R7-A05 Turbidity and fluid mud in Nanao Bay

How are the turbidity of the sea in Nanao Bay and the fluid mud that settles on its seabed said to be related to the decline of the seaweed and seagrass beds, how far have they been measured, and what is known after the earthquake and the heavy rain of 2024?

Readers

Fishers and fishery cooperatives, local governments (staff in charge of fisheries, the environment and ports), research institutes and others without specialist knowledge, who want to check, with figures and sources, what has been measured about the turbidity and fluid mud of Nanao Bay and what is still at the stage of "is thought".

Takeaways

1. In Nanao Bay, the turbidity of the sea and the fine mud that settles on the seabed are thought to be one of the reasons for the decline of the seaweed and seagrass beds. This mud is called fluid mud (fudei). When turbidity reduces the light that reaches into the sea, seaweeds and seagrasses find it harder to photosynthesise. When fluid mud settles, the young shoots of seaweeds find it harder to attach to the seabed. The prefecture's seaweed and seagrass bed vision writes, for the Noto–Uchiura district, that turbidity and fluid mud "are thought" to be one of the reasons, and the Nanao Bay area plan writes, for the sea areas in the prefecture that have declined, that turbidity "is thought" to be one of the reasons. For Nanao Bay, an interview in a national government project raises the possibility of a shortage of light, and a 2026 report by a business association raises the effects of turbidity, the settling of mud and the like. We find no study that has checked how much of the decrease in the seaweed and seagrass beds is explained by turbidity and fluid mud.
2. As official values measuring turbidity in Nanao Bay, we found only the transparency in the prefecture's water quality measurements. Transparency is the depth at which a white disc lowered into the sea can no longer be seen. In the 6 measurements in fiscal 2024, the central part of the South Bay was 4.5–8.5 m, and the insides of the breakwaters at Kotobuki-cho and Mangyo were 1.5–3.5 m. In the West Bay and the North Bay, transparency is not measured. The tables for fiscal 2023 and other years have no values for the same points, and a comparison with the time before the earthquake cannot be made.
3. The lower depth limit at which eelgrass (a kind of seagrass) grows is written to have become shallower. Around 1990 it was about 8 m, but in a survey in December 2011 it was about 3–5 m. An explanatory article by a researcher at a prefectural facility states that a fall in transparency is thought to be the cause. In September 2023, a prefectural researcher recorded turbidity so strong that the tip of the hand could not be seen, and eelgrass remaining only at water depths of 1–1.5 m. This joins together materials that used different survey methods; it is not a change over time measured by the same method.
4. We found no material that measured the turbidity or fluid mud of Nanao Bay after the earthquake of January 2024 and the heavy rain of September. The prefecture's monthly observations measure water temperature, salinity and so on, but turbidity is not among the items measured. In October–December 2024, after the heavy rain, the average salinity at a water depth of 10 m at 4 points was 1.9 lower than in a normal year. This is thought to be because much rain and river water entered (this paper's view). The business association's report states, on the eelgrass beds that had disappeared at the head of the bay, that the extent of the direct damage from the earthquake and the heavy rain is not clear, but that the possibility that they dealt a further blow is very large.
5. We found no record of efforts in Nanao Bay to reduce turbidity or to remove fluid mud. The prefecture's plan says that shallow places which light reaches are to be chosen as places for

	creating seaweed and seagrass beds. The February 2026 report on satoumi-building at Wakura Onsen listed, as a future task, the verification of restoration methods that take bottom sediment and transparency into account. Nationwide, too, turbidity and fluid mud are receiving attention: in a survey in which the national government asked 39 prefectures in 2021, 13 prefectures gave them as a reason for the decline of seaweed beds on rocky shores.
After reading	When writing in documents or plans that the turbidity or fluid mud of Nanao Bay is a reason for the decline of the seaweed and seagrass beds, add that the prefecture's plans, too, are worded as "is thought", and that the only measured values this paper found are the transparency at 4 points in the South Bay (6 occasions in fiscal 2024).

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1. Key points

- In Nanao Bay, the turbidity of the sea and the fine mud that settles on the seabed are thought to be one of the reasons for the decline of the seaweed and seagrass beds. This mud is called fluid mud (fudei). When turbidity reduces the light that reaches into the sea, seaweeds and seagrasses find it harder to photosynthesise. When fluid mud settles, the young shoots of seaweeds find it harder to attach to the seabed. The prefecture's seaweed and seagrass bed vision writes, for the Noto–Uchiura district, that turbidity and fluid mud "are thought" to be one of the reasons, and the Nanao Bay area plan writes, for the sea areas in the prefecture that have declined, that turbidity "is thought" to be one of the reasons. For Nanao Bay, an interview in a national government project raises the possibility of a shortage of light, and a 2026 report by a business association raises the effects of turbidity, the settling of mud and the like. We find no study that has checked how much of the decrease in the seaweed and seagrass beds is explained by turbidity and fluid mud. [S1, S2, S8, S15]
- As official values measuring turbidity in Nanao Bay, we found only the transparency in the prefecture's water quality measurements. Transparency is the depth at which a white disc lowered into the sea can no longer be seen. In the 6 measurements in fiscal 2024, the central part of the South Bay was 4.5–8.5 m, and the insides of the breakwaters at Kotobuki-cho and Mangyo were 1.5–3.5 m. In the West Bay and the North Bay, transparency is not measured. The tables for fiscal 2023 and other years have no values for the same points, and a comparison with the time before the earthquake cannot be made. [S3]
- The lower depth limit at which eelgrass (a kind of seagrass) grows is written to have become shallower. Around 1990 it was about 8 m, but in a survey in December 2011 it was about 3–5 m. An explanatory article by a researcher at a prefectural facility states that a fall in transparency is thought to be the cause. In September 2023, a prefectural researcher recorded turbidity so strong that the tip of the hand could not be seen, and eelgrass remaining only at water depths of 1–1.5 m. This joins together materials that used different survey methods; it is not a change over time measured by the same method. [S9, S5]
- We found no material that measured the turbidity or fluid mud of Nanao Bay after the earthquake of January 2024 and the heavy rain of September. The prefecture's monthly observations measure water temperature, salinity and so on, but turbidity is not among the items measured. In October–December 2024, after the heavy rain, the average salinity at a water depth of 10 m at 4 points was 1.9 lower than in a normal year. This is thought to be because much rain and river water entered (this paper's view). The business association's report states, on the eelgrass beds that had disappeared at the head of the bay, that the extent of the direct

damage from the earthquake and the heavy rain is not clear, but that the possibility that they dealt a further blow is very large. [S4, S15]

- We found no record of efforts in Nanao Bay to reduce turbidity or to remove fluid mud. The prefecture's plan says that shallow places which light reaches are to be chosen as places for creating seaweed and seagrass beds. The February 2026 report on satoumi-building at Wakura Onsen listed, as a future task, the verification of restoration methods that take bottom sediment and transparency into account. Nationwide, too, turbidity and fluid mud are receiving attention: in a survey in which the national government asked 39 prefectures in 2021, 13 prefectures gave them as a reason for the decline of seaweed beds on rocky shores. [S2, S6, S19, S21]

2. What is happening

World and Japan: how turbidity and fluid mud damage seaweed and seagrass beds

Turbidity and fluid mud damage seaweed and seagrass beds in 2 ways: by reducing light and by covering the seabed. Seaweed and seagrass beds are places where seaweeds and seagrasses grow thickly. Seaweeds are algae, such as Sargassum species and arame (a kelp), that grow attached to rocks and the like, and seagrasses are plants that, like eelgrass, put down roots in a seabed of sand or mud and bear flowers. Both grow by photosynthesis, so they do not grow if light is insufficient. The Fisheries Agency's guidelines on measures to prevent the loss of seaweed and seagrass bed resources (2009) state that a major cause of the withering of seaweeds is the reduction of light by turbidity and the like, that fluid mud also settles easily in a turbid sea, and that when fluid mud settles on top of seaweeds, the light is reduced still further. [S20]

Fluid mud consists of fine clumps that drift in the sea or sink to the seabed. The same guidelines describe fluid mud as a collection of organic matter, such as the remains and excrement of animals and plants, and inorganic matter. The sources of fluid mud are the earth and sand that enter from rivers with the rain of the rainy season and of typhoons (seasonal sources) and the leftover feed of aquaculture farms and sewage effluent (sources that are always present). Even when fluid mud or sand has only settled thinly on the seabed, the attachment of the seeds of seaweeds (spores and young shoots) to the seabed is markedly hindered. The seeds of Sargassum species attach to rock by thread-like roots, so they attach poorly when sand and the like becomes entangled, and even after attaching, they wither if they are covered by fluid mud that sinks onto them. [S20]

The national government's guidance focuses on turbidity and fluid mud, rather than salinity, as the harm that river water does to seaweed and seagrass beds. The Fisheries Agency's guidelines on measures against barren ground (isoyake) (3rd edition, 2021) state that, as damage done by fresh water to seaweed and seagrass beds, the turbidity of seawater and the settling of fluid mud on the seabed are receiving more attention than changes in salinity, and that the effects of the settling of fluid mud and the turbidity of seawater at times of heavy rain are serious. The same guidelines give, as reasons why sediment in the sea increases, that storms become more violent and precipitation increases, so that soil erosion and floods increase, and that seawalls and wave-dissipating structures increase, so that the waves along the coast become calmer; and they state that drifting sand (sand moved by waves) and fluid mud are closely related to the alteration of coasts and rivers in recent years. These guidelines are aimed mainly at seaweed beds on rocky shores (barren ground). [S19]

In eelgrass beds, which are seagrass beds, light is also an important condition. A study (2017) that examined 31 years of aerial photographs and water quality in Chesapeake Bay in the United States states that the fall in transparency acted little by little on eelgrass beds in deep places, where light was limited to begin with, and that in shallow places poor visibility strengthened the harm done by sudden high temperatures. [S22]

World and Japan: examples so far, and what has been learned

Nationwide, too, the number of prefectures that give turbidity and fluid mud as a reason for the decline of seaweed and seagrass beds is increasing. In a survey in which the Fisheries Agency asked 39 prefectures in November 2021 about seaweed beds on rocky shores, 13 prefectures gave "turbidity and settling of fluid mud" among the reasons why the beds had declined compared with about 10 years earlier (multiple answers allowed), up from 7 in the previous year's survey. The reasons given most often in the same survey were the rise in seawater temperature, 25; grazing by fish that eat seaweed, 23; and grazing by sea urchins, 20 (read from a figure). As examples of places where fluid mud has increased, the surroundings of river mouths and places made calm by artificial structures (Akita Prefecture) and earth and sand from places where mountainsides have collapsed (Fukui Prefecture) are given. As measures against turbidity and fluid mud, the Fisheries Agency gives raising the height of the base on which seaweeds grow and placing bases of a shape on which fluid mud does not readily collect. How Ishikawa Prefecture answered is not written in the material. [S21]

There are trials of removing fluid mud, but cases in which it settled again after removal are also recorded. The guidelines on measures to prevent the loss of seaweed and seagrass bed resources introduce a method of removing fluid mud with a jet pump that sprays water, and give an example from Saiki Bay in Oita Prefecture in which fluid mud was blown away before the seaweeds released their eggs and many young seaweeds grew. On the other hand, in another sea area, earth and sand flowed out from the land with the rain of the rainy season, and fluid mud settled again within less than 1 month. In a trial in which fluid mud was removed in June 2007, too, fluid mud settled after the rainy season and typhoons, and the effect was gone in about 2 months. For this reason, the guidelines state that measures to reduce the outflow are needed, not only the removal of fluid mud, and they also try a method in which bases with seeds attached are placed temporarily in a natural seaweed bed until the season when there is little fluid mud, and are moved in October (the place to which they were moved is a propagation ground of placed stones where 1–3 mm of fluid mud settles throughout the year. The name of the place is not written). [S20]

There is also a case in which turbid water and mud that entered from a river settled on the seabed over a wide area. The report of the Kanazawa Association of Corporate Executives (2026) gives as an example the sediment flushing from dams that has been carried out on the Kurobe River in Toyama Prefecture almost every year since December 1993. In the early years, the organic matter in the sediment rotted and gave off a foul smell, and the turbid water and sediment were carried to the eastern part of Toyama Prefecture, sometimes reaching as far as near the border with Niigata Prefecture. The flushed sediment is said to have settled in hollows in the seabed and to have fallen on seaweeds, turban shells, abalone and sea urchins, and there were also cases of death by being buried alive (quoted from a 1999 material of the Toyama Prefectural Fisheries Experiment Station). The report states that mud and sediment on the seabed over a wide area are extremely difficult to remove by human hands. [S15]

Overseas, there is a case in which management to reduce the nutrients entering the sea was continued and the beds of seagrasses and other underwater plants came back. In Chesapeake Bay, eelgrass decreased by 29% in total from 1991, and the main reason was that a fall in transparency and a rise in water temperature coincided. In the same bay, as a result of continued management, the concentration of nitrogen fell by 23% from 1984, and eelgrass and other underwater plants came back over 17,000 ha, reaching their widest extent in almost half a century. This study (2018) links, with a computational model, the change in land use, the amount of nutrients entering the sea, and the decrease in underwater plants. [S22]

The world's seagrass beds have decreased greatly. A paper (2009) that brought together 215 studies states that, since 1879, when records began, 29% of the known area of seagrass beds has been lost, and that since 1980 they have been disappearing at a rate of 110 km^2 per year. This paper states that the effects of coastal development, the deterioration of water quality and climate change have each been recorded. In works that dig up the seabed

(dredging), a total of 21,023 ha of seagrass beds is said to have been lost in 45 cases around the world (a 2006 review article). This review article gives, as the main effects of dredging and sand extraction, that seagrasses are dug up or buried and that turbidity and sedimentation increase. The review article states that, because the limits of turbidity and sedimentation that seagrasses can tolerate differ greatly from species to species, the standards of other places should not be copied as they are, and the assessment needs to take into account the natural variation in turbidity at the place concerned. [S24, S23]

Table 1 What has been learned in Japan and the world about turbidity, fluid mud and seaweed and seagrass beds

Place (material)	What happened	What has been learned
39 prefectures nationwide (Fisheries Agency survey of seaweed beds on rocky shores, November 2021)	13 prefectures gave "turbidity and settling of fluid mud" as a reason for the decline of the beds (7 in the previous year's survey)	It increases around river mouths, in places made calm by structures, and from places where mountainsides have collapsed. The measures are raising the height of the base, and shapes on which fluid mud does not readily collect
Sea areas in Japan (Fisheries Agency guidance, 2009)	Trials in which fluid mud was removed with a jet pump	In Saiki Bay, many young seaweeds grew. In another sea area, it settled again within less than 1 month after the rainy season
Kurobe River in Toyama Prefecture (1993 onwards)	Turbid water and sediment from the flushing of sediment from dams spread into the sea	Cases of it settling on seaweeds and shellfish, which died by being buried alive. Mud on a wide seabed is extremely difficult to remove by human hands (quoted)
Chesapeake Bay in the United States	With a fall in transparency and high water temperature, eelgrass decreased by 29% from 1991	Management continued, the concentration of nitrogen fell by 23% from 1984, and underwater plants came back over 17,000 ha
45 cases of dredging around the world	21,023 ha of seagrass beds were lost through dredging (including digging up and burial, and turbidity and sedimentation)	The tolerable limits differ by species. Standards are to be set taking into account the natural turbidity of the place concerned
The world's seagrass beds (215 studies)	In the records since 1879, 29% of the known area has been lost	The effects of coastal development, the deterioration of water quality and climate change have each been recorded

Note: These are examples that differ in method, in period and in the kind of sea. The sizes of the values cannot be compared as they are. [S21, S20, S15, S22, S23, S24]

Region (Nanao Bay): the scope of this paper, and the sea of Nanao Bay

Nanao Bay in this paper means the North Bay, the West Bay and the South Bay around Notojima Island, that is, the coasts of Nanao City and Anamizu Town. It does not include the Toyama Bay side of the coast of Nanao City (Nadaura), nor Uchiura in Noto Town and Suzu City, nor Sotoura (the northern coast of Shika Town, Wajima City and Suzu City). The materials of the prefecture and the national government contain many statements about the Noto–Uchiura district, which includes Nanao Bay, or about the prefecture as a whole. The prefecture's seaweed and seagrass bed vision divides the coast of the prefecture into 2 districts, the Kaga and Noto–Sotoura district and the Noto–Uchiura district, and gives, as the seaweed and seagrass beds of the Noto–Uchiura district, those of the coast from Suzu City to Nanao City and of Iida Bay and Nanao Bay. The evaluation document of the national government's project explains that the district of the same name consists of the sea area of Sotoura, the

sea area of Uchiura facing Toyama Bay, and Nanao Bay. This paper does not use these as values or statements for Nanao Bay alone, and indicates which area is being discussed. [S1, S14]

Nanao Bay is a bay surrounded by land, with calm waves. A researcher at the Noto Marine Center (a prefectural facility) describes the West Bay as the most inner-bay-like place in Ishikawa Prefecture, and states that the Kumaki River, the Hiyo River, the Otsu River, the Ninomiya River and others flow into it and that it can be said to be a sea area where eutrophication is especially advanced even within the prefecture (a 2017 explanatory article for general readers). Eutrophication means that the nutrients of the sea (nitrogen, phosphorus and the like) become abundant. The national government's material also states that Nanao Bay is rich in nutrients and is a ground for the aquaculture of oysters and egg cockles (torigai) and a place where the young of red sea bream and other fish grow. [S9, S14]

The seabed of the West Bay is mud, and fluid mud is said to be abundant. A report (2015) by researchers of the same center and others states that, because the West Bay has a mud bottom and much fluid mud, they considered that turbidity would take away visibility when surveying by diving, and collected eelgrass with a specially made net-shaped frame. It states that Kurikawashiri Bay in Noto Town, with which it was compared, has a bottom of sand mixed with shells and little fluid mud. The same report states that, because many rivers flow into the West Bay, eutrophication is advanced and the turbidity level (the degree of turbidity of the water) is also high, but it carries no measured values of the turbidity level. The prefecture's seaweed and seagrass bed vision also states that the bottom along the coast of the Noto–Uchiura district is, except for Nanao Bay and Iida Bay, mostly rock or sand. A 2014 report writes that, at a point off the mouth of the Kumaki River in the West Bay, turbidity was severe in the autumn of 2014 and photographs could not be taken. The proportion of mud in the seabed and the pollution of the seabed by organic matter are covered in R7-A06 "The seabed of Nanao Bay turning to mud, and organic pollution". [S10, S1, S11]

Region (Nanao Bay): how turbidity and fluid mud are written about as a reason for the decline of the seaweed and seagrass beds

The seaweed and seagrass beds of Nanao Bay have decreased greatly. The change over time in the area of the eelgrass beds is covered in R7-A03 "The decrease of the eelgrass beds of Nanao Bay", and the beds of Sargassum species and the like (Sargassum beds) in R7-A04 "The decline of the Sargassum beds of Nanao Bay". This paper covers turbidity and fluid mud, which are regarded as one of the reasons.

The prefecture's plans give turbidity and fluid mud as one of the reasons for the decline of the seaweed and seagrass beds. The prefecture's seaweed and seagrass bed vision (March 2022) states, as reasons for the decline of the beds of the Noto–Uchiura district and after saying that the factors are hard to identify at present, that, in addition to poor growth due to the rise in seawater temperature and the like, it is thought that suspended matter in the sea (fine particles floating in the water) increases and transparency falls, so that photosynthesis is hindered, and that fluid mud that has settled hinders the photosynthesis of seaweeds and the attachment of young shoots. The plan for the development of fishing grounds in the Nanao Bay area (fiscal 2022–2026) states that there are sea areas in the prefecture where the seaweed and seagrass beds have declined, and that one cause is thought to be that the turbidity of seawater has increased and transparency has fallen. The evaluation document (March 2023) of the national government's (Fisheries Agency's) project also states that the seaweed and seagrass beds of the Noto–Uchiura district tend to decline as suspended matter coming from the land increases and photosynthesis is hindered. None of them shows measured values of turbidity, and their scope is not Nanao Bay alone. [S1, S2, S14]

For Nanao Bay, researchers and fishers also point to a shortage of light and to fluid mud. In the Ministry of the Environment's project on adaptation to climate change (Chubu region, a 2020 report), a researcher of a national fisheries research institute who was interviewed in September 2019 said that, if transparency is high, eelgrass

can escape to deeper places when the water temperature rises, but that, looking at the past changes in distribution in Nanao Bay, there is a possibility that light has become insufficient. The same report states that the interviews with experts showed the need to pay attention, besides water temperature, also to the reduction of underwater light by turbidity. An abstract (published in 2024) reported by a researcher of the Northwest Pacific Region Environmental Cooperation Center (NPEC) at the research presentation meeting of Toyama Prefecture's fisheries research institute writes, after stating that a fall in the germination rate due to high water temperature in autumn may be a factor in the decrease of the eelgrass beds, that fishers have also pointed out the effect of a fall in transparency due to fluid mud. Who said this, when and where is not written. [S8, S7]

Materials from 2026 also treat turbidity and mud as factors to be considered from now on. The report of the Kanazawa Association of Corporate Executives (March 2026) states that the decrease and disappearance of eelgrass beds along the coast centred on Nanao Bay is a trend that was seen from before the earthquake disaster, and that, as other factors, in addition to the rise in seawater temperature and the like, the effects of a fall in transparency due to increased turbidity, the settling of mud and the like are thought possible. The report on satoumi-building (February 2026) that the council of Wakura Onsen carried out under a Ministry of the Environment project states, as a future task, that it is necessary to verify scientific and concrete restoration methods that also take into account environmental factors such as bottom sediment (the settling of sludge and the like) and transparency. The chair of a group that has sown eelgrass seeds locally (the Noto Forest, Village and Sea Study Group) also writes that the rise in seawater temperature and the eutrophication of the seabed, its turning to mud and the like have combined to bring about a large change in the environment of Nanao Bay (an article with no date of posting written). None of them shows measured values of turbidity or mud. [S15, S6, S17]

Table 2 Materials that give turbidity and fluid mud as a reason for the decline of the seaweed and seagrass beds of Nanao Bay

Material (year)	Area discussed	Wording	Measured values
The prefecture's seaweed and seagrass bed vision (2022)	Noto–Uchiura district	A fall in transparency due to suspended matter, and the hindering by fluid mud of photosynthesis and of the attachment of young shoots, "are thought" to be reasons. The factors are hard to identify	None
Nanao Bay area plan (fiscal 2022–2026)	Sea areas in the prefecture that have declined	That turbidity has increased and transparency has fallen "is thought" to be one cause	None
Evaluation document of the Fisheries Agency's project (2023)	Noto–Uchiura district	Photosynthesis is hindered by suspended matter coming from the land, and the beds tend to decline	None
The Ministry of the Environment's Chubu region project (a 2020 report)	Nanao Bay	A "possibility" that light has become insufficient (interview with a researcher)	None
Abstract by an NPEC researcher (2024)	The West Bay of Nanao Bay	A fall in transparency due to fluid mud "has been pointed out" by fishers	None
Report of the Kanazawa Association of Corporate Executives (2026)	The coast centred on Nanao Bay	The effects of a fall in transparency due to increased turbidity, the settling of mud and the like "are thought possible"	None
Report on satoumi-building at Wakura Onsen (2026)	Nanao Bay	The verification of restoration methods that take bottom sediment, transparency and the like into account is a future task	None

Note: The words in quotation marks are the wording of each material. [S1, S2, S14, S8, S7, S15, S6]

Region (Nanao Bay): measured values (transparency in the South Bay)

The only official values measuring turbidity in Nanao Bay that we found are the transparency in the prefecture's water quality measurements. Under the Water Pollution Prevention Act, the prefecture measures and publishes the water quality of rivers and the sea every year. In the tables of these measurements for fiscal 2024 (Reiwa 6), transparency had been measured at 4 points in the South Bay. Transparency is the depth at which a white round disc lowered into the sea can no longer be seen from above. The larger the figure, the clearer the water. The measurements were made 6 times, on 27 April, 10 June, 5 August, 22 October and 13 December 2024 and 9 March 2025, and the water is taken from the sea surface (water depth 0 m). In the tables, the column for the surveying body says Ishikawa Prefecture, and the columns for the body that took the water and the body that analysed it say the Environmental Pollution Research Center (in the column for the analysing body for the central part of the South Bay, the Ishikawa Prefectural Institute of Public Health and Environmental Science is also written). The column for the state of the current said "normal state" on all 6 occasions (Table 3). [S3]

Table 3 Transparency in the South Bay of Nanao Bay (the prefecture's water quality measurements, fiscal 2024)

Point	Transparency on the 6 occasions (m)	Range
Central part of the South Bay	4.5, 8.5, 6.5, 8.5, 6.2, 8.5	4.5–8.5 m
Inside the Kotobuki-cho breakwater	1.5, 1.5, 2.5, 2.0, 2.0, 2.5	1.5–2.5 m
Inside the Mangyo breakwater	2.5, 2.8, 2.2, 3.5, 3.5, 3.5	2.2–3.5 m
Inside the Ota breakwater	3.8, 4.5, 5.8, 7.4, 5.5, 6.0	3.8–7.4 m

Note: From the tables for sea areas in the prefecture's "Report on the results of water quality measurements of public water areas and groundwater, fiscal 2024 (Reiwa 6)". The values are in the order of the dates of measurement (27 April, 10 June, 5 August, 22 October and 13 December 2024, and 9 March 2025). For the central part of the West Bay and the central part of the North Bay in the same tables, there are no values of transparency. For suspended solids (SS; the weight of the particles floating in the water), there are no values at any point. The column for total water depth also has no values, and whether there were occasions on which the white disc was visible down to the seabed cannot be known from the tables. The times at which the water was taken are between 7 and 8 o'clock in the morning at all 4 points. [S3]

Inside the breakwaters at Kotobuki-cho and Mangyo, it was possible to see only to shallower depths than in the central part of the bay. These 2 points were 1.5–3.5 m, smaller values than the 4.5–8.5 m of the central part of the South Bay. Inside the breakwater at Ota it was 3.8–7.4 m, overlapping with the values of the central part (this paper's comparison). However, transparency is how the water near the sea surface looks, and does not show the amount of fluid mud that has settled on the seabed. The values are from only 6 occasions, and there are no values for the West Bay, where the seaweed and seagrass beds are. [S3]

The time before the earthquake and the time after it cannot be compared by the same method. The tables for fiscal 2023, fiscal 2022, fiscal 2019 and fiscal 2012 for the same 4 points in the South Bay have no values of transparency. This paper has not checked the tables for other fiscal years. The reason why the prefecture put transparency in the tables for fiscal 2024 was not written within the range that this paper was able to read. [S3]

Region (Nanao Bay): the depth at which eelgrass grows, and the turbidity seen on site

The lower depth limit at which eelgrass grows is written to have become shallower. According to an explanatory article (2017) by a researcher of the Noto Marine Center, in the eelgrass beds of the West Bay about 25 years

earlier (1990 in the figure), the deepest place of growth appears to have been about 8 m. In the survey of December 2011, the area of the eelgrass beds had decreased, and the water depth of growth had also become shallower, to about 3–5 m. The article states that the cause is thought to be a fall in transparency, so that sunlight no longer reaches deep down. No measured values of transparency are written. A researcher of the Ishikawa Prefecture Fisheries Research Center also states, in a 2019 publication of the prefecture, that in the 2011 survey the eelgrass beds had disappeared at deep water depths (the cause is not written). [S9, S13]

In an on-site survey in 2019, too, there was a tendency for eelgrass to be scarcer the deeper the place. The Ministry of the Environment's Chubu region project surveyed the number and weight of eelgrass shoots in May–June at 3 points in the West Bay in fiscal 2019, and states that they were more abundant the nearer the point was to the shore. The report states that one factor is thought to be that the water is deeper further offshore and light is insufficient. [S8]

In September 2023, a prefectural researcher recorded strong turbidity. According to material presented at a meeting in September 2025 by a researcher of the Ishikawa Prefecture Fisheries Research Center, on 1 September 2023 Nanao Bay had a water temperature of 32°C, the turbidity was so severe that the tip of an outstretched hand could not be seen, and the eelgrass was close to withering. Eelgrass was confirmed only at water depths of 1–1.5 m. In October, the places that had previously been eelgrass beds had become muddy ground, and only a few rhizomes of withered eelgrass remained. Dwarf eelgrass, which is resistant to high water temperature, had survived. The material consists of photographs and short explanations, and measured values of turbidity, the exact location, and whether the turbidity was due to mud or to phytoplankton are not written. "Muddy ground" is also a description of appearance, not a measurement of the thickness of the mud. This observation is from before the earthquake, and high water temperature also coincided in the same period (seawater temperature is covered in R7-A02 "The rise in the seawater temperature of Nanao Bay"). [S5]

Table 4 The lower depth limit at which eelgrass grows in Nanao Bay (according to the materials)

Period	Depth	Material and survey method
Around 1990 (about 25 years earlier)	The deepest place was about 8 m	Explanatory article by a researcher at a prefectural facility (2017). Worded as "appears to have been"
December 2011	About 3–5 m	The same article. It states that the cause is thought to be a fall in transparency
2011	The eelgrass beds had disappeared at deep water depths	Publication of the prefecture (2019). The cause is not written
May–June 2019	More shoots at shallower points nearer the shore	Survey of 3 points in the Ministry of the Environment's project. It states that a shortage of light is thought to be one factor
1 September 2023	Confirmed only at water depths of 1–1.5 m	Presentation material of a prefectural researcher (2025). Turbidity so strong that the tip of the hand could not be seen. Water temperature 32°C

Note: This sets side by side materials that differ in period, in place and in survey method; it is not a change over time measured by the same method. The value for September 2023 is an observation from a period of extreme heat. [S9, S13, S8, S5]

Region (Nanao Bay): what is known after the earthquake and the heavy rain

We found no material that measured the turbidity or the amount of fluid mud in Nanao Bay after the Noto Peninsula Earthquake of 1 January 2024 and the Oku-Noto heavy rain of September 2024. How the land along

the coast of Nanao Bay moved in the earthquake is covered in R7-A19 "Land subsidence and flooding in Nanao Bay". The poor catches of sea cucumbers in Nanao Bay are covered in R7-A16 "The poor catches of sea cucumbers in Nanao Bay".

The prefecture's monthly observations do not measure turbidity. The Ishikawa Prefecture Fisheries Research Center, at fixed points in Nanao Bay, once every month lowers an instrument from the sea surface to the seabed and measures water temperature, salinity, chlorophyll (a guide to the amount of phytoplankton) and dissolved oxygen at every 0.1 m of water depth. Transparency and the turbidity level are not among the items measured. In the report for fiscal 2024, the average salinity at a water depth of 10 m at the 4 representative points was 31.0 in October–December 2024, 1.9 lower than the 32.9 of a normal year (the average of the past 5 years). The prefecture states that, because the summer air temperature was high and there was much rain from the Oku-Noto heavy rain and other events, the upper and lower layers of the sea separated more easily and there was concern that much oxygen-poor water would appear, but that it was confirmed on only 1 occasion. The low salinity is thought to show that much rain and river water entered (this paper's view), but the amount of mud and turbidity carried by the river water has not been measured (oxygen-poor water is covered in R7-A01 "The oxygen-poor water masses of Nanao Bay"). [S4]

Within the range that this paper looked at, the only record touching on the turbidity of Nanao Bay after the earthquake was an observation on 1 occasion. A research report of the Noto Marine Center (March 2025), in the course of surveying the organisms of rocky shores after the earthquake, states that at Karashima in Nanao City (the westernmost part of the West Bay) on 26 June 2024, the tide level was high and the seawater was also turbid, so that it was difficult to observe the places that remain below the sea surface even when the tide goes out. This may have been a state of that day alone, due to wind and tide, and it does not show an effect of the earthquake or the heavy rain. [S12]

The business association's survey has not confirmed the effect of the earthquake and the heavy rain on turbidity and mud either. The report of the Kanazawa Association of Corporate Executives (March 2026) surveyed the seaweed and seagrass beds of Nanao Bay with satellite images from March 2025 and an underwater camera in May, and states that the eelgrass beds that had been at the head of Nanao Bay had disappeared (R7-A03). The report's summary states that, because the eelgrass beds of this sea area had tended to decline from about 10 years before the earthquake and the heavy rain, because there is a gap of 5–8 years from the earlier survey with which the comparison was made, and because grazing by rabbitfish (a fish that eats seaweed) is also seen, the extent of the direct damage from the earthquake and the heavy rain is not clear, but the possibility that they dealt a further blow is very large. It states that in part of the shallow Sargassum beds along the coast of Nanao Bay, sand and gravel (small stones) had been moved by waves, the tsunami and the like and were covering the beds, but the point given as an example is in Nadaura (outside the scope of this paper), and there is no statement that mud or turbidity was seen at a point in Nanao Bay (R7-A04). [S15]

In the same Noto, along the coast of Wajima in Sotoura, the report of the Kanazawa Association of Corporate Executives writes that earth and sand washed out by the floods settled on the seaweed beds and that turbidity was also confirmed to arise when the waves are high. The mud and turbidity that enter from river mouths are covered in R7-B09 "The mud and turbidity that keep entering from river mouths (the seaweed beds and rocky-shore fishing grounds of the Wajima coast)". For Nanao Bay, how much the earthquake and the heavy rain added to the long-standing problem of turbidity and fluid mud has not been measured. [S15]

3. Existing measures, and how they are assessed

The efforts found in the materials that this paper looked at are of 4 kinds: measuring turbidity and fluid mud, choosing the places where seaweed and seagrass beds are created, hauling up rubbish and the like from the

seabed, and trying out methods of removing fluid mud around the country. Besides these, we also touch on the activity of sowing seeds to increase eelgrass. We found no record of efforts in Nanao Bay that reduced the turbidity itself or removed fluid mud. We also found no material that assessed the effectiveness of the efforts with respect to turbidity and fluid mud.

Arrangements for measuring

We found no arrangement for continuing to measure the turbidity of Nanao Bay by a fixed method, other than the transparency in the South Bay. The prefecture's water quality measurements measured transparency 6 times at 4 points in the South Bay in fiscal 2024, but do not measure it in the West Bay and the North Bay (chapter 2). The monthly observations of the Ishikawa Prefecture Fisheries Research Center cover water temperature, salinity, chlorophyll and dissolved oxygen, and turbidity is not included. In the satoumi-building at Wakura Onsen, a division of roles was set out in which NPEC makes observations 2 times a year (June and October) and citizens make observations at 15 points mainly in March–September, but what is measured is seaweeds and seagrasses, water depth and water temperature, and turbidity and transparency are not among the items observed. [S3, S4, S6]

Choosing the places where seaweed and seagrass beds are created

The prefecture's plan says that the places for creating seaweed and seagrass beds are to be chosen from shallow places which light reaches. The Nanao Bay area plan states that, because the transparency of seawater differs considerably from one sea area to another, sea areas of shallow water depth, where sunlight reaches sufficiently and where it can be confirmed that seaweeds are growing thickly nearby, will be chosen for the creation of beds. The prefecture's seaweed and seagrass bed vision also gives, because the decline of the beds of Uchiura is severe, the concentrated building of propagation grounds for Sargassum species around Nanao Bay, which lies up-current, and the placing of stones and the like in places where beds have not formed because the bottom is not stone or rock. In the national government's project (fiscal 2023–2031), the plan is to build 14 ha of propagation grounds and other facilities in the Noto–Uchiura district (for the places to be built and the effectiveness, see R7-A04). These are methods of creating seaweed and seagrass beds while avoiding turbidity, and do not reduce the turbidity or fluid mud itself (this paper's view). [S2, S1, S14]

Hauling up rubbish and the like from the seabed

A group of fishers in Nanao Bay also cleans the seabed, but it is not written that this removes fluid mud. The Ishizaki Satoumi Conservation Group of Nanao City (27 people: fishers and the Nanao branch of the Ishikawa Prefecture Fisheries Cooperative) states, on the national government's information site for the programme to bring out the multiple functions of fisheries, that as "removal of floating and deposited matter" it tows dredge nets with bottom-trawl fishing boats to haul up rubbish and the like from the seabed, and also cleans the shore and the fishing port. The same group also sets out mother seaweeds (parent seaweeds that release seeds). The site states that the rise in seawater temperature and the shortage of the workforce are thought to be causes of the decrease in the sea cucumber and egg cockle resources of this district, and treats the decrease of the seaweed and seagrass beds in particular as a major issue for the area, but it does not touch on turbidity or fluid mud. [S16]

Methods of removing fluid mud, and their limits

Methods of removing fluid mud are being tried around the country, but the fact that it settles again is the problem. The national government's guidance gives the method of blowing fluid mud away with a jet pump, the method of placing bases with seeds attached in another place until the season when there is little fluid mud, the method of raising the height of the base, and bases of a shape on which fluid mud does not readily collect. On

the other hand, there is also a case in which fluid mud settled again within less than 1 month after the rainy season, and the guidance states that measures to reduce the outflow are also needed (chapter 2). The report of the Kanazawa Association of Corporate Executives also states that mud and sediment on the seabed over a wide area are extremely difficult to remove by human hands, and that on the Noto Peninsula, where the exchange of seawater by the rise and fall of the tide is small, much depends on the rough waves of winter. [S20, S21, S15]

The need for measures was written by a national government project in 2020, but we found no material that decided who is to take them on. The Ministry of the Environment's Chubu region project states that, because the reduction of underwater light by the pollution of water quality hinders the growth of eelgrass in deep places, which are comparatively favourable in terms of water temperature, knowing the situation and taking measures are indispensable for maintaining the eelgrass beds as water temperature rises. However, it states that, because eelgrass itself is not the object of an industry and nobody benefits directly, it is necessary to consider and discuss which of the parties concerned is to carry out the surveys and measures, and with what sharing of the costs. No project to reduce turbidity appears in the later materials of the prefecture and the local area either (within the range that this paper looked at). [S8, S2, S6, S16, S18]

The activity of sowing seeds

In the West Bay, a local group has sown eelgrass seeds. This is an activity to increase eelgrass, and its purpose was not to reduce fluid mud or turbidity. According to the article by the chair of the Noto Forest, Village and Sea Study Group, the seeds were sown at a place of sandy mud at a water depth of around 1 m at the mouth of the Funao River in the West Bay. Since 2020 the eelgrass has not grown well, and the article states that the cause is not certain at present. The organised activities of this group have been suspended since 2024, after the earthquake. Since 2024, volunteers have been working on a trial of growing eelgrass in small containers hung in the sea. The suspension of the activities is covered in R7-A26 "The suspension of activities to restore eelgrass beds (the earthquake)". [S17]

4. What is changing

Turbidity and fluid mud have been written about as a long-standing problem, but in the materials of 2026 they are beginning to be treated as factors to be investigated from now on (as of 12 November 2026). Much of what this chapter covers consists of plans, policies and schedules.

The state of the sea

How the amounts of turbidity and fluid mud are changing now is not known, because there are no measured values. For the transparency in the South Bay in fiscal 2024 (chapter 2), the tables for fiscal 2023 and the other years that this paper checked have no values for the same points, and it cannot be compared with earlier times. The amounts of turbidity and mud in Nanao Bay after the earthquake and the heavy rain have not been measured either (chapter 2). [S3, S4]

Plans and scheduled efforts

- March 2022: The prefecture's seaweed and seagrass bed vision. It gave turbidity and fluid mud among the reasons for the decline of the beds of the Noto–Uchiura district. [S1]
- Fiscal 2022–2026: The plan for the development of fishing grounds in the Nanao Bay area. It treated turbidity as one cause, and said that shallow places which light reaches would be chosen for creating seaweed and seagrass beds. Its period ends in fiscal 2026. [S2]

- Fiscal 2023–2031: The national government's project in the Noto–Uchiura district (propagation grounds and other facilities). [S14]
- September 2025: The prefecture's report on the water quality measurements of fiscal 2024. It carried the transparency at 4 points in the South Bay. [S3]
- 19 September 2025 to February 2026: The satoumi-building of the council of Wakura Onsen (a Ministry of the Environment project). In 3 meetings, it took the view that restoring eelgrass as a whole is difficult, and made spreading and protecting dwarf eelgrass the priority for the time being. As a future task, it listed the verification of restoration methods that take bottom sediment, transparency and the like into account. [S6]
- March 2026: The report of the Kanazawa Association of Corporate Executives. It stated that the eelgrass beds at the head of Nanao Bay had disappeared, and gave turbidity, the settling of mud and the like as one of the factors. [S15]
- Fiscal 2026 (Reiwa 8): The council of Wakura Onsen intends to begin a trial of growing eelgrass in containers and to consider registration as a nature coexistence site (a place, recognised by the national government, where nature is protected). [S6]
- 4 September 2026: The 1st meeting of the study committee for the prefecture's new vision for the promotion of the fishing industry. The material states that the decline of coastal seaweed and seagrass beds was confirmed in the surveys after the earthquake, and that the activities of fishers for the beds will be supported, but the words turbidity, fluid mud and transparency do not appear (the result of a text search by this paper). [S18]
- Fiscal 2027 (Reiwa 9): The same council intends to begin the certification and sale of J Blue Credits (a scheme that puts the carbon dioxide absorbed by seaweed and seagrass beds and the like into a tradable form). [S6]

5. What is not yet known

Where there are no figures

- We found no long-term values of the turbidity level, the transparency, or the thickness or rate of settling of fluid mud for Nanao Bay, and in particular for the West Bay, where the eelgrass beds are. What we found in official measurements is only the transparency at 4 points in the South Bay in fiscal 2024 (6 occasions). [S3]
- We found no values of the amounts of turbidity and mud in Nanao Bay after the earthquake (1 January 2024) and the Oku-Noto heavy rain (September 2024). What is known is that the salinity at a water depth of 10 m in October–December 2024 was 1.9 lower than in a normal year. [S4]
- How much of the decrease in the seaweed and seagrass beds of Nanao Bay is explained by turbidity and fluid mud is not known. We found no study that examined them separately from water temperature and grazing. The prefecture's seaweed and seagrass bed vision also states that the factors are hard to identify. [S1]
- We found no material that confirmed whether the turbidity of Nanao Bay is due to soil particles, phytoplankton or organic matter. The wording differs from material to material: inflow from rivers and eutrophication (S9, S10), suspended matter and fluid mud (S1), and the pollution of water quality (S8). The definition of fluid mud in the national government's guidance includes both organic matter and inorganic matter. [S9, S10, S1, S8, S20]
- The location of the observation of strong turbidity on 1 September 2023, and the value of the turbidity, are not written in the material. [S5]
- The forecast of the future of eelgrass in the Ministry of the Environment's Chubu region project is based on water temperature alone, and does not take into account changes in underwater light due to changes in water depth and water quality. [S8]

The limits of the comparisons

- The lower depth limit at which eelgrass grows (about 8 m, 3–5 m) and the water depth at which eelgrass was confirmed in September 2023 (1–1.5 m; the location is not written) join together materials that differ in period, in place and in survey method (Table 4). The 1–1.5 m of September 2023 is an observation from a period of extreme heat with a water temperature of 32°C, and the effect of water temperature is also superimposed. [S9, S13, S5]
- Transparency is how the water near the sea surface looks, and is a different thing from the amount of fluid mud that has settled on the seabed. The values for the South Bay are from only 6 occasions, and there are no values for the West Bay and the North Bay. [S3]
- The method of surveying seaweed and seagrass beds with satellite images can be used over a narrower range in a turbid sea. The report of the Kanazawa Association of Corporate Executives states that, when transparency is low, sunlight is greatly weakened in the water, so that the range that can be analysed is limited to shallow sea, and it selects and uses images from days of high transparency. In a turbid bay, the beds in deep places may come out as fewer than they are (this paper's view. For the comparison of the areas of the beds, see R7-A03). [S15]
- The voices of fishers are not shown as values for Nanao Bay alone. The abstract by the NPEC researcher records what fishers have pointed out without writing who said it, when and where. In the interviews with 32 fishers of Oku-Noto in the report of the Kanazawa Association of Corporate Executives, 2 people live in Anamizu Town, which faces Nanao Bay, and answers for Nanao Bay alone are not shown (for the content of the interviews, see R7-B09). [S7, S15]
- Much of the material of the prefecture and the national government is written about the Noto–Uchiura district (S1, S14) or "this prefecture" (S2), and was not confirmed for Nanao Bay alone. [S1, S2, S14]

Where the figures disagree

- On the effect of the earthquake and the heavy rain, the wording is divided even within the report of the Kanazawa Association of Corporate Executives. The summary states that the extent of the direct damage is not clear but that the possibility that they dealt a further blow is very large, and the satellite image team states that the decrease of the eelgrass beds of Nanao Bay is a trend that was seen from before the earthquake disaster. This paper has summarised it as: a long-standing problem, with the effect added by the earthquake and the heavy rain not measured. [S15]
- The time when the lower depth limit of the eelgrass beds of the West Bay was about 8 m is written as "about 25 years earlier" in the text of the explanatory article and as "1990" in the figure. The year of the area of the eelgrass beds at around the same time is written differently from material to material, as 1990, about 25 years earlier, and the national government's survey of 1994, and is covered in R7-A03. [S9, S5, S13]
- The area to which turbidity and fluid mud refer differs from material to material. The prefecture's seaweed and seagrass bed vision and the national government's evaluation document cover the Noto–Uchiura district, the area plan covers "this prefecture", and the interview in the Ministry of the Environment's project, the abstract by the NPEC researcher and the Wakura Onsen report cover Nanao Bay (or the West Bay) (Table 2). [S1, S14, S2, S8, S7, S6]

Reliability and the standpoint of the materials

Reliability differs from item to item. That the bottom of the West Bay is mud, with much fluid mud, and readily becomes turbid is written so in the reports of the Noto Marine Center (by researchers of the same center), and the prefecture's seaweed and seagrass bed vision also excludes Nanao Bay from the coasts whose bottom is mostly rock or sand, and there is no disagreement. The reliability can be said to be high. However, there are no measured values of the turbidity level. That turbidity and fluid mud are thought to be one of the reasons for the

decline of the seaweed and seagrass beds of Nanao Bay is given by the prefecture's 2 plans and the national government's evaluation document, the interview in the national government's project, and the 2 reports of 2026, but all of them are worded as "are thought" or "possibility", and there is no study that has confirmed it in quantity, so the reliability is medium. That the lower depth limit at which eelgrass grows has become shallower is something on which the materials point in the same direction, but it joins together materials that used different survey methods, and the reliability is medium. That the transparency inside the breakwaters at Kotobuki-cho and Mangyo in the South Bay was 1.5–3.5 m and that of the central part of the bay was 4.5–8.5 m are values from the prefecture's measurements and the reliability is high, but they are values for 6 occasions in fiscal 2024, near the sea surface, and for the South Bay alone. Whether the turbidity and fluid mud of Nanao Bay increased after the earthquake and the heavy rain can be said to be of low reliability, because there is no material that measured it. That there is no record of efforts in Nanao Bay to reduce turbidity or remove fluid mud is based on the materials of the prefecture and the local area that this paper looked at, and the reliability is medium.

The standpoint of the materials also calls for care. The 2014 and 2015 reports and the 2017 explanatory article of the Noto Marine Center were written by researchers of the same center. The authors of the 2014 report also include the researcher of the Ishikawa Prefecture Fisheries Research Center (Takahiko Ikemori) who wrote the 2019 publication of the prefecture and the presentation material on the observation of September 2023. The figure of the eelgrass beds that the 2017 explanatory article draws on is also quoted from the study by Ikemori et al. (2016). For that reason, the materials on the lower depth limit cannot be called independent confirmation. The observation of September 2023 is presentation material (photographs and short explanations) used at a meeting on satoumi-building at Wakura Onsen, and is carried as reference material to the report. The Wakura Onsen report was produced by the local council under a Ministry of the Environment project, and the Ishikawa Prefecture Fisheries Research Center, NPEC and the Nanao branch of the Ishikawa Prefecture Fisheries Cooperative take part in the meetings. 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 it is not peer-reviewed. Staff of the prefecture's Fisheries Division and Fisheries Research Center took part in this survey as observers, and 1 of them is Takahiko Ikemori. The abstract by the NPEC researcher is an abstract for a research presentation meeting. The nationwide survey of prefectures on seaweed beds collected the answers of the prefectures, and these are not measured values. For the papers on Chesapeake Bay, dredging and the world's seagrass beds, we read only the abstracts. The example of the sediment flushing on the Kurobe River is a quotation in the report of the Kanazawa Association of Corporate Executives, and this paper has not checked the original material.

The publisher of this paper (SeatecHIROSHIMA Ltd.) runs a business that controls the attachment of living things by surface treatment of materials. This covers both preventing fouling from attaching (antifouling) and making it easier for eelgrass (a kind of seagrass) to take root for the restoration of seaweed and seagrass beds. It is also developing a system that identifies the positions of oyster rafts and informs ships of them. This paper does not cover the company's own technology or results. This paper covers turbidity and fluid mud, which are regarded as one of the reasons for the decline of the eelgrass beds and Sargassum beds of Nanao Bay, and also touches on efforts to create seaweed and seagrass beds. The restoration of seaweed and seagrass beds overlaps with the publisher's field of business. This paper also touches on the fact that turbidity is a hindrance when seaweed and seagrass beds are surveyed with satellite images. The publisher is developing, in joint research with Hiroshima University and others, a system that uses satellite data to identify the positions of oyster rafts, and the analysis of satellite images overlaps with the publisher's field of development. The relationships with the organisations taken up in this paper and with organisations 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 for the prefecture's (Commerce, Industry and Labour Department, Industrial Policy Division) "survey project for attracting start-ups

to Noto" (fiscal 2025 [Reiwa 7]) (September 2025). 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 Fisheries Division and the Fisheries Research Center of the prefecture took part as observers in the survey for the report of the Kanazawa Association of Corporate Executives that this paper draws on. In October 2026, in the "Start-up Business Plan Contest Ishikawa 2026" run by Ishikawa Prefecture and the public interest incorporated foundation Ishikawa Sunrise Industries Creation Organization, the publisher received the top entrepreneur award for a plan on the theme of Nanao Bay (according to the announcement on the Organization's website). The Organization's website states that this award comes with a subsidy, the free use for 3 years of a facility that rents rooms to newly founded companies, and other benefits. In Noto, the publisher has concluded non-disclosure agreements and is working together with Nanaibe LLC and Yamaguchi Suisan of Nanao City, Atsumasa Nakamura of Kanazawa University, and the Noto council for raising fisheries earnings. With the Ishikawa Prefecture Fisheries Cooperative, there is the relationship that the publisher secured a site for its demonstration through Nanaibe LLC, its partner in the collaboration. The Nanao branch of the same cooperative takes part in the Ishizaki Satoumi Conservation Group that this paper draws on, and the same branch also participates in the meetings on satoumi-building at Wakura Onsen. The representative senior managing director of the same cooperative is a member of the study committee for the prefecture's new vision for the promotion of the fishing industry that this paper draws on. In the interviews for the Association's report, the branches of the same cooperative were asked to cooperate. The publisher is not a member of the Noto council for raising fisheries earnings. This paper touches on the fact that the council of Wakura Onsen intends to begin the certification and sale of J Blue Credits. The Japan Blue Economy Association (JBE), which certifies these credits, is an organisation that Michio Imai, the publisher's co-representative CEO, named as a candidate collaborator (not yet arranged) in an application for research to a research centre of Tohoku University (nature positive) in October 2026. The area in Ishikawa Prefecture with which the publisher has been involved is mainly Nanao Bay, which overlaps with the sea that this paper covers. Among the materials that this paper draws on, researchers of Kanazawa University are among the authors of the 2014 and 2015 reports of the Noto Marine Center. 1 of the members of the study committee for the prefecture's new vision for the promotion of the fishing industry is also a person of the same university. The name of Atsumasa Nakamura does not appear among the authors of these materials, nor in the lists of members of the committee and of the survey team for the Association's report. With Hiroshima University, the publisher has participated since October 2025, as one company in a consortium, in a research centre of the university (JST COI-NEXT). Michio Imai, the publisher's co-representative CEO, has served since 1 November 2026 as a researcher (part-time) at a research institute of the same university (the institute for the future of ocean and maritime affairs) (concurrently with his post as the publisher's co-representative CEO). In addition, the publisher joined joint research under the Town & Gown initiative of Kure City and Hiroshima University (an initiative in which the city and the university work together) (the research period is October 2025 to August 2026, with the contract concluded in March 2026). This joint research is funded by a research grant from 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 from Kure City for the 2nd year (from September 2026). This paper does not use the data or results of this joint research. Apart from the above, there are no relationships between the publisher and the organisations taken up in this paper (national government bodies, the prefecture and the cities and towns, universities and research institutes, the business association and its survey team, local councils and groups, the companies and organisations named in this paper, overseas universities and research institutes, and others) or the organisations active in Nanao Bay (fisheries cooperatives, local groups and others) that would affect the content of this paper. Relationships here means transactions, funding, joint research, and officers or employees of the publisher concurrently serving as employees or officers of the organisation. 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 that had been published by 12 November 2026. Focusing on materials of the national government and the prefecture, reports of research institutes and peer-reviewed papers, we used figures that a separate researcher had checked against the very materials listed as sources (for overseas papers, the abstract 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 we have marked these "quoted" in the text. Values read from figures are marked "read from a figure". Reliability: A = laws and regulations, statistics, materials of the national government and the prefecture; B = papers, reports of research institutes that state their method; C = explanatory materials for general readers, descriptions and reports by organisations, presentation materials; D = news reports.

ID	Material (publisher, year)	Type	Reliability	Where this material is used
S1	Ishikawa Prefecture: Ishikawa Prefecture seaweed and seagrass bed vision (in Japanese) (March 2022. The statements on turbidity and fluid mud are about the Noto–Uchiura district)	Plan	A	Chapters 1–5
S2	Ishikawa Prefecture: Nanao Bay area (Ishikawa Prefecture) comprehensive plan for fisheries infrastructure development projects (R4-R8) (in Japanese) (2022)	Plan	A	Chapters 1–5
S3	Ishikawa Prefecture: tables for sea areas in the report on the results of water quality measurements of public water areas and groundwater (fiscal 2024 (Reiwa 6) [list. The report of September 2025]; fiscal 2023 (Reiwa 5); fiscal 2022 (Reiwa 4); fiscal 2019 (Reiwa 1); fiscal 2012 (Heisei 24)) (in Japanese)	Measurement	A	Chapters 1–5
S4	Ishikawa Prefecture Fisheries Research Center: Annual project report for fiscal 2024 (Reiwa 6) (in Japanese) (March 2026. Survey of the fishing-ground envi - ronment of Nanao Bay)	Report	A	Chapters 1–5
S5	Takahiko Ikemori (Ishikawa Prefecture Fisheries Research Center): The eelgrass beds of Nanao Bay and climate change; the workings of Sargassum beds (in Japanese) (presentation material for the 1st meeting for the exchange of opinions on satoumi-building in Nanao Bay, 19 September 2025. Reference material to the report in S6. Photographs and short explanations)	Presentation	C	Chapters 1, 2, 5
S6	Wakura Onsen council for promoting town development for creative recon - struction: Report on the implementation of the model project "Nanao Bay satoumi project around Wakura Onsen" (in Japanese) (February 2026. A satoumi-building project of the Ministry of the Environment. A report by an organisation)	Report	C	Chapters 1–5
S7	Akira Kozuka (Northwest Pacific Region Environmental Cooperation Center): Changes in the eelgrass beds of the West Bay of Nanao Bay and their factors (in Japanese) (abstract for the research presentation meeting of the Fisheries Research Institute of the Toyama Prefectural Agricultural, Forestry and Fisheries Research Center, fiscal 2023 [Reiwa 5]. Published September 2024)	Abstract	B	Chapters 2, 5
S8	Ministry of the Environment, Regional Adaptation Consortium, Chubu region project: Survey of the effects of climate change on the fishing industry and on the habitats of living things (seaweed beds, eelgrass beds and the like), final report (in Japanese) (2020. Includes interviews with experts)	Report	A	Chapters 1–3, 5
S9	Keiichi Sakai (Noto Marine Center): The eelgrass beds of the West Bay of Nanao, Noto Peninsula, which show a peculiar seasonal growth and decline (in Japanese) (Noto no Kaichurin [Noto's underwater forests] No.46, March 2017. An explanatory article for general readers)	Explanatory	C	Chapters 1, 2, 5

ID	Material (publisher, year)	Type	Reliability	Where this material is used
S10	Sakai, Higashide and Ogiso: Characteristics of the eelgrass Zostera marina growing in the West Bay of Nanao, Noto Peninsula (in Japanese) (Report of the Noto Marine Center 21, 2015. Issued March 2016)	Report	B	Chapters 2, 5
S11	Higashide, Ogiso and Ikemori: On the state of growth of eelgrasses in the West Bay of Nanao Bay, Noto Peninsula (in Japanese) (Report of the Noto Marine Center 20, 2014. Issued March 2015)	Report	B	Chapter 2
S12	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) (Report of the Noto Marine Center 30, March 2025)	Report	B	Chapter 2
S13	Ishikawa Prefecture Fisheries Research Center: Fishing and sea conditions in - formation No. 425 (in Japanese) (26 April 2019. The present state of the sea - weed and seagrass beds of Noto and the use of seaweeds. A report of a lecture)	Explanatory	C	Chapters 2, 5
S14	Fisheries Agency: Ex-ante evaluation document, Noto–Uchiura district, fish - eries environment development project (March 2023); Material 4-2 (8 March 2023) (in Japanese)	Evaluation	A	Chapters 2–5
S15	Kanazawa Association of Corporate Executives: Report on the fiscal 2025 (Rei - wa 7) survey of the effects of the earthquake disaster on the coast of the Noto Peninsula (in Japanese) (March 2026. A report of a survey by a business asso - ciation. A grant from The Nippon Foundation. Not peer-reviewed)	Report	C	Chapters 1–5
S16	Hitoumi.jp (information site for the programme to bring out the multiple functions of fisheries. A project commissioned by the Fisheries Agency): Ishizaki Satoumi Conservation Group (Nanao City, Ishikawa Prefecture) (in Japanese) (no date of posting stated. An introduction to the group)	Description	C	Chapter 3
S17	Noriyuki Okei (Noto Forest, Village and Sea Study Group): Activities to propa - gate eelgrass in Nanao Bay (in Japanese) (CAINES Journal No.6. No date of posting stated)	Explanatory	C	Chapters 2, 3
S18	Ishikawa Prefecture: Meeting materials of the 1st meeting of the study com - mittee for drawing up the new "Ishikawa vision for the promotion of the fishing industry" (in Japanese) (4 September 2026. The date of the meeting is accord - ing to the committee's page)	Meeting	A	Chapters 3, 4
S19	Fisheries Agency: Guidelines on measures against barren ground (isoyake), 3rd edition, Chapter 3 (in Japanese) (March 2021)	Guidance	A	Chapters 1, 2
S20	Fisheries Agency: Guidelines on measures to prevent the loss of seaweed and seagrass bed resources (main part 1; main part 2; main part 3) (in Japanese) (March 2009)	Guidance	A	Chapters 2, 3, 5
S21	Fisheries Agency, Construction Division: On the state of efforts to create sea - weed beds that are resistant to high water temperature (in Japanese) (material for the national council on measures against barren ground, February 2023. The survey of prefectures was in November 2021)	Material	A	Chapters 1–3
S22	Eelgrass in Chesapeake Bay: Lefcheck et al. (Global Change Biology 23, 2017); Lefcheck et al. (PNAS 115, 2018) (abstract only checked)	Paper	B	Chapter 2
S23	Erftemeijer and Lewis: dredging and seagrass beds (review article) (Marine Pollution Bulletin 52, 2006. Abstract only checked)	Paper	B	Chapter 2
S24	Waycott et al.: the decrease of the world's seagrass beds (PNAS 106, 2009. Abstract only checked)	Paper	B	Chapter 2

Related materials: R2 Seaweed and seagrass beds and the living things of the sea, R6 What is changing (why now), R7-A01 The oxygen-poor water masses of Nanao Bay, R7-A02 The rise in the seawater temperature of

Nanao Bay, R7-A03 The decrease in the eelgrass beds of Nanao Bay, R7-A04 The decline of the Sargassum beds of Nanao Bay, R7-A06 The seabed of Nanao Bay turning to mud, and organic pollution, R7-A16 The poor catches of sea cucumbers in Nanao Bay, R7-A19 Land subsidence and flooding in Nanao Bay, R7-A26 The suspension of activities to restore eelgrass beds (the earthquake), R7-B09 Mud and turbidity that keep entering from river mouths (the seaweed and seagrass beds and rocky-shore fishing grounds of the Wajima coast), I1 List of assessments