R7-B08 Shallow seaweed beds dried out by uplift, and the decrease in the area of seaweed beds in Sotoura

In the uplift of the earthquake of 1 January 2024, where and how much did the shallow seaweed beds of Sotoura dry out, and how much has the area of the seaweed beds of Sotoura changed compared with before the earthquake? How reliable are those values?

Readers

Fishers and fishery cooperatives, local governments (those in charge of fisheries and coasts), research institutions and others without specialist knowledge, who want to check, with figures and sources, what the shallow seaweed beds of Sotoura lost through uplift, how much the area of the seaweed beds decreased, and how reliable those values are.

Takeaways

1. In the Noto Peninsula Earthquake of 1 January 2024, the coast of Sotoura (the outer, Sea of Japan coast of the Noto Peninsula) was lifted up. This is called uplift. The shallow seaweed beds (places where seaweeds and similar plants grow thickly) that lay just off the water's edge came out of the sea and dried out. In a diving survey in June 2025, the coastline had moved about 15–100 m offshore at 5 sites in Sotoura, and the seaweed beds that had been in that width were gone. Sotoura has a small tidal range, about 50 cm at most at Wajima. For that reason, even with the uplift of 0.8–4.1 m at the 5 sites, the shallow seaweed beds dried out all together.
2. The seaweed beds that dried out in the 3 districts of Wajima City are thought to have been Sargassum beds, where large seaweeds called Sargassum species grow thickly. When they were examined in February–March 2024, almost all the seaweeds of the dried-out beds had died. Many of the same species survive in today's sea. The seaweeds suited to deeper places that remain near today's coastline are expected to die before long.
3. The survey by a business association used satellite images to compare the area of the seaweed beds of Sotoura with the survey before the earthquake. The area in 2025 was 1,915 ha in the Wajima district, 416 ha in the Monzen district and 1,362 ha in the Saikai district. These values are 47.0%, 61.4% and 43.0% smaller, respectively, than the values that the report recalculated from the data of the prefecture's fiscal 2019 survey. The ha (hectare) is a unit of area, and 1 ha is 100 m square.
4. Most of the area lost was that of beds in deep places where Sargassum species and kajime-type kelps are mixed. The seabed that became land through uplift is about 4.4 km^2 on the north and north-west coasts of Sotoura. This is about 440 ha, and even including the part on the north coast of Suzu City, which is outside the 3 districts, it is a little over 10% of the total area lost in the 3 districts (this paper's calculation). The report states that in Sotoura a decrease of seaweed beds due to uplift was seen in many places. It regards the decrease over the whole of the sea surveyed as the result of several causes, including uplift, acting together.
5. The decrease in area is a value of medium reliability. The previous survey was in fiscal 2019, about 4 years before the earthquake, and it differs from the present one in such things as how the types of seaweed bed were divided. The satellite identification is said to have had many misses for the beds on the offshore side. On the rocky areas newly exposed on the seabed, a succession of species has begun, starting from seaweeds that grow in 1 year. The report calls for continued measurement, centred on the shallow places.

After reading

When using the values of the area of the seaweed beds of Sotoura in documents or plans, add the name of the district, the years of the 2 surveys compared (fiscal 2019 and 2025), how a seaweed bed was defined (for 2025, cover of 25% or more) and the fact that they are values from the analysis of

satellite images, and treat them separately from the matter of the shallow seaweed beds that dried out through uplift.

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

1. Key points

- In the Noto Peninsula Earthquake of 1 January 2024, the coast of Sotoura (the outer, Sea of Japan coast of the Noto Peninsula) was lifted up. This is called uplift. The shallow seaweed beds (places where seaweeds and similar plants grow thickly) that lay just off the water's edge came out of the sea and dried out. In a diving survey in June 2025, the coastline had moved about 15–100 m offshore at 5 sites in Sotoura, and the seaweed beds that had been in that width were gone. Sotoura has a small tidal range, about 50 cm at most at Wajima. For that reason, even with the uplift of 0.8–4.1 m at the 5 sites, the shallow seaweed beds dried out all together. [S1, S5]
- The seaweed beds that dried out in the 3 districts of Wajima City are thought to have been Sargassum beds, where large seaweeds called Sargassum species grow thickly. When they were examined in February–March 2024, almost all the seaweeds of the dried-out beds had died. Many of the same species survive in today's sea. The seaweeds suited to deeper places that remain near today's coastline are expected to die before long. [S2, S1]
- The survey by a business association used satellite images to compare the area of the seaweed beds of Sotoura with the survey before the earthquake. The area in 2025 was 1,915 ha in the Wajima district, 416 ha in the Monzen district and 1,362 ha in the Saikai district. These values are 47.0%, 61.4% and 43.0% smaller, respectively, than the values that the report recalculated from the data of the prefecture's fiscal 2019 survey. The ha (hectare) is a unit of area, and 1 ha is 100 m square. [S1]
- Most of the area lost was that of beds in deep places where Sargassum species and kajime-type kelps are mixed. The seabed that became land through uplift is about 4.4 km^2 on the north and north-west coasts of Sotoura. This is about 440 ha, and even including the part on the north coast of Suzu City, which is outside the 3 districts, it is a little over 10% of the total area lost in the 3 districts (this paper's calculation). The report states that in Sotoura a decrease of seaweed beds due to uplift was seen in many places. It regards the decrease over the whole of the sea surveyed as the result of several causes, including uplift, acting together. [S1, S4]
- The decrease in area is a value of medium reliability. The previous survey was in fiscal 2019, about 4 years before the earthquake, and it differs from the present one in such things as how the types of seaweed bed were divided. The satellite identification is said to have had many misses for the beds on the offshore side. On the rocky areas newly exposed on the seabed, a succession of species has begun, starting from seaweeds that grow in 1 year. The report calls for continued measurement, centred on the shallow places. [S1, S6]

2. What is happening

Japan and the world: seaweed and seagrass beds, and the role of beds in shallow places

Seaweed and seagrass beds are places where seaweeds and seagrasses (plants that flower in the sea) grow thickly. The name changes with the kind that grows there: places where Sargassum species grow thickly are

called Sargassum beds, places where kajime-type kelps (such as tsuruarame and kurome) grow thickly are called kajime kelp beds, and places where the seagrass eelgrass grows thickly are called eelgrass beds. [S1]

Seaweed beds in shallow places become the home of young shellfish. The report of a business association that surveyed the seaweed beds of the coast of the Noto Peninsula (Kanazawa Association of Corporate Executives [Kanazawa Keizai Doyukai], March 2026; hereafter, the Doyukai report) states that seaweed beds formed in very shallow places are known to be the main home of the spat (young shellfish) of abalones and turban shells (sazae). [S1]

Japan's seaweed and seagrass beds have been declining nationwide. According to the Fisheries Agency's guidelines for measures against barren ground (isoyake) (2021), in a questionnaire in 2020, 31 (the value in the figure) of the 39 coastal prefectures answered that the decline of seaweed beds on rocky areas was continuing. As for the causes, of the number of answers, feeding damage by sea urchins was 26%, and feeding damage by seaweed-eating fish and the rise in seawater temperature were 21% each (the view of the officials in charge). The Doyukai report states that on the Sea of Japan side of Honshu too, the rise in water temperature in recent years is marked; that in the south, feeding damage by sea urchins and seaweed-eating fish and the loss of seaweed beds at times of high water temperature in summer are seen; and that in the north, the purple sea urchin (murasaki-uni) is spreading northwards. The decrease of seaweed and seagrass beds nationwide is covered in R2 "Seaweed and seagrass beds and the living things of the sea". [S23, S1]

The extent of seaweed beds over a wide area is measured with images from satellites, aircraft and drones, among other means. The places where there are seaweed beds are identified from the colours of the image, and checked against the results on site examined by boat or by diving. The Doyukai report states that it referred to the national guidance (the Fisheries Agency's guidance on wide-area monitoring of seaweed and seagrass beds, 2021) and to the Ministry of the Environment's manual for the work of preparing seaweed and seagrass bed distribution maps (2021). [S1]

The Fisheries Agency's guidance shows how to use satellite images, and their limits. The accuracy of identifying the presence or absence of seaweed beds from satellite images is about 60–90%, and the target is about 70–80%. The accuracy is checked by comparison with on-site examination by diving or from a boat at places separate from those used as the training examples for the identification calculation. In temperate seas, what can be surveyed for seaweed beds with satellite images is the range shallower than a water depth of about 10 m, the limit at which seaweeds can be seen from the water surface. It states that the boundary of cover (the proportion of the seabed covered by seaweeds) for counting a place as a seaweed bed is not fixed, and that the boundary is often set somewhere between 1 and 50%. It also states that comparing old surveys made by a different method with today's area as they are, without checking, could lead to wrong conclusions. As a yardstick for accuracy, the Doyukai report also cites the 60–80% of the Ministry of the Environment's results of the survey of the distribution of seaweed and seagrass beds and tidal flats in the Seto Inland Sea (2018). [S15, S1]

Japan and the world: what happened to seaweed beds when earthquakes lifted the coast

When a coast is uplifted, the seaweed beds that had until then been in the sea are exposed to the air all at once. The dried-out seaweeds die, and the calcareous seaweeds that cover the rocks turn white. Living things have to settle anew at the new water's edge and offshore of it. [S1, S11]

In Japan, seaweeds also dried out in the Kanto Earthquake of 1923. According to a 1924 report of the fisheries experimental station of Kanagawa Prefecture, the Shonan coast was uplifted by up to 2 m, and the hijiki, funori and tsunomata seaweeds that grew in the intertidal zone of the rocky shore (the part that is under the sea at high tide and out on land at low tide) dried out and died, and the calcareous algae covering the rocks also died and turned white (as quoted in the Doyukai report). The Doyukai report states that the effect of the uplift of the Noto Peninsula Earthquake was far greater than this. On the Noto Peninsula too, in the magnitude 6.9

earthquake of 2007, the coast at Akakami, Monzen-machi, Wajima City was uplifted by up to 41 cm (as quoted in the 2025 research report of the prefecture's Noto Marine Center). This research report states that no record remains of coastal living things having died at that time. [S1, S14]

In Chile, in the earthquake of 3 March 1985, the coast at the coastal research station of Las Cruces was uplifted by about 40–60 cm, and the living things of the intertidal zone died widely. What suffered particular damage was the belt of a kelp (Lessonia nigrescens) (according to the abstract). [S18]

In Chile, the coast was also uplifted in the magnitude 8.8 earthquake of 27 February 2010. A study that measured, a few weeks after the earthquake, by the height of living things that attach in belts gives the uplift of the coast of the Gulf of Arauco and other places as about 0.2–3.1 m. At the places of large uplift, the main living things of the intertidal zone and the shallow sea, such as calcareous seaweeds, large brown algae (brown-coloured seaweeds) such as kelps, and mussels, died in large numbers. At 5 of the 9 places examined, the living things of the intertidal zone and the shallow sea that attach in belts had all died. The tidal range of this sea is about 2 m at most, and most of the uplifted places came out above the upper limit that the tide reaches. At the 2 places where the uplift was small, 0.2–0.3 m, the communities of living things of the intertidal zone and the shallow sea looked as usual. [S10]

At Kaikoura in New Zealand, in the moment magnitude 7.8 earthquake of 2016, the coast was uplifted by up to 6 m. Along about 130 km of coast, the seaweeds and animals of the intertidal zone died widely. The tidal range of this coast is roughly 2 m. According to a study that examined 16 sites divided into 4 by the size of the uplift (in the values of the abstract: no uplift, 0.4–1 m, 1.5–2.5 m and 4.5–6 m; in the methods section, the places of small uplift are given as 0.5–1.4 m, the medium ones as 1.5–2.5 m and the large ones as 4–5.5 m), the communities of large brown algae (the species that form canopies are almost all fucoids) were greatly damaged by the uplift, and even 4 years later, recovery remained poor except at the places where the uplift was less than 1 m. The top of the dried-out rocks often exceeded 35°C and sometimes reached 50°C, killing the remaining seaweeds and the newly attached seaweeds. Soft rock was greatly eroded, sand and pebbles covered part of the low rocky areas during storms, and there were many days when light in the sea was also insufficient. Even at the places of small uplift, it was only in the low intertidal zone that a considerable part of the communities from before the earthquake returned. At all the uplifted places, the middle and high intertidal zones remained poor in living things. In the low intertidal zone of the places of small uplift, large brown algae attached well, but they decreased in a strong heatwave 1 year after the earthquake, and the fleshy red algae (red-coloured seaweeds) that increased greatly afterwards hindered large brown algae from attaching anew. [S11]

At Kaikoura, seaweeds were lost even where the uplift was small. According to a study that divided the coast into 50 m sections and compared the uplift using laser survey data, at 9 of the 10 uplifted sites more than 80% of the canopy-forming seaweeds were lost, and these included the site with the smallest uplift, 0.6 m. The researchers consider that great damage occurred with uplift exceeding about 1/4 of the tidal range (about 2 m). Seaweeds that had originally been below the intertidal zone and were moved into the low intertidal zone by the uplift also did not remain in the places where they should have remained. [S19]

Another study at Kaikoura states that Durvillaea, a large kelp-like brown alga, lost 75% of its canopy through the uplift. The canopy that survived the uplift decreased by a further 35% in the heatwaves that followed. It had still not returned 4 years later, and much of the intertidal zone was covered by small turf-like seaweeds and thin-bladed seaweeds (the uplift in the range of this study is up to 2 m; according to the abstract). A 2024 study that includes the same researchers also states that the Durvillaea canopy has not returned, and that another canopy-forming brown alga, which was subordinate before the earthquake, has increased and is now more abundant than Durvillaea (according to the abstract). [S12, S20]

There are also cases in which a tsunami changed seaweed beds. In the Great East Japan Earthquake of 2011, the height of the tsunami reached 15 m at Onagawa Town, Miyagi Prefecture. In shallow sea where sea urchins had

increased and seaweeds had become scarce, there were places where the sea urchins were carried offshore and kelp and other seaweeds returned for a time. On the other hand, debris and sediment piled up, and the eelgrass beds on the sandy-mud seabed declined (according to the Doyukai report, quoting the 2011 collection of lecture abstracts of the Japan Seaweed Association). The possibility that the tsunami and other things changed the seaweed beds at Suzu City in Sotoura is covered in R7-B10 "The decline of the offshore-side seaweed beds of Sotoura in Suzu (tsunami or winter waves?)". [S1]

Table 1 Main examples of seaweed beds and seaweeds when earthquakes lifted the coast

Earthquake	Uplift of the coast	What happened to seaweed beds and seaweeds	Material
1923 Kanto Earthquake	Up to 2 m on the Shonan coast	Hijiki, funori and tsunomata of the intertidal zone died, and calcareous algae turned white	Quotation of the report of the fisheries experimental station of Kanagawa Prefecture (1924)
1985 earthquake in Chile (Las Cruces)	About 40–60 cm	The living things of the intertidal zone died widely, and the belt of a kelp suffered particular damage	Abstract of a paper (1988)
2007 Noto Peninsula Earthquake	Up to 41 cm at Akakami, Monzen-machi, Wajima City	No record remains of coastal living things having died	Research report (2025). The value of the uplift is a quotation of a research bulletin (2007)
2010 Maule earthquake (Chile)	About 0.2–3.1 m	Calcareous seaweeds, large brown algae, mussels and others died in large numbers	Paper (2010)
2016 Kaikoura earthquake (New Zealand)	Up to 6 m	The communities of large brown algae were greatly damaged, and even 4 years later recovery is poor except at the places of uplift of less than 1 m. At 9 of the 10 uplifted sites, more than 80% of the canopy-forming seaweeds were lost (including the 0.6 m site). Durvillaea lost 75% of its canopy through the uplift and has not returned since	Papers (2 from 2021), abstracts of papers (2021, 2024)
2024 Noto Peninsula Earthquake	0.1–5.2 m (510 sites)	The "Region (Sotoura)" sections of this chapter	Paper (2026) and others

Note: The values are as each material expresses them. The way of measuring, the period and the tidal range differ, so they cannot be compared as they are (Chapter 5). The Great East Japan Earthquake of 2011 is an example of a tsunami, so it is not included in the table. [S1, S18, S14, S10, S11, S19, S12, S20, S4]

Region (Sotoura): the seaweed beds of Sotoura (before the earthquake)

Sotoura is the Sea of Japan coast of the Noto Peninsula. In this paper, it means the coast of Shika Town, Wajima City (including Monzen, Hegurajima and Nanatsujima), and the north coast of Suzu City as far as Jike. The Doyukai report states that along the coast of the Noto Peninsula rocky areas spread widely, the sea is washed by the Tsushima Warm Current and is highly transparent, the sea is stirred by the winter monsoon, and snowmelt water carries nutrients from the mountains, so that wide seaweed beds have grown. Sotoura faces the open sea and is a sea of severe rough waves in winter. According to the Doyukai report, about 300 species of seaweed are

known on the coast of the Noto Peninsula, including Uchiura. Before the earthquake, many seaweeds were laid out at the Wajima morning market. At Sosogi in Wajima City and Maura in Suzu City, there was also a period when seaweed festivals were held every year. The destruction of the morning market by fire and the matter of selling places are covered in R7-B28 "The destruction of the Wajima morning market by fire, and the selling places for fish and seaweed". [S1]

The main seaweeds of the seaweed beds of Sotoura are Sargassum species and kajime-type kelps. In the report's on-site survey in 2025, on the Wajima coast, Sargassum species such as nokogirimoku, yoremoku, yatsumatamoku, mametawara and yanagimoku, and the kajime-type kelps kurome and tsuruarame, were the main species. The lower limit at which seaweeds grow differs from place to place, but is said to be roughly a water depth of 20–35 m, and the rocky area is said to be wide to the east of Wajima Port and narrow to the west. Around Togi Port in Shika Town, Sargassum species and wakame grew thickly mixed together down to a water depth of around 5–10 m, at 10–20 m there were Sargassum beds of nokogirimoku, yanagimoku and others, and in places deeper than 20 m large brown algae became scarce. These are from the survey in 2025, after the earthquake, but the report states of the seaweed beds in today's sea that, on the Wajima coast (excluding the east side of Wajima Port) and around Togi Port, the way seaweeds grow and the way the seaweed beds are divided by water depth have not changed greatly from before the earthquake. [S1]

The area of the seaweed beds before the earthquake had been surveyed by the prefecture. In fiscal 2019 (Heisei 31), the prefecture surveyed the distribution of the seaweed beds of Sotoura by analysis of satellite images and by on-site examination with underwater cameras from a boat and with a device that searches the seabed by sound (scanning sonar). Seaweed beds found in places deeper than a water depth of 20 m are also counted. The values of this survey shown in the prefecture's Ishikawa Prefecture Seaweed and Seagrass Bed Vision (March 2022) are 3,441.0 ha for the Wajima district, 1,078.0 ha for the Monzen district and 2,224.3 ha for the Saikai district. The Doyukai report corrected part of the extent of the districts and recalculated with the data of that time, giving 3,611 ha for the Wajima district, 1,078 ha for the Monzen district and 2,389 ha for the Saikai district. These differ from the prefecture's values by 170 ha in the Wajima district and about 165 ha in the Saikai district (the differences are this paper's calculation). Table 3 of this paper and the percentages of decrease are based on the report's recalculated values. The extent of the districts is explained in Chapter 5. [S13, S1]

Before the earthquake, the prefecture regarded the seaweed beds of the districts that include Sotoura as being in a broadly good state. The prefecture's Seaweed and Seagrass Bed Vision, after stating that they cannot simply be compared with the Environment Agency's survey of fiscal 1990–91 because the method and the divisions differ, states that although there was some decrease in parts of Saikai and Monzen, as a whole they maintain a generally good state. [S13]

The shallow seaweed beds before the earthquake were rich. In the 3 districts of Hikariura, Wajimazaki and Najimi in Wajima City, since 2013 the "Association to Protect Wajima's Satoumi", an activity organisation under a Fisheries Agency programme (measures to bring out the multiple functions of fisheries), has removed sea urchins and surveyed the seaweed beds. According to a material of the association from before the earthquake (around 2016), what the association protected at Najimi and Hikariura were shallow seaweed beds down to a water depth of 5 m, and the cover of seaweeds in the relatively dense Sargassum beds was stable at 60–100% throughout the period before and after the activities. The researchers of Kanazawa University and others who examined the dried-out rocky area at Kaiso in Monzen-machi state, from the remains of the living things left there, that before the earthquake the rocky area of Kaiso supported many kinds of living things with a rich "forest" of seaweeds. On the other hand, there is also a report that at Hikariura, west of Wajimazaki, tsuruarame had already decreased in 2023, before the earthquake; the decline from before the earthquake is covered in R7-B11 "Barren ground (isoyake) that has continued since before the earthquake, and the decline of the seaweed beds of the offshore islands". [S2, S22, S5, S1]

Region (Sotoura): the shallow seaweed beds that dried out through uplift

Sotoura is a sea with a small tidal range. According to the announcement by researchers of Kanazawa University and others, whereas at Tokyo on the Pacific side the difference in tide level is about 2 m at most, at Wajima it is about 50 cm at most throughout the year. For that reason, an uplift of several metres far exceeds the width of the intertidal zone. The shallow seaweed beds did not wait for the tide to go out; they came out of the sea as they were. The size and places of the uplift are covered in R7-B01 "Earthquake uplift on the Sotoura coast". [S5]

The diving survey of the Doyukai report confirmed dried-out seaweed beds at 5 sites in Sotoura. The business association Kanazawa Association of Corporate Executives, receiving a grant from The Nippon Foundation and with the Fisheries Division and the Fisheries Research Center of Ishikawa Prefecture as observers, surveyed the seaweed beds of the coast of the Noto Peninsula in 2025 and issued its report in March 2026. The diving survey, on 6–19 June 2025, recorded every 10 m the seaweeds and animals within 1 m on both sides along a line from the waterline (the line of the water's edge) before the earthquake to a water depth of 8 m, which is regarded as the lower limit of ama diving fishing. At the 5 Sotoura sites of Kaiso, Wajimazaki, Nagahashi, Kinoura and Noroshi, the coastline had moved offshore everywhere, and the seaweed beds that had been in that width had dried out and gone (Table 2). [S1]

Table 2 Shallow seaweed beds that dried out at 5 sites in Sotoura (diving survey of June 2025)

Site	Uplift	Width by which the coastline moved offshore	Date surveyed	Comparison with materials from before the earthquake
Kaiso (Monzen-machi, Wajima City)	4.1 m	About 100 m	19 June 2025	There is no record from before the earthquake. Wakame is abundant and perennial Sargassum species are few. The rocks were covered in many places by mud 1–2 mm thick
Wajimazaki (Wajima City)	1.5 m	About 50 m	6 June 2025	Compared with the survey of June 2023, Sargassum species were almost unchanged and tsuruarame had decreased greatly
Nagahashi (Suzu City)	2.8 m	About 60 m	8 June 2025	Compared with the survey of June 2020, the places of calm waves had dried out and umitoranoo had disappeared
Kinoura (Suzu City)	1.8 m	About 15 m	9 June 2025	Compared with the survey of June 2020, the intertidal zone and the places of calm waves had dried out, and narasamo and sugimoku had disappeared
Noroshi (Suzu City)	0.8 m	About 65 m	7 June 2025	There is no record from before the earthquake. Nokogirimoku and others remained in tide pools in the dried-out area

Note: From the table and the text of the diving survey of the Doyukai report. Perennial means species that go on living for many years. The values of uplift are the values shown by the report. Those for Kaiso, Nagahashi and Noroshi are the same values as the prefecture's provisional values for the fishing ports of the same names (for Noroshi, the Noroshi district of Noroshi Fishing Port), and that for Wajimazaki is the same as that for Wajima Port. The 1.8 m for Kinoura is the same as the value for the Takaya district of Noroshi Fishing Port, and the prefecture's value for the Orito district of the same fishing port, in Orito-machi where Kinoura lies, is 1.2 m (this paper's cross-check; R7-B01). The fact that seaweeds that die within 1 year were abundant in the sea at Nagahashi, Kinoura and Noroshi is covered in R7-B10, and the mud at Kaiso in R7-B09 "Mud and turbidity that keep entering from river mouths (the seaweed beds and rocky-shore fishing grounds of the Wajima coast)". [S1]

In the 3 districts of Wajima City, there is a record of the seaweeds of the dried-out beds having been examined immediately after the earthquake. Ryoko Ishikawa of the sole-proprietor office Wajima Seaweed Lab, under the

Fisheries Agency's fishing ground restoration measures support project, examined the dried-out seaweed beds of the 3 districts of Hikariura, Wajimazaki and Najimi together with fishers, mainly ama divers (a 2025 report article). When seaweeds other than calcareous seaweeds were collected from late February to early March 2024, they were almost all dead Sargassum species, 13 species including yatsumatamoku. The total dry weight by species (in the state of having dried naturally on the spot) was 315.3–764.5 g per 1 m^2 in the 3 districts, and all 3 districts are thought to have been Sargassum beds before the earthquake. The only living seaweed was seiyo-habanori at the water's edge at Hikariura, and as it is a species that comes up every spring, it was considered to have grown anew after the earthquake. [S2]

The animals of the dried-out seaweed beds had also all died, except in a few tide pools (pools left by the tide) (the same 3 districts, survey of late March to early June 2024). There were many dead turban shells (sazae), purple sea urchins (murasaki-uni), kuro-awabi abalones and others, and Ryoko Ishikawa states that the dried-out shallow seaweed beds were also fishing grounds for turban shells. The mass death of shellfish and the effect on fishing are covered in R7-B13 "The mass death of abalone and turban shells, and the decrease in catch that continues for some years". The animals of the intertidal zone are covered in R7-B07 "The wiping out of the living things of the intertidal zone and shallow rocky reefs, and the recovery afterwards". [S2]

Many of the species that dried out survive in today's sea. Ryoko Ishikawa also confirmed, in later diving surveys, that many species of the Sargassum that dried out and died survive in today's sea and form communities. She expects that the make-up of the seaweeds will change in line with today's water depth and that the seaweed beds will be replaced. In the presentation by researchers of the prefecture's Noto Marine Center and others (November 2024) too, in the new intertidal zones at Kinoura (uplift of about 2 m) and Kaiso (uplift of about 4 m), seaweeds that originally grow below the intertidal zone, such as yanagimoku and yatsumatamoku, were growing and mature, although torn and shortened. On the other hand, narasamo, umitoranoo, togemoku and others, which the summary of the presentation listed as species whose main home is the intertidal zone, were not seen in the new intertidal zones. The summary also lists fushisujimoku as such a species and states that it was not seen, but in the table on the same slide, fushisujimoku is shown as seen at Kinoura, with uplift of about 2 m. The Center's research report (2025) lists only narasamo and umitoranoo as species that all died and disappeared, and in its table too, fushisujimoku at the Kinoura site is seen after the earthquake as well. [S2, S3, S14]

Some of the seaweeds that remain near today's coastline are expected to die from now on. The Doyukai report predicts that, although seaweeds that attached and grew before the earthquake remain near today's coastline, those not suited to shallow places, such as nokogirimoku, will before long die and be washed away. At Noroshi, nokogirimoku and yatsumatamoku thought to have attached before the earthquake remained in tide pools about 30 cm deep formed on the dried-out rocky area, but it predicts that eventually they will give way to umitoranoo and others that prefer such places. [S1]

The way the shallow seaweed beds were lost differs with the size of the uplift. In the on-site survey of the satellite team of the Doyukai report, on the coast around Monzen-machi, because the uplift was large, the seaweed beds that had been on rocky areas and the like shallower than a water depth of 5 m had gone. Around Togi Port in Shika Town, where the effect of uplift is small, there were seaweed beds of Sargassum species, kajime-type kelps and others on the rocky areas and stony seabed shallower than a water depth of 20 m, and the way the seaweed beds are divided by water depth had also not changed greatly from before the earthquake. [S1]

Fishers also say that they have lost the seaweeds of the water's edge. In the interviews of the Doyukai report (32 fishers who gather seaweed and shellfish in the 4 cities and towns of Oku-Noto; October 2025 to January 2026), there was nobody who gathered kasukamo and umizomen, which grow at the water's edge, in 2025. The reason was that the fishing grounds had dried out and gone through uplift. The drying out of the rocky shores where rock nori (iwanori) is picked at the water's edge and of the man-made nori beds of Monzen-machi is covered in

R7-B14 "The rocky shores of rock nori and wakame (the drying out of nori beds, footing, and processing places)". [S1]

Region (Sotoura): the area of the seaweed beds of Sotoura, as seen by satellite

The Doyukai report measured the area of the seaweed beds after the earthquake with satellite images. The 3 districts of Sotoura are analysed mainly with an image of the artificial satellite SPOT6 (resolution 1.5 m) taken on 14 March 2025 (the extent of the image is this paper's reading of the figure). The presence or absence of seaweed beds and their cover were examined with underwater cameras and other means at 355 sites in all, the peninsula part in April–May 2025 and the offshore islands in November, and with these results as a clue the seaweed beds were identified from the colours of the image. Places with cover of 25% or more were counted as seaweed beds, and engineers made corrections while also looking at materials from before the earthquake, water depth and so on. The report states that the water depth at which seaweed beds can be identified from the image is about 20 m at most when the water is clear, and that seaweed beds found in places deeper than that were also added. [S1]

The seaweed beds of the 3 districts of Sotoura were 40–60% smaller than in the fiscal 2019 survey (Table 3). The area in 2025 is 1,915 ha in the Wajima district (3,611 ha in fiscal 2019), 416 ha in the Monzen district (1,078 ha) and 1,362 ha in the Saikai district (2,389 ha). The 3 districts together come to 3,693 ha, a value 3,385 ha, or 47.8%, smaller than the 7,078 ha of fiscal 2019 (the total and the percentage for the 3 districts are this paper's calculation). As districts that decreased by 40% or more, the report lists, besides these 3 districts, the districts of Nanao Bay and of the offshore islands. The values for the Nanao Bay districts are covered in R7-A03 "The decrease of the eelgrass beds of Nanao Bay" and R7-A04 "The decline of the Sargassum beds of Nanao Bay", and the values for Hegurajima, Nanatsujima and Yomeguri in R7-B11. The district of Suzu City has only a value combining Uchiura and Sotoura, so it is covered in R7-B10. [S1]

Table 3 Area of the seaweed beds of the 3 districts of Sotoura (analysis of satellite images; for 2025, cover of 25% or more was counted as seaweed bed)

District	Type of seaweed bed	Fiscal 2019	2025	Percentage change
Wajima	Kajime kelp beds	43 ha	6 ha	−86.0%
Wajima	Mixed Sargassum and kajime	2,340 ha	281 ha	−88.0%
Wajima	Sargassum beds	1,223 ha	1,628 ha	+33.1%
Wajima	Small seaweeds	5 ha	No category	—
Wajima	Total	3,611 ha	1,915 ha	−47.0%
Monzen	Kajime kelp beds	27 ha	104 ha	+285.2%
Monzen	Mixed Sargassum and kajime	598 ha	52 ha	−91.3%
Monzen	Sargassum beds	452 ha	261 ha	−42.3%
Monzen	Total	1,078 ha	416 ha	−61.4%
Saikai	Kajime kelp beds	No category	505 ha	—
Saikai	Mixed Sargassum and kajime	1,352 ha	142 ha	−89.5%
Saikai	Sargassum beds	1,035 ha	715 ha	−30.9%
Saikai	Eelgrass beds and small seaweeds	2 ha	No category	—
Saikai	Total	2,389 ha	1,362 ha	−43.0%

Note: From the tables of the Doyukai report. The fiscal 2019 values are values that the report recalculated from the data of the prefecture's fiscal 2019 (Heisei 31) survey. The values of the same survey shown in the prefecture's Seaweed and Seagrass Bed Vision (2022) are Wajima 3,441.0 ha, Monzen 1,078.0 ha and Saikai 2,224.3 ha, and for Wajima and Saikai they differ from the values in the table. For the values by type, the way the types are divided has also been revised (the report writes "recalculated and modified"). How the fiscal 2019 survey decided what was a seaweed bed is written neither in the report nor in the prefecture's Seaweed and Seagrass Bed Vision. The increases and decreases by type are easily affected by the difference in the way of dividing, and are thought to be less reliable than the increase or decrease of the totals (this paper's view). Each value is rounded to the nearest whole number, so in some places the sum of the breakdown does not match the total. "No category" shows that the analysis of that year did not divide beds into that type. Mixed Sargassum and kajime means seaweed beds where Sargassum species and kajime-type kelps grow thickly mixed together. [S1, S13]

Most of the area lost is that of the mixed beds in deep places. The report states that in the Wajima district the mixed Sargassum and kajime beds in deep places decreased greatly, while the Sargassum beds increased. It states that in the Monzen and Saikai districts the kajime kelp beds near the shore increased greatly, while the mixed beds and Sargassum beds in deep places decreased greatly. However, for the Saikai district, the survey before the earthquake did not separate out kajime kelp beds (Table 3). The mixed beds of the 3 districts decreased by 3,815 ha in all (this paper's calculation). This is larger than the total area lost in the 3 districts (3,385 ha); the whole decreased after offsetting the amount by which other types of seaweed bed increased. [S1]

The shallow places that dried out cannot by themselves explain most of the area lost. The area of seabed that became land through uplift is, in the paper that measured uplift at 510 sites (2026; hereafter, the 510-site paper), about 4.4 km^2 in total for the north and north-west coasts of Sotoura. This is about 440 ha, which corresponds to a little over 10% of the total area lost in the 3 districts (3,385 ha) (this paper's calculation). This figure of about 4.4 km^2 also includes the part on the north coast of Suzu City, outside the 3 districts, so the area that became land within the 3 districts, and its percentage, are smaller than this (this paper's view). Even if all the places that became land had been seaweed beds, most of the area lost would have been lost outside the places that dried out (this paper's view). [S4, S1]

The report states of Sotoura that a decrease of seaweed beds due to uplift was seen in many places. It states that on the Wajima coast it also confirmed that sediment washed out by the floods had piled up on the seaweed beds and that turbidity arose when there were waves. As for the decrease over the whole of the sea surveyed (including Nanao Bay and Uchiura), it infers that several causes acted together, lists as 1 of them that the coastline moved offshore through uplift, and states that near Suzu City and elsewhere, where the uplift was especially large, it was confirmed in the satellite images too that the distribution of the seaweed beds had moved further offshore than before the earthquake. The causes that the report gives for the decrease of the eelgrass beds of Nanao Bay are covered in R7-A03. The report has no values that separate the decrease in the 3 districts of Sotoura into the part due to uplift and the part due to other causes. [S1]

The figures for the 3 districts of Sotoura are values for Sotoura alone. The same report also shows the area for the whole of the sea surveyed, including Nanao Bay and Uchiura, but as these are not values for Sotoura alone, this paper does not use them (R7-A03, R7-A04). A material of the review committee for the prefecture's fisheries plan (September 2026) also states that a decline of the coastal seaweed beds was confirmed in the survey of the distribution of seaweed beds after the earthquake, but its figures are values for the whole coast of the prefecture. [S1, S8]

Region (Sotoura): the rocky areas newly exposed on the seabed, and the re-forming of seaweed beds

Through uplift, rocks that had been buried under the sand offshore came out on the seabed. The Doyukai report states that what was newly confirmed as an effect of uplift in the diving and satellite surveys was that rocky areas that had been buried in sand on the offshore side of the seaweed beds had emerged. It states that on the rocky areas that have emerged, a succession of seaweed species has begun, starting from small seaweeds that grow in 1 year, and that, as new seaweed beds are thought to form over time while sand piles up or is scoured by waves, it is necessary to watch over them without haste. A material of the review committee for the prefecture's basic plan for coastal protection (November 2025) also mentions, from the emergency survey report of the surveying for The Nippon Foundation's "Map of the Sea", that new rocky areas appeared off Monzen-machi (the topography of the shallow sea is covered in R7-B04 "The changed topography of the shallow sea, and the lack of maps and observations that fishers can use"). [S1, S6]

There are also seaweeds that increased on the new rocky areas. In the interviews of the Doyukai report, of the 31 people who answered, the largest share, 39%, answered that the wakame resource had increased, and next was rock nori (multiple answers allowed; including people of Uchiura). The reason given was that rock nori, habanori and wakame, which grow in 1 year, attached quickly to the newly emerged rocks. However, because the processing places were damaged in the disaster, among other reasons, the increase is said not to be gathered, and this is covered in R7-B14. [S1]

On the uplifted rocky coasts, of the perennial seaweeds that grow in the intertidal zone, narasamo and umitoranoo disappeared, and the seaweeds whose life is less than 1 year did not change greatly. The research report of the prefecture's Noto Marine Center (2025) examined, in May–June 2024, the 10 sites it had been surveying since before the earthquake and 6 sites added on the uplifted coasts. On the uplifted coasts, narasamo and umitoranoo, perennial seaweeds that grow in the intertidal zone, had all died and disappeared. The seaweeds whose life is less than 1 year did not change greatly between before and after the earthquake, and the decrease in the species seen was also not as marked as for the bottom-living animals. Of the 37 main species of seaweed and seagrass, the number of species seen had decreased from 24 species (2020) to 13 species (2024) at Nagahashi in Sotoura, and from 25 species to 17 species at the Kinoura survey site (Shakuzaki in the table). In the new intertidal zone at Kaiso, the perennial yanagimoku, which originally grew below the intertidal zone, had been moved to a place shallower than its natural one, so that part of its body dried out and part of the community had died. The report considers that the perennial Sargassum species at other sites are under the same strain, and states that it is necessary to go on examining whether they can cope with the sudden change. The material of the review committee for the prefecture's basic plan for coastal protection states, from this research report, that there were also sites where the number of seaweed species increased, but the places where it increased are Ossaka (Noto Town) and Kurosaki (Nanao City), outside Sotoura. [S14, S6]

Region (Sotoura): what else, besides uplift, is bearing on the seaweed beds

Besides uplift, several other things are bearing on the seaweed beds of Sotoura. All of them are covered in other materials of this series.

- Mud: Sediment from the mountains that collapsed in the earthquake was carried by rain from the rivers into the sea, and from July 2024 onwards, mainly around the river mouths, the seaweed beds that remained in the sea are also said to have worsened greatly. At Kaiso, the places covered by mud had become small patches of barren ground (isoyake; a state in which the seaweeds have gone) (R7-B09 "Mud and turbidity that keep entering from river mouths (the seaweed beds and rocky-shore fishing grounds of the Wajima coast)"). [S1, S2]

- Tsunami and winter waves: At Nagahashi in Suzu City over the whole of the line surveyed, at Kinoura on the offshore side from about the middle of the line, and at Noroshi in the section of about 100 m offshore from today's waterline, seaweeds that die within 1 year were abundant and large perennial seaweeds had become few. The report mentions the possibility that stones were rolled by the tsunami or by high winter waves (R7-B10). [S1]
- Decline from before the earthquake, and water temperature: Of the tsuruarame that had decreased greatly at Wajimazaki, the report states that, since it had been decreasing nearby from before the earthquake, it is highly likely that the earthquake had almost no effect, while the possibility that it was due to uplift cannot be ruled out either. The decline from before the earthquake and the seaweed beds of the offshore islands are covered in R7-B11, and the high water temperature in summer in R7-B12 "High water temperature in summer (the shallow sea of Sotoura)". [S1]

Fishers most often give mud as the reason the resources decreased. In the interviews of the Doyukai report, 58% of the 31 people who answered on the reason the resources decreased gave the inflow and accumulation of mud, followed by warming and the loss of growing places through uplift. The people interviewed also include fishers of Uchiura (Chapter 5). [S1]

3. Existing measures, and how they are assessed

The seaweed beds of the places that became land through uplift will not return to their original places (this paper's view). The efforts mentioned in the materials this paper examined are of 3 kinds: surveying and recording the seaweed beds, activities to protect and rebuild the seaweed beds, and including seaweed beds in the works and plans for ports and coasts. There are numbers and schedules for the efforts, but we found no material that assessed the effect of efforts for the seaweed beds that dried out.

Surveying and recording the seaweed beds

The seaweed beds after the earthquake have been surveyed separately by a number of organisations. At the review committee for the prefecture's basic plan for coastal protection (5 November 2025) too, a member gave the opinion that various surveys of living things and ecosystems are being carried out after the earthquake, but that as they are being carried out piecemeal, the committee would like them to be put in order in cooperation with the prefecture's environment department and others. The chair also asked that they be put in order and that useful data be shown at future meetings of the committee. [S6]

Fishers too have surveyed the fishing grounds under a national programme. Since February 2024, Ryoko Ishikawa has surveyed the seaweed beds of Wajima together with fishers, mainly ama divers, under the Fisheries Agency's fishing ground restoration measures support project (according to the report article received in March 2025). However, she herself states in the report article that it cannot be denied that there are many data that are subjective and cannot be expressed in numbers, and that to show the damage in quantities it is necessary to strengthen scientific surveys. According to the report on conservation activities of the Ishikawa Prefecture Fisheries Cooperative (posted by the prefecture), in the waters off Wajima City in fiscal 2024, under this project a cumulative total of 3,747 people carried out monitoring surveys of the fishing grounds (examining the state of the fishing grounds continuously) and a cumulative total of 4,932 people carried out the removal of drifted debris and the like (the totals of the numbers of people are this paper's calculation). The Doyukai report states that this project is due to end in fiscal 2025. The gap in support is covered in R7-B24 "The income of fishers affected by the disaster, and the gap in support". [S2, S21, S1]

The prefecture's Noto Marine Center has surveyed the animals and plants of the rocky coasts at 12 sites about every 5 years since 2008 (the latest is 2020–2021). In 2024, to see the effect of the earthquake, it added 6 sites on

the uplifted coasts and surveyed 16 sites (Katano in Kaga City was not surveyed, and Kounyu in Wajima City could not be reached). [S14, S3]

The Doyukai report surveyed both the wide area and the fine points. These are the analysis of satellite images, the survey with underwater cameras and other means at 355 sites, lines searching the seabed by sound at 3 places (about 12,000 m in total), the diving survey at 7 sites, and interviews with 32 fishers. The satellite identification, compared with the on-site results at the 355 sites, matched on the presence or absence of seaweed beds at 82.3% of the sites (111 of the 136 sites where there were seaweed beds on site, and 181 of the 219 sites where there were none; this is a value for the whole of the sea surveyed, including Nanao Bay, Uchiura and the offshore islands, and no value for the 3 districts of Sotoura alone is shown). In the report's explanation of its method, the results of these 355 sites are also used to make the training examples (training data) for the calculation that identifies seaweed beds from the image. The Fisheries Agency's guidance states that accuracy is to be checked by on-site examination at places separate from those used as training examples, and the 82.3% is not a value checked in that way. The report compares the 82.3% with the yardsticks of the Ministry of the Environment's survey results and of the Fisheries Agency's guidance (60–80%, and about 70–80%) and states that the necessary accuracy was secured. On the other hand, it states that there was a tendency for many errors of identification in the seaweed beds on the offshore side. [S1, S15]

The prefecture is also surveying the distribution of the seaweed beds after the earthquake. A material of the review committee for the prefecture's fisheries plan (September 2026) shows distribution maps of the seaweed beds of the coast of Ishikawa Prefecture before and after the earthquake, from the report of the prefecture's fiscal 2025 (Reiwa 7) seaweed bed survey work. The figure labels the survey after the earthquake as the "R7–R8 survey" (the survey of fiscal 2025–2026). This paper could not find that report itself. The prefecture's Seaweed and Seagrass Bed Vision (March 2022) planned to survey the distribution of the seaweed beds of the whole prefecture in fiscal 2024, 5 years after the previous survey. [S8, S13]

Activities to protect and rebuild the seaweed beds

In Wajima, a local association is reorganising its activities to protect the seaweed beds. The seaweed beds (tsuruarame and Sargassum beds) that the Association to Protect Wajima's Satoumi has had as the subject of its activity agreement are 81 ha, and the report of a project commissioned by the Fisheries Agency (March 2026) writes that the seaweed beds of this area disappeared on a large scale in the earthquake and the torrential rain of 2024. From fiscal 2026 the association plans, in consultation with the prefecture and specialists, to begin producing kajime seed (seaweed seedlings), transplanting mother plants (parent seaweeds that give off seed) and seed, and cleaning away mud that has piled up 1 cm or more on the rocks. The prefecture too put 3.5 million yen into its initial budget for fiscal 2026 (announced 20 January 2026) as "support for rebuilding ama diving fishing", and stated that it would support activities to protect the seaweed beds, such as the removal of inflowing driftwood and the propagation of seaweeds. A newspaper advertisement by the prefecture's Fisheries Division (22 February 2026) states that from fiscal 2026, in cooperation also with the national government and Wajima City, it will support the planting of seaweed seed, the removal of driftwood and the like in the fishing grounds of the ama divers on the Sotoura coast. We found no material showing whether this support was carried out. The content of the association's activities and of the prefecture's support is covered in R7-B26 "Rebuilding the local activities to protect the seaweed beds of Wajima". [S7, S16, S1]

The prefecture has supported activities to protect seaweed beds in its fisheries plans up to now. The 2017 "Ishikawa Fisheries Promotion Vision" listed "conservation and effective use of seaweed and seagrass beds" as 1 of its priority issues, and has stated that it supports activities by fishers to protect seaweed beds, such as the placing of mother plants. How the decline of the seaweed beds after the earthquake will be handled in the new plan is, as shown in Chapter 4, at the stage where consideration has begun. [S8]

Including seaweed beds in the works and plans for ports and coasts

In the restoration of Wajima Port, there is a plan to create seaweed beds using the sediment that comes from dredging (scraping out the bottom of the port). The restoration and reconstruction plan for Wajima Port of the national government, the prefecture and the city (revised 30 January 2026) states that dredged sediment will be received behind the No. 4 breakwater to build a shallow place, and that seaweed beds will be created for maintaining the homes of living things and for reducing CO2. The content of the plan and the effect on the fishing grounds of the ama divers are covered in R7-B18 "Where the dredged sediment of Wajima Port goes (a disposal site built in the sea and the creation of seaweed beds)". [S9]

The Fisheries Agency also states that the effect on seaweed beds is to be considered when choosing the method of restoring damaged fishing ports. The Fisheries Agency's technical study material (July 2024) includes, among the items for comparing proposals for temporary restoration and full restoration, whether there is a bad effect on the surrounding environment (seaweed beds and so on), and gives the use of seaweed beds inside the fishing port as an example of how to use fishing ports that are not restored. The matter of the small fishing ports of Sotoura is covered in R7-B19 "The small fishing ports of Sotoura (ports that cannot be used, and the policy of consolidation)". [S25]

The prefecture states that it will consider seaweed beds in its plan to protect the coast as well. A material of the review committee for the prefecture's basic plan for coastal protection (November 2025) states that, in the light of the changes in the environment caused by the earthquake, it is necessary to provide the facilities that protect the coast in accordance with the characteristics of the coast, such as sandy beaches, rocky areas and seaweed beds. The remaking of the plan is covered in R7-B05 "Remaking the basic plan for coastal protection (uplift and waves that are growing larger)". [S6]

Assessment of the effect

We found no material that assessed the effect of efforts for the seaweed beds that dried out. What the materials show are outlooks and requests. The Doyukai report surmises that even if the seaweed beds remaining near the coastline decline and disappear, succession will proceed as time passes and the original make-up of species will eventually return, and it calls for regular surveys centred on the shallow places and, as necessary, for considering the creation of seaweed beds and the release of shellfish seed. At Kaikoura, it is reported that even 4 years after the uplift, the recovery of large brown algae was poor except at the places where the uplift was less than 1 m (Chapter 2). The same study states that reducing the pressures that people can do something about, such as sediment run-off and over-harvesting, helps recovery, and that the places where the effect was small and the places where fishing has been held back can become sources that give off the seed of the main canopy-forming seaweeds. Among the materials this paper examined, the Kaikoura studies were the only example that followed and showed the recovery of seaweeds after uplift over a number of years. [S1, S11]

4. What is changing

The seaweed beds are thought to be still in the middle of succession even now, 2 years and 10 months after the uplift (as of 5 November 2026; the latest survey in the materials that examined the seaweed beds is from 2025). Most of what this chapter covers is the outlooks of the materials, and plans and schedules. [S1, S2]

The succession of the seaweed beds

Near today's coastline and on the newly emerged rocky areas, the make-up of the seaweed beds is in the middle of being replaced. The Doyukai report predicts that nokogirimoku and others not suited to shallow places will before long die and be washed away, and that in the tide pools of Noroshi they will give way to umitoranoo and

others. It considers that on the newly emerged rocky areas succession begins from small seaweeds that grow in 1 year, and that new seaweed beds will form over time. Ryoko Ishikawa too expects that the make-up of the seaweeds will change in accordance with today's water depth and that the seaweed beds will be replaced. We found no outlook that showed, from survey results, how far they will return in how many years. In news reports, in June 2024, a biologist of Kanazawa University who took part in a newspaper company's diving survey indicated the possibility that it would take at least 3–5 years for the living things of the uplifted coast to return to how they were (this is not a view limited to seaweed beds). [S1, S2, S24]

At Najimi in Wajima City, the places where mud had piled up spread again at the end of summer 2025 too. The Doyukai report attributes this to the localised heavy rain that was frequent at the end of summer, and states that as long as mud keeps piling up, the seaweed beds of the shallow sea cannot return (R7-B09). [S1]

Plans and schedules

- 20 November 2024: The prefecture's Noto Marine Center and others presented their survey of the animals and plants of the uplifted intertidal zone. [S3]
- 14 March 2025: The date on which the satellite image that the Doyukai report mainly used for the analysis of the 3 districts of Sotoura was taken. The on-site survey was in April–May and the diving survey in June. [S1]
- 15 June 2025: Publication of Ryoko Ishikawa's report article (Fisheries Engineering). It reported the dried-out seaweed beds of Wajima and the damage from mud and torrential rain. [S2]
- 5 November 2025: The review committee for the prefecture's basic plan for coastal protection (2nd meeting). It stated that the provision of facilities in accordance with the characteristics of the coast, such as seaweed beds, is necessary. The plan is due to be drawn up in fiscal 2026, after the committee meets about 2 times and after a call for opinions. [S6]
- 20 January 2026: Announcement of the prefecture's initial budget for fiscal 2026. Under "support for rebuilding ama diving fishing" (3.5 million yen), it supports activities to protect the seaweed beds, such as the removal of inflowing driftwood and the propagation of seaweeds. [S16]
- 30 January 2026: Revision of the restoration and reconstruction plan for Wajima Port. The receiving of dredged sediment behind the No. 4 breakwater is scheduled to last until the end of fiscal 2026, and the creation of an environment for growing seaweed beds is scheduled for fiscal 2027–2034 (Reiwa 9–16). [S9]
- 24 March 2026: Publication of the Doyukai report. [S1]
- Fiscal 2026: The Association to Protect Wajima's Satoumi plans to begin producing kajime seed, transplanting mother plants and seed, and cleaning away mud on the rocks (report of a project commissioned by the Fisheries Agency, March 2026). [S7]
- 4 September 2026: The review committee for the prefecture's new Fisheries Promotion Vision (1st meeting). A new vision showing the direction of fisheries policy for about the next 10 years is due to be made, with a target of within fiscal 2026. [S8]

5. What is not yet known

Things for which there are no figures

- We found no figure for the area of the seaweed beds that dried out through uplift. What the materials have are the width by which the coastline moved offshore in the diving survey at 5 sites (about 15–100 m) and the area of the whole of the seabed that became land (about 4.4 km^2; including things other than seaweed beds). [S1, S4]

- We found no breakdown of the area lost in the 3 districts of Sotoura into the part due to uplift and the part due to other causes. [S1]
- This paper could not find the report of the prefecture's fiscal 2025 (Reiwa 7) seaweed bed survey work. The figures shown in the prefecture's material are values for the whole coast of the prefecture. [S8]
- For the area of the seaweed beds of Sotoura after the earthquake, there is only the 1 measurement of 2025. We found no values showing changes after that. The prefecture's survey is labelled the "R7–R8 survey", and is thought to be continuing in fiscal 2026 as well (this paper's view). [S1, S8]
- The report of the national government's (Ministry of the Environment's) fiscal 2025 (Reiwa 7) survey of the natural environment of the Noto Peninsula (March 2026) has no description of seaweed beds. [S26]
- Of the 5 sites of the diving survey, Kaiso and Noroshi have no record from before the earthquake. [S1]
- For the area of the seaweed beds of Sotoura in Suzu City, we found no value separated from Uchiura (R7-B10). [S1]

Limits of the comparison

- The 2 surveys compared are far apart in time. From the fiscal 2019 survey to the image of March 2025 is 5–6 years, of which about 4 years are before the earthquake. However, the date on which the images of the previous survey were taken is written neither in the report nor in the prefecture's Seaweed and Seagrass Bed Vision. The specification for the prefecture's fiscal 2018 (Heisei 30) survey of Uchiura states that spring images taken within the past 3 years are to be used, and the images of Sotoura too could be from before the fiscal year of the survey. If so, the interval becomes longer still (this paper's view). For that reason, the amount lost could also include change from before the earthquake (R7-B11) and change due to the torrential rain and mud after the earthquake (R7-B09). The Doyukai report too states that the present survey was not immediately after the disaster, and that a comparison with the time immediately before the earthquake and the torrential rain has not been made sufficiently. [S1, S13, S17]
- The 2 surveys compared differ both in how the values were produced and in how the seaweed beds were divided. The values before the earthquake are the data of the prefecture's fiscal 2019 survey recalculated by the report, with the district boundaries also partly corrected, and they differ from the values of the prefecture's Seaweed and Seagrass Bed Vision for the Wajima and Saikai districts (Chapter 2). The way the types of seaweed bed are divided also differs, and there are types, like the kajime kelp beds of the Saikai district, that were not separated out in the survey before the earthquake. According to the prefecture's Seaweed and Seagrass Bed Vision, the survey before the earthquake too was carried out by analysis of satellite images and on-site examination from a boat. However, neither the report nor the Vision writes the resolution of the images of the survey before the earthquake or the boundary of cover counted as seaweed bed, and this paper could not confirm whether the method was the same. The Fisheries Agency's guidance states that comparing old surveys made by a different method with today's area as they are, without checking, could lead to wrong conclusions, and that the boundary of cover for counting a place as a seaweed bed is not fixed either (Chapter 2). [S1, S13, S15]
- The water depth that can be identified by satellite is, according to the report, about 20 m at most when the water is clear, and identification becomes difficult when there is turbidity, cloud or waves. The Fisheries Agency's guidance gives the range to be surveyed for seaweed beds with satellite images in temperate seas as the range shallower than a water depth of about 10 m. The report states that there was a tendency for many errors of identification in the seaweed beds on the offshore side. Since most of the area lost is mixed beds in deep places, this paper considers that the increases and decreases in deep places could also include differences in how the images came out (this paper's view). [S1, S15]
- The districts are frames decided by the report on the basis of the districts of the prefecture's survey before the earthquake, and are not the same as the boundaries of the cities and towns. The Saikai district is thought

to correspond to the coast of Shika Town, the Monzen district to the coast of Monzen-machi, Wajima City, and the Wajima district to the north coast of Wajima City (this paper's reading of the report's figure). In the prefecture's Seaweed and Seagrass Bed Vision, there is a "Shika and Hakui" district separate from the Saikai district. The report states that it corrected the boundaries of the Saikai district, but there is no detailed explanation of how it corrected them. [S1, S13]

- The diving survey was made only once, in June 2025, with 1 line (160–200 m) per site. The counterparts for comparison from before the earthquake also differ by site in year and in the people who surveyed (2023 for Wajimazaki, 2020 for Nagahashi and Kinoura). [S1]
- The 32 people interviewed are people who had been fishing keenly since before the disaster, chosen in consultation with the prefecture's fisheries officials, and they live in Wajima City (16 people), Suzu City (8 people), Noto Town (6 people) and Anamizu Town (2 people). As people of Uchiura are also included, the percentages are not values for Sotoura alone. [S1]
- Of Ryoko Ishikawa's survey, she herself states that it cannot be denied that there are many data that are subjective and cannot be expressed in numbers. [S2]
- The examples in Japan and abroad also differ in tidal range. Kaikoura is roughly 2 m, the sea of the Maule earthquake in Chile is about 2 m at most (both are values from the papers), and Wajima is about 50 cm at most throughout the year (a value from the announcement), and the ways of expressing them also differ. Even with the same uplift, the size relative to the width of the intertidal zone differs, so they cannot be compared as they are. We found no material that applied the yardstick of the Kaikoura study, "about 1/4 of the tidal range", to Sotoura and examined it. [S11, S10, S19, S5]

Figures that disagree

- For places with the same place name, the width by which the coastline moved offshore and the value of the uplift differ from material to material (Table 4). This is thought to be because the time of measurement, the position of the line measured and what was taken as the coastline differ, but it cannot be confirmed from the materials.

Table 4 Values that differ from material to material for places with the same place name

Site	Value	Material and way of measuring
Kaiso	Coastline about 100 m offshore, uplift 4.1 m	The Doyukai report (diving survey of June 2025; the uplift is the same value as the prefecture's provisional value for the fishing port)
Kaiso	Coastline advanced 116 m, uplift of about 4 m	Presentation by the prefecture's Noto Marine Center and others (survey of a line from the old coastline to the new coastline; presented November 2024)
Kaiso	Uplift 400 cm	The Center's research report (survey of June 2024)
Kaiso	Uplift 3.6–3.9 m	Announcement by Kanazawa University and others (around Kaiso Fishing Port)
Nagahashi	Coastline about 60 m offshore, uplift 2.8 m	The Doyukai report (diving survey of June 2025; the uplift is the same value as the prefecture's provisional value for the fishing port)
Nagahashi	Waterline advanced 44 m, uplift 226 cm	The Center's research report (survey of May 2024)
Kinoura	Coastline about 15 m offshore, uplift 1.8 m	The Doyukai report (diving survey of June 2025). The 1.8 m of uplift is, in the prefecture's provisional values for fishing ports, the same as the value for the Takaya district of Noroshi Fishing Port, and the value for the Orito district, in Orito-machi where Kinoura lies, is 1.2 m (R7-B01)

Site	Value	Material and way of measuring
Kinoura	Coastline advanced 33 m, uplift of about 2 m	Presentation by the prefecture's Noto Marine Center and others (presented November 2024)
Kinoura	Waterline advanced 33 m (Shakuzaki in the ta - ble), uplift 171 cm	The Center's research report (survey of May 2024)
Noroshi	Coastline about 65 m offshore, uplift 0.8 m	The Doyukai report (diving survey of June 2025; the uplift is the same value as that for the Noroshi district in the prefecture's provisional values for fishing ports)
Noroshi	Uplift 117–147 cm	The Center's research report (survey of June 2024)

Note: The values are as each material expresses them. The values of uplift in the research report are quoted from a photograph collection of the uplift (2024). [S1, S3, S14, S5]

- There are places where the satellite area and the wording of the on-site observations do not match. Of the on-site survey of the Wajima coast, the report states that the way seaweeds grow shows no great change overall compared with before the earthquake, and that on the coast on the east side of Wajima Port it had worsened because of the sediment and turbidity of the torrential rain. On the other hand, in the satellite area, the Wajima district has decreased by 47.0%. In the Saikai district too, while it states that the way the seaweed beds are divided by water depth around Togi Port has not changed greatly from before the earthquake, the area has decreased by 43.0%. The on-site observations are examinations of points in shallow places, and most of the decrease in area is that of the mixed beds in deep places, so this is thought to be because the places being looked at differ (this paper's view). [S1]
- The seaweeds of the new intertidal zone are described differently from material to material. The summary of the presentation by the prefecture's Noto Marine Center and others (November 2024) states that the seaweeds that grow in a short period are unchanged, and that no great effect is seen on the seaweeds that grow below the intertidal zone either. On the other hand, in the figure in the material of the prefecture's review committee, the number of seaweed species at Nagahashi has decreased. The Center's research report (2025) states that the number of species decreased at the Nagahashi and Kinoura sites, while the seaweeds whose life is less than 1 year did not change greatly. The wording of the summary and the number of species are thought not to be a disagreement but to be saying different things (this paper's view). However, the research report also states that at Kaiso part of the community of yanagimoku that had grown below the intertidal zone had died. [S3, S6, S14]
- The total area of the 3 districts is this paper's calculation. The report's values for each district are rounded values, so the total and the percentage could have small differences due to rounding. [S1]

Reliability and the standpoint of the materials

Reliability differs from item to item. That the shallow seaweed beds of Sotoura dried out and disappeared through uplift has been confirmed separately by the diving survey at 5 sites of the Doyukai report, by Ryoko Ishikawa's survey of the 3 districts of Wajima, and by the research report and presentation of the prefecture's Noto Marine Center, and its reliability can be said to be high. The width that dried out differs with the material and the time, as in 15 m and 33 m, 60 m and 44 m, and 100 m and 116 m, and the uplift at Noroshi also differs, as in 0.8 m and 117–147 cm, so the reliability of the values is medium. That the area of the seaweed beds of the 3 districts of Sotoura decreased by 40–60% from the fiscal 2019 survey is the result of 1 survey that checked the satellite identification against 355 sites on site (the sites checked against are also used as the training examples for the identification), and the method is written in detail. However, it differs from the survey before the earthquake in such things as how the seaweed beds were divided, and the values before the earthquake are the

report's recalculated values, which differ from the values of the prefecture's Seaweed and Seagrass Bed Vision for Wajima and Saikai. The interval of 5–6 years includes about 4 years before the earthquake, and depending on the date on which the previous images were taken, it could be longer still. Errors of identification on the offshore side also remain, so the reliability is medium. Of the reasons for the decrease, for the proportions of the part due to uplift and the part due to other things there are no figures, and the reliability can be said to be low. When and how far the seaweed beds will return rests only on the outlooks and expectations of the materials, and the reliability can be said to be low. The examples in Japan and abroad come from papers and from old reports quoted by the report and the research report, and cannot be applied to Sotoura as they are.

Care is also needed about the standpoint of the materials. The Doyukai report is the report of a survey that the business association Kanazawa Association of Corporate Executives carried out with a grant from The Nippon Foundation and the special cooperation of the Hokkoku Shimbun, and it is not peer-reviewed. The head of the survey team is the president of the Japan Seaweed Association; the satellite analysis was handled by a surveying company (Kokusai Kogyo), the diving survey by a survey company and the interviews by Ryoko Ishikawa; and people from the prefecture's Fisheries Division and Fisheries Research Center are included as observers. Ryoko Ishikawa's report article and the interviews of the Doyukai report were written by the same person, and the Doyukai report also cites the paper of Ryoko Ishikawa's 2024 lecture. For that reason, the agreement between them about the dried-out seaweed beds of Wajima cannot be called independent confirmation. The material of the Association to Protect Wajima's Satoumi from before the earthquake was also written by Ryoko Ishikawa. One of the authors of the presentation by the prefecture's Noto Marine Center and others is a person from the prefecture's Fisheries Research Center who took part as an observer in the survey of the Doyukai report. Whether the fiscal 2025 (Reiwa 7) seaweed bed survey shown in the prefecture's material and the satellite analysis of the Doyukai report are the same survey is not known from the materials. The presentation by the prefecture's Noto Marine Center and others is the slides of a meeting. The Center's research report shows the dates surveyed and the method, but it looked down to a depth of about 0.5 m from the sea surface with a glass-bottomed viewing box and recorded quantity in 4 grades, and the report itself states that from now on it is necessary to continue surveys that measure quantity by placing quadrats. The Kaikoura studies all include the same researchers. For the 1985 study in Chile and the 2 studies on Durvillaea, only the abstracts were read. The examples of the Kanto Earthquake of 1923 and the Great East Japan Earthquake of 2011 are quotations in the Doyukai report, and the value of the uplift in the Noto Peninsula Earthquake of 2007 is a quotation in the Center's research report; this paper has not checked the original materials.

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 boats of them. This paper does not cover the company's own technology or results. This paper deals with the decline of seaweed beds itself, and the restoration of seaweed and seagrass beds overlaps with the publisher's field of business. This paper also touches on the reliability of the method of identifying seaweed beds from satellite images. 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 publisher's field of development. The publisher's relationships with the organisations taken up in this paper and with organisations active in Sotoura are as follows (as of 5 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 (in September 2025) for the prefecture's (Commerce, Industry and Labour Department, Industrial Policy Division) "survey project for attracting start-ups 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). 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 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 and, among other things, the free loan for 3 years of a facility that rents rooms to newly founded companies. In Noto, the publisher collaborates, under non-disclosure agreements, with Nanaibe LLC and Yamaguchi Suisan of Nanao City, with Atsumasa Nakamura of Kanazawa University, and with the Noto fisheries profitability improvement council. With the Ishikawa Prefecture Fisheries Cooperative (which also has branches in Sotoura, and whose president is a member of the review committee for the prefecture's basic plan for coastal protection and whose representative director and senior managing director is a member of the review committee for the prefecture's new Fisheries Promotion Vision), there is the relationship of having secured the site for the publisher's demonstration through its collaboration partner Nanaibe LLC. Fishers and staff of the Wajima branch of the same cooperative took part in the surveys of the seaweed beds of Wajima quoted in this paper, and in the interviews of the Doyukai report, the branches of the same cooperative were asked to cooperate. This paper also quotes the report on conservation activities issued by the same cooperative. The publisher is not a member of the Noto fisheries profitability improvement council. The area in which the publisher has been involved in Ishikawa Prefecture is mainly Nanao Bay, and Nanao Bay is covered in R7-A (Nanao Bay) of this series. In Sotoura (Shika Town, Wajima City and the north coast of Suzu City as far as Jike), the publisher is not active. Among the materials quoted in this paper, researchers of Kanazawa University took part in the 510-site paper and in the announcement on seashore living things by Kanazawa University and others, and the researcher who spoke in the news report quoted in this paper is also a person from the same university. The chair and 1 of the members of the review committee for the prefecture's basic plan for coastal protection, and 1 of the members of the review committee for the new Fisheries Promotion Vision, are also people from the same university. The name of Atsumasa Nakamura does not appear among the authors of these materials, or in the lists of members of the 2 committees and of the survey team of the Doyukai report. 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 510-site paper quoted 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 510-site paper has 1 author from Nagoya University, but Kensuke Kuroda is not an author. Apart from the above, between the publisher and the organisations taken up in this paper (national government bodies, the prefecture and the cities and towns, universities and research institutions, the business association and its survey team, the companies and organisations named in this paper, overseas universities and research institutions, and so on) or the organisations active in Sotoura (fishery cooperatives, local organisations and so on), there is no relationship of a kind that would affect the content of this paper. Relationship here means transactions, funding, joint research, and officers or employees of the publisher concurrently serving as employees or officers of that 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 5 November 2026. Working mainly from materials of the national government and the prefecture, peer-reviewed papers and reports of research institutions, we used figures checked against the very materials listed as sources (for the 1985 study in Chile and the 2 studies on Durvillaea, the abstract only). Among the figures that 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 that this paper calculated from the values in the sources are written as "this paper's calculation", and things read from figures as "this paper's reading of the figure". Reliability: A = laws and regulations, statistics, materials of the national government and prefectures; B = papers, reports of research institutions that state their method; C = explanatory materials for the general public, explanations by organisations, guidance with little description of method, presentations at meetings; D = news reports.

ID	Source (publisher, year)	Type	Reliability	Chapters used
S1	Kanazawa Association of Corporate Executives, special committee for the survey of the effects of the earthquake disaster on the coast of the Noto Peninsula: Fiscal 2025 (Reiwa 7) report of the survey of the effects of the earthquake disaster on the coast of the Noto Peninsula (in Japanese) (published 24 March 2026. The head of the team is Daisuke Fujita [president of the Japan Seaweed Association]. A grant from The Nippon Foundation and the special cooperation of the Hokkoku Shimbun. The prefecture's Fisheries Division and Fisheries Research Center are observers. Not peer-reviewed. "The Doyukai report" in this paper. The advertisement of the prefecture's Fisheries Division is on p. 198 of the reference section)	Report	C	Chapters 1–5
S2	Ryoko Ishikawa: On the changes in seaweed bed resources accompanying the uplift of the Wajima coast in the Noto Peninsula Earthquake (in Japanese) (Fisheries Engineering 62(1): 39-42, 15 June 2025. A report article. Received 27 March 2025 and accepted 31 March; whether it was peer-reviewed is not stated. A survey under the Fisheries Agency's fishing ground restoration measures support project)	Report	B	Chapters 1–5
S3	Yukimasa Higashide, Hiroaki Arakawa and Yusuke Nakade (Ishikawa Prefecture Noto Marine Center) and Takahiko Ikemori (Ishikawa Prefecture Fisheries Research Center): On the uplift in the Noto Peninsula Earthquake and its effects on the animals and plants of the intertidal zone (in Japanese) (material of an oral presentation at the 27th liaison conference of nature-related survey and research institutions [NORNAC27], 20 November 2024. The notice of the conference is by the Biodiversity Center of Japan, Ministry of the Environment)	Presentation	C	Chapters 2–5
S4	Goto et al. (Hiroshima University, Kanazawa University and others): Coast uplifted by nearby shore-parallel active submarine faults during the 2024 Mw 7.5 Noto Peninsula earthquake (Geomorphology 493, 110069, 2026. CC BY. "The 510-site paper" in this paper); Kanazawa University, Hiroshima University and others: announcement (in Japanese) (20 January 2026)	Paper	B	Chapters 1, 2, 5
S5	Kanazawa University, Natural History Museum and Institute, Chiba, and Kyushu University: The coastal ecosystem of the Sea of Japan "exposed" by the coastal uplift of the 2024 Noto Peninsula Earthquake is revealed (in Japanese) (announcement, 3 March 2026. The paper is in Plankton and Benthos Research 21)	Explanatory	C	Chapters 1, 2, 5
S6	Ishikawa Prefecture: review committee for the basic plan for coastal protection of the Noto Peninsula coast (in Japanese) (2nd meeting, Material 3; summary of the meeting; list of members, 5 November 2025. The number of species of animals and plants of the rocky areas is a figure made from Report of the Noto Marine Center No. 30)	Meeting	A	Chapters 1–5

ID	Source (publisher, year)	Type	Reliability	Chapters used
S7	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 (in Japanese) (project commissioned by the Fisheries Agency, March 2026)	Report	A	Chapters 3, 4
S8	Ishikawa Prefecture: review committee for drawing up the new "Ishikawa Fisheries Promotion Vision" (in Japanese) (1st meeting, meeting materials, 4 September 2026. The source of the distribution maps of seaweed beds is the prefecture's re - port of the fiscal 2025 [Reiwa 7] fisheries environment improvement project, Kaga and Noto Sotoura district seaweed bed survey work)	Meeting	A	Chapters 2–5
S9	Hokuriku Regional Development Bureau, Ishikawa Prefecture and Wajima City: Wajima Port restoration and reconstruction plan (in Japanese) (drawn up June 2025, revised 30 January 2026. The timeline is on p. 25)	Plan	A	Chapters 3, 4
S10	Castilla et al.: Effects of rocky shore coseismic uplift and the 2010 Chilean mega-earthquake on intertidal biomarker species (Marine Ecology Progress Series 418: 17-23, 2010)	Paper	B	Chapters 2, 5
S11	Schiel et al.: Cataclysmic Disturbances to an Intertidal Ecosystem: Loss of Ecological Infrastructure Slows Recovery of Biogenic Habitats and Diversity (Frontiers in Ecology and Evolution 9, 767548, 2021. CC BY)	Paper	B	Chapters 2, 3, 5
S12	Thomsen et al.: Cascading impacts of earthquakes and extreme heatwaves have destroyed populations of an iconic marine foundation species (Diversity and Distributions 27(12): 2369-2383, 2021. CC BY. Abstract only checked)	Paper	B	Chapter 2
S13	Ishikawa Prefecture: Ishikawa Prefecture Seaweed and Seagrass Bed Vision (in Japanese) (March 2022. The values by district for fiscal 2019 [Heisei 31] are in Table 2, p. 5. The method and the prefecture's view are on p. 3. The plan to survey the seaweed beds of the whole prefecture is on p. 29)	Plan	A	Chapters 2, 3, 5
S14	Yukimasa Higashide, Hiroaki Arakawa and Yusuke Nakade (Ishikawa Prefecture Noto Marine Center): Monitoring survey of benthic invertebrates and seaweeds and seagrasses on rocky coasts after the 2024 (Reiwa 6) Noto Peninsula Earthquake (in Japanese) (Report of the Noto Marine Center 30: 83-102, 2025. The dates surveyed are in Table 1, and the number of seaweed species in Table 3-1, p. 100)	Report	B	Chapters 2, 3, 5
S15	Fisheries Agency: Guidance on wide-area monitoring of seaweed and seagrass beds (in Japanese) (March 2021. The yardstick for accuracy and the way of check - ing are on p. 24 and p. 28, and the comparison with old surveys on p. 29)	Guidelines	A	Chapters 2, 3, 5
S16	Ishikawa Prefecture: Main projects of the fiscal 2026 (Reiwa 8) initial budget (in Japanese) (20 January 2026. The support for rebuilding ama diving fishing is on p. 7 of the PDF)	Budget	A	Chapters 3, 4
S17	Fisheries Agency: Reference section: survey of the distribution of seaweed beds using satellite image analysis technology (in Japanese) (the specification for Ishikawa Prefecture's fiscal 2018 [Heisei 30] fisheries environment improvement project, Noto and Uchiura district, commissioned survey work on the conserva - tion, creation and use of seaweed beds. The PDF was created in June 2020)	Material	A	Chapter 5
S18	Castilla: Earthquake-caused coastal uplift and its effects on rocky intertidal kelp communities (Science 242: 440-443, 1988. Abstract only checked)	Paper	B	Chapter 2
S19	Orchard et al.: Threshold Effects of Relative Sea-Level Change in Intertidal Ecosystems: Empirical Evidence from Earthquake-Induced Uplift on a Rocky Coast (GeoHazards 2(4): 302-320, 2021. CC BY)	Paper	B	Chapters 2, 5
S20	Montie et al.: Shifts in foundation species dominance and altered interaction net - works after compounding seismic uplift and extreme marine heatwaves (Marine Environmental Research 202, 106738, 2024. CC BY. Abstract only checked)	Paper	B	Chapter 2

ID	Source (publisher, year)	Type	Reliability	Chapters used
S21	Ishikawa Prefecture Fisheries Cooperative (coastal fishing ground management body): Report on the state of implementation of conservation activities by the coastal fishing ground management body (for fiscal 2024 [Reiwa 6], waters off Wajima City) (in Japanese) (posted by the prefecture, November 2025)	Report	A	Chapter 3
S22	Ryoko Ishikawa (Kaiyo Planning Co., Ltd.): On the efforts of the Association to Protect Wajima's Satoumi (in Japanese) (no date stated. The PDF was created in February 2016)	Explanatory	C	Chapters 2, 5
S23	Fisheries Agency: Guidelines for measures against barren ground (isoyake), 3rd edition (in Japanese) (March 2021. The 2020 questionnaire is on p. 60)	Guidelines	A	Chapter 2
S24	Hokuriku Chunichi Shimbun: diving survey of the uplifted coast of the northern Noto Peninsula (a researcher of Kanazawa University took part) (in Japanese) (27 June 2024, Chunichi Shimbun Web)	News	D	Chapter 4
S25	Fisheries Agency: 2024 (Reiwa 6) Noto Peninsula Earthquake: technical study material for the restoration and reconstruction of fishing communities, detailed version (in Japanese) (July 2024. The items of assessment are on p. 21, and the use of fishing ports that are not restored on p. 40)	Material	A	Chapter 3
S26	Ministry of the Environment, Nature Conservation Bureau, Biodiversity Center of Japan: Fiscal 2025 (Reiwa 7) survey report of the survey work on the natural environment of the Noto Peninsula (in Japanese) (March 2026)	Report	A	Chapter 5

Related materials: R2 Seaweed and seagrass beds and the living things of the sea, R7-A03 The decrease in the eelgrass beds of Nanao Bay, R7-A04 The decline of the Sargassum beds of Nanao Bay, R7-B01 Earthquake uplift on the Sotoura coast, R7-B04 The changed topography of the shallow sea, and the lack of maps and observations that fishers can use, R7-B05 Remaking the basic plan for coastal protection (uplift and waves that are growing larger), R7-B07 The total die-off of living things in the intertidal zone and on shallow rocky reefs, and their recovery afterwards, 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), R7-B10 The decline of the offshore-side seaweed beds of the Sotoura coast of Suzu (tsunami or winter waves), R7-B11 Barren ground (isoyake) that has continued since before the earthquake, and the decline of the seaweed beds of the offshore islands, R7-B12 High water temperature in summer (the shallow sea of Sotoura), R7-B13 The mass death of abalone and turban shells, and the decrease in catch that continues for some years, R7-B14 The rocky shores of rock nori and wakame (the drying out of nori beds, footing, and processing places), R7-B18 Where the dredged sediment of Wajima Port goes (a disposal site built in the sea and the creation of seaweed beds), R7-B19 The small fishing ports of Sotoura (ports that cannot be used, and the policy of consolidation), R7-B24 The income of fishers affected by the disaster, and the gap in support, R7-B26 Rebuilding the local activities that protect the seaweed beds of Wajima, R7-B28 The destruction of the Wajima morning market by fire, and the selling places for fish and seaweed, I1 List of assessments