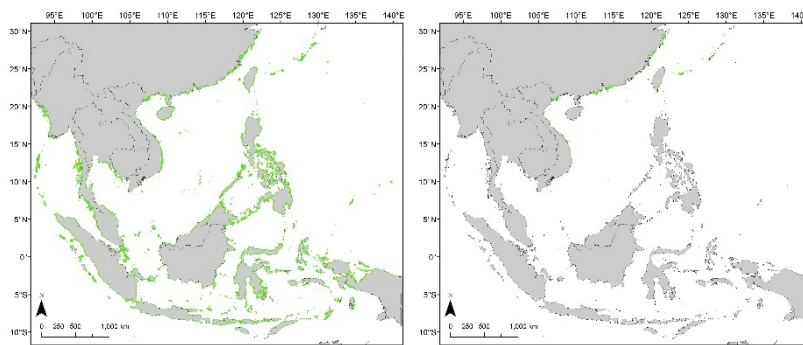
Enhalus acoroides

Fig 4-S1-2 Estimated distribution of each seagrass species using SDMs in the August models



Halophila beccarii

Halophila ovalis



Thalassia hemprichii

Zostera japonica

Fig 4-S1-2 Estimated distribution of each seagrass species using SDMs in the August models

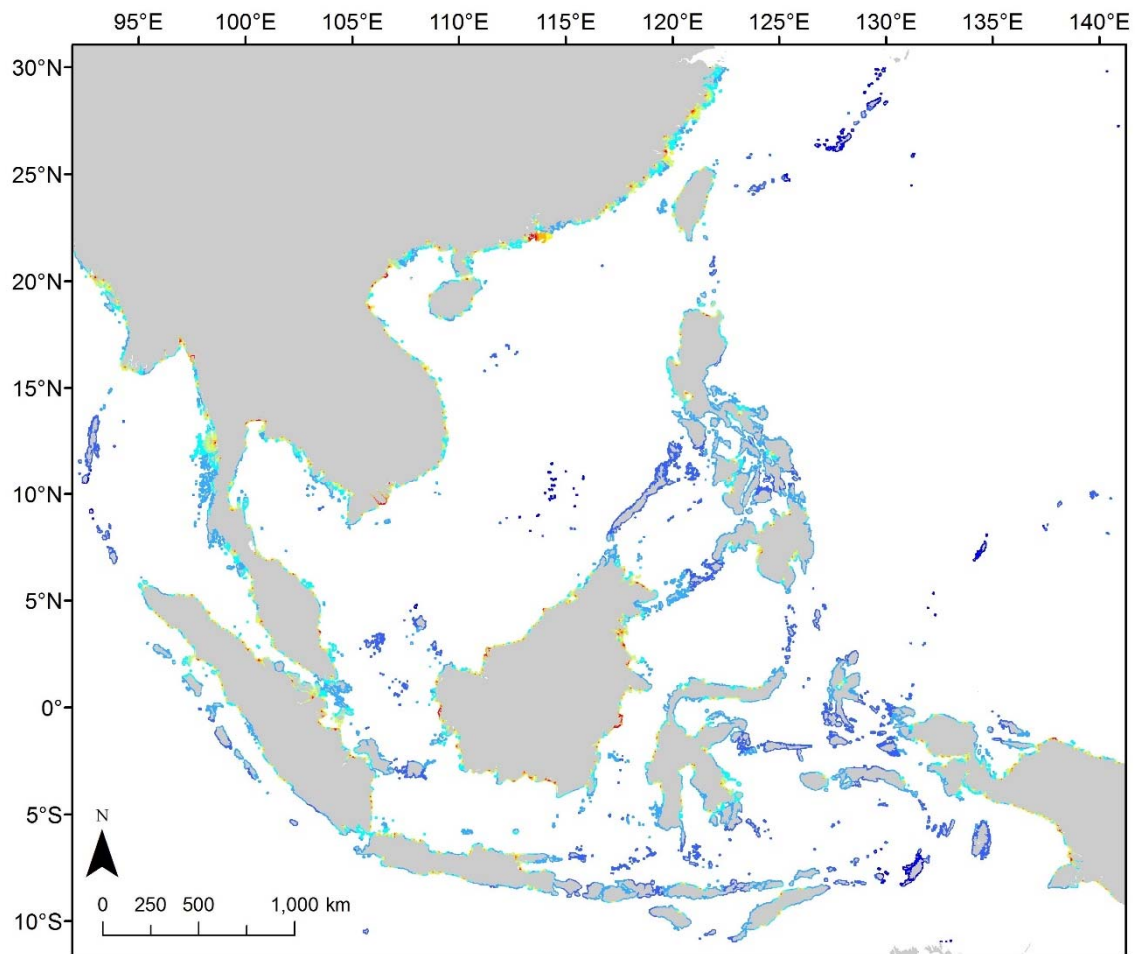


Fig 4-S2 Calculated watershed effect in the southeast Asia

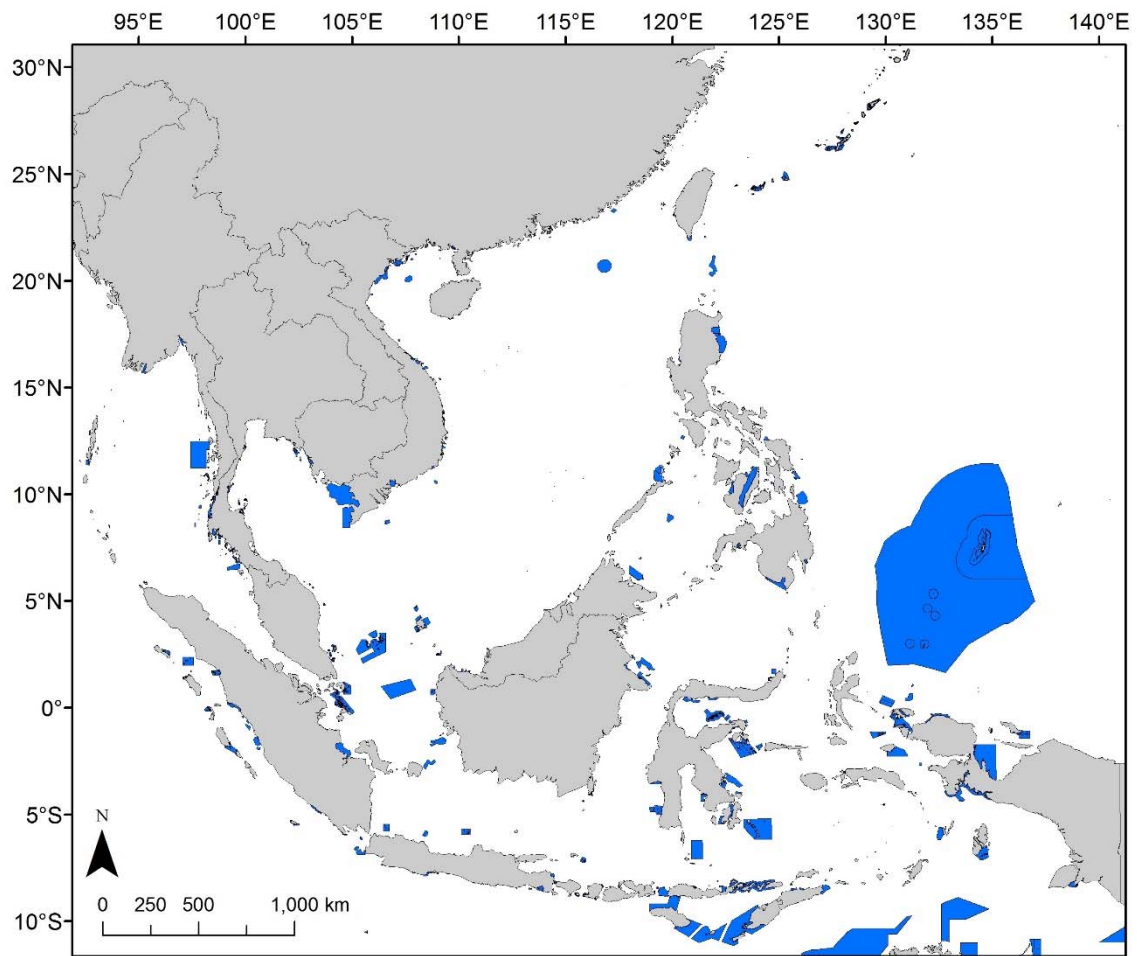


Fig 4-S3 MPAs in the southeast Asia

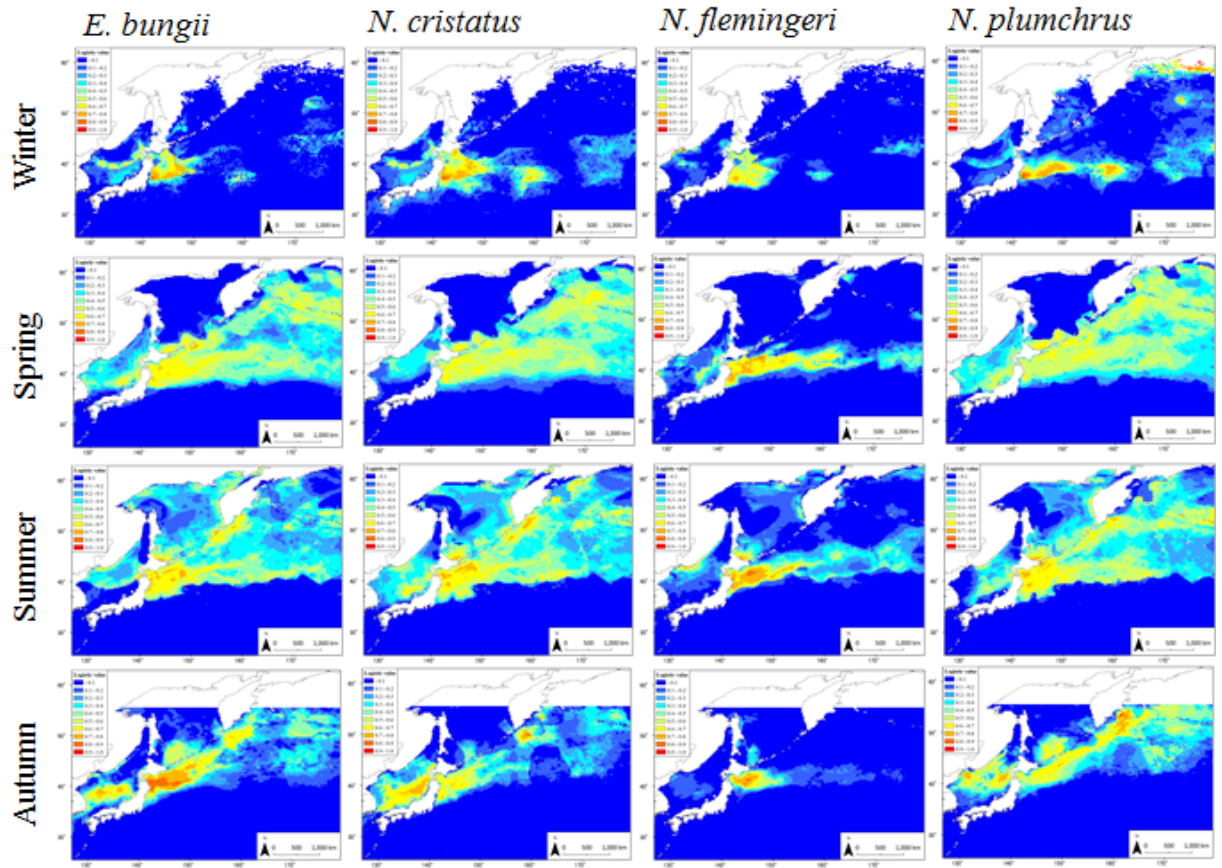
Chapter5

Current species distribution and future projection for copepods

in the western North Pacific

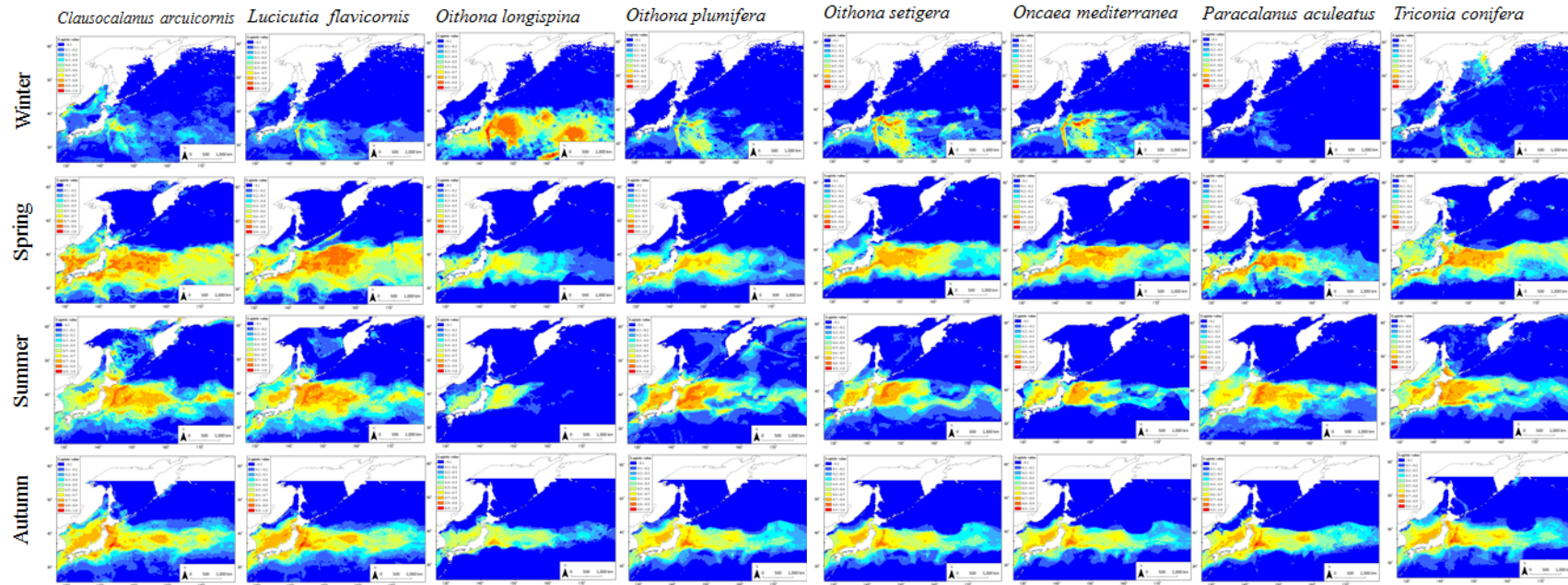
Supporting information

5-S1: Seasonal variation in the predicted distribution of each species of cold-water copepods in each season.



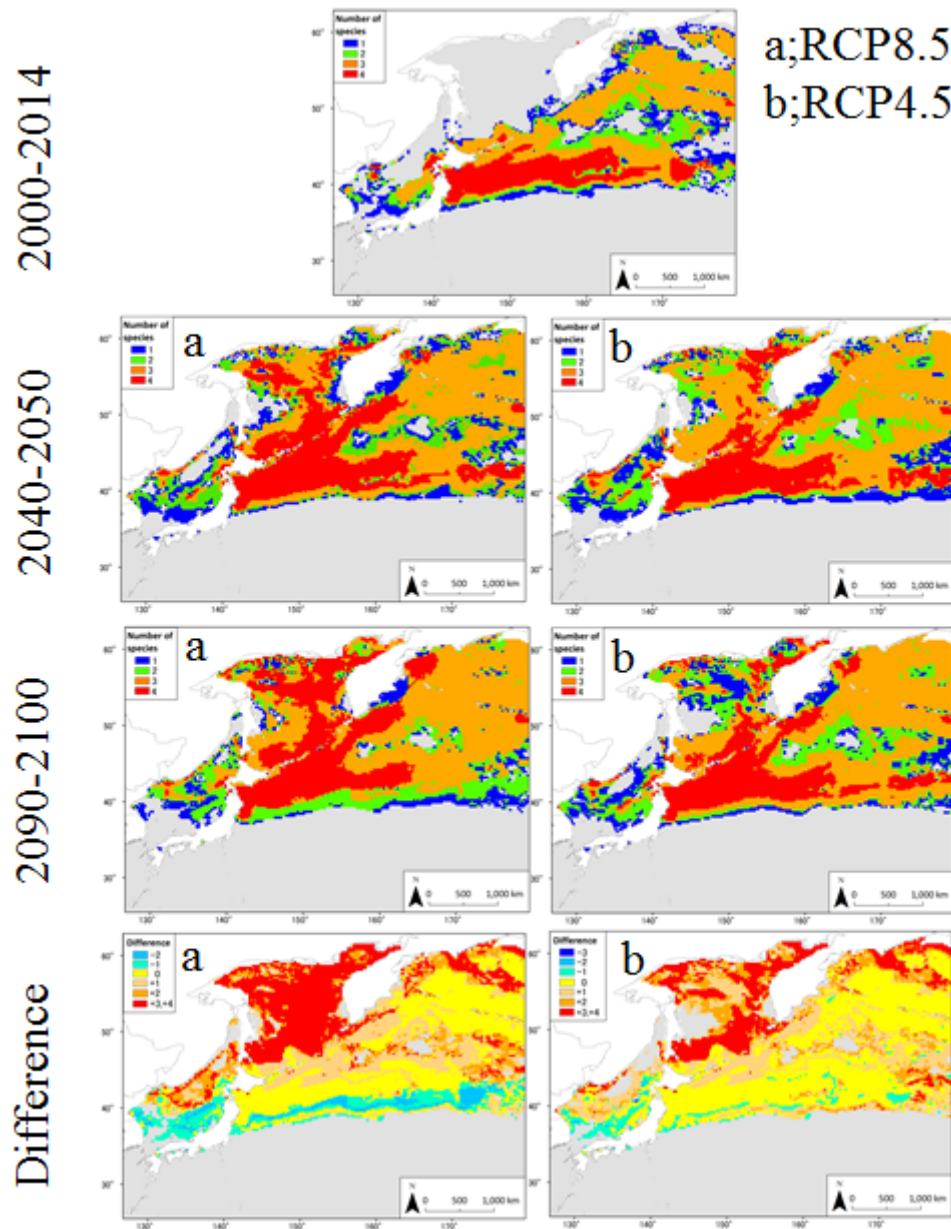
The prediction range is limited in winter due to sea-ice cover. In addition, the prediction range of the northern limit is N55° in autumn due to the lack of primary production data.

5-S2: Seasonal variation in the predicted distribution of each species of warm-water copepods in each season.



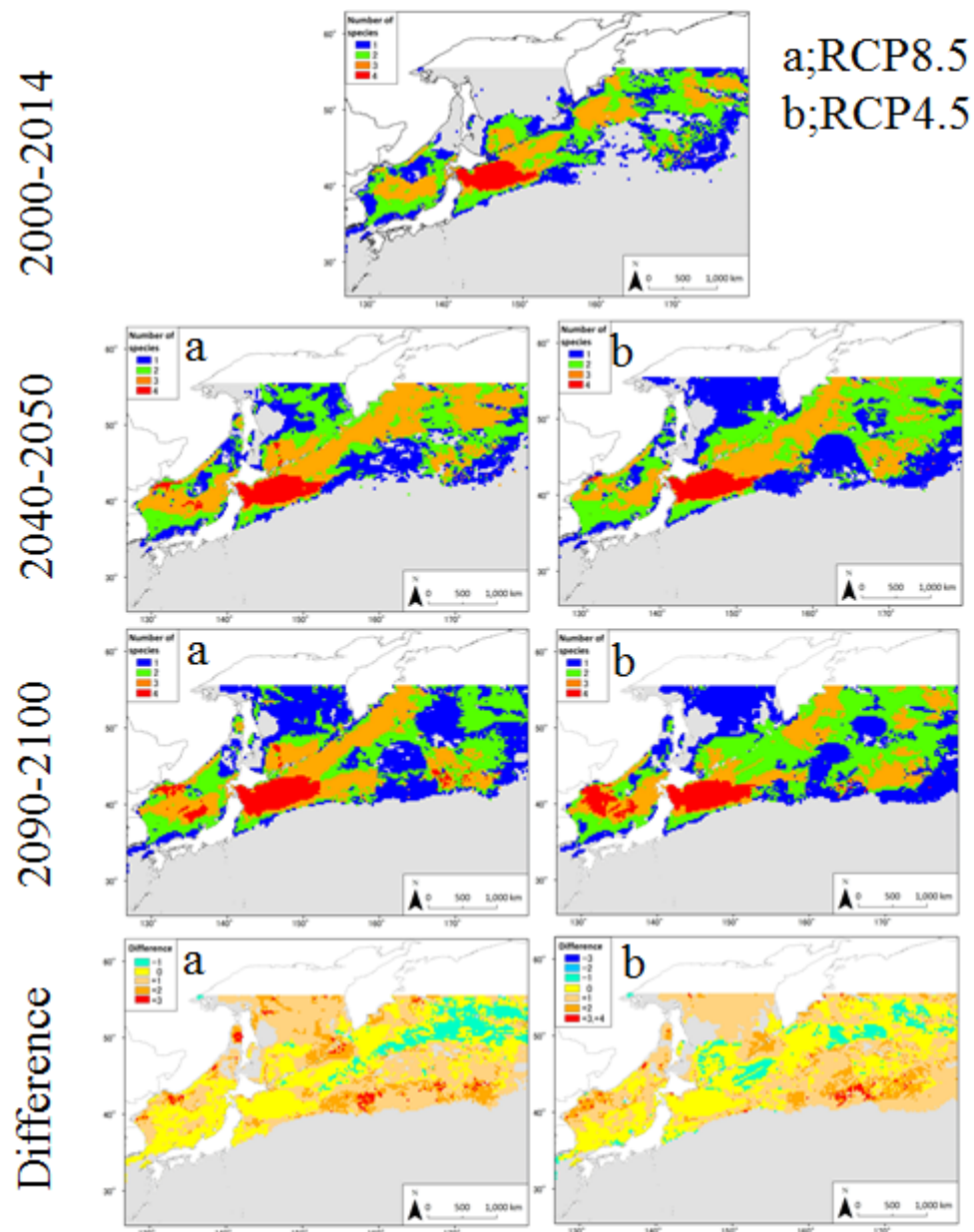
The prediction range is limited in winter due to sea-ice cover. In addition, the prediction range of the northern limit is N55° in autumn due to the lack of primary production data.

5-S3: Predicted distribution of the cold-water copepods for spring (5-3-1), autumn (5-3-2) and winter (5-3-3) based on different climate scenarios.



5-S3-1: Predicted distribution of the cold-water copepods for spring based on different climate scenarios.

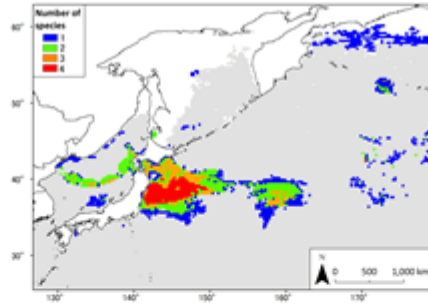
Difference: Showing the difference in the number of species between 2000–14 and 2090–2100



5-S3-2: Predicted distribution of cold-water copepods for autumn based on different climate scenarios.

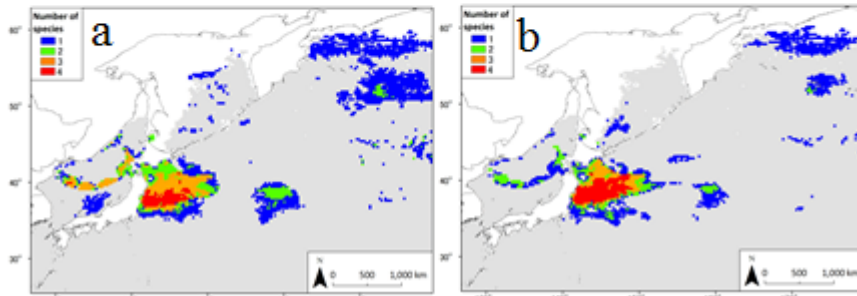
Difference: Showing the difference in the number of species between 2000–14 and 2090–2100

2000-2014

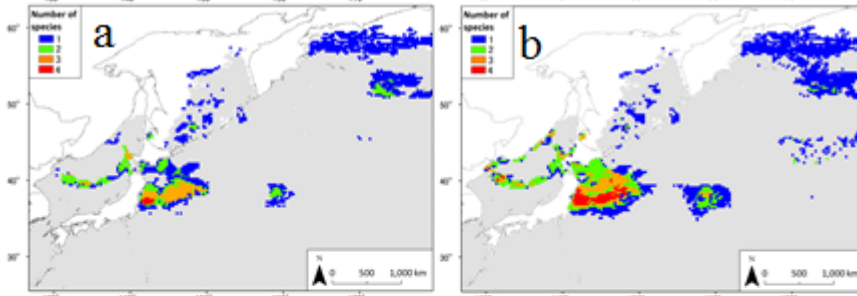


a;RCP8.5
b;RCP4.5

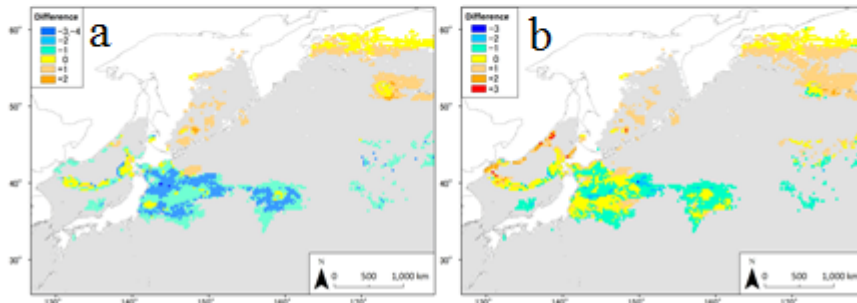
2040-2050



2090-2100



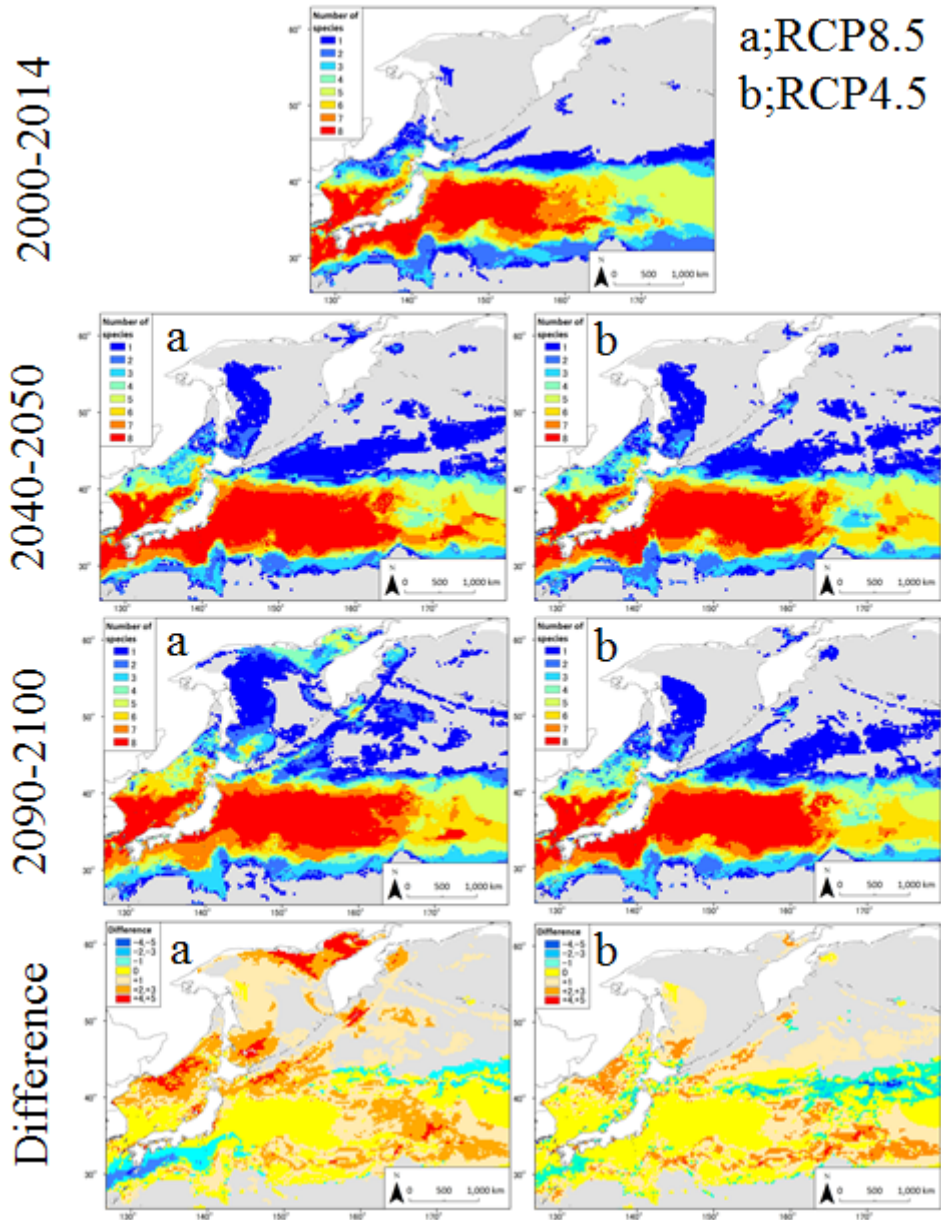
Difference



5-S3-3: Predicted distribution of cold-water copepods for winter based on different climate scenarios.

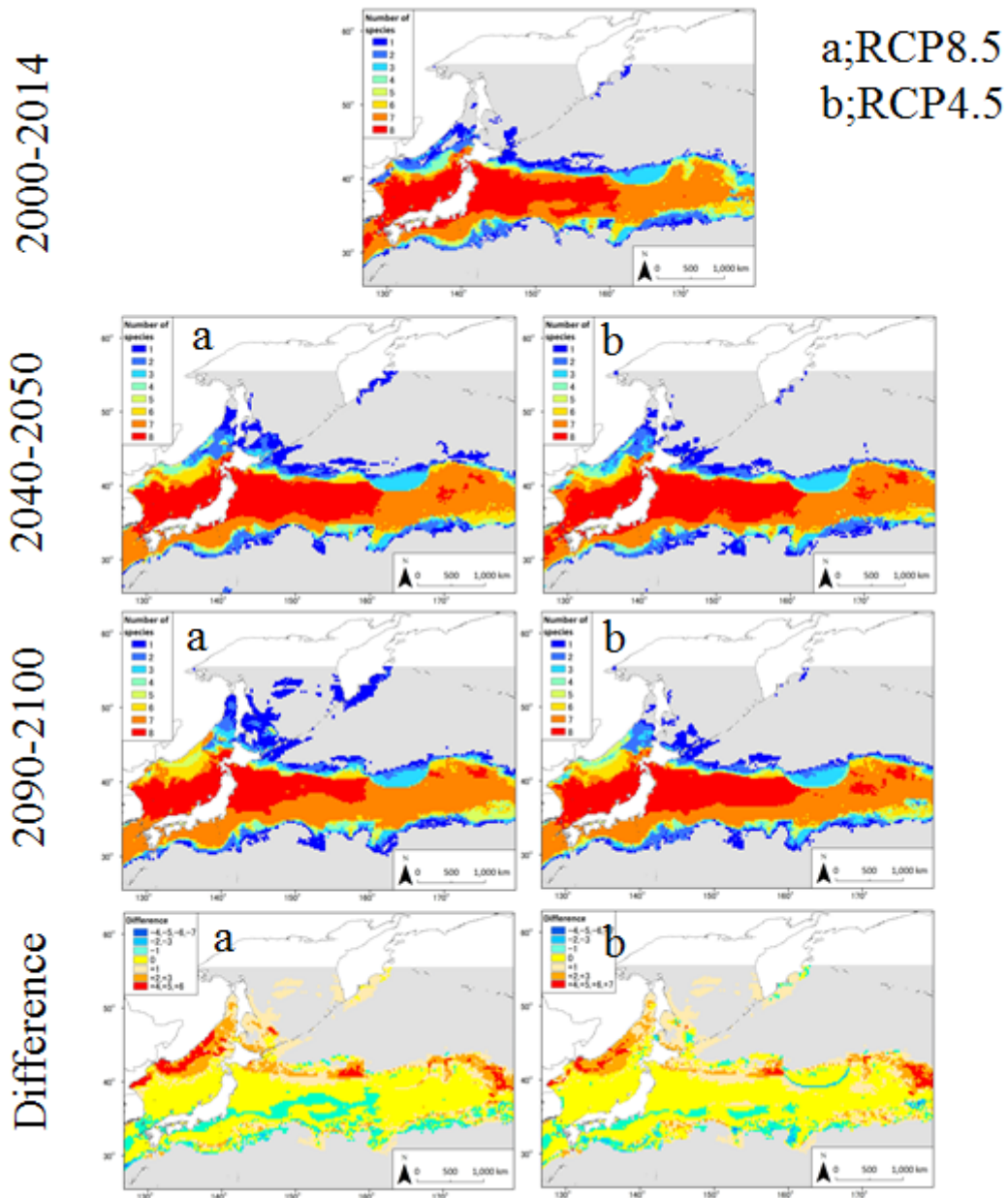
Difference: Showing the difference in the number of species between 2000–14 and 2090–2100

5-S4: Predicted distribution of warm-water copepods for spring (5-4-1), autumn (5-4-2) and winter (5-4-3) based on different climate scenarios.



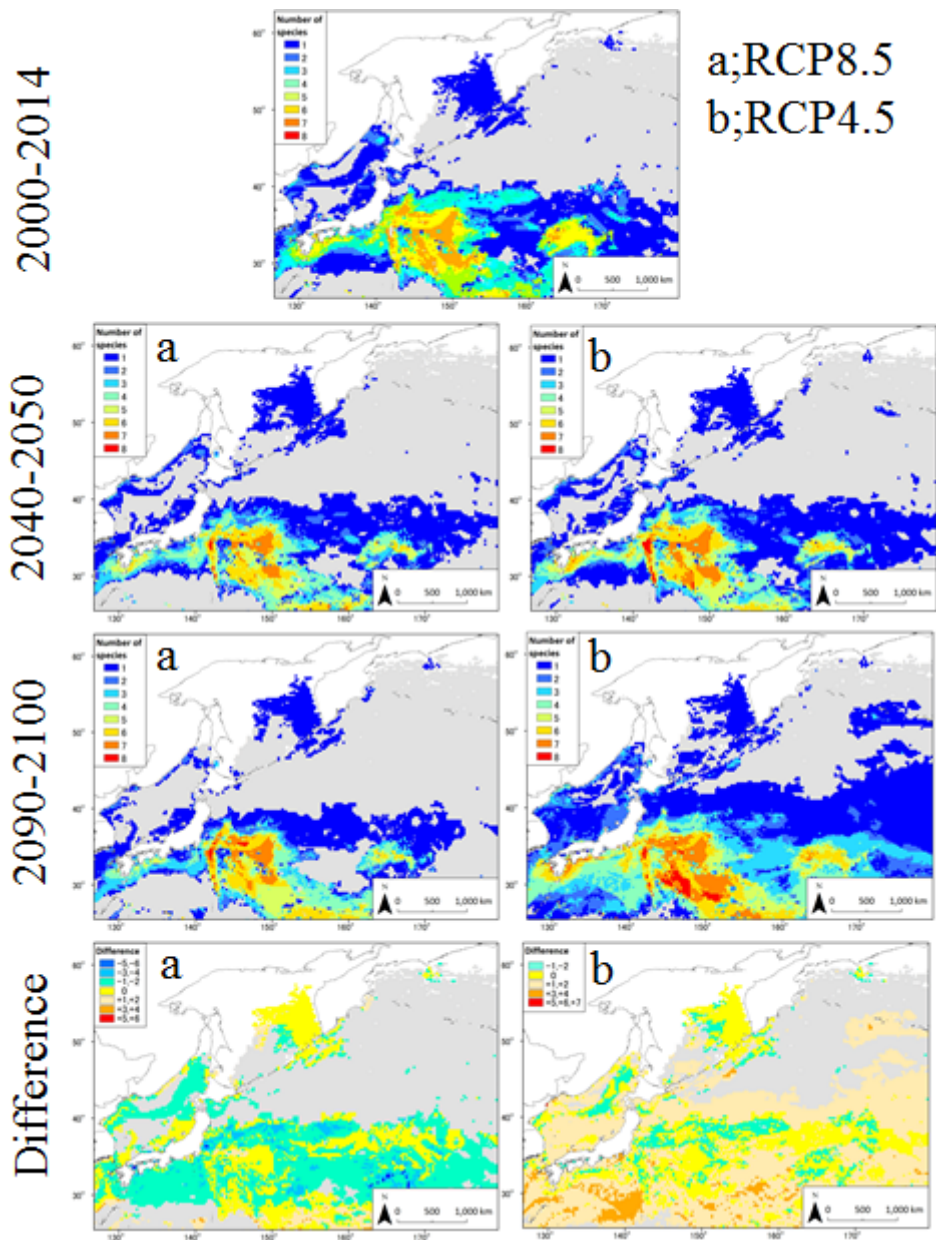
5-S4-1: Predicted distribution of warm-water copepods for spring based on different climate scenarios.

Difference: Showing the difference in the number of species between 2000–14 and 2090–2100



5-S4-2: Predicted distribution of warm-water copepods for autumn based on different climate scenarios.

Difference: Showing the difference in the number of species between 2000–14 and 2090–2100



5-S4-3: Predicted distribution of warm-water copepods for winter based on different climate scenarios.

Difference: Showing the difference in the number of species between 2000–14 and 2090–2100