R7-A03 The decrease in the eelgrass beds of Nanao Bay

Since when, and by how much, have the eelgrass beds of Nanao Bay decreased? What is known for before and after the earthquake, and what do the sources show about the causes and the measures?

Readers

Fishers and fishery cooperatives, local governments (staff in charge of fisheries and the environment), research institutions, groups working to protect seaweed and seagrass beds and others without specialist knowledge. Those who want to check, with figures and sources, since when and by how much the eelgrass beds of Nanao Bay have decreased, how reliable those values are, and what is known about the causes and the measures.

Takeaways

1. The eelgrass beds of Nanao Bay have decreased greatly. Eelgrass is a seagrass that flowers under the sea. In the national government's survey of around 1990, there were 1,923 ha of eelgrass beds in the Nanao Bay district. In the prefecture's survey of fiscal 2018, there were 768.8 ha. The prefecture states that they cannot simply be compared because the survey methods differ. In the West Bay, on the western side of the bay, the 1,258 ha of around 1990 had become 1,042 ha in 2011.
2. The decline had already become steep before the earthquake of 2024. In a research institution's analysis of satellite images, the early-summer eelgrass beds in an area centred on the West Bay went from 1,005 ha in 2015 to 464 ha in 2019 and 6 ha in May 2023. A prefectural researcher recorded a water temperature of 32°C on 1 September 2023. Eelgrass remained only at water depths of 1–1.5 m, and in October the former eelgrass beds had become mud flats.
3. In the surveys after the earthquake, too, almost no eelgrass beds were found. In the survey by the Kanazawa Association of Corporate Executives, a business association, the figure from a satellite image of March 2025 was 4 ha. The Association states that this is a 99.5% decrease from the 769 ha of fiscal 2018. When 63 sites were viewed with an underwater camera in May 2025, eelgrass was present at only 1 site. In Nanao Bay, no uplift due to the earthquake has been recognised. No source is found that measured how much the earthquake and the heavy rain affected the eelgrass beds.
4. The causes that the sources give are mainly high water temperature in summer and a lack of light due to turbidity. In the summer of 2012, the water temperature exceeded 30°C in the centre of the West Bay, and the eelgrass died down to the rhizomes at all the sites surveyed. The eelgrass of Nanao Bay becomes, in some years, an annual that dies within 1 year. The lower depth limit at which eelgrass grows was said to be about 8 m around 1990, and by 2011 it had become shallower, at about 3–5 m. A national project predicts that the summer water temperature of the West Bay will rise by about 2–4°C above the present by the end of this century. No study is found that confirmed the share of each cause.
5. No record is yet found of a measure that brought the eelgrass beds back. A citizens' group sowed seeds 5 times in 2019–2023. Only the sowing of the first year grew until the summer of the following year. The prefecture's Seaweed and Seagrass Bed Vision sets out seed sowing and monitoring at least once a year, but the results of the monitoring are not found in published materials. From fiscal 2025, a satoumi creation project of the Ministry of the Environment began at Wakura. For the time being, this project puts its emphasis on dwarf eelgrass (koamamo; a small relative of eelgrass), which is said to withstand high water temperature.

After reading

When using the area of the eelgrass beds of Nanao Bay in documents or plans, state which source the value is from, together with the time and season surveyed, the method and the area covered.

Methods include interviews, diving, satellite images and underwater cameras. The area covered is either the Nanao Bay district or the West Bay. The values for around 1990, fiscal 2018 and 2025 come from different survey methods, so do not read the differences as they are as the amount of decrease.

November 2026 · English edition 1 (translation of the Japanese 1st edition) · SeatecHIROSHIMA Ltd.

This is an English translation. The Japanese edition is the authoritative text.

1. Key points

- The eelgrass beds of Nanao Bay have decreased greatly. Eelgrass is a seagrass that flowers under the sea. In the national government's survey of around 1990, there were 1,923 ha of eelgrass beds in the Nanao Bay district. In the prefecture's survey of fiscal 2018, there were 768.8 ha. The prefecture states that they cannot simply be compared because the survey methods differ. In the West Bay, on the western side of the bay, the 1,258 ha of around 1990 had become 1,042 ha in 2011. [S7, S9, S5, S6]
- The decline had already become steep before the earthquake of 2024. In a research institution's analysis of satellite images, the early-summer eelgrass beds in an area centred on the West Bay went from 1,005 ha in 2015 to 464 ha in 2019 and 6 ha in May 2023. A prefectural researcher recorded a water temperature of 32°C on 1 September 2023. Eelgrass remained only at water depths of 1–1.5 m, and in October the former eelgrass beds had become mud flats. [S4, S2]
- In the surveys after the earthquake, too, almost no eelgrass beds were found. In the survey by the Kanazawa Association of Corporate Executives, a business association, the figure from a satellite image of March 2025 was 4 ha. The Association states that this is a 99.5% decrease from the 769 ha of fiscal 2018. When 63 sites were viewed with an underwater camera in May 2025, eelgrass was present at only 1 site. In Nanao Bay, no uplift due to the earthquake has been recognised. No source is found that measured how much the earthquake and the heavy rain affected the eelgrass beds. [S1, S21]
- The causes that the sources give are mainly high water temperature in summer and a lack of light due to turbidity. In the summer of 2012, the water temperature exceeded 30°C in the centre of the West Bay, and the eelgrass died down to the rhizomes at all the sites surveyed. The eelgrass of Nanao Bay becomes, in some years, an annual that dies within 1 year. The lower depth limit at which eelgrass grows was said to be about 8 m around 1990, and by 2011 it had become shallower, at about 3–5 m. A national project predicts that the summer water temperature of the West Bay will rise by about 2–4°C above the present by the end of this century. No study is found that confirmed the share of each cause. [S5, S6, S8]
- No record is yet found of a measure that brought the eelgrass beds back. A citizens' group sowed seeds 5 times in 2019–2023. Only the sowing of the first year grew until the summer of the following year. The prefecture's Seaweed and Seagrass Bed Vision sets out seed sowing and monitoring at least once a year, but the results of the monitoring are not found in published materials. From fiscal 2025, a satoumi creation project of the Ministry of the Environment began at Wakura. For the time being, this project puts its emphasis on dwarf eelgrass (koamamo; a small relative of eelgrass), which is said to withstand high water temperature. [S27, S7, S3]

2. What is happening

World and Japan: what eelgrass beds are

Eelgrass beds are shallow seas where the seagrasses of the eelgrass group grow thickly. The eelgrasses are plants that flower and set seed under the sea; unlike the seaweeds that attach to rocks, they spread rhizomes (stems that run sideways through the ground) in a seabed of sand or mud and grow in stands. Fish, shrimps, squid and other animals use them as places to grow, places to feed and places to lay eggs; the rhizomes steady the sand of the seabed, and the leaves take up carbon dioxide by photosynthesis (the Ministry of the Environment's explanation). The functions of seaweed and seagrass beds, and the figures for the carbon stored in them, are covered in R2 "Seaweed and seagrass beds and the life of the sea". [S19]

Eelgrass is normally a perennial that lives on for many years, but in warm seas it becomes an annual that dies within 1 year. This is the type that sprouts from seed in autumn, grows from winter to spring, flowers and sets seed in early summer, and then dies in summer. In Japan, annual eelgrass beds are known in Kagoshima Bay, Lake Hamana and elsewhere, and the eelgrass of Ibusuki in Kagoshima Prefecture, close to the southern edge of the distribution of eelgrass, is all annual. On the east coast of the United States too, at places close to the southern edge of the distribution, there are populations that lose all their above-ground parts in summer and come back from seed, populations that remain all year round, and populations that have the characteristics of both, and this is seen as a response to summer water temperature. [S5, S19, S24]

Eelgrass is a plant that is weak against heat. In an indoor experiment (reported in 1987) that the Central Research Institute of Electric Power Industry carried out on eelgrass from Odawa Bay (Kanagawa Prefecture), when the water temperature was raised by 6°C in summer so that the maximum was 32°C, all the shoots bearing leaves and rhizomes (vegetative shoots) died. When it was raised by 6°C in winter so that the minimum was 18°C, the share of seeds that sprouted (the germination rate) fell. For Ago Bay in Mie Prefecture, there is a report that puts the upper limit of the water temperature at which eelgrass grows at 28°C (quoted). [S22, S5]

The depth at which eelgrass grows is determined by the amount of light that reaches it. When the water becomes turbid, light does not reach the deep places, and the eelgrass disappears from the deep places first. A researcher interviewed in a national project says that, if the water is clear, eelgrass can escape to cool, deep places even if the water temperature rises. Conversely, in a turbid sea, the eelgrass is caught between the heat and the lack of light, and the range of depths at which it grows becomes narrow (this paper's summary). [S8, S11]

World and Japan: cases where eelgrass beds decreased, and what was learned afterwards

Both in the world and in Japan, seagrass beds, including eelgrass beds, have been decreasing. A paper that brought together 215 studies (2009) states that 29% of the area of the seagrass beds for which there are records has been lost since 1879. Another paper (2021) states that 19.1% (5,602 km^2) of the area surveyed has been lost on a net basis since 1880. The later paper states that the beds surveyed are about 10% of the world's seagrass beds, and that they are unevenly spread over periods and regions. In Japan, the Environment Agency's 4th National Survey on the Natural Environment (around 1990; reported in 1994) found that 3.2% (6,403 ha) of the seaweed and seagrass beds nationwide had disappeared over about 13 years, and eelgrass beds were 15.7% of the seaweed and seagrass beds nationwide. The details are covered in R2 "Seaweed and seagrass beds and the life of the sea". [S23, S9]

There are cases in which heat and turbidity came together and eelgrass beds decreased greatly. In Chesapeake Bay in the eastern United States, 31 years of aerial photographs and water quality data showed that the area of eelgrass had decreased by 29% since 1991, and the main cause was the combination of a fall in water clarity and a rise in water temperature. In the York River of the same bay, in the abnormally hot summer of 2005, days above

30°C continued in large numbers, and almost all the eelgrass shoots died. The decline was larger in the deep parts of the beds and upstream, where light is scarce. [S24]

How the beds come back after dying once has also been studied. After the large die-off of 2005 in Chesapeake Bay, in 2006 most of the shoots that came back were sprouts from seed (seedlings). However, in the first year of the return, the living seeds remaining in the seabed were almost used up, and because seedlings do not flower until their 2nd year, the store of seeds does not come back quickly. The researchers state that, if such hot years are repeated, the eelgrass could remain gone for a longer time. [S24]

In Japan too, cases have been recorded in which eelgrass could not survive the summer in a year of high water temperature, and in which eelgrass was replaced by another species (Table 1). The eelgrass bed of Ibusuki in Kagoshima Prefecture disappeared from fiscal 2018 and was not seen for 7 years in a row, up to fiscal 2024. On the other hand, when local collaborators tried regeneration inside an enclosure net that keeps out fish that eat seaweeds and seagrasses, an eelgrass bed formed with about the same density and shoot height as in the past, and in fiscal 2025 eelgrass also grew naturally on the survey line. At Futtsu in Chiba Prefecture (Tokyo Bay), in fiscal 2025, a site where eelgrass and dwarf eelgrass had been mixed became almost dwarf eelgrass alone. [S19]

There are also cases in which eelgrass beds disappeared because of the tsunami of a large earthquake. In the tsunami of the Great East Japan Earthquake of 2011, most of the eelgrass beds of Funakoshi Bay and Otsuchi Bay in Iwate Prefecture disappeared for several years. In fiscal 2024, stands of eelgrass have come back in the shallow places, while tachiamamo (Zostera caulescens; a large relative of eelgrass) in the deep places remains scarce. [S19]

There are also cases in which seagrass was lost widely at one time because of a marine heatwave. In Shark Bay in Western Australia, after the marine heatwave of 2010–2011, in which summers 2–5°C hotter than normal continued, 36% of the seagrass beds were damaged and 1,310 km^2 of densely growing seagrass was lost. Depending on the assumptions about the conditions, it is said that 2–9 million tonnes (Tg) as carbon dioxide may have been released to the atmosphere in the following 3 years. What was lost here was a seagrass of a different kind from eelgrass. [S26]

Table 1 Main cases in Japan and abroad in which eelgrass beds and other seagrass beds decreased

Place	Period	What happened	What was learned
Ibusuki, Kagoshima Prefecture (the southern edge of eelgrass)	Shrinking from around 2017, gone from fiscal 2018	An annual eelgrass bed not seen for 7 years in a row	An eelgrass bed formed by regeneration inside an enclosure net that keeps out fish, and in fiscal 2025 eelgrass also grew naturally
Kasasa, Kagoshima Prefecture	Decrease from 2022 onwards, gone in fiscal 2024	Eelgrass disappeared, leaving only dwarf eelgrass and umihirumo (Halophila)	A decline similar to that at Ibusuki. Many marks of grazing on the leaves
Futtsu, Chiba Prefecture (Tokyo Bay)	Fiscal 2025	A site where eelgrass and dwarf eelgrass were mixed became almost dwarf eelgrass alone	Replacement of species is taking place
Omura Bay, Nagasaki Prefecture	2016 (a year of high water temperature)	Less eelgrass than in the previous year, and it disappeared from September onwards	It cannot survive the summer in a hot year
Seto Inland Sea	Recent years	A report that aigo (rabbitfish), a fish of southern seas, ate eelgrass	With the rise in water temperature, the effect of grazing fish appears

Place	Period	What happened	What was learned
Funakoshi Bay and Otsuchi Bay, Iwate Prefecture	The tsunami of 2011	Most of the eelgrass beds disappeared for several years	They came back from the shallow places. Tachiamamo in the deep places remains scarce
Chesapeake Bay, United States	Since 1991; the extreme heat of 2005	A 29% decrease since 1991. In 2005 almost all the shoots died	Turbidity and heat combined. The return is from seed. The store of seeds is used up in the first year
Shark Bay, Western Australia	The marine heat - wave of 2010–2011	36% of the beds were dam - aged, and 1,310 km² of dense seagrass was lost	Sudden heat causes wide loss at one time

Note: Because the ways of measuring and the scales differ, the sizes of the values cannot be compared as they are. The "marks of grazing on the leaves" at Kasasa are an inference by the report. [S19, S20, S24, S26]

Things have also been learned from attempts at restoration. A paper that brought together 1,786 restoration trials around the world (2016) states that it is important to remove the cause of the decline before planting. Places where the cause is a deterioration in water quality (mainly too many nutrients in the sea) are hard to succeed in, most of the trials are small, and the share of trials that continued to survive was estimated at about 37% overall. On the other hand, in the shallow lagoons of the mid-Atlantic coast of the United States, more than 70 million seeds have been sown since 1999, and 3,612 ha of seagrass has come back. In Chesapeake Bay, lowering the concentration of nitrogen in the bay's water by 23% from 1984 brought back 17,000 ha of underwater plants (according to R2, including freshwater species). The details are covered in R2 "Seaweed and seagrass beds and the life of the sea". [S25, S24]

Region (Nanao Bay): Nanao Bay and its eelgrass beds

Nanao Bay is an enclosed bay on the inner side of the Noto Peninsula. In this paper, it means the North Bay, West Bay and South Bay, which are divided by Notojima Island, and Nanao City and Anamizu Town on their coasts. Figures for the Toyama Bay side of Nanao City (Nadaura), for Noto Town, for Iida Bay in Suzu City and for Sotoura (the outer, Sea of Japan coast of the Noto Peninsula) are not used as this paper's figures. The area of the bay is about 183 km², and the average water depth is 22.2 m in the North Bay, 6.3 m in the West Bay and 10.0 m in the South Bay; the deepest place, at the entrance to the North Bay, is 60 m. The West Bay, surrounded by land on three sides, has the most enclosed shape, and rivers such as the Kumaki River and the Ninomiya River flow into it. [S13, S11, S6]

The eelgrass beds of Nanao Bay have spread over the western side of the bay, especially the West Bay. In the national government's survey of around 1990, the eelgrass beds of the West Bay (west of the line joining Kotanibana and Cape Byobu) were 1,258 ha, which is about 65% of the 1,923 ha of the Nanao Bay district (this paper's calculation). In the Ishikawa Prefecture table of this survey, the eelgrass beds of the West Bay are Wakura 796 ha, Karashima 430 ha, Fujiyoshibana 25 ha and Tanegashima 7 ha, which add up to 1,258 ha (this paper's calculation; the source does not state this way of adding). Of the eelgrass beds of the whole prefecture (2,403.0 ha), the Nanao Bay district accounted for 80.0% (this paper's calculation from the values in the prefecture's table). [S5, S9, S7]

The sources have described the eelgrass beds of Nanao Bay as large. An abstract by a research institution posted on the website of a research institute of Toyama Prefecture (2024) writes "the largest eelgrass bed on the Sea of Japan side", a separate English-language presentation by the same institution (2025) writes "one of the largest on the Sea of Japan side" (this paper's translation), the Ministry of the Environment writes "a large-scale eelgrass bed of an inner bay of the Sea of Japan", and a prefectural researcher writes "the largest in the

prefecture". These are the wordings of the respective sources, and we found no source that compared the area with other eelgrass beds on the Sea of Japan side. As large eelgrass beds nationwide, the national government's 4th survey listed, among others, the 3,497 ha of Mutsu Bay and the 2,800 ha of Kushiro. These values are values for each division of seaweed and seagrass beds in the national survey, and the unit of counting differs from the total for the Nanao Bay district, which the prefecture compiled after aligning the categories. [S2, S12, S14, S6, S9]

Several kinds of eelgrass relatives grow in Nanao Bay. Besides eelgrass, dwarf eelgrass, sugeamamo (Zostera caespitosa) and a relative of umihirumo (Noto-umihirumo) are recorded. Sugeamamo is Near Threatened in the national 5th Red Data Book (March 2025), and is also Near Threatened in Ishikawa Prefecture. The Ministry of the Environment has selected the sea area including Nanao Bay as a "sea area of high importance from the viewpoint of biodiversity", and writes that sugeamamo is abundant. In the national survey of June 2020 around Notojima Island, eelgrass on sandy ground had a cover (the share of the seabed covered) of less than 5%, and sugeamamo had a cover of up to 30%. [S4, S14, S18]

The eelgrass beds are also a place where the fish of Nanao Bay grow. A Fisheries Agency document (2023) states that the juveniles of red sea bream born in Nanao Bay stay and grow on the sandy seabed at water depths of 5–15 m where eelgrass grows in stands. The prefecture's Seaweed and Seagrass Bed Vision (2022) expects the eelgrass beds of calm seas such as Nanao Bay to function as a place where sea breams and other fish lay eggs and juveniles grow, and to function to stabilise water quality. We found no source that showed in figures how much the fish decreased as the eelgrass beds decreased. [S16, S7]

Region (Nanao Bay): changes in the area of the eelgrass beds

The area of the eelgrass beds of Nanao Bay differs from source to source in the area covered, the season surveyed and the method (Table 2). Even so, all the sources agree that the beds have been decreasing.

The oldest area is from the national government's survey of around 1990. This was the 4th National Survey on the Natural Environment, which the Environment Agency asked the prefectures to carry out in fiscal 1989 to 1991 (Heisei 1 to 3); it was based on the materials of the previous round, aerial photographs and interviews, and checked on site where necessary. In Ishikawa Prefecture, the sites in the report of the previous round were checked by swimming at the sea surface, and interviews were also carried out. The eelgrass beds of the Nanao Bay district were 1,923 ha, and those of the West Bay were 1,258 ha. The value for the Nanao Bay district is a value that the prefecture recompiled after aligning the categories of seaweed and seagrass beds, and it is the part on the Nanao Bay coast of Nanao City. The part in Anamizu Town (170 ha) is in a separate district in the prefecture's table. [S9, S7]

In December 2011, prefectural researchers surveyed the West Bay by diving, and the eelgrass beds were 1,042 ha. This was 83% of the figure of around 1990, a decrease of 216 ha (about 17%) in 21 years, and the eelgrass beds in the deep places had disappeared. [S5, S6, S11]

In fiscal 2018, the prefecture, with a subsidy from the Fisheries Agency, surveyed with satellite images and with an underwater camera and an acoustic instrument (scanning sonar) from a boat. The eelgrass beds of the Nanao Bay district were 768.8 ha. The prefecture states that this cannot simply be compared with the survey of around 1990 because the method and the categories differ. A presentation document by a prefectural researcher gives the eelgrass beds of the West Bay in 2018 as 746 ha (72% of 2011) (this appears to be a value from the prefecture's survey, but the method is not stated in the document). The West Bay is about 97% of the Nanao Bay district, which would mean that almost no eelgrass beds remained outside the West Bay (this paper's calculation and view; whether the boundary lines of the areas are the same is not known). In the Anamizu Town district, the 170 ha of around 1990 is 0.0 ha in fiscal 2018. However, the prefecture's table calculates places with no data as 0.0; it can be seen that no eelgrass bed was classified in Anamizu Town in the survey of fiscal 2018, but when and why it disappeared is not known. [S7, S4]

Since 2015, a research institution, the Northwest Pacific Region Environmental Cooperation Center (NPEC; a public interest incorporated foundation in Toyama City), has been monitoring the West Bay. By a method of viewing the seabed with an underwater camera from a boat and judging the cover on 6 levels, it surveyed about 130 sites in the autumn of 2023. The share of sites where dense eelgrass of cover level 3 or above was seen in early summer fell from 35% in 2015 to 9% in 2023. In 2021–2023, early-summer eelgrass was seen only in the shallow places in the southern part of the bay. The abstract describes the eelgrass beds that decreased as "on a scale of several hundred ha". [S2]

The same institution also produced areas from satellite images. In a presentation document of September 2025, the early-summer eelgrass beds in an area centred on the West Bay were 1,005 ha on 1 June 2015 (an image from the US satellite Landsat 8), 464 ha on 25 July 2019 and 6 ha on 10 May 2023 (both images from the European satellite Sentinel-2). The area covered is this paper's view as read from the figure, and the North Bay and the South Bay appear to be outside the analysis. From autumn to early winter, the figures are 111 ha on 10 December 2015, 17 ha on 8 September 2019 and 0 ha on 1 November 2023. These are values obtained by classifying the seabed in the images by machine learning (a method called random forest), using on-site observations as the model, and the only explanation of the method is the note to the figure. [S4]

The area after the earthquake is in the survey of the Kanazawa Association of Corporate Executives (report of March 2026). Nanao Bay was surveyed with a satellite image (SPOT6; a resolution of 1.5 m) of 14 March 2025, and the eelgrass beds of the Nanao Bay district of Nanao City were 4 ha. The Association compares this with 769 ha, which it recalculated from the data of the time of the prefecture's fiscal 2018 survey, and gives a decrease of 99.5%. In this survey, a seaweed or seagrass bed is defined as a place where seaweeds or seagrasses cover 25% or more of the seabed. In the Anamizu Town district, no eelgrass bed was classified either the previous time or this time. [S1]

Table 2 Area of the eelgrass beds of Nanao Bay (differences by source and method)

Period surveyed	Area covered	Area of eelgrass beds	Method and source
Around 1990	Nanao Bay district	1,923 ha	The national 4th National Survey on the Natural Environment (in Ishikawa Prefecture, the sites of the previous round were checked by swimming at the sea surface, and interviews were also carried out). Compiled by the prefecture after aligning the categories
Around 1990	West Bay	1,258 ha	The same survey
December 2011	West Bay	1,042 ha	Diving survey by prefectural researchers
1 June 2015	Area cen - tred on the West Bay	1,005 ha, 846.6 ha	Satellite image (apparently the same image). NPEC's machine-learn - ing classification (presented in 2025) and a different classification in a report of an international organisation (2018)
Fiscal 2018	Nanao Bay district	768.8 ha (769 ha as recalculated by the Association)	The prefecture's survey (satellite images, camera and acoustics from a boat)
2018	West Bay	746 ha	Presentation document by a prefectural researcher (apparently a value from the prefecture's survey)
25 July 2019	Area cen - tred on the West Bay	464 ha	Satellite image (NPEC)

Period surveyed	Area covered	Area of eelgrass beds	Method and source
10 May 2023	Area cen - tred on the West Bay	6 ha	Satellite image (NPEC)
14 March 2025	Nanao Bay district of Nanao City	4 ha	Satellite image (Kanazawa Association of Corporate Executives; a cover of 25% or more is treated as a bed)

Note: Because the method, season and area covered differ, the differences between the values in the table cannot be read as they are as the amount of decrease (chapter 5). The eelgrass of Nanao Bay is thickest in early summer and decreases in autumn. The NPEC values for autumn to early winter (111 ha in 2015, 17 ha in 2019, 0 ha in 2023) are not included in the table. [S9, S7, S5, S6, S4, S11, S1]

Region (Nanao Bay): what was happening before the earthquake

The decline of the eelgrass of Nanao Bay had already been recorded in the survey of around 1990. The Ishikawa Prefecture chapter of the national government's 4th survey (1994) writes that, compared with the previous round in fiscal 1978, the decrease in the amount of sugeamamo, which had been seen in abundance in Nanao Bay, was marked, and that in the sea of Uchiura the density of eelgrass had become considerably lower. The cause was given as "unknown". This is not an area but a record of observations made by swimming at the sea surface and of interviews. [S9]

In the summer of 2012, the eelgrass of the West Bay died down to the rhizomes. When prefectural researchers surveyed 5 sites in the West Bay (water depths of about 1.6–3.3 m), the eelgrass beds that had been growing densely in spring had, by October, died down to the rhizomes over a wide area, leaving only seedlings that had just sprouted. The water temperature in the centre of the West Bay (water depth 5 m) exceeded 30°C in August–September 2012. The researchers thought that this might be an "unstable bed", in which perennial eelgrass all dies in the high water temperature of summer and the eelgrass bed temporarily disappears. In the following years, 2013 and 2014, the summer maximums were 28.8°C and 27.9°C and did not exceed 30°C, and some shoots survived the summer and remained. [S5, S6]

The eelgrass of Nanao Bay becomes annual or perennial depending on the year. When shoots were collected at 4 sites in the West Bay in the spring of 2015, the share of seedlings that had grown from seed in that year differed greatly from place to place: 96.3% off the mouth of the Kumaki River, 85.1% off Tatsuruhama, 56.3% off Shirasaki and 10.0% off Karashima (in Kurikawashiri Bay in Noto Town, used for comparison, it was 16.0%). The share of the seedlings that could survive the summer and become perennial is estimated at 17% off the mouth of the Kumaki River and off Tatsuruhama, and at about 44% off Shirasaki. A prefectural researcher said in 2017, in an interview for a national project, that the eelgrass of Nanao Bay could be seen changing from perennial to single-year (annual) plants, and NPEC's annual report (posted October 2025) also writes that the eelgrass beds of Nanao Bay may be switching from perennial to annual. [S5, S8, S12]

The lower depth limit at which eelgrass grows became gradually shallower. Around 1990, it is said to have grown down to a water depth of about 8 m at the deepest, but by 2011 this had become about 3–5 m. The prefectural researchers think that this was because the clarity of the seawater fell and light no longer reached the deep places. In a report of an international organisation (2018) that used satellite images of 2015–2016 and on-site surveys, dense seagrass was mainly in places shallower than a water depth of 5 m. In the observations of a national project in 2019, there were more shoots at the site with a water depth of 3.7 m than at the sites of 4.7 m and 6.3 m, and the report gives the fact that light is more lacking the deeper the place as one of the reasons.

Because the method differs from source to source, this way of setting them side by side is this paper's summary. [S6, S11, S8]

In 2018–2019, a national project measured the water temperature and the eelgrass of the West Bay continuously. This was the Chubu regional project of the Ministry of the Environment's Regional Adaptation Consortium (fiscal 2017–2019). When the water temperature was measured continuously at 3 sites in the West Bay (water depths of 3.7 m, 4.7 m and 6.3 m), the maximum was about 32°C (the main text of the report says "around 32°C"; the time, as read from the figure, was around the first half of August, and the "around the first half of March" in the main text appears to be a slip of the pen). In April–August, the water temperature at a water depth of 5.3 m was often 3–4°C lower than at a water depth of 1 m. In 2019, at every site, the number and weight of eelgrass shoots fell in the summer when hot days continued, and in September they were no longer seen. [S8]

By 2023, the eelgrass beds of the West Bay had almost disappeared. In the satellite analysis, the early-summer area was 6 ha and that of November was 0 ha. With the underwater camera too, the dense sites were 9%. The presentation document by a prefectural researcher gives the water temperature of Nanao Bay on 1 September 2023 as 32°C, and states that eelgrass was seen only at water depths of 1–1.5 m, that the water was so turbid that one could not see the tips of one's hands, and that the rhizomes and roots had turned black and were close to dying (the place and depth of the measurement are not stated). In October, the eelgrass at the place where seeds had been sown the year before had also disappeared, and the long-standing eelgrass beds had become mud flats. Dwarf eelgrass was surviving at water depths of less than 1 m. [S4, S2]

Region (Nanao Bay): the situation after the earthquake

In the Noto Peninsula Earthquake of 1 January 2024, no uplift of the coast was recognised in Nanao Bay. The press release (January 2026) on a paper by researchers of Hiroshima University, Kanazawa University and others states that, while uplift was clearly confirmed on the north coast of the Noto Peninsula, no uplift was recognised in Nanao Bay or Toyama Bay. The eelgrass beds of Nanao Bay did not dry out and disappear like the shallow seaweed beds of Sotoura. The subsidence of the ground and the flooding in Nanao Bay are covered in R7-A19 "Ground subsidence and flooding in Nanao Bay". The drying out of the seaweed beds of Sotoura is covered in R7-B08 "Shallow seaweed beds dried out by uplift, and the decrease in the area of seaweed beds in Sotoura". [S21]

In an observation half a year after the earthquake, too, eelgrass was scarce. On 26 June 2024, the prefecture's Noto Marine Center surveyed the coasts of Karashima in Nanao City, at the westernmost part of the West Bay, and Niizaki in Anamizu Town. It states that at Karashima eelgrass and sugeamamo were growing on the seabed of sandy mud but "the growing density was low", and that at Niizaki they were "quite scarce". This was a survey of the organisms of rocky shores, viewing from the shore to a water depth of about 0.5 m with glass-bottomed viewing boxes and the like, and it did not measure the area of eelgrass beds. In the table of the same report, compared with 2021, Niizaki fell from "often found" to "found if searched for", and Karashima remains "often found". [S10]

In the surveys of 2025, almost no eelgrass beds were found. The survey of the Kanazawa Association of Corporate Executives gave the eelgrass beds of the Nanao Bay district as 4 ha from the satellite image of March 2025, and on 2 May 2025, at 63 sites in Nanao Bay, it lowered an underwater camera (ROV) from a boat and viewed the seabed. Eelgrass was recorded at only 1 site near the entrance of the bay (water depth 7.4 m, cover 5%); there was no eelgrass at the 9 sites in the West Bay (water depths of 0.9–6.0 m), and the photograph of 1 of those sites is marked "eelgrass disappeared". The summary of the report states that the eelgrass beds that had been distributed in the inner part of Nanao Bay had been lost. This "lost" means that eelgrass beds covering 25% or more of the seabed are no longer seen; it does not mean that there is not a single shoot of eelgrass (this

paper's reading; the report treats a cover of 25% or more as a bed, and it recorded eelgrass with a cover of 5% at 1 site). [S1]

In the same survey, the Sargassum beds of Nanao Bay (beds of large seaweeds such as the Sargassum group) had, on the contrary, increased. The total of the seaweed and seagrass beds of the Nanao Bay district of Nanao City was 742 ha (1,276 ha the previous time, a decrease of 41.8%). The Sargassum beds increased from 507 ha to 733 ha, but the decrease in the eelgrass beds (from 769 ha to 4 ha) exceeded that (values from the Association's table). The Sargassum beds are covered in R7-A04 "The decline of the Sargassum beds of Nanao Bay". Outside Nanao Bay, in Iida Bay in Suzu City, dense eelgrass covering 70–90% of the seabed was recorded at several sites on 28 April 2025 (not a figure for Nanao Bay). [S1]

We found no source that measured how much the earthquake and the Okunoto heavy rain of September 2024 affected the eelgrass beds of Nanao Bay. The overall summary of the Association's report (by the leader of the survey team, Daisuke Fujita, president of the Japan Seaweed Association) states that the eelgrass beds of these waters had been declining since about 10 years before the earthquake disaster and the heavy rain, and that, because 5–8 years had passed since the previous survey among other reasons, the extent of the direct damage is not clear, but that, as for the earthquake and the heavy rain, "the possibility that they dealt a further blow is very high". This is a view, not a measured value. The same overall summary states that the effect of the earthquake's tsunami (maximum 4 m) was limited to the tip of the peninsula, close to the epicentre. [S1]

Region (Nanao Bay): what is given as the causes

The sources give a number of causes (Table 3). For none of them did we find a study that confirmed the share of each cause in Nanao Bay.

The cause with the strongest evidence is high water temperature in summer. In the summer of 2012, when 30°C was exceeded, the eelgrass died down to the rhizomes at all the sites surveyed, and in 2013 and 2014, when 30°C was not exceeded, there were shoots that survived the summer. For the Nanao West Bay, the national Chubu regional project set 30°C as the guide water temperature at which eelgrass die-off occurs, and 28°C as the water temperature at which perennial eelgrass disappears and the decline of the eelgrass beds becomes clear. Both are guides, and it is not the case that the eelgrass dies as soon as they are exceeded. The long-term change in the water temperature of Nanao Bay is covered in R7-A02 "The rise in seawater temperature in Nanao Bay". [S5, S8]

It has also been shown that autumn water temperature may be affecting the amount of eelgrass in the following year. NPEC's abstract states that there was a relationship in which early-summer eelgrass beds were smaller when the water temperature in November of the previous year was high, and that, because the germination rate of eelgrass falls at high water temperature, a decrease in sprouts due to high autumn water temperature may be one of the causes of the decline. However, the water temperature compared is the value for water pumped up from a water depth of 7 m by a facility in Himi City, Toyama Prefecture, and is not a value for Nanao Bay. The relationship is a tendency seen over the 7 years in the figure of the abstract (2015, 2016, 2019–2023; this paper's count), and it does not confirm the cause. [S2]

A lack of light due to turbidity is also given. The lower depth limit of growth becoming shallower, from about 8 m to 3–5 m, is thought to be because clarity fell. Fishers have also pointed to a fall in clarity due to fine mud that collects on the seabed (fluid mud). The West Bay is a place that prefectural researchers describe as "waters where eutrophication is especially advanced even within the prefecture"; the bottom is mud with much fluid mud, and off the mouth of the Kumaki River in the autumn of 2014 the turbidity was so bad that photographs could not be taken. Turbidity and fluid mud are covered in R7-A05 "Turbidity and fluid mud in Nanao Bay", and the mud of the seabed in R7-A06 "The muddying and organic pollution of the seabed of Nanao Bay". [S6, S2, S5]

Fish that eat seaweeds and seagrasses are also a worry. However, we found no record of aigo (rabbitfish) or other fish eating eelgrass in Nanao Bay. The overall summary of the Association's report writes that grazing damage by aigo has also been recognised, but the literature it cites is an observation that schools of aigo ate tachiamamo and other plants in Tsukumo Bay in Noto Town in 2000 and 2002. A Fisheries Agency document (2023) gives grazing damage to seaweed and seagrass beds by fish that eat seaweed as "a concern" in the Noto and Uchiura district, which includes Nanao Bay. [S1, S33, S16]

Table 3 What the sources give as causes of the decrease in the eelgrass beds of Nanao Bay

Cause given	Evidence	Strength of evidence (this paper's view)
High water temperature in summer	30°C was exceeded in 2012, and the eelgrass died down to the rhizomes at all sites. In years when 30°C was not exceeded, shoots remained. In 2019 it was no longer seen in September. Indoor experiment	Strong. In Nanao Bay, observation and water temperature are both available. There is no study that confirmed the share
High water temperature in autumn (fewer sprouts)	Relationship between the water temperature in November of the previous year and the amount of early-summer eelgrass beds	Weak. Water temperature at Himi, a tendency over 7 years
Lack of light due to turbidity and fluid mud	The lower depth limit of growth became shallower. Pointed out by fishers. The severe turbidity of September 2023	Medium. There is no comparison with measured light or clarity
Too many nutrients in the sea; mud of the seabed	View of researchers and a citizens' group	Weak. There is no source that showed quantities for the eelgrass of Nanao Bay
Fish that eat seaweeds and seagrasses	The "concern" in a national document. Observation in Tsukumo Bay in Noto Town	Weak. There is no record for Nanao Bay
Earthquake and heavy rain	View of the overall summary of the Association	Weak. There is no source that measured it. No uplift has been recognised in Nanao Bay

Note: The strength of the causes is a guide that this paper assigned by setting the sources side by side.
[S5, S8, S22, S2, S6, S1, S16, S33, S21]

Region (Nanao Bay): what changes when the eelgrass beds decrease

When the eelgrass beds decrease, the places for the living things that use them decrease. The prefectural researchers write that in 2012 the eelgrass beds were gone from summer to autumn, and that the living things that live there would have been deprived of their habitat during that time. The function as a place where the juveniles of red sea bream grow is as described in the first section of this chapter. A group of fishers in Ishizaki, Nanao City, states that the stocks of sea cucumber and egg cockle (torigai) have decreased, and that the decrease in eelgrass beds and Sargassum beds in particular is a major issue for the area, but this is not a source that confirmed the relationship between eelgrass beds and stocks. Egg cockle and sea cucumber are covered in R7-A14 "The decrease in wild egg cockle (torigai)" and R7-A16 "The poor catch of sea cucumber in Nanao Bay".
[S6, S30]

There is also a view that other seaweeds increased on the nutrients of the sea that were no longer used because the eelgrass beds had decreased. An explanatory article by researchers of Nanao Bay and others (2021) states that tsurushiramo (Gracilariopsis chorda) and nagamiru (Codium cylindricum) grew in large quantities on the

nutrients left over by the decrease in the seaweed and seagrass beds, and this is covered in R7-A17 "The mass occurrence of seaweeds in Nanao Bay". [S13]

The August 2014 issue of Nanao City's public relations magazine wrote that, while activities to plant eelgrass were flourishing in various places, in the satoumi of Nanao it "grows in such rich stands that there is no need for that". In 2019, a citizens' group began sowing eelgrass seeds in the West Bay (chapter 3). [S31, S27]

3. Existing measures, and how they are assessed

The measures taken so far for the eelgrass beds of Nanao Bay centre on monitoring (keeping watch) and seed sowing by a citizens' group. From fiscal 2025, a national satoumi creation project has also begun. We found no record of a measure that brought the eelgrass beds of Nanao Bay back.

Monitoring

The eelgrass beds have been surveyed by the national government, the prefecture, a research institution and a business association, each by a different method (Table 2). These are the diving surveys by prefectural researchers (2011–2015), NPEC's underwater camera monitoring (from 2015), the observations of the national Chubu regional project (2018–2019), the prefecture's satellite survey (fiscal 2018), and the Association's satellite and underwater camera survey (2025). Every survey showed that the beds have been decreasing, but because the methods and the areas covered differ, they do not form a record of area that can be compared continuously (chapter 5). [S5, S2, S8, S7, S1]

In fiscal 2025, NPEC also tried a new monitoring method. It writes in its own annual report (posted August 2026) that it measured on site with a fish finder (Deeper) that can be attached to a small boat or a board, classified satellite images using that as the model, and was able to pick out with high accuracy the eelgrass beds remaining in shallow places. No figures for area are given. On 27 August 2025, using a board paddled standing up (SUP) and snorkelling, it confirmed that there was dense eelgrass (probably dwarf eelgrass) at a water depth of 1 m on the right bank of the mouth of the Ninomiya River. [S12, S4]

A national document states that there is an issue with the cost of monitoring. The report of the national Chubu regional project (2020) states that, because eelgrass is not a target of fishing and there is no one who benefits, how to secure the cost of monitoring is an issue. [S8]

The prefecture's plans

The prefecture's Seaweed and Seagrass Bed Vision (March 2022) sets out seed sowing and monitoring for the eelgrass beds of Nanao Bay. It states that seeds will be sown around the stands of eelgrass in Nanao Bay where decline is seen, to protect the eelgrass beds, and it lists the seed sowing of a citizens' group, the Noto Forest, Village and Sea Study Group (Noto no Mori-Sato-Umi Kenkyukai), as that effort. It also states that the seaweed and seagrass beds of the whole prefecture will be surveyed in fiscal 2024, that monitoring will be done at least once a year in the district of Nanao City where activities to increase eelgrass are carried out, and that a council of the prefecture, cities and towns, experts and fishers will be held at least once every fiscal year to make an assessment. We found the results of the monitoring and the records of the council in no published material. No target for the area of eelgrass beds is set. [S7]

The beds that the prefecture creates by construction work are beds of the Sargassum group, and eelgrass beds are not covered. The prefecture's plan for the Nanao Bay area (fiscal 2022–2026) gives, as one factor in the decline of the beds, the fact that the turbidity of the seawater increased and clarity fell, and states that beds will be created in shallow places that light reaches, but it has no mention of eelgrass. In the items of the Fisheries Division in the prefecture's budget explanatory material for fiscal 2026 (Reiwa 8), too, no project for the eelgrass

beds of Nanao Bay was to be seen. The beds created by construction work are covered in R7-A04 "The decline of the Sargassum beds of Nanao Bay". [S7, S28]

Local plans, and the activities of fishers

In the plans of the fisheries of Nanao Bay and of the city, we found no mention of measures for eelgrass beds. We searched the Plan for Revitalising Fishing Communities (Hama Plan) of the Nanao district (3rd period, fiscal 2025–2029), Nanao City's Strategic Reconstruction Plan (February 2025), its Reconstruction Action Plan (March 2026) and its 2nd Basic Environment Plan (March 2019) for the words for seaweed and seagrass beds and for eelgrass. [S29]

In Nanao Bay, the only activity organisation under the national measures to bring out the multiple functions of fisheries (national support for activities in which fishers and others protect seaweed and seagrass beds and tidal flats) that appears in the list on the website of a project commissioned by the Fisheries Agency (hitoumi.jp) was the Ishizaki Satoumi Conservation Group. Its 27 members, fishers and the Nanao branch of the Ishikawa Prefecture Fisheries Cooperative Association, carry out activities of hauling up rubbish and sediment from the seabed with nets and placing blocks with seaweed seed attached, but there is no mention of sowing or transplanting eelgrass. On 16 May 2025, an expert of the nationally commissioned project came to give individual guidance on seaweed and seagrass beds. The content and results of the guidance are not stated. [S30]

Seed sowing by a citizens' group

A citizens' group, the Noto Forest, Village and Sea Study Group, sowed eelgrass seeds 5 times in 2019–2023 in the sandy mud at a water depth of around 1 m at the mouth of the Funao River in the West Bay. By a method of sowing the seeds in hemp sacks filled with sand and sinking them, sprouts appeared after about 1 month every time. However, only the seeds sown in 2019 grew until the summer of the following year, and from 2020 onwards only a few sprouts appeared and they did not grow. The Study Group states that the cause is not known. Its base of activity collapsed in the earthquake, among other things, and its activity as an organisation has been stopped since 2024. Since 2024, volunteers have been carrying out a trial of growing eelgrass in small containers hung in the sea, and state that about 10% had sprouted by the spring of 2025. The details are covered in R7-A26 "The interruption of activities to regenerate eelgrass beds (earthquake)". [S27]

We found no source that linked the failure of the sowings from 2020 onwards to grow with the effect of high autumn water temperature that NPEC describes. The report of the national Chubu regional project, after citing the opinion of a researcher of the University of Tokyo that sowing seeds in a sea whose environment has changed and become unsuitable is not recommended, states that around the existing eelgrass beds there is a possibility that the plants will take root. The Fisheries Agency's Seaweed Bed and Tidal Flat Vision (revised 2023) states that, because eelgrass seeds are carried far on the tide, the place should be chosen with the movement of the seeds in mind, and that, when a bed is created, the seeds and sand should be kept from being washed away by waves. [S8, S17]

The national satoumi creation project (Wakura)

From fiscal 2025, a project of the Ministry of the Environment began in Nanao Bay. On 25 April 2025, the Ministry of the Environment selected 8 groups from 37 applications for its support project for building the foundations of "Reiwa-era satoumi creation" (the 3 years of fiscal 2025–2027), and in Ishikawa Prefecture the Wakura Onsen Creative Reconstruction Town Development Promotion Council was selected. According to the report on the first year (February 2026), opinion exchange meetings joined by the Prefectural Fisheries Research Center, NPEC, the Nanao branch of the prefectural fisheries cooperative, people from tourism and inns, and others were held at Wakura Onsen on 19 September, 20 October and 1 December 2025. [S3]

This project puts its emphasis for the time being on dwarf eelgrass. The report states that, as the result of the 1st meeting, the hypothesis was set that, while bringing eelgrass back in full is difficult, protecting and spreading dwarf eelgrass has a high prospect of being achieved. The monitoring combines NPEC's wide-area observations twice a year (June and October) with the Council's observations with citizen participation (mainly March–September), and a method of measuring with a fish finder and an underwater camera attached to a board (SUP) was made the standard. The observations with citizen participation are at 15 sites, and NPEC's observations at about 137 sites. On 19 January 2026, a training session for satoumi guides was held, and 5 people took part. [S3]

The effectiveness of this project is not yet known. The report gives as issues that the present accurate distribution of dwarf eelgrass and the places where it can be increased by transplanting have not been grasped, and that it is necessary to confirm a method of regeneration that also takes into account the way sludge collects and the clarity. The results of the second year, fiscal 2026, were not found in published materials as of 12 November 2026. [S3]

What can be learned from measures in other seas

Cases in Japan and abroad show that, while the cause remains, the beds are hard to bring back even by planting. The analysis of 1,786 cases around the world showed that the cause should be removed before planting, and that places where the cause is too many nutrients in the sea are hard to succeed in (chapter 2). A wide area came back in Chesapeake Bay by reducing nitrogen, and in the shallow lagoons of the mid-Atlantic coast of the United States by seed sowing. At Ibusuki, an eelgrass bed formed inside an enclosure net that keeps out fish. In Nanao Bay, high summer water temperature and turbidity are given as the causes, and the water temperature of the sea cannot be lowered by local measures alone. The national Chubu regional project gives, as methods of adaptation, monitoring, reducing the sources that make the water turbid, and seed sowing around the existing eelgrass beds. [S25, S24, S19, S8]

4. What is changing

The eelgrass beds of Nanao Bay had almost disappeared by 2023, and in the surveys of 2025, too, almost none were found. While there is a prediction that the water temperature will rise further from now on, new projects and plans of the national government and the prefecture are under way (as of 12 November 2026).

The outlook for the sea and the eelgrass beds

Summer water temperature is predicted to go on rising. From the relationship between the water temperature of the West Bay and the air temperature at Nanao (a correlation coefficient of 0.96 or more), the national Chubu regional project predicted that summer water temperature will rise by about 1°C above the present by the middle of this century, and by about 2–4°C by the end of this century. In the case in which emissions of greenhouse gases remain high, the days on which the guide temperature is exceeded at a water depth of 1 m become 2–3 times the present number. In terms of water temperature, eelgrass is expected to move to deeper places, but because the amount of light limits the depth, the report states that further decline is a concern. This prediction deals only with the effect of water temperature, and does not include underwater light, grazing organisms or the nutrients of the sea. [S8]

Dwarf eelgrass appears to withstand heat. Even in the 32°C sea of September 2023, dwarf eelgrass appears to have been growing normally, roots included, at water depths of less than 1 m, and it survived after the eelgrass disappeared in October. In the summer of 2025, dense eelgrass (probably dwarf eelgrass) was found at a water depth of 1 m at the mouth of the Ninomiya River. In other seas too, cases are appearing in which eelgrass is

replaced by dwarf eelgrass, as at Futtsu and Kasasa (chapter 2). We found no source showing the area of dwarf eelgrass in Nanao Bay. [S4, S19]

Plans and schedules of the national government, the prefecture and the region

- March 2022: The prefecture's Seaweed and Seagrass Bed Vision (fiscal 2022–2031). Seed sowing around the stands of eelgrass in Nanao Bay, monitoring at least once a year in the district of Nanao City, and a council every fiscal year. Fiscal 2026 is the year of the interim target. [S7]
- 25 April 2025: The Ministry of the Environment selected the Wakura Onsen Creative Reconstruction Town Development Promotion Council for the support project for satoumi creation (fiscal 2025–2027). [S3]
- September 2025 to February 2026: The first year of the Wakura project. 3 opinion exchange meetings, a method of monitoring with citizen participation, and training of guides. [S3]
- 16 February 2026: The Ministry of the Environment's 3rd Climate Change Impact Assessment Report. On the basis of this, the national Climate Change Adaptation Plan is due to be revised within fiscal 2026. The materials for the revision give the conservation of the eelgrass of Ibusuki as an example of coastal measures. [S20]
- 7 August 2026: The Hokkoku Shimbun reported that a professor of the University of Tokyo graduate school and others surveyed the seaweed and seagrass beds along the Wakura coast (according to the headline and lead). [S34]
- 4 September 2026: The 1st meeting of the review committee for the prefecture's new "Ishikawa Fisheries Promotion Vision". It gives "creating healthy fishing grounds through the conservation of seaweed and seagrass beds and the like" as one of the directions, and the vision is due to be drawn up within fiscal 2026 (the preliminary draft at the 2nd meeting around December, the final draft around March). [S28]
- Fiscal 2026 (planned): The second year of the Wakura project. Monitoring with citizen participation will continue, a trial of growing eelgrass in containers will begin, and registration as a Nationally Certified Sustainably Managed Natural Site (a place recognised by the national government where biodiversity is protected through the efforts of the private sector and others) will be considered. The outline of the project states that a target for the area by which the habitat of dwarf eelgrass is to be widened will be decided in fiscal 2026. The prefecture's plan for the Nanao Bay area (fiscal 2022–2026) also ends in this fiscal year. [S3, S28]
- Fiscal 2027 (planned): The third year of the Wakura project. The plan is to begin obtaining certification for, and selling, "J Blue Credits", which turn the carbon absorbed by seaweed and seagrass beds into credits, and, together with the restoration of the seawall of Wakura Onsen, to start a base for satoyama and satoumi activities. The seawall is covered in R7-A21 "The restoration of the seawall of Wakura Onsen", and the mechanism and price of J Blue Credits in R2. [S3]

5. What is not yet known

Where there are no figures

- We found neither the results of NPEC's underwater camera monitoring from 2024 onwards nor the areas from the satellite analysis for fiscal 2024 and fiscal 2025. NPEC's annual report states that the observations of 2020 showed that "the eelgrass beds decreased sharply from summer onwards", but it gives no figures. [S12]
- We found neither the results of the monitoring in the district of Nanao City under the prefecture's Seaweed and Seagrass Bed Vision nor the records of the council. The meeting materials for the prefecture's new fisheries promotion vision state that the decline of the seaweed and seagrass beds of the prefecture's coast

was confirmed in the survey of beds after the earthquake disaster, but they give no values for Nanao Bay. [S7, S28]

- We found no source that measured the direct effect of the earthquake and the heavy rain of September 2024 on the eelgrass beds of Nanao Bay. [S1]
- We found neither the area nor the distribution of dwarf eelgrass in Nanao Bay. The Wakura project also gives grasping this as an issue. [S3]
- We found neither a record of fish that eat seaweeds and seagrasses eating eelgrass in Nanao Bay, nor a study that separately confirmed how much each of water temperature, light and mud contributed. [S1, S16]
- We found no source that showed in figures how much the catch of fish such as red sea bream, or of sea cucumber and egg cockle, changed as the eelgrass beds decreased. [S16, S30]
- As for the 2016 paper by prefectural researchers and others (Nihon-kaiiki Kenkyu [Japan Sea Research], No. 47), the website of the university that holds it was under maintenance, and this paper has not been able to read the original. Its content was checked through the reports by the same researchers and through the other sources that cite it. [S5, S6, S14]

Limits of comparison

- The values for area come from different survey methods. The national survey of around 1990 was, in Ishikawa Prefecture, a check of the sites of the previous round by swimming at the sea surface, with interviews added, while the prefecture's survey of fiscal 2018 and the Association's survey of 2025 are satellite images with on-site checks. The Fisheries Agency's guidance (2021) states that, if an area from old interviews and an area from satellites are compared as they are, it cannot be told whether the difference is a change over the years or a difference of method, which could lead to a wrong conclusion. In the national survey of the Seto Inland Sea (2015–2017), the satellite area was 0.5–0.8 times the interview area. The prefecture, too, states that around 1990 and fiscal 2018 cannot simply be compared. [S17, S9, S7]
- Satellite areas have a margin. The Fisheries Agency's guidance puts the accuracy of telling the presence or absence of beds from satellite images at about 60–90%. In the Ministry of the Environment's nationwide survey of seaweed and seagrass beds (fiscal 2018–2020), the share of correct answers was 53.42–85.91% depending on the sea zone, and the year in which the images were taken and the year of the on-site survey were up to 9 years apart. The accuracy of the Association's survey is 82.3% over all 355 sites, but these sites were also used as the model for the classification, so this is not a separately checked value. The accuracy for Nanao Bay alone is not stated. [S17, S15, S1]
- The season surveyed also differs. The eelgrass of Nanao Bay sprouts in autumn, is thickest in early summer, and dies from summer to autumn. The Association's image of 2025 is from 14 March, a time before the eelgrass is thickest (this paper's view; the report contains no such consideration). The prefecture's survey of fiscal 2018 used spring images and on-site surveys in August–October that mainly targeted the Sargassum group. However, the satellite of May 2023, the observations of September–October 2023, the observation of June 2024 and the 63 sites of May 2025 all show a state of scarcity or disappearance, and the sources agree that there has been a great decrease. [S1, S2, S32, S4, S10]
- The area covered also differs. There are the Nanao Bay district (the prefecture's table), the Nanao Bay district of Nanao City (the Association), the West Bay (west of the line joining Kotanibana and Cape Byobu), the area centred on the West Bay (NPEC's satellite) and the sites of the underwater camera in the West Bay. The percentages attached to the figure of NPEC's satellite analysis (78.43% and so on) have no explanation. [S7, S1, S5, S4]
- Satellite areas also change with the method of classification. From what appears to be the same image of 1 June 2015, NPEC's machine-learning classification (presented in 2025) gives 1,005 ha and the classification in the report of an international organisation (2018) gives 846.6 ha (the total of dense seagrass and seagrass

mixed with the Sargassum group); NPEC's value is about 1.2 times the international organisation's value (this paper's calculation). The report of the international organisation gives the accuracy of the classification as 0.73. [S4, S11]

- NPEC's 3 early-summer values differ both in satellite and in the day of the image. The image of 2015 is from Landsat 8 and those of 2019 and 2023 are from Sentinel-2, and the dates are 1 June, 25 July and 10 May. The values can change with the difference of satellite and with whether the date is before or after the time when the eelgrass is thickest (this paper's view). However, the share of dense sites seen with the underwater camera has also fallen in the same direction. [S4, S2]
- The share of dense sites (from 35% to 9%) is a share of sites placed evenly over the whole of the bay, and is not a substitute for area. The difference from the satellite's 6 ha of May 2023 may possibly be explained by the timing (May, and June–July) and by the fact that satellites can miss stands in turbid water and small stands (this paper's view). [S2, S4, S17]

Where the figures disagree

- Even among sources that write about the same thing, there are some whose years and values disagree (Table 4). When using them, it is necessary to show which source the value is from.

Table 4 Values and wordings for the eelgrass beds of Nanao Bay that differ from source to source

Item	Difference between sources	How this paper treats it
Year of the 1,258 ha of the West Bay	The national survey of around 1990 (reports by prefectural researchers and others); "1999" (an explanatory article of 2021)	Taken as around 1990. 1999 appears to be an error
Satellite area of the West Bay in 2015	1,005 ha (NPEC, presented in 2025); 846.6 ha (report of an international organisation, 2018). As for the date of the image too, the main text of the report says 2016 and the figure says 2015	Regarded as the difference from classifying the same image of 1 June 2015 by different methods
Nanao Bay district in fiscal 2018	768.8 ha (the prefecture's Seaweed and Seagrass Bed Vision); 769 ha (the Association's recalculation). The West Bay is 746 ha (presentation document by a prefectural researcher)	The decrease of 99.5% is a calculation between the Association's own values, and is not mixed with the prefecture's value
Share of dense sites in the West Bay	From 35% in 2015 to 9% in 2023 (NPEC's abstract, cover level 3 or above); 31% in 2020, 13% in 2021, 7% in 2022 and 2023 (article by the president of the citizens' group, June, cover of 26% or more)	NPEC's abstract values were used. The article's values appear to be values quoted from the same monitoring by a different way of counting
Year and extent of the die-off of perennial eelgrass	"At all sites" in the year after the survey of 2011 (prefectural researchers); "in some places" in the survey of 2011 (article by the president of the citizens' group)	Taken as having died at all the sites surveyed in 2012
Shoots in the spring of 2013	Died at all sites in the autumn of 2012. In the spring of 2013, vegetative shoots were confirmed off Tatsuruhama and off Shirasaki	Shoots may have remained outside the sites surveyed, or seedlings may have grown, so both are compatible (the sources give no reason)

Item	Difference between sources	How this paper treats it
Beds visible in autumn becoming smaller	Sources that write of the die-off at all sites in 2012 as something new, and the report of an in - ternational organisation stating that the seagrass visible by satellite was small in the autumn of 1991 as well	Reading it as "leaves have long decreased in autumn, and years in which the plants die down to the rhizomes in summer have come to be recorded" fits both (this paper's view)
Time of germination	Late October (quoted in NPEC's abstract); the end of October (report of 2014); in 2015, during September (report of 2015)	Taken as differing from year to year
Period of the project	The 3 years of fiscal 2025–2027 (the Ministry of the Environment's selection); fiscal 2025–2029 (NPEC's presentation at an international conference)	The period in the Ministry of the Environment's selection was used
Date of the 3rd opinion exchange meeting at Wakura	The schedule table of the report says 18 November, and the record of implementation says 1 December	The date in the record of implementation was used
Timing of the Nationally Certified Sustainably Managed Natural Site	Registration to be "considered" in fiscal 2026 (the report); "application for registration" in fiscal 2026 (the outline of the project)	Both are plans, and the wording of the report was used
Bibliographic details of the 2016 paper cited by the Association	"Nihon-kaiiki Kenkyu 4, 27-33" (the Association); "No. 47, 29–33" (many other sources)	Taken as No. 47
Eelgrass at Karashima (June 2024)	The main text says "the growing density was low"; the table gives "often found" on a 4-level scale	The table is a scale of ease of finding, not density, so the wording of the main text was used

Note: [S5, S6, S13, S4, S11, S7, S1, S2, S27, S3, S12, S10]

- "The largest on the Sea of Japan side" is the wording of the sources. The research institution's abstract (2024) and the article by the president of the citizens' group write "the largest on the Sea of Japan side" and "once of the largest scale on the Sea of Japan side", the English-language presentation by the same research institution (2025) writes "one of the largest on the Sea of Japan side", and the Ministry of the Environment writes "a large-scale eelgrass bed of an inner bay of the Sea of Japan". No source was found that confirmed this by comparison with other eelgrass beds on the Sea of Japan side, and the 4 ha of 2025 does not fit this wording as the present state. This paper does not use "the largest", for which there is no comparative source, as this paper's own word. [S2, S27, S12, S14, S1]
- The report of an international organisation (2018) lists in a table, as a compilation of the literature by experts in Japan, the loss of seagrass in Nanao Bay in 2008 and its causes, land reclamation and the repair of a pier, but the name of the original source is not stated, and this paper has not used it. [S11]

Reliability and the position of the sources

Reliability differs from item to item. That the eelgrass beds of Nanao Bay decreased greatly from around 2015 to 2023, and had almost disappeared in 2023, is supported by records made by different methods that agree, namely NPEC's underwater camera and satellite and the on-site observations of prefectural researchers, and its reliability can be said to be high. That almost no eelgrass beds were found in 2025, after the earthquake, is supported by the agreement of the Association's satellite analysis and the underwater camera at 63 sites, and it

also connects with the record of 2023, before the earthquake, so its reliability can be said to be high. However, these 2 are surveys within the same study. The observation of June 2024 by a prefectural facility shows that eelgrass, though scarce, was growing at 2 sites near the shore. On the other hand, the values for area themselves change greatly with the method, the season and the area covered, and differ by about 1.2 times with the method of classification even for the same image, so their reliability is medium. The size of the decrease from around 1990 to fiscal 2018 (from 1,923 ha to 768.8 ha) is of medium to low reliability, because the survey methods differ. Among the causes, that high summer water temperature is having an effect is supported by both observation and water temperature in Nanao Bay, and its reliability can be said to be high. However, the share of each cause has not been confirmed. The lack of light due to turbidity is medium, and for autumn water temperature, the nutrients of the sea, grazing fish and the effects of the earthquake and the heavy rain, there is no source that confirmed them in Nanao Bay, and their reliability can be said to be low. The prediction of future water temperature is an outlook from a model, and the report itself lists the factors that it did not deal with, so its reliability is medium.

The position of the sources also calls for care. The surveys of the West Bay in 2011–2015, the introduction of the lecture of 2019 and the presentation document of 2025 are from the same group of researchers at the Prefectural Fisheries Research Center and the prefecture's Noto Marine Center, and are not independent checks. One of these researchers is also an observer of the Association's survey and a member of the opinion exchange meetings of the Wakura project. NPEC's abstract, the satellite presentation document, the annual reports, the presentation at an international conference and the report of an international organisation (for which NPEC is the secretariat) are also from the same line of one institution. The president of the citizens' group, the Noto Forest, Village and Sea Study Group, is a former prefectural researcher, and is also an adviser to the national Chubu regional project. The report of the Kanazawa Association of Corporate Executives is the report of a survey that a business association carried out with a grant from The Nippon Foundation and the special cooperation of the Hokkoku Shimbun; it is not peer-reviewed, and the satellite analysis was carried out by a surveying company. The report of the Wakura project is a report by the group that carried out the project, and this paper does not quote the group's words of self-assessment. For the world papers, only the abstracts were read. For the Hokkoku Shimbun article, only the headline and lead were read.

The publisher of this paper (SeatecHIROSHIMA Ltd.) runs a business that controls biofouling by surface treatment of materials. This is both preventing fouling from attaching (antifouling) and making it easier for eelgrass (a kind of seagrass) to take root for the regeneration of seaweed and seagrass beds. It is also developing a system that identifies the positions of oyster rafts and notifies ships of them. This paper does not cover the company's own technology or results. This paper deals with the decrease in the eelgrass beds of Nanao Bay itself, and the regeneration of eelgrass beds overlaps with the field of the publisher's business. This paper also touches on the area of eelgrass beds surveyed with satellite images, and on its reliability. The publisher is developing, in joint research with Hiroshima University and others, a system that identifies the positions of oyster rafts using satellite data, and the analysis of satellite images overlaps with the field of the publisher's development. The relationships with the bodies taken up in this paper, and with bodies active in Nanao Bay, are as follows (as of 12 November 2026; based on information the publisher has made public, the publisher's contracts and records, and the research for this paper). With Ishikawa Prefecture, there is the relationship of having been selected (September 2025) for the prefecture's (Commerce, Industry and Labour Department, Industrial Policy Division) "survey project for attracting startups to Noto" (fiscal 2025 [Reiwa 7]). In this project, specialists accompany and support the selected companies in drawing up business plans and building connections in Noto (according to the prefecture's announcement). The prefecture's Fisheries Division and Fisheries Research Center take part as observers in the survey of the report of the Kanazawa Association of Corporate Executives that this paper cites. In October 2026, in the "Startup Business Plan Contest Ishikawa 2026" held by Ishikawa Prefecture and the Ishikawa Sunrise Industries Creation Organization (a public interest incorporated foundation), the publisher received the Best Entrepreneur Award for a plan on the subject of the

eelgrass of Nanao Bay (the award is according to the announcement on the Organization's website). The Organization's website states that this award comes with a subsidy and with the free loan for 3 years of a room in a facility that rents rooms to newly founded companies, among other things. In Noto, the publisher works in collaboration, under non-disclosure agreements, with Nanaibe LLC and Yamaguchi Suisan of Nanao City, with Atsumasa Nakamura of Kanazawa University, and with the Noto Fisheries Profit Improvement Council. With the Ishikawa Prefecture Fisheries Cooperative Association (its representative director and senior managing director is a member of the review committee for the prefecture's new fisheries promotion vision, and the cooperative association's Nanao branch takes part in the Ishizaki Satoumi Conservation Group cited in this paper and in the opinion exchange meetings of the Wakura project), there is the relationship that the publisher secured the site for its demonstration through its collaboration partner Nanaibe LLC. In the interviews for the report of the Kanazawa Association of Corporate Executives, each branch of the same cooperative association was asked to cooperate. The publisher is not a member of the Noto Fisheries Profit Improvement Council. The area in Ishikawa Prefecture with which the publisher has been involved is mainly Nanao Bay, which overlaps with the sea that this paper deals with. In Sotoura (Shika Town, Wajima City and the north coast of Suzu City as far as Jike), the publisher is not active. This paper touches on the fact that the Wakura project aims to obtain J Blue Credits. The Japan Blue Economy Association (JBE), which certifies these credits, is a body that Michio Imai, the publisher's joint representative CEO, named as a candidate partner (not yet arranged) in an application for research to a research centre of Tohoku University (Nature Positive) in October 2026. Among the sources this paper cites, the reports of 2014 and 2015 on the West Bay include among their authors a researcher of Kanazawa University's marine laboratory, and the report of 2014 states that part of it was carried out in a project of the same university. The press release stating that no uplift was recognised in Nanao Bay is also from Kanazawa University and others. One of the members of the review committee for the prefecture's new fisheries promotion vision is also a person of the same university. The name of Atsumasa Nakamura does not appear among the authors of these sources, nor in the lists of members of this committee or of the survey team of the report of the Kanazawa Association of Corporate Executives. With Hiroshima University, the publisher has taken part since October 2025, as one company of a consortium, in a research centre of the university (JST COI-NEXT). Michio Imai, the publisher's joint representative CEO, has served since 1 November 2026 as a researcher (part-time) at a research institute of the university (the institute for the future of the ocean and maritime affairs) (concurrently with being the publisher's joint representative CEO). In addition, the publisher joined joint research under the Town & Gown concept of Kure City and Hiroshima University (a concept under which the city and the university work together) (the research period is October 2025 to August 2026, and the contract was made in March 2026). This joint research is funded by a research grant of Kure City, and the publisher received an allocation of research funds from that grant (April 2026). It has also been selected for the research grant of Kure City for the 2nd year (from September 2026). The paper of the press release on uplift cited in this paper has authors from Hiroshima University, but the researchers who are the publisher's partners in the joint research are not among the authors. This paper does not use the data or results of this joint research. As for Nagoya University, the publisher's technology is supervised, in a personal capacity, by Kensuke Kuroda (representative of Nagoya Surface Technology; designated professor at the Institutes of Innovation for Future Society, Nagoya University). The same paper has 1 author from Nagoya University, but Kensuke Kuroda is not an author. Apart from the above, there are no relationships between the publisher and the bodies taken up in this paper (national bodies, the prefecture and the cities and towns, universities and research institutions, the business association and its survey team, the companies and bodies named in this paper, overseas universities and research institutions, and so on) or the bodies active in Nanao Bay (fisheries cooperatives, local bodies and so on) that would affect the content of this paper. The relationships meant here are transactions, funding, joint research, and officers or staff of the publisher concurrently serving as staff or officers of the body. This is the publisher's judgement, made after checking the information the publisher has made public, the publisher's contracts and records, and the research for this paper.

6. Sources

We examined materials published up to 12 November 2026. We examined mainly materials of the national government and the prefecture, reports of research institutions and peer-reviewed papers, and we used figures that a separate researcher had checked against the very materials listed as sources (for the world papers, the abstract only; for the Hokkoku Shimbun article, the headline and lead only). Among the figures that the materials quote from other studies, there are some that we have not checked back to the original study, and these are marked "quoted" in the text. Values read from figures are marked "read from the figure". Reliability: A = laws and regulations, statistics, materials of the national government, prefectures and cities; B = papers, reports of research institutions that state their method; C = explanatory materials for the general public, explanations and reports of organisations, presentation documents; D = news reports.

ID	Source (publisher, year)	Type	Reliability	Chapters used
S1	Kanazawa Association of Corporate Executives: Fiscal 2025 (Reiwa 7) report of the survey of the effects of the earthquake disaster on the coast of the Noto Peninsula (in Japanese) (24 March 2026; the report of a survey by a business association; a grant from The Nippon Foundation and the special cooperation of the Hokkoku Shimbun; the satellite image analysis was by Kokusai Kogyo; not peer-reviewed)	Report	C	Chapters 1–3, 5
S2	Kozuka (Northwest Pacific Region Environmental Cooperation Center): Changes in the eelgrass beds of the West Bay of Nanao Bay and their factors (in Japanese) (abstracts of the research presentation meeting of the Fisheries Research Institute, Toyama Prefectural Agricultural, Forestry and Fisheries Research Center, fiscal 2023 (Reiwa 5), posted September 2024)	Abstract	B	Chapters 1–3, 5
S3	Ministry of the Environment: groups selected for the fiscal 2025 (Reiwa 7) support project for building the foundations of strategic "Reiwa-era satoumi creation" (attachment, 25 April 2025); Wakura Onsen Creative Reconstruction Town Development Promotion Council: report on the implementation of the model project (February 2026, C); outline of the project (March 2026, C) (in Japanese)	Project	A	Chapters 1, 3–5
S4	Presentation documents of the opinion exchange meeting of the Wakura project (19 September 2025): Ikemori (Ishikawa Prefecture Fisheries Research Center), "The eelgrass beds of Nanao Bay and climate change"; Terauchi (Northwest Pacific Region Environmental Cooperation Center), "Seasonal and year-to-year changes in the seaweed and seagrass beds of Nanao Bay captured by satellite re - mote sensing, and the use of small acoustic devices" (in Japanese) (reference materials of the S3 report; little explanation of the method)	Presentation	C	Chapters 1–5
S5	Noto Marine Center: Higashide, Ogiso and Ikemori: on the state of growth of eel - grasses in the West Bay of Nanao Bay, Noto Peninsula (Research Report 20, 2014); Sakai, Higashide and Ogiso: characteristics of the eelgrass growing in the Nanao West Bay of the Noto Peninsula (Research Report 21, 2015) (in Japanese)	Report	B	Chapters 1–3, 5
S6	Sakai (Noto Marine Center): The eelgrass beds of the Nanao West Bay of the Noto Peninsula, which show a peculiar seasonal rise and fall (Noto no Kaichurin 46, 2017, C); Ishikawa Prefecture Fisheries Research Center: Fishing and Sea Conditions Information No. 425 (26 April 2019; an introduction of Ikemori's lec - ture, A) (in Japanese)	Explanatory	C	Chapters 1, 2, 5
S7	Ishikawa Prefecture: Ishikawa Prefecture Seaweed and Seagrass Bed Vision (in Japanese) (March 2022)	Plan	A	Chapters 1–5
S8	Ministry of the Environment, Regional Adaptation Consortium, Chubu regional project (Japan Weather Association and Nippon Mikuniya): final report of the survey of the effects of climate change on fisheries and on the habitat base of liv - ing things (2020); outline of the results of fiscal 2017 (Heisei 29) (2018); Ishikawa Prefecture: summary of adaptation measures for eelgrass (2020) (in Japanese)	Report	A	Chapters 1–4

ID	Source (publisher, year)	Type	Reliability	Chapters used
S9	Environment Agency: from the report of the marine biotic environment survey of the 4th National Survey on the Natural Environment (1994), the analysis of sea - weed and seagrass beds; Ishikawa Prefecture chapter; survey guidelines (in Japanese) (website of the Biodiversity Center of Japan)	Survey	A	Chapters 1, 2, 5
S10	Higashide, Arakawa and Nakade: Monitoring survey of benthic invertebrates and of seaweeds and seagrasses on rocky shores after the 2024 (Reiwa 6) Noto Peninsula Earthquake (in Japanese) (Noto Marine Center, Research Report 30, 2025)	Report	B	Chapters 2, 5
S11	NOWPAP CEARAC: Feasibility Study for Assessment of Seagrass Distribution in the NOWPAP Region (2018; the report of an international organisation; the secretariat is the Northwest Pacific Region Environmental Cooperation Center)	Report	B	Chapters 2, 5
S12	Northwest Pacific Region Environmental Cooperation Center: annual business reports (fiscal 2023; fiscal 2024; fiscal 2025) (in Japanese); Yoshida: SATOUMI cre - ation in the Nanao Bay, Japan (presentation document of PICES-2025)	Annual	C	Chapters 2, 3, 5
S13	Harada et al.: the present state and issues of the environment and fisheries of in - ner bay areas: the case of Nanao Bay (in Japanese) (Systems, Control and Information 65(1), 2021; an explanatory article in the journal of an academic society)	Explanatory	C	Chapters 2, 5
S14	Ministry of the Environment: sea areas of high importance from the viewpoint of biodiversity: Nanao Bay and southern Toyama Bay; Biodiversity Center of Japan: seaweed and seagrass bed survey, Nanao Bay (survey of June 2020) (in Japanese)	Material	A	Chapters 2, 5
S15	Ministry of the Environment: results of the seaweed and seagrass bed survey (fis - cal 2018–2020) (31 August 2021); outline of the results; Biodiversity Center of Japan: specifications of the satellite images; accuracy verification (in Japanese)	Survey	A	Chapter 5
S16	Fisheries Agency: prior evaluation of the fisheries environment development project for the Noto and Uchiura district, Ishikawa Prefecture (Document 4-2) (in Japanese) (8 March 2023)	Material	A	Chapters 2, 5
S17	Fisheries Agency: guidance on wide-area monitoring of seaweed and seagrass beds (March 2021); Seaweed Bed and Tidal Flat Vision (revised December 2023) (in Japanese)	Guidelines	A	Chapters 3, 5
S18	Ministry of the Environment: 5th Red Data Book, sugeamamo (Zostera caespitosa) (in Japanese) (March 2025)	Material	A	Chapter 2
S19	Ministry of the Environment, Biodiversity Center of Japan: fiscal 2024 Monitoring Sites 1000 report on the survey of eelgrass beds and seaweed beds (March 2025); fiscal 2025 eelgrass beds, preliminary survey report (March 2026) (in Japanese)	Survey	A	Chapters 2–4
S20	Ministry of the Environment: 3rd Climate Change Impact Assessment Report (16 February 2026; details); materials for the revision of the Climate Change Adaptation Plan (2026) (in Japanese)	Assessment	A	Chapters 2, 4
S21	Kanazawa University, Hiroshima University and others: press release (in Japanese) (20 January 2026; the paper is Geomorphology 493, 110069; this paper checked the press release only)	Explanatory	C	Chapters 1, 2
S22	Kawasaki (Central Research Institute of Electric Power Industry): The effect of temperature on eelgrass, 3: changes in the life cycle due to a rise in temperature (in Japanese) (Central Research Institute of Electric Power Industry Report U87046, 1987; summary only checked)	Report	B	Chapter 2
S23	The decrease of the world's seagrass beds: Waycott et al. (PNAS 106, 2009); Dunic et al. (Global Change Biology 27, 2021)	Paper	B	Chapter 2

ID	Source (publisher, year)	Type	Reliability	Chapters used
S24	Eelgrass in Chesapeake Bay and elsewhere: Moore and Jarvis (Journal of Coastal Research SI 55, 2008); Jarvis and Moore (Hydrobiologia 649, 2010); Jarvis et al. (Marine Ecology Progress Series 444, 2012); Lefcheck et al. (Global Change Biology 23, 2017); Lefcheck et al. (PNAS 115, 2018); Orth et al. (Science Advances 6, 2020)	Paper	B	Chapters 2, 3
S25	van Katwijk et al.: a global analysis of seagrass restoration trials (Journal of Applied Ecology 53, 2016)	Paper	B	Chapters 2, 3
S26	The marine heatwave of Shark Bay: Arias-Ortiz et al. (Nature Climate Change 8, 2018); Strydom et al. (Global Change Biology 26, 2020)	Paper	B	Chapter 2
S27	Okei (president of the Noto Forest, Village and Sea Study Group): Activities to propagate eelgrass in Nanao Bay (in Japanese) (CAINES Journal 6; Osaka Metropolitan University, research centre for the advancement of aquaculture farms; no date of posting is stated; a report of activities, not peer-reviewed)	Explanatory	C	Chapters 1–3, 5
S28	Ishikawa Prefecture: Nanao Bay area comprehensive fisheries infrastructure de - velopment project plan (fiscal 2022–2026); fiscal 2026 (Reiwa 8) budget explana - tory material (January 2026); materials of the 1st meeting of the review committee for drawing up the new "Ishikawa Fisheries Promotion Vision" (4 September 2026) (in Japanese)	Plan	A	Chapters 3–5
S29	Nanao Regional Fisheries Revitalisation Committee: Plan for Revitalising Fishing Communities (Hama Plan), 3rd period (fiscal 2025–2029); Nanao City: Strategic Reconstruction Plan (February 2025); Reconstruction Action Plan (March 2026); 2nd Basic Environment Plan (March 2019) (in Japanese)	Plan	A	Chapter 3
S30	hitoumi.jp (website of a project commissioned by the Fisheries Agency): Ishizaki Satoumi Conservation Group (18 April 2025, C); JF Zengyoren (National Federation of Fisheries Co-operative Associations) and others: fiscal 2025 (Reiwa 7) survey report of the commissioned project to support measures for strengthening the productivity of fishing grounds and the multiple functions of fisheries (March 2026, commissioned by the Fisheries Agency) (in Japanese)	Report	A	Chapters 2, 3, 5
S31	Nanao City: Koho Nanao, August 2014 issue, feature "Rediscovering the satoumi of Nanao!" (in Japanese) (a feature article in the city's public relations magazine; an article for the general public, used only to quote the city's wording at the time)	Bulletin	C	Chapter 2
S32	Fisheries Agency: Survey of the distribution of seaweed and seagrass beds using satellite image analysis technology (the specification for Ishikawa Prefecture's fiscal 2018 (Heisei 30) survey of seaweed and seagrass beds) (in Japanese)	Material	A	Chapter 5
S33	Higashide (Noto Marine Center): Aigo (rabbitfish), which also eat eelgrass (in Japanese) (Noto no Kaichurin 18, 2003; an observation in Tsukumo Bay in Noto Town)	Explanatory	C	Chapter 2
S34	Hokkoku Shimbun: Survey of seaweed and seagrass beds along the Wakura coast, by a University of Tokyo graduate school professor and others (in Japanese) (7 August 2026; a paid article, headline and lead only checked)	News	D	Chapter 4

Related materials: R2 Seaweed and seagrass beds and the living things of the sea, R7-A02 The rise in seawater temperature in Nanao Bay, R7-A04 The decline of the Sargassum beds of Nanao Bay, R7-A05 Turbidity and fluid mud in Nanao Bay, R7-A06 The muddying and organic pollution of the seabed of Nanao Bay, R7-A14 The decrease in wild egg cockle (torigai), R7-A16 The poor catch of sea cucumber in Nanao Bay, R7-A17 The mass occurrence of seaweeds in Nanao Bay, R7-A19 Ground subsidence and flooding in Nanao Bay, R7-A21 The restoration of the seawall of Wakura Onsen, R7-A26 The interruption of activities to regenerate eelgrass beds (earthquake), R7-B08 Shallow seaweed beds dried out by uplift, and the decrease in the area of seaweed beds in Sotoura, I1 List of assessments