PREDICTING & ASSESSING NATURAL CAPITAL & ECOSYSTEM SERVICES

PANCES

Predicting and Assessing Natural Capital and Ecosystem Services
through an Integrated Social-Ecological Systems Approach

PolicyBrief

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Theme 3

Predicting and Assessing Natural Values Created by Natural Capital and Ecosystem Services in Marine Areas

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Introduction

The establishment of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) reflected the need to enhance the interface between science and policy, including through the construction of a conceptual framework for assessment in this field and an approach to make the framework operational. In parallel with this, the group of nearly 100 experts across Japan has started the national scale scenario analysis of nature and ecosystem services to help the government to revise the existing National Biodiversity Strategy and Action Plan. The IPBES Global Assessment Report published in May 2019 indicated that the ongoing loss of biodiversity on a global scale might jeopardise the achievement of the Aichi Biodiversity Targets, as well as the Sustainable Development Goals (SDGs), the 2050 Vision for Biodiversity and the Paris Agreement adopted under the UN Framework Convention on Climate Change (UNFCCC), among others. However, many of the insights presented in the IPBES Global Assessment do not directly apply to Japan due to its declining birth rate, and dwindling and ageing population, where declining utilisation (underuse) of nature is considered to be one of the drivers causing biodiversity loss. In line with the global efforts of assessing nature and ecosystem services, it is of vital importance to conduct assessments and gain a future perspective in light of the unique social and economic conditions of Japan. Based on the findings so far of the Predicting and Assessing Natural Capital and Ecosystem Services through an Integrated Social-Ecological Systems Approach (PANCES) project, which is funded by the Environment Research and Technology Development Fund (S-15) from the Ministry of the Environment, Japan, this Policy Brief sets out comprehensive policy recommendations with a view to building future scenarios and integrated model of social-ecological systems on national and regional scales, in particular.

Policy recommendation 1

There has been no formula to consider future scenarios for marine areas. This project identified changing factors within the framework of four future scenarios revolving around the key factors that may bring transformational changes to our future leading to 2050, namely ‘population distribution’ (compactification or dispersion) and ‘capital to be leveraged proactively’ (natural or produced), while qualitatively presenting the necessary preconditions and the corresponding policy measures.

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Policy recommendation 2

Our estimation of ecosystem services through nationwide analyses indicated a wide local variation, as Western Japan is characterised by substantial catches of marine species (distribute mainly temperate zone and living in coastal ecosystems), other than seaweeds, while leisure activities are more frequently observed in southern sea areas. When overlaid with the service data, the magnitude of sea temperature changes under the future forecast scaled down to a higher resolution indicates a greater impact on the Pacific coast of Eastern Japan in terms of the rise in sea temperatures (with a larger dispersion in forecast), as well as discrepancies between the areas with higher service levels and variations in sea temperatures. It is necessary to identify prediction results by area and take measures focused on seasonality, including on specialty products.

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Policy recommendation 3

As one of the specific cases, our findings show a substantial impact of climate change on kelp seaweed beds in Northern Japan, with the possible loss of many existing species under a scenario supposing a significant rise in sea temperatures. This impact would be smaller under the modest Representative Concentration Pathway (RCP) scenario, which indicates the importance of climate change mitigation measures. In addition, measures need to be considered in light of the possibility that the ecosystems cannot be sustained as they are, including the shift of species to be caught or the selection of areas fit for aquaculture.

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Policy recommendation 4

We evaluated the recreational value of sandy beaches with location-enabled mobile devices. The result showed that the decline in the recreational value of sandy beaches exceeds the rate of future decrease in beach area due to climate change (rising sea level), suggesting that the result of assessing climate change impact solely based on forecasts of the natural environment underestimates its impact on society. Furthermore, the recreational value of sandy beaches may change in future, implying that future outcomes must be considered when prioritising beach conservation measures.

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Policy recommendation 5

We evaluated the socio-economic value of neritic ecosystems based on willingness to pay. The result indicates that seaweed beds and coral reefs are highly evaluated. Since they are both vulnerable to climate change, we presented one of the reasons why measures for their conservation and regeneration should be prioritised.

page 8

Policy recommendation 6

We identified the impact of climate change on the socio-ecological system of Sekisei Lagoon. From the result, we concluded that mitigation of the negative impact depends on policy measures such as coral protection, a network of marine reserves suited to the life history of fish species, construction of shallow bottoms and habitats, and spontaneous regeneration.

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Policy recommendation 7

This study found that land use changes, including agricultural land development to facilitate economic activities, have huge impacts on supply and coordination services in coastal ecosystems. Thus, predicting and assessing community developments on land will need to consider impacts on the whole catchment area and coastal waters surrounding the area.

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Policy recommendation 8

Our analysis of the Ocean Health Index found that the composition and evaluation value of key ecosystem services may vary significantly even within a single prefecture, for example, as each local community has its distinctive industrial structure and natural ecosystem. The finding shows the importance of taking into account the specificities and actual conditions at the sub-prefectural local level, as well as on a national scale, in developing environmental measures based on future scenarios.

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Policy Recommendation 1

1. Elements of future socio-economic scenarios for marine areas

We identified change elements for marine areas for each of the four scenarios for socio-economic changes in the future around key uncertainties over Japanese society going forward (Saito et al., 2019). Specifically, we conducted brainstorming sessions on elements not found on land, followed by an expert meeting to select and specify the relevant elements, and determine the direction of such changes.

Key elements extracted include: decline in coastal production and increase in imports including through feeding fish culture and offshore/pelagic fishing under the produced capital scenario; limitation of seawall and infrastructure development to suburban areas under the compactification scenario; and promotion of eco-tourism and other emerging industries as a cultural service under the natural capital scenario (Fig. 1, Table 1).

In qualitative terms, the following measures may be taken in response to those elements. First, measures to mitigate ecosystem degradation by the construction of produced capital are important (e.g. building of a network of reserves suited to the life history of the target species, spontaneous regeneration projects for degraded areas, and FAD deployment and seed-releasing as necessary) under the produced capital scenario. Second, required measures under the natural capital scenario include the enhancement of ecosystem conservation and regeneration activities including in marine reserves, and the promotion of robust fish stock management and eco-tourism. Under the compactification scenario, assuming the retention of urban population, effective measures would include building a comprehensive system to promote measures against environmental load from land sources (such as pollutants) in a basin area including cities. Under the population dispersion scenario, necessary measures will entail wide-area networking and labour saving through the promotion of IoT, including promoting a smart fishery sector.

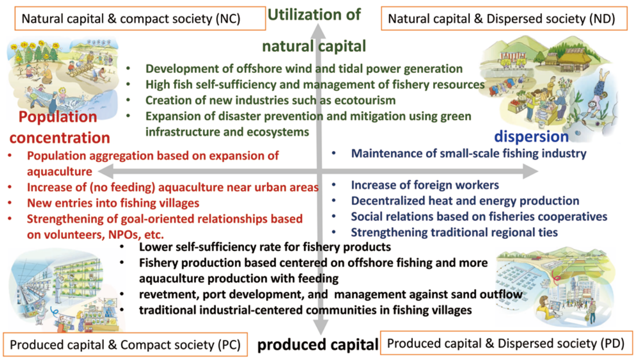


Fig. 1 Concept of marine-area scenarios and characteristics of individual scenarios

		Natural capital & Dsipersed (ND)	Natural capital · compact (NC)	Produced capital · Dispersed(PD)	Produced capital · compact (PC)
Natural capital / artificial capital		Utilization of domestic natural capital		Utilization of overseas natural capital and artificial capital	
Population	Present / Concentration	Present projection	Concentration	Present projection	Concentration
	Correction of population concentration		Population sub scenario according to the other change		Population sub scenario according to the other change
Economy	Seafood self-sufficiency rate	· Exceeds the current situation (65%)	· Exceeds the current situation (65%)	· Below the national target (Fisheries Basic Plan 60%)	· Below the national target (Fisheries Basic Plan 60%)
	Aquaculture production	· Maintain current status	· Increase aquaculture (no feeding) near urban	· Increase feeding aquaculture · Increase import	· Increase of feeding aquaculture near the city · Increase import
	Fishery production	·Local fishery	· Increase in shellfish fishery	· Offshore fishery industry · Increase import	· Offshore fishery industry · Increase import
Social politics	Policy · Infrastructure	· Fisheries resources management	· Fisheries resources management	· Gray infra all over Japan such as Sea wall, port maintenance, protection from sand runoff	· Gray infrastructures only near the cities
Science and technology	Energy	· Development of offshore wind power, tidal current power generation	· Development of offshore wind power, tidal current power generation		
	Social relationship	· New industries such as ecotourism by local fishery cooperatives	· New industries such as ecotourism by new company	· Classical fishery indestries by local fishery cooperatives	· Classical fishery industries by local fishery cooperatives

Table 1 Preconditions to the concept of marine area scenarios (measures and outcomes assumed in each scenario)

2. Huge differences in the local impact of climate change on ecosystem services

The downscaling of climate models revealed significant local variations in the impact of climate change due to ocean currents, as well as higher sea temperatures and increased uncertainties, particularly on the Pacific coast of Eastern Japan (Fig. 2). Elsewhere, the impact of climate change varies between areas located less than 100 km apart, with an insignificant correlation between sea temperature changes and the ranks of services provided. It is thus expected that the qualitative change in ecosystem services will be determined by the extent of climate shift in the area concerned. It should be noted that areas receiving similar levels of services at present may be subject to different changes in future.

The national distribution of services indicates that a high level of seafood production related to coastal ecosystems in Honshu is linked with a high level of adjustment services through carbon absorption, particularly in parts of Western Japan (Fig. 3). The social impact that would be felt in Western Japan might exceed that implied by the absolute amount of change in water temperatures.

Some of the sub-prefectural areas, including municipalities, experience a greater change than the surrounding areas. In particular, we need to focus on the relationships between environmental changes in those areas on the one hand, and local specialties and tourism resources on the other. For example, some indicate a decline in habitable areas for kelp and an increase in areas suited for diving along the coasts of Honshu (Sudo et al., 2020; Yamakita 2018). Depending on the changing ecosystems at the local level, it is necessary to invest social capital in developing infrastructure to benefit from services or to consider flexible collaboration with an area that already has such infrastructure.

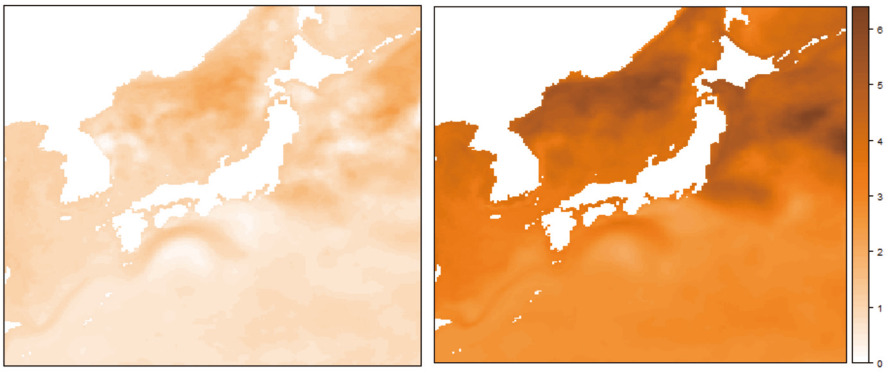


Fig. 2
Variation of estimated sea surface temperatures in 2050 (left) and in 2100 (right) vs. the present level. Sharp rises may be observed in the area ranging from the Pacific coast of Eastern Japan to the Black Current zone off the coast of Wakayama Prefecture. Note that the zone of convergence off the Pacific coast of Eastern Japan is subject to a wide dispersion of estimated values.

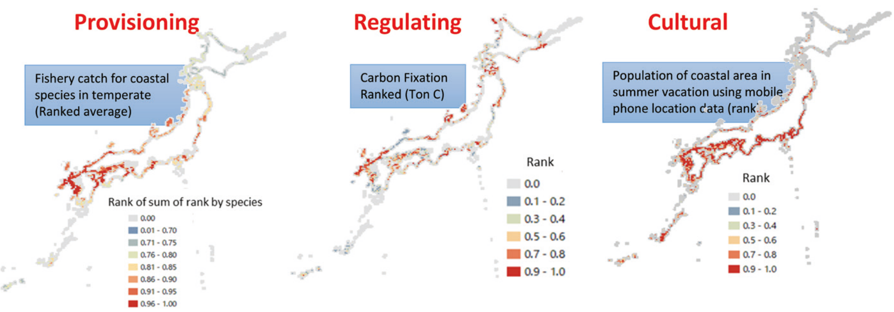


Fig. 3
Nationwide distribution of types of ecosystem services under current climatic conditions, based on: the integrated values of ranked fish catch along the Honshu coasts for the fish corresponding to coastal natural capital; estimated carbon absorption according to unit value for natural capital in the seven regions nationwide (fixation; Kuwae et al., 2019); and the rankings for the difference in the number of coast users between late spring and winter as observed through mobile phone location data.

Policy Recommendation 3

3. Substantial impact of climate change on kelp grounds in Northern Japan, with the possible loss of many existing species under a scenario assuming a rapid rise in water temperatures

We collected information on the past and present distribution of 11 major kelp species found in Northern Japan from an existing biodiversity database to estimate the distribution area for each of the species in the 1980s, when the effect of global warming was not yet apparent. Then we predicted changes in the distribution in the 2040s and 2090s based on future global warming scenarios (Fig. 4).

The result indicates that a substantial northward shift of the range, or possible disappearance of the habit area, is expected for all of the analysed kelp species. According to the scenario supposing rapid progress in global warming, the range of kelp in Northern Japan in the 2090s will be reduced to 0–25% of that in the 1980s. Even under a scenario assuming slower global warming, six of the 11 species might vanish from Japanese waters in the 2090s (Sudo et al., 2020). Another scenario, incorporating some mitigation measures, predicts that 39–58% of the range will survive into the 2090s, indicating the importance of such measures.

Accordingly, suggested actions include: 1) shifting the target species in each area; and 2) selecting an area suited to aquaculture. For example, the latter option would entail enhanced, systematic management of the cultured species, such as Japanese kelp, including by maintaining populations in some areas where water temperatures are expected to rise less rapidly.

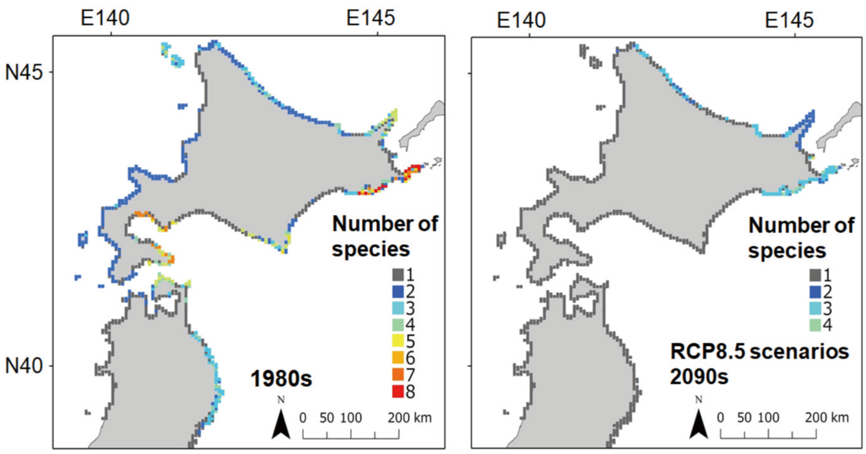


Fig. 4
Estimated diversity of kelp species in Northern Japan. Assuming that the range of kelp depends on the water temperature in the coldest month, the habitable area in the 2090s under the RCP8.5 scenario will be reduced to some 25% of that in the 1980s.

4. Leveraging mobile big data to estimate a larger drop in values due to the sea level rise on sandy beaches in the south

By integrating big data on location information available via mobile phones, we identified the recreational value of sandy beaches nationwide to predict future value changes in view of the rising sea level driven by climate change (Fig. 5). In general, the recreational value declines faster than the reduction of area itself, implying that the result of assessing climate change impact based on predictions of the natural environment alone might underestimate its impact on society (Kubo et al., 2020).

Focusing on geographical differences, the recreational value of sandy beaches will vary in future, as the high present value of southern beaches will tend to be eroded while northern beaches are not expected to have much value in the future. The result reveals the importance of taking the future status into account when prioritising efforts for beach conservation.

The findings of this study may be used to assess the recreational value of individual beaches, and hence to predict substantial changes in the current beach ranking in terms of recreational value going forward. As the urgent need for climate action becomes apparent worldwide, our findings will help make decisions on how to allocate limited resources and where to focus management efforts.

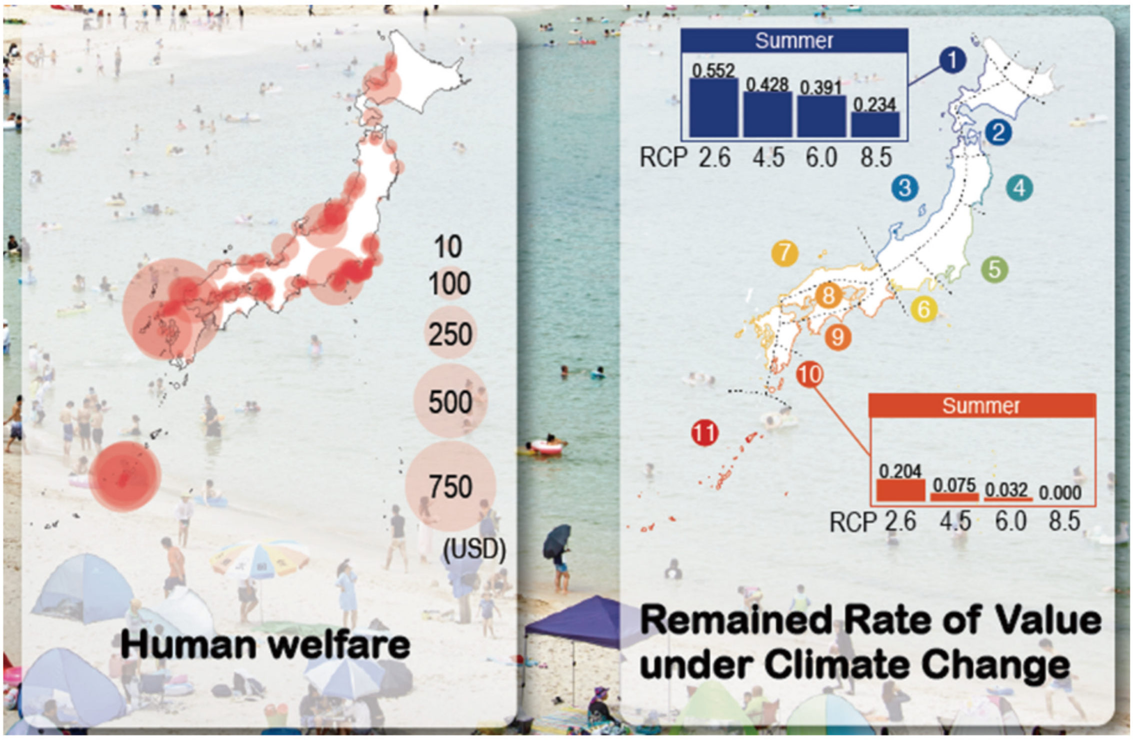


Fig. 5 Estimated recreational value and its erosion by climate change

Policy Recommendation 5

5. Substantial willingness to pay for kelp grounds and coral reefs vulnerable to climate change

We estimated the socioeconomic value of six ecosystems: kelp bed, seaweed bed, mixed habitat for seaweed and coral, eelgrass bed, tidal land and coral reef, using citizens' willingness to pay for mitigating the impact of climate change and development, to conserve coastal environments (Fig. 6). Targeting 2100, we applied a selection-based experiment to establish a coastal environment tax. The result indicates that kelp beds in the north and coral reefs in the south received the highest willingness to pay for preventing changes in the environment, followed by tidal land and seaweed beds at the same level, and then mixed habitats and eelgrass beds. Since climate change will shift kelp beds to the north and cause bleaching and decline of coral reefs, we expect the value of Japan's natural capital to decline as a whole in the future.

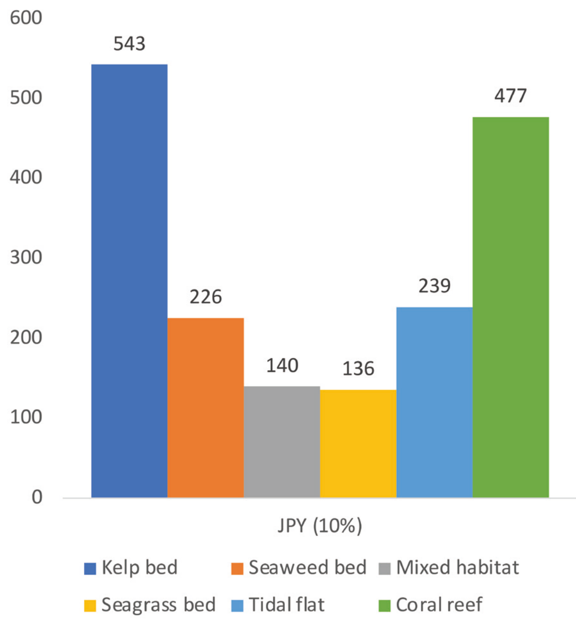


Fig. 6
Willingness to pay for 10% of the current status

6. Using the causal connection map for a case study area to present an example to identify intervention options qualitatively

We clarified the network of causal connections and summarised the impact of climate change on the socio-ecological system of Sekisei Lagoon (Fig. 7). We concluded that policy options are crucial for mitigating the negative impact, including coral protection, a network of marine reserves suited to the life history of fish species, and the construction and protection of shallow bottoms and habitats (or any combination of such interventions).

The bleaching and death of hermatypic coral due to climate change may impair the functions of spawning grounds, feeding grounds, habitats and seascape. The rising sea level is also expected to have a substantially negative impact on intertidal zones, affecting social aspects such as the traditional use of nearshore areas by local communities, as well as fisheries, tourism, education and research. Effective policy options for mitigating such negative impacts would include: coral protection (conservation of climate-resilient marine areas, protection and development of bleaching-resistant species and individuals); building a network of reserves suited to the life history of fish species, enhanced construction and protection of shallow bottoms and habitats; control of pests including acanthaster and action against red soil runoff; and the implementation of spontaneous regeneration in severely degraded areas. Meanwhile, global warming may help expand the range of seaweed beds, and the resulting phenomena may help reduce the negative impacts of global warming.

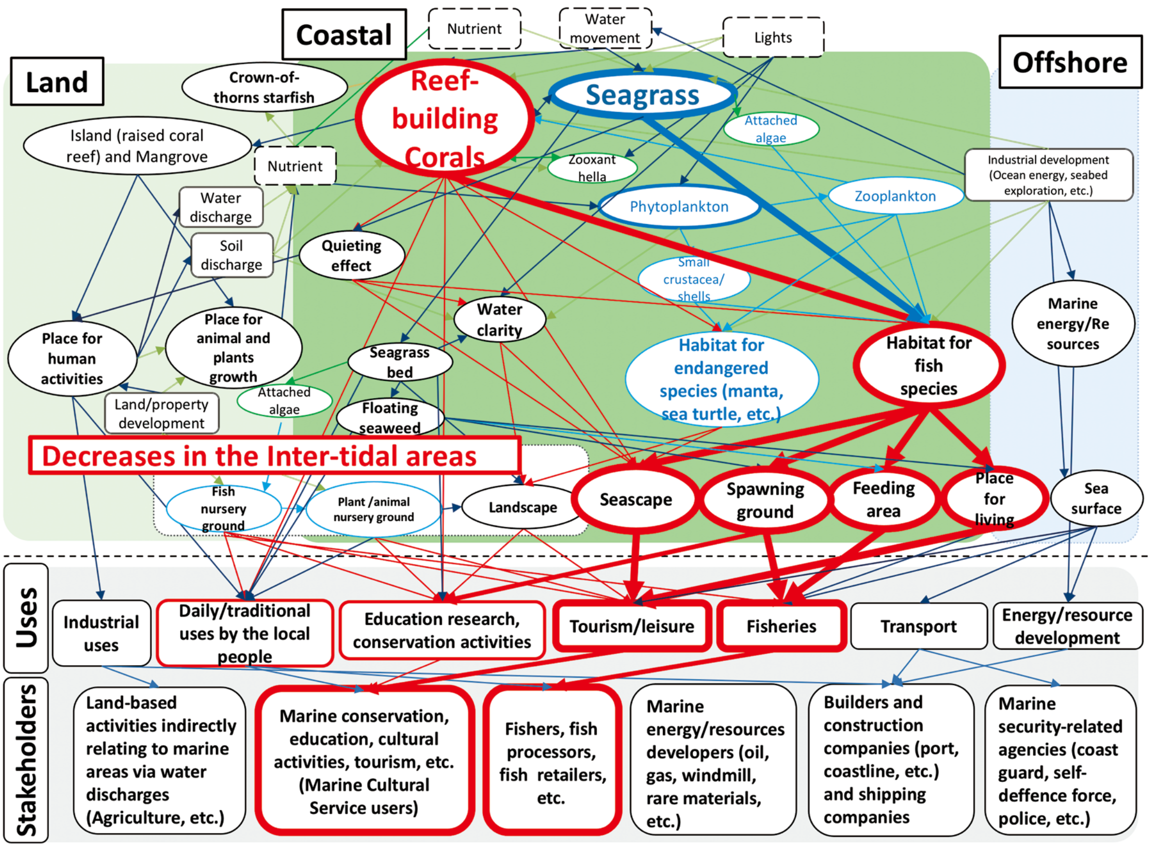


Fig. 7
Example of assessing the impact of coral reef bleaching from the causal association network

Policy Recommendation 7

7. Necessity of integrated management measures in light of the impact of changing land-based ecosystems and land use

This study found that changes in land use accompanying economic activities have a substantial impact on supply services and coordination services in coastal ecosystems.

At the local level, we analysed the impact of changing land use on the coastal ecosystems in Eastern Hokkaido. The result indicates that the increased nutrient flow into coastal areas through rivers and streams due to agricultural land development exacerbated eutrophication in some waters, possibly affecting the production of various useful marine species (Fig. 8).

At the national level, our analysis revealed a correlation between the distribution of eelgrass and seaweed grounds, both performing key supply services and coordination services in coastal areas on the one hand, and land use on the other. Regarding land use, the forest rate and agricultural land rate are known to have a highly negative correlation, possibly impacting the nutrient and sediment outflows from rivers and streams. This effect is particularly evident in an area where the catchment area for eelgrass beds is small (Fig. 9).

It follows that, in order to predict and assess community changes on land, it is necessary to include the impact on the whole catchment area and surrounding coastal waters.

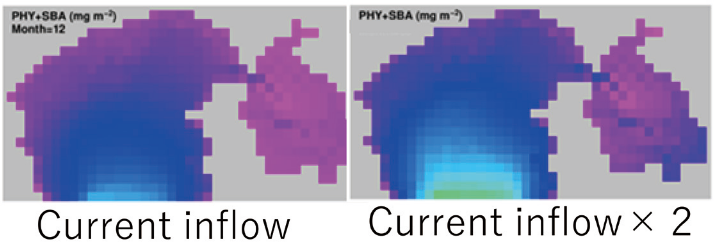


Fig. 8
Predicted variation in basic production in Akkeshi Bay and Akkeshi Lake, based on changes in nutrient inflows from land

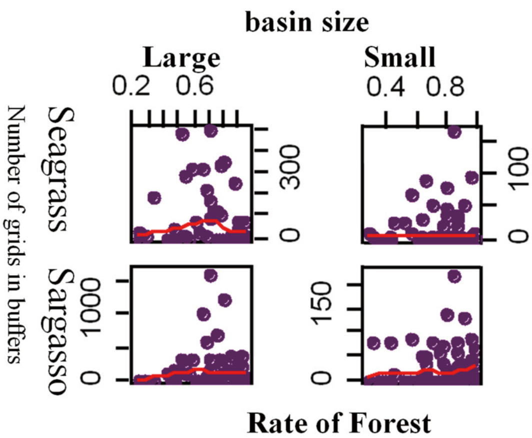


Fig. 9
Scatter diagram with land use, one of the environmental factors affecting the distribution of seaweed beds across Japan. The correlation is weak in large catchment areas (left), predominantly impacted by marine environmental factors. In contrast, smaller catchment areas (right) have a significant correlation with land use (forest rate).

Policy Recommendation 8

8. Relative importance of marine ecosystem service elements largely dependent on the community environment and social characteristics

The Ocean Health Index (OHI) is an indicator to assess the various ecosystem services that humans receive from oceans more comprehensively, with objectives defined according to a functional, socioeconomic approach. OHI can make comparisons between objectives and sites by assessing each objective with a score ranging from 0 to 100. The analysis found that the composition and evaluation value of key ecosystem services may vary significantly even within a single prefecture, for example, as each local community has its distinctive industrial structure and natural ecosystem. From a comparison of marine areas in Eastern Hokkaido (Okhotsk sea area and Kushiro sea area), we concluded that the Okhotsk area significantly exceeds the Kushiro area in terms of values such as food supply, livelihood and economy, whereas Kushiro exceeds Okhotsk in water conditioning (Fig. 10). These findings indicate the importance of taking into account the specificities and actual conditions at the local level, as well as on a national scale, when developing environmental measures based on future scenarios.

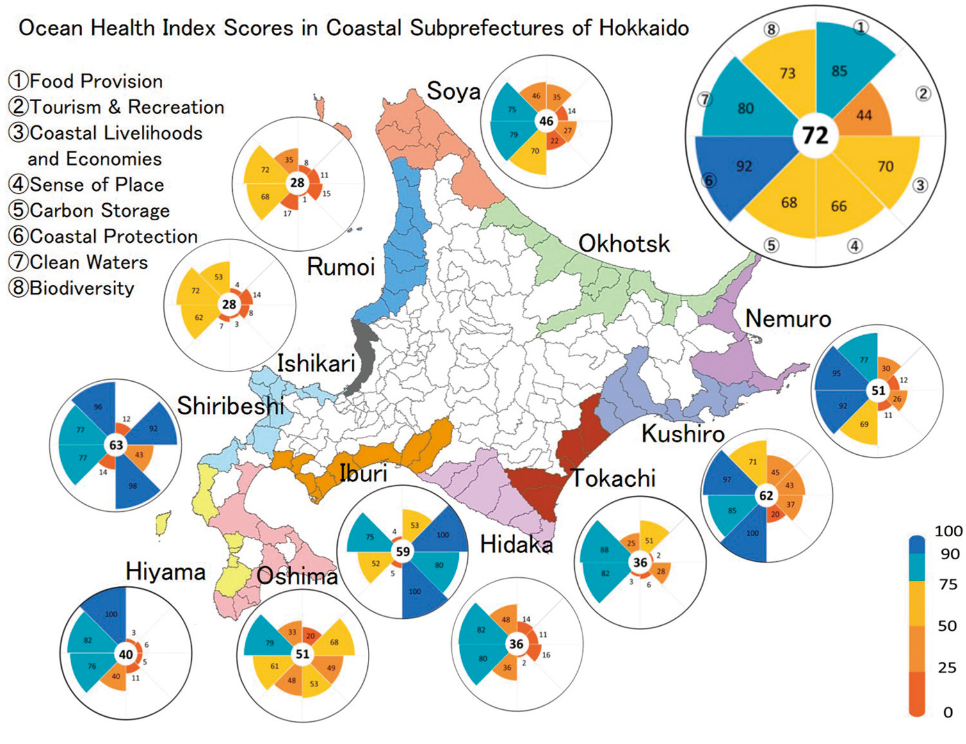
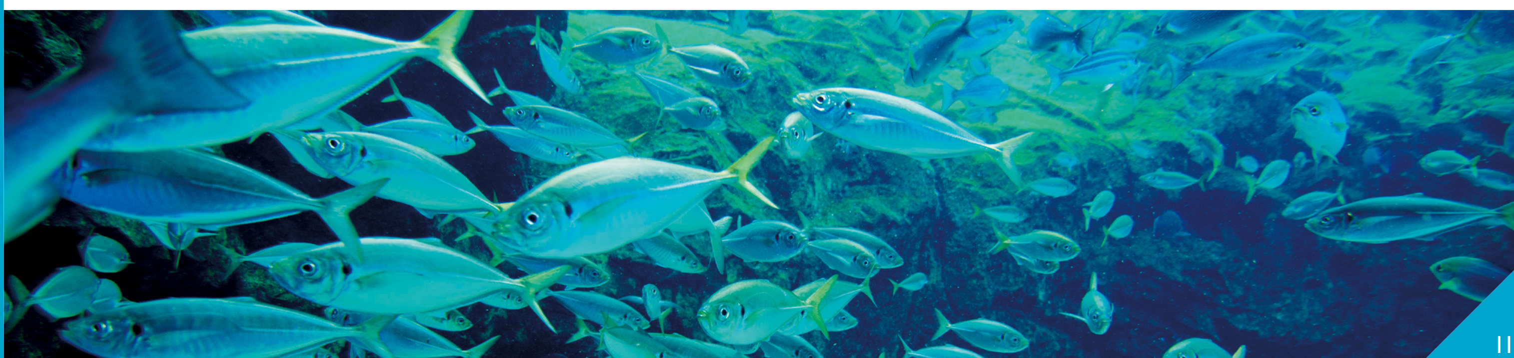


Fig. 10

Result of a comparative analysis of OHI between subprefecture in Hokkaido. It measures each of the following eight elements with a score ranging from 0 to 100: (1) food; (2) livelihood and economy; (3) tourism and recreation; (4) perception of the site; (5) carbon storage; (6) coastal protection; (7) water conditioning; and (8) biodiversity (Tamura, 2018;Wang, 2020)



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