R7-B07 The total die-off of living things in the intertidal zone and on shallow rocky reefs, and their recovery afterwards

What happened to the living things of the intertidal zone and shallow rocky reefs of Sotoura in the uplift of the earthquake of 1 January 2024, and how far have they returned since? How reliable are the figures?

Readers

Fishers, fishery cooperatives, local governments (staff in charge of fisheries, the environment and the coast), research institutes and others without specialist knowledge, who want to check, with figures and sources, what happened to the living things of the rocky shores and shallow rocky reefs of Sotoura in the uplift and how far they have returned.

Takeaways

1. Sotoura (the Sea of Japan side of the Noto Peninsula) is a sea where the difference between high and low tide is small. At Wajima, the tidal difference in 1 day is about 40 cm even on a day when it is large. In the earthquake of 1 January 2024, the Sotoura coast was lifted by more than 4 m in some places. This is called uplift. The part of a rocky shore that is under water at high tide and exposed at low tide is called the intertidal zone. The uplift left dry the intertidal zone and also the places below it that had always been under water.
2. On the rocky reef at Kaiso (Monzen-machi, Wajima City), researchers from Kanazawa University and other institutions surveyed the living things that had been left dry and had died, starting 66 days after the earthquake. According to the paper, the ground around Kaiso fishing port had been lifted by about 3.6–3.9 m. Inside just the 18 frames of 30 cm × 50 cm that were placed on 21 April 2024, 92 species of molluscs, such as shellfish, and 5 species of echinoderms, such as sea urchins, were found. The living things inside the frames were all dead. Many of the shellfish still had their flesh, and they are thought to have died immediately after the earthquake. The place with the most species was a place with calm waves that is thought to have been at a water depth of around 1 m before the earthquake.
3. In the survey by the Ishikawa Prefecture Noto Marine Center, too, on the uplifted rocky shores the intertidal snails ishidatami (Monodonta confusa), sugai (Lunella coreensis) and others had almost completely died out. In May–June 2024, the Center searched for 37 species of animals that had been decided in advance. Compared with before the earthquake, the species found fell from 19 species to 5 species at Nagahashi in Suzu City, and from 23 species to 6 species at Kinoura. At Oshima and Akasumi in Shika Town, which the Center's research report treats as coasts that were not uplifted, the figures went from 22 species to 19 species and 20 species, and the decrease was small. Many of the animals seen at the new water's edge were living things that had originally lived below the intertidal zone, always under water. The seaweeds narasamo (Sargassum nigrifolium) and umitoranoo (Sargassum thunbergii), which grow in the intertidal zone and live for many years, had all withered on the uplifted coasts.
4. Living things have begun to return, but the way they return is thought to differ from species to species. In the preliminary figures of a 2025 survey shown by a researcher of Kanazawa University, the cap-shaped shell of the rocky shore yomegakasa (Cellana toreuma) is said to be relatively numerous, while unoashi (Patelloida saccharina lanx) is said to be very scarce. In the Center's 2024 survey, too, 50 or more individuals of yomegakasa were found at 3 of the 8 uplifted sites. Turban shells (sazae) are seen in the present shallow sea of the rocky reef at Kaiso, but the diversity of living things has not reached the level before the earthquake (announcement of March 2026). On seven coasts of Sotoura, a survey that keeps watching the same places began in April

2025. We found neither its results nor any source that showed the recovery of Sotoura as a whole in numbers.

5. In the examples from overseas, the living things of rocky shores died over wide areas even with a small uplift, and recovery has taken many years. In the 1985 earthquake in Chile, the living things of the intertidal zone died over wide areas even with an uplift of about 40–60 cm. In the 2016 Kaikōura earthquake in New Zealand, even 4 years after an uplift of up to about 6 m, the return of large seaweeds remained poor. Much of the mix of species from before the earthquake returned only in the low part of the intertidal zone at places where the uplift was less than 1 m. Limpets came in in large numbers in about 2 years, but recovery to the original state is said to be far off.

After reading When using the damage to, or the recovery of, the living things of the rocky shores of Sotoura in documents or plans, state which place, which time and which survey method the result comes from. The figures that exist now are from a single survey of limited sites, such as Kaiso and the 10 sites in Sotoura surveyed by the prefectural body, and are not values for Sotoura as a whole. The numbers of species from the prefectural body also include sites in Uchiura and Nanao Bay, so as values for Sotoura use only the values for the sites in Sotoura.

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

1. Key points

- Sotoura (the Sea of Japan side of the Noto Peninsula) is a sea where the difference between high and low tide is small. At Wajima, the tidal difference in 1 day is about 40 cm even on a day when it is large. In the earthquake of 1 January 2024, the Sotoura coast was lifted by more than 4 m in some places. This is called uplift. The part of a rocky shore that is under water at high tide and exposed at low tide is called the intertidal zone. The uplift left dry the intertidal zone and also the places below it that had always been under water. [S1, S2, S3, S18]
- On the rocky reef at Kaiso (Monzen-machi, Wajima City), researchers from Kanazawa University and other institutions surveyed the living things that had been left dry and had died, starting 66 days after the earthquake. According to the paper, the ground around Kaiso fishing port had been lifted by about 3.6–3.9 m. Inside just the 18 frames of 30 cm × 50 cm that were placed on 21 April 2024, 92 species of molluscs, such as shellfish, and 5 species of echinoderms, such as sea urchins, were found. The living things inside the frames were all dead. Many of the shellfish still had their flesh, and they are thought to have died immediately after the earthquake. The place with the most species was a place with calm waves that is thought to have been at a water depth of around 1 m before the earthquake. [S1, S2]
- In the survey by the Ishikawa Prefecture Noto Marine Center, too, on the uplifted rocky shores the intertidal snails ishidatami (Monodonta confusa), sugai (Lunella coreensis) and others had almost completely died out. In May–June 2024, the Center searched for 37 species of animals that had been decided in advance. Compared with before the earthquake, the species found fell from 19 species to 5 species at Nagahashi in Suzu City, and from 23 species to 6 species at Kinoura. At Oshima and Akasumi in Shika Town, which the Center's research report treats as coasts that were not uplifted, the figures went from 22 species to 19 species and 20 species, and the decrease was small. Many of the animals seen at the new water's edge were living things that had originally lived below the intertidal zone, always under water. The seaweeds narasamo (Sargassum nigrifolium) and umitoranoo (Sargassum thunbergii), which grow in the intertidal zone and live for many years, had all withered on the uplifted coasts. [S3, S15]

- Living things have begun to return, but the way they return is thought to differ from species to species. In the preliminary figures of a 2025 survey shown by a researcher of Kanazawa University, the cap-shaped shell of the rocky shore yomegakasa (Cellana toreuma) is said to be relatively numerous, while unoashi (Patelloida saccharina lanx) is said to be very scarce. In the Center's 2024 survey, too, 50 or more individuals of yomegakasa were found at 3 of the 8 uplifted sites. Turban shells (sazae) are seen in the present shallow sea of the rocky reef at Kaiso, but the diversity of living things has not reached the level before the earthquake (announcement of March 2026). On seven coasts of Sotoura, a survey that keeps watching the same places began in April 2025. We found neither its results nor any source that showed the recovery of Sotoura as a whole in numbers. [S6, S15, S2, S16]
- In the examples from overseas, the living things of rocky shores died over wide areas even with a small uplift, and recovery has taken many years. In the 1985 earthquake in Chile, the living things of the intertidal zone died over wide areas even with an uplift of about 40–60 cm. In the 2016 Kaikōura earthquake in New Zealand, even 4 years after an uplift of up to about 6 m, the return of large seaweeds remained poor. Much of the mix of species from before the earthquake returned only in the low part of the intertidal zone at places where the uplift was less than 1 m. Limpets came in in large numbers in about 2 years, but recovery to the original state is said to be far off. [S8, S10, S20, S12]

2. What is happening

Japan and the world: what uplift does to the living things of rocky shores

Where the living things of a rocky shore live is decided by height above the sea surface. The part of a rocky shore that is under the sea at high tide and exposed at low tide is called the intertidal zone, and the places that are in the sea even when the tide is at its lowest are called the subtidal zone. The places above the intertidal zone are called the supratidal zone. The way living things live divided into bands by height, in step with the sea surface that rises and falls with the tide, is called zonation. [S2, S3]

When an earthquake lifts a coast (uplift), these bands come out above the sea all together. Shellfish and seaweeds that are attached to rock and do not move cannot escape; they are left dry and die. Dead calcareous algae (red algae that store lime in their bodies) and the like remain on the rock as white marks, and serve as a marker of the former height of the sea surface. Overseas studies consider the size of the damage not only by the size of the uplift but also by comparing it with the tidal range of that sea (next section). [S1, S2, S5, S11]

Japan and the world: examples so far, and what was learned afterwards

In Japan, it is reported that in the 1923 Kanto earthquake the Shonan coast of Kanagawa Prefecture was uplifted by up to 2 m, that the hijiki, funori and tsunomata seaweeds growing in the intertidal zone were left dry and withered, and that the calcareous algae covering the rocks also withered and turned white (a 1924 report of the fisheries experiment station of Kanagawa Prefecture; quoted in the report of the Kanazawa Association of Corporate Executives). The 2026 paper that surveyed Kaiso in Noto (below, the Kaiso paper) states that there are few examples in which a mass die-off immediately after an earthquake has been recorded in detail in numbers. In the Great East Japan Earthquake of 2011, the coast at Oshika in Miyagi Prefecture sank by 1.2 m (quoted in the Kaiso paper). The press release of Kanazawa University and the other institutions states that it has been reported that, after this disaster, the living things of the subtidal zone changed over several years, but it does not give the place or the cause (quotation). The Kaiso paper also cites studies stating that the changes in living things after an earthquake continued for several years or more. [S5, S1, S2]

One of these, an article written by researchers of Hokkaido University for a special feature in an academic society's journal (2017), reports the following, based on a survey that had been continued since 2003 on five

rocky shores in central Iwate Prefecture, where the ground sank by 50–60 cm in the 2011 earthquake. After the tsunami, the numbers of the 11 species surveyed fell by 45% on average, but this decrease was about the same as, or smaller than, that caused by the high waves of a large low-pressure system of the kind that comes once in several decades. Only living things that move about decreased clearly. The bands of living things attached to rock shifted downwards in step with the sinking of the ground, and the way they changed after that differed greatly from species to species. For many species, the large increases and decreases occurred more than 1 year after the earthquake. Even 5 years after the earthquake, the communities of living things attached to rock had not fully returned to their original state, and the article states that it takes a very long time to return to the original state. It also states that these changes after an earthquake in which the ground sank differ greatly from those after an earthquake in which the ground was uplifted. One of the same researchers states, in a 2025 explanatory article, that the survey sites at which a tendency to approach the mix of species from before the earthquake was seen 10 years after the earthquake were 3 of 22 sites (the original paper is not given). [S19, S16]

In the Alaska earthquake of March 1964, there was uplift of up to 38 feet (about 11.6 m; this paper's conversion) on land. According to a report of the US Geological Survey (1969), the living things that were lifted by the uplift above their proper height all died. In places where the uplift exceeded the local tidal range, the living things that are attached to rock and do not move were almost completely wiped out, and many of the living things that can move, such as starfish, snails and small fish, also failed to survive. The author of the report states that, as far as he knew, no record of a survey of the living things of the rocky shores before the earthquake had been published for anywhere on the coast of the Gulf of Alaska. [S22]

In Chile, the living things of the intertidal zone died over wide areas even with a small uplift. In the earthquake of 3 March 1985, the coast of the marine laboratory at Las Cruces was uplifted by about 40–60 cm, and the living things of the intertidal zone died over wide areas. What was damaged in particular was the band of a kelp (Lessonia nigrescens). Much of the rock left bare at the upper edge of that band was taken over by barnacles. [S8]

In the Maule earthquake in Chile of 27 February 2010 (its size was 8.8 in moment magnitude, a way of measuring that is different from the magnitude of the Japan Meteorological Agency), the uplift measured, several weeks after the earthquake, from the height of living things that attach in bands was about 0.2–3.1 m. In places with large uplift, the main living things of the intertidal zone and the shallow subtidal zone (calcareous algae, large brown algae and mussels) died in large numbers, and the ecosystem of the rocky shore changed greatly. According to the main text of the paper, of the 9 sites surveyed, at the 5 sites with large uplift the living things of the intertidal zone and the shallow subtidal zone that attach in bands were all dead. At the 2 sites where the uplift was small, about 0.2–0.3 m, the communities of living things looked as they normally do. The tidal difference of the sea surveyed is about 2 m at most. The paper states that species whose larvae do not drift and spread in the sea depend on parents that survived nearby, so their recovery becomes difficult. The paper also states that changes in the numbers of shellfish and other animals that become parents, and in the amount of young newly added, could also bear on the management and conservation of resources. [S9]

In the Kaikōura earthquake in New Zealand of November 2016 (moment magnitude 7.8), the coast was uplifted by up to about 6 m (the length of the uplifted coast ranges, depending on the source, from 110 km or more to about 130 km). In the intertidal zone, seaweeds withered over wide areas and many of the animals living on the bottom also died. The main species survived only as small groups, and many of these were inside the protected areas around Kaikōura. Because the surviving groups became separated from one another, it became hard for new young to reach them. Sediment from landslides on land and the erosion of newly exposed soft rock are also said to have hindered living things from attaching and growing. [S10, S12]

In Kaikōura, seaweeds were lost even where the uplift was small. According to a study that used laser survey (LiDAR) data to compare the vertical movement for each 50 m section of the coast, at 9 of the 10 uplifted sites more than 80% of the seaweeds that serve as habitat for living things were lost, and these included the site with

the smallest uplift, 0.6 m. The researchers consider that major damage occurred with uplift exceeding about a quarter of the tidal range (about 2 m). Seaweeds that had originally been in the subtidal zone and were moved by the uplift to the lower part of the intertidal zone also did not survive in places where they should have survived. [S11]

Recovery in Kaikōura is slow, and things had not returned to the original state even 3 years after the earthquake. According to a report of Fisheries New Zealand (March 2021), when 16 sites (uplift of about 0–6 m) were surveyed in November 2019, the uplifted rocky shores everywhere still had almost no seaweed, and a variety of seaweeds was seen only in the very lowest places. Limpets (mainly of the genus Cellana, the same genus as yomegakasa) came in in large numbers within about 2 years. On the other hand, the large brown alga bull kelp (genus Durvillaea) remained scarce at many sites; in many places it was replaced by other brown algae, and large brown algae were further replaced by fleshy red algae. The report states that recovery to the original state is far off. It also states that, in earlier experiments on the coast of the South Island of New Zealand, when a few m^2 of large seaweeds are removed, it can take up to 8 years to return to the original cover. As things that hinder recovery, it gives the erosion of rock and the movement of gravel, and the weakness of the connections between the surviving groups. [S12]

A paper by the same group of researchers (November 2021) states that, at the point 4 years after the earthquake, at sites where the uplift was less than 1 m much of the mix of species from before the earthquake had returned in the low part of the intertidal zone, while at every uplifted site the middle and upper parts of the intertidal zone remained poor in living things. At the sites with large uplift, the proportion of rock covered by large brown algae went from about 70% before the earthquake to less than 20% even after 4 years. As things that hindered recovery, the paper gives the fact that the temperature when the tide was out often exceeded 35°C and reached a maximum of 50°C (values from recorders placed near the rocky shore), the erosion of soft rock, the movement of sand and gravel, and the marine heatwave 1 year after the earthquake. [S20]

In Kaikōura, pāua, a kind of abalone, died in large numbers at every stage of growth because of the uplift. The taking of shellfish and seaweeds was stopped as an emergency measure, and the later reopening of the fishery is described in chapter 3 (the mass die-off of abalone and turban shells in Sotoura and the fishery for them are covered in R7-B13 "The mass die-off of abalone and turban shells, and the fall in catches that continues for some years"). [S13, S12]

Table 1 Earthquake uplift, and what happened to the living things of rocky shores (main examples in Japan and overseas)

Earthquake	Uplift	What happened to the living things of rocky shores	Afterwards
1923 Kanto earthquake (Shonan coast of Kanagawa Prefecture)	Up to 2 m	Hijiki, funori and tsunomata of the intertidal zone withered, and the calcareous algae turned white (quotation of the 1924 report)	Not written in the materials this paper looked at
1964 Alaska earthquake (United States)	Up to 38 feet (about 11.6 m) on land	In places uplifted beyond the tidal difference, the living things attached to rock were almost completely wiped out, and many of the living things that can move also died	No record of the living things of the rocky shores before the earthquake had been pub - lished (as far as the author of the report knew)

Earthquake	Uplift	What happened to the living things of rocky shores	Afterwards
1985 earthquake in Chile (Las Cruces)	About 40–60 cm	The living things of the inter - tidal zone died over wide ar - eas, and the band of kelp was damaged in particular	Barnacles came in on the bare rock
2010 Maule earthquake (Chile)	About 0.2–3.1 m	Calcareous algae, large brown algae and mussels died in large numbers	It was stated that this could bear on the management and conservation of resources
2016 Kaikōura earthquake (New Zealand)	Up to about 6 m	At 9 of the 10 uplifted sites, more than 80% of the sea - weeds were lost (including the 0.6 m site)	After 3 years the seaweeds had hardly re - turned, and after 4 years the return was still poor except in the low part of places with uplift of less than 1 m. Limpets came in in about 2 years. The pāua fishery was stopped from November 2016 and reopened for only 3 months in December 2021
2024 Noto Peninsula Earthquake (Sotoura)	Up to about 4.4 m on the north-west coast (quotation), 3.6–3.9 m at Kaiso	The "Region (Sotoura)" sec - tions of this chapter	The section "Region (Sotoura): the living things that returned afterwards" of this chapter

Note: The values of uplift are as stated in each source. The methods of measurement and the periods differ, and the tidal range also differs from sea to sea, so the sizes of the values cannot be compared as they are (chapter 5). The values of uplift in Sotoura, and the differences between sources, are covered in R7-B01 "Earthquake uplift on the Sotoura coast". [S5, S22, S8, S9, S10, S11, S12, S20, S13, S1, S2]

Region (Sotoura): the tidal range, and the size of the uplift

Sotoura is the coast on the Sea of Japan side of the Noto Peninsula. In this paper, it means the coast of Shika Town, Wajima City (including Monzen, Hegura Island and the Nanatsujima Islands), and the north coast of Suzu City as far as Jike. At about 16:10 on 1 January 2024, an earthquake of magnitude 7.6 (the value of the Japan Meteorological Agency) occurred, with its hypocentre 16 km underground at the north-eastern tip of the Noto Peninsula. In this earthquake, many people died through the collapse of houses and other causes, and fishing villages, fishing ports and fisheries also suffered great damage. Of all this, this paper covers the living things of the intertidal zone and the shallow rocky reefs that were left dry by the uplift, and their recovery afterwards. [S1, S5]

The rocky shores of Noto also have bands by height. The material of the Ishikawa Prefecture Noto Marine Center gives, as examples for the rocky shores of Noto, araretamakibi (Echinolittorina radiata; a small snail) in the supratidal zone; narasamo and umitoranoo (seaweeds) and sugai and ishidatami (snails) in the intertidal zone; and purple sea urchins (murasaki-uni, Heliocidaris crassispina) and turban shells, and yanagimoku (Sargassum ringgoldianum subsp. coreanum) and yatsumatamoku (Sargassum patens) (seaweeds), in the subtidal zone. [S3]

The Sea of Japan side is a sea where the tidal range is small. According to the press release of Kanazawa University and the other institutions, whereas in Tokyo, on the Pacific side, the difference in tide level is up to about 2 m, at Wajima it is up to about 50 cm throughout the year. The paper gives the tidal difference in 1 day as about 0.4 m on the coast of the Sea of Japan and about 2 m on the Pacific side (quotation of a 1978 study), and states that in the Sea of Japan the difference between seasons is larger than the difference within 1 day. The paper also gives, from the tide tables of the Japan Meteorological Agency, the width of the intertidal zone at

Wajima in 2024 (between the high-tide line of summer and the low-tide line of spring) as about 60 cm at most, and the average tidal difference in 1 day as about 40 cm (quotation). When this paper calculates from the predicted values for 2024 in the same tide tables, the tidal difference in 1 day at Wajima (the difference between the highest high tide and the lowest low tide of that day) was about 24 cm on average and 40 cm at most. The difference between the highest high tide of the year (August) and the lowest low tide (March) is 67 cm. The difference in 1 day at Tokyo was about 140 cm on average and 217 cm at most. The values in the tide tables are predicted values called the astronomical tide, and differ from the tide levels actually observed. A figure in the material of the Ishikawa Prefecture Noto Marine Center gives the width of the intertidal zone as 20–30 cm. [S2, S1, S18, S3]

Compared with this narrow intertidal zone, the uplift in Sotoura was far larger. The Kaiso paper and the press release give the uplift of the north-west coast of the Noto Peninsula as about 4.4 m at most (quotation of a 2024 study). The uplift at Kaiso fishing port is given as 3.6–3.9 m in a survey by AIST (the National Institute of Advanced Industrial Science and Technology) (quoted in the paper), and the paper states that this far exceeds the tidal difference of the Sea of Japan. The Ishikawa Prefecture Noto Marine Center treats Kaiso as a site with uplift of about 4 m and Kinoura in Suzu City as a site with uplift of about 2 m. The values used in the report of the Kanazawa Association of Corporate Executives are 4.1 m at Kaiso, 1.5 m at Wajimazaki, 2.8 m at Nagahashi in Suzu City, 1.8 m at Kinoura and 0.8 m at Noroshi. In Sotoura, in the 2007 Noto Peninsula Earthquake (magnitude 6.9) as well, the coast at Akakami, Monzen-machi, Wajima City was uplifted by up to 41 cm. The research report of the Ishikawa Prefecture Noto Marine Center (March 2025) shows this by citing a 2007 report, and states that no record remains of coastal living things having died at that time. The fact that the values of uplift differ between sources and methods of measurement is covered in R7-B01 "Earthquake uplift on the Sotoura coast". [S1, S2, S3, S5, S15]

With the uplift, the shoreline moved offshore. On the survey lines of the Ishikawa Prefecture Noto Marine Center, the shoreline moved forward by 33 m at Kinoura and by 116 m at Kaiso. In the diving survey of the Association, the coast was left dry over about 100 m at Kaiso, about 50 m at Wajimazaki, about 60 m at Nagahashi, about 15 m at Kinoura and about 65 m at Noroshi. The Association's report states that the flat rocky shores that had been natural nori (laver) grounds (from the intertidal zone to where the waves break) became land, and that the ground was exposed down to the depths that had been the home of the spat of abalone and turban shells. [S3, S5]

Region (Sotoura): the mass die-off of living things recorded at Kaiso

At Kaiso, the communities of living things that were left dry are thought to have been left with their arrangement from before the earthquake almost intact. A group of researchers from Kanazawa University, the Natural History Museum and Institute, Chiba, and Kyushu University surveyed three places, namely Kaiso fishing port, the rocky reef that continues to its south (the Kaiso rocky reef), and the coast south of Kuroshima fishing port (the Kuroshima coast), on 7 occasions from 7 March 2024, 66 days after the earthquake, to 11 July. Kuroshima fishing port is about 1.2 km south of the Kaiso rocky reef. The results of the survey are set out in a peer-reviewed paper (its title includes "Preliminary assessment"; published online on 26 February 2026) and in a press release by the university and the other institutions (3 March 2026). [S1, S2]

On the rocky reef, the living things inside frames of a fixed size were counted (this is called a quadrat survey). On 21 April 2024 (111 days after the earthquake), a line was drawn from the land towards the sea, almost at right angles to the coast, and 18 frames of 30 cm × 50 cm were placed at 14 points. When the living things inside the frames were taken back and their species and numbers examined, the living things were all dead. In these frames alone, 92 species of molluscs, such as shellfish, 5 species of echinoderms, such as sea urchins, arthropods, such as crabs, and the three main groups of seaweeds, red algae, green algae and brown algae, were recorded. [S1, S2]

The living things are thought to have died immediately after the earthquake. Many of the shellfish were found with their flesh remaining, in the orientation they had when alive. The paper states that snails have the habit of staying where they are without moving in order to protect their bodies from drying, and, citing other studies as well, considers that the arrangement from before the earthquake remained almost as it was. It states that arthropods such as crabs may also have moved downwards after the earthquake. The press release describes this as a "snapshot" record in which communities of living things of the subtidal zone, which can otherwise be seen only by diving, could be seen directly from land. [S1, S2]

The number of species differed greatly according to the height before the earthquake (Table 2). The positions of the frames were measured with a laser rangefinder and compared with the height of the tide on the day of the survey, to estimate at what depth below the sea surface they had been before the earthquake. The species were most numerous in the place with calm waves from the lower part of the intertidal zone before the earthquake to the very top of the subtidal zone (around 3.0 m above sea level after the earthquake, around about 1 m of water depth before the earthquake). Here there were many small snails that live attached to seaweeds, crustaceans such as crabs, and sea urchins, and the press release states that the Kaiso rocky reef before the earthquake supported many species through a rich "forest" of seaweeds. Bivalves that bore holes in rock and live in them were found in large numbers from around frame 5 downwards (the lower part of the intertidal zone before the earthquake). Further down, the species decreased, and the paper states that the accumulation of sand and the effect of a weak tsunami may have been involved. [S1, S2]

Table 2 Number of species of molluscs in each frame on the Kaiso rocky reef (21 April 2024)

Frame	Height above the sea surface on the day of the survey	Position before the earthquake (the paper's estimate)	Number of species of molluscs	Living things mainly seen
1–4	Frame 2 is at 3.8 m	From around the upper edge of the intertidal zone to the upper part of the intertidal zone	1–15 species	Araretamakibi (118 individuals in frame 1), yomegakasa and unoashi (both cap-shaped shells), the oyster kegaki (Saccostrea kegaki) and calcareous algae (frame 2)
5–6	Frame 6 is at 3.0 m	From the lower part of the intertidal zone to the very top of the subtidal zone	20–32 species	Small snails attached to seaweeds, crus - taceans, sea urchins. Bivalves that bore holes and live in them
7–9	Frame 8 is at 1.8 m	Subtidal zone	12–19 species	Species decrease somewhat
10–11	Frame 11 is less than 10 cm above the high-tide line of that day	Subtidal zone	4–5 species	Species decrease greatly
12–14	Frame 12 is at 3.2 m	A place exposed to waves. Frame 13 is at almost the same height as frame 6	8–20 species	Most numerous in frame 13

Note: Compiled by this paper from Table 1 of the paper (the number of species of molluscs in each frame) and its main text. Frames 5–8 include the values of frames placed side by side in pairs. Heights are given only for the frames for which the paper shows them. The tidal difference at Wajima on the day of the survey was 11 cm at most. [S1]

The living things that were numerous include araretamakibi of the supratidal zone (118 individuals), bosatsugai, a small snail attached to seaweeds (100 individuals), the cap-shaped shell yomegakasa (70 individuals), funegai,

a bivalve attached to rock (45 individuals), the cap-shaped shell unoashi (43 individuals), and the sea urchins purple sea urchin (31 individuals) and bafun-uni (Hemicentrotus pulcherrimus) (18 individuals). Turban shells (15 individuals) and Japanese black abalone (kuro-awabi) (2 individuals) were also included (the numbers are the values in the paper's table excluding shells thought to have died before the earthquake). The paper states that, whereas an earlier survey of the coast of the Sea of Japan (1978) listed roughly 10 or so taxa (groupings of kinds of living things) per place, the present record far exceeds that. While considering that the difference is also due to differences in the purpose and scope of the surveys, it states that the view that the rocky shores of the Sea of Japan have few species needs to be reviewed. [S1]

Inside the fishing port, living things different from those of the rocky reef were found. At Kaiso fishing port, the bottom of the port was completely dried out, and the quay walls were covered with the shells of several hundred dead oysters and similar animals and with the calcareous tubes of polychaete worms. On the dried-out bottom of the port, many skeletons of kikumeishi-modoki (Oulastrea crispata), a kind of coral, were found. Kikumeishi-modoki is treated in the prefecture's Red Data Book as corresponding to Near Threatened (a category for species whose present risk of extinction is small but could rise if conditions change). The bivalve habokigai (the press release treats it as a nationally Near Threatened species) had died still in the posture it had when alive. The paper, citing the prefecture's Red Data Book, considers the habokigai here to be at the northern limit in the Sea of Japan. As an exception, on the sandy bottom where seawater remained, the starfish itomaki-hitode (Patiria pectinifera) was alive. [S1, S2]

On the rocky reef, rare living things were also recorded. Under overhangs of rock, there were small dead remains of tsukumo-juzu-sango, a colony-forming coral (the press release treats it as a rare regional population). The rocks of the new shoreline at the time of the survey were covered with several hundred dead bivalves, and at their base, from around the present high-tide line downwards, living green algae were seen. On the other hand, at this height no living individuals were seen of species that live from the upper part of the intertidal zone to the supratidal zone, such as yomegakasa, unoashi and araretamakibi. The rocks between the former shoreline and the new shoreline were covered with the dead remains of seaweeds that had turned white. On the Kuroshima coast, on rocks exposed on the widened sandy beach, turban shells with their flesh remaining had died with many suzumegai (small shellfish that attach to shells) still attached around the mouth of the shell. [S1, S2]

The abundance of living things is also said to differ between the walls of a fishing port and natural rock. The paper, citing a separate study (2024) that surveyed the fouling organisms of Kaiso by a similar method, states that vertical port walls have fewer species than natural rocky reefs, and that the difference is due to the unevenness of the surface of the soft rock of the Kaiso rocky reef. The paper states that the recovery after the earthquake, too, will probably differ from place to place according to the fine topography. [S1]

Region (Sotoura): differences by place and by size of uplift

Prefectural bodies also surveyed the living things of the rocky shores by size of uplift. The Ishikawa Prefecture Noto Marine Center has surveyed the animals and plants at 12 sites on the prefecture's rocky reef coasts once every 5 years (the most recent being 2020–2021). In 2024 it brought this survey forward, and from 10 May to 28 June it surveyed 16 sites: the 10 sites from before the earthquake plus 6 sites on uplifted coasts. Katano in Kaga City was not surveyed, and Kounyu in Wajima City could not be reached. The results are set out in the research report of March 2025. In the presentation given with the prefecture's Fisheries Research Center (at the liaison conference of natural environment survey and research institutes on 20 November 2024), the size of uplift is divided into three levels, no uplift, 2 m or less, and about 4 m, and Kinoura is introduced as an example of 2 m or less and Kaiso as an example of about 4 m. [S3, S15]

There are two survey methods. The first is to check, along a line about 5 m wide from the former shoreline to the new shoreline, whether shellfish and crustaceans are alive or dead, and to measure how far the sea surface has

dropped. The second is for 2 people to search for animals and seaweeds at the new water's edge, in an area about 50 m wide and down to a water depth of about 50 cm, and to record them at four levels: "abundant", "often found", "found if searched for" and "not found". According to the research report, what is recorded is 37 species of animals and 37 species of seaweeds that are widely seen on the prefecture's rocky reef coasts, and the method is the same as before the earthquake. [S3, S15]

The results show that, both at Kinoura with uplift of about 2 m and at Kaiso with uplift of about 4 m, the living things of the former intertidal zone almost completely died out. According to the Center's summary, the intertidal snails ishidatami, sugai and uminina (Batillaria multiformis) had almost completely died out. The turban shells, sea urchins and starfish that had originally been in the subtidal zone were also dead in the uplifted places. In the survey along the lines, the sea surface had dropped by about 2 m at Kinoura and by about 4 m at Kaiso. [S3]

At the new water's edge, living things that had originally been in the subtidal zone were seen. The Center's summary states that, with both the 2 m and the 4 m uplift, turban shells, sea anemones, sea urchins and others had appeared in the new intertidal zone. However, in the table of results in the presentation slides (which does not state the survey dates), the animals found number 10 species in the 2 m column and 3 species in the 4 m column, and the marks for turban shells and sea anemones are only in the 2 m column. In the table of the research report, of the 37 species decided in advance, the animals found were 6 species at Kinoura (10 May 2024) and 4 species at Kaiso (27 June). The 4 species at Kaiso are urauzugai (Astralium haematragum) ("abundant"), the barnacle iwafujitsubo (Chthamalus challengeri), purple sea urchin and reishigai (Reishia bronni), and in the Kinoura column there are no marks for turban shells or sea urchins (chapter 5). Araretamakibi, tamakibi (Littorina brevicula), kamenote (Capitulum mitella), ishidatami, sugai and others that live in the supratidal and intertidal zones have no marks either in the 2 m and 4 m columns of the slides' table or in the Kinoura and Kaiso columns of the research report's table. The summary of the presentation states that, even at the same place, there were differences according to how the waves strike and other factors. [S3, S15]

The seaweeds showed a different picture from the animals. The seaweeds found were 13 species in both the 2 m and the 4 m columns in the slides' table, and 17 species at both Kinoura and Kaiso in the research report's table (the slides' table lists fewer species than the research report; chapter 5). In the Center's summary, there was no large change in the species that are abundant in the new intertidal zone, and there was no change in the seaweeds that grow in a short period. On the other hand, the summary states that narasamo, umitoranoo, fushisujimoku (Sargassum confusum), togemoku (Sargassum micracanthum) and others, whose main place of growth is the intertidal zone, are not growing. Yanagimoku and yatsumatamoku, which grow in the subtidal zone, were growing, and some were mature even though they had been torn off and shortened. The research report states that, on the uplifted coasts, narasamo and umitoranoo, which grow in the intertidal zone and live for many years, had all withered and disappeared, while for the seaweeds that complete their life in less than 1 year there was no large change in how they grew before and after the earthquake. In the new intertidal zone at Kaiso, yanagimoku, which had been in the subtidal zone and lives for many years, became too shallow and was partly left dry, and part of the stand had withered. [S3, S15]

The research report shows the results of the 10 sites that correspond to this paper's Sotoura, site by site (Table 3). Of the 4 sites that can be compared with before the earthquake, at uplifted Nagahashi and Kinoura the number of species of animals fell greatly, and at Oshima and Akasumi in Shika Town, which the research report treats as coasts that were not uplifted, the decrease was small. Seaweeds had decreased at every one of these 4 sites. The report states that, on the uplifted coasts, there were very few sites where living things of the supratidal and intertidal zones, such as araretamakibi, yomegakasa, bekkogasa (Cellana grata) and ishidatami, were seen, and that living things of the subtidal zone were seen relatively often. It states that, in the places that had become land, many dead remains of turban shells and purple sea urchins were seen. Because the uplift moved the

shoreline forward by 44 m at Nagahashi and by 33 m at Kinoura, in 2024 the survey location was moved to the new water's edge. [S15]

Table 3 Number of species of animals and seaweeds found on the rocky reef coasts of Sotoura (the number out of the 37 species of each decided in advance)

Site	Height of uplift (research report)	2024 survey	Animals	Seaweeds
Oshima, Shika Town	No uplift	27 June	22→19	25→19
Akasumi, Shika Town	No uplift	27 June	22→20	28→26
Kaiso, Wajima City	400 cm	27 June	4	17
Sodegahama, Wajima City	163–183 cm	13 June	5	9
Inafune, Wajima City	About 100 cm	13 June	1	5
Sosogi, Wajima City	187 cm	28 June	15	14
Maura, Suzu City	186–216 cm	28 June	6	14
Nagahashi, Suzu City	226 cm	10 May	19→5	24→13
Kinoura, Suzu City	171 cm	10 May	23→6	25→17
Noroshi, Suzu City	117–147 cm	28 June	8	17

Note: The value to the left of the arrow is the value before the earthquake (2020), and sites without an arrow are sites added after the earthquake. The numbers are the numbers of species marked "abundant", "often found" or "found if searched for", not numbers of individuals. The heights of uplift are values that the research report took from a collection of photographs, and the value for Inafune is one estimated from the upper edge of dried coralline algae. The research report gives Kinoura in its list of sites and, in its tables, writes what appears to be the same site as Shakuzaki (this paper's view). The values for Nagahashi in the figure in the material of the prefecture's committee are the same as the values in this table. [S15, S4]

The research report shows the possibility that survival was not decided by the size of the uplift alone. Among the uplifted coasts, the number was highest, 15 species, at Sosogi, which had medium uplift (187 cm), while it was 1 species at Inafune and 8 species at Noroshi, where the uplift was small, and 5 species at Sodegahama and 6 species at Kinoura, where the uplift was about the same. At Sosogi, living things of the intertidal zone were seen in large numbers around rocks that rise vertically. The report states that the topography and how the waves strike may also have been involved in survival, but that the details are not known. [S15]

The material of the review committee for the prefecture's basic plan for coastal protection (5 November 2025) carries a figure, made from this research report, comparing the numbers of species at Nagahashi and at 3 sites outside Sotoura (Ossaka, Karashima and Kurosaki). The material states that, while the number of species of animals decreased on the rocky reef coasts, there were also sites where seaweeds increased, and that the previous environment was lost because of the tsunami and a new ecosystem is in the process of forming. In the tables of the research report, the sites where seaweeds increased are Ossaka, Ninzaki and Kurosaki, in Uchiura (the inner coast) and Nanao Bay, and are not sites in Sotoura. The research report states that at Akasaki and Ossaka in Uchiura, which were hit by the tsunami, there was no large change in the numbers of species or the state of the animals and plants, and that no conspicuous effect of the tsunami could be confirmed on the rocky reef coasts. [S4, S15]

In three districts of Wajima City as well, almost all the animals of the shallow seaweed beds that were left dry had died. According to a 2025 report by Ryoko Ishikawa of the sole-proprietor office Wajima Kaiso Lab (Wajima

seaweed laboratory), when the dried-out seaweed beds of Hikariura, Wajimazaki and Najimi were surveyed from late March to early June 2024, all individuals were dead except in a few tide pools, and many dead remains of turban shells, purple sea urchins, Japanese black abalone and others were found. The seaweeds in this survey are covered in R7-B08 "Shallow seaweed beds dried out by uplift, and the decrease in the area of seaweed beds in Sotoura". [S14]

Region (Sotoura): the living things that returned afterwards

Recovery is thought to be proceeding at speeds that differ from species to species. The material shown by a researcher of Kanazawa University at a symposium on 31 January 2026 states, as preliminary figures of the 2025 recovery survey, that yomegakasa is relatively numerous while the number of unoashi is very small, and that it is highly likely that the degree of survival of, and recovery from, the earthquake uplift differs greatly from species to species. It states that, because the species and numbers before the earthquake could be reconstructed by the frame survey, it has become possible to compare before and after the earthquake. No numbers are given in these preliminary figures. [S6]

According to the research report of the Ishikawa Prefecture Noto Marine Center, in the survey of May–June 2024, 50 or more individuals of the cap-shaped shell yomegakasa were found at Sosogi, Maura and Noroshi among the 8 uplifted sites, and the distribution of shell sizes was also similar to that on coasts that were not uplifted. It was not found at Kaiso, Sodegahama or Inafune, and at Nagahashi and Kinoura, where there had been stable groups in 2020, there were almost none (2 individuals at Kinoura). The report states that some living things of the intertidal zone, including yomegakasa, may have survived the uplift. It states that the living things of the subtidal zone seen in the new intertidal zone are considered to be individuals that had lived, before the earthquake, at places deeper than the height of the uplift, and that it is not known whether living things of the intertidal zone newly came in after the earthquake. [S15]

Turban shells are seen in the present shallow sea of the Kaiso rocky reef. The press release of Kanazawa University and the other institutions (3 March 2026) states that the group is still continuing its survey, and that turban shells are already seen in the subtidal zone of the present Kaiso rocky reef, but that the diversity of living things has not yet reached the level before the earthquake. The press release states that the lost living things are considered to return little by little, as survivors spread the area where they live from surrounding places that were not affected by the uplift. However, it states that, because global warming, changes in topography and other factors overlap, the species that return may not be the same as before the earthquake. [S2]

In the diving survey of the shallow sea as well, shellfish and sea urchins that had originally been in the subtidal zone were seen. In the diving survey of the Kanazawa Association of Corporate Executives (6–19 June 2025), lines were drawn offshore from the shoreline of before the earthquake and surveyed; at Kaiso (19 June) there were turban shells along the whole of the line, and on the shore side of the middle of the line, places with 1 individual or more per 1 m^2 were seen. Purple sea urchins were also present along the whole of the line, but there was no place with more than 1 individual per 1 m^2. In Suzu City, snails such as urauzugai were present at high densities per 1 m^2: up to 20 individuals or more at Nagahashi, 5 individuals or more near the shore at Kinoura, and 10 individuals or more on the offshore side at Noroshi. Turban shells and abalone are covered in R7-B13 "The mass die-off of abalone and turban shells, and the fall in catches that continues for some years". [S5]

Among the seaweeds of the intertidal zone, too, there are species that disappeared. The Association's report states, in comparison with a survey of June 2020 (quotation of the research report of the Noto Marine Center), that umitoranoo had disappeared at Nagahashi because the place with calm waves was left dry, and that at Kinoura narasamo had disappeared because the intertidal zone was uplifted and sugimoku (Coccophora langsdorfii) had disappeared because the place with calm waves was left dry. At Noroshi, nokogirimoku (Sargassum macrocarpum) and yatsumatamoku that are thought to have attached before the earthquake

remained in tide pools about 30 cm deep that had formed in the dried-out places, but the report predicts that these will eventually give way to species that prefer such places, such as umitoranoo. The drying out of the shallow seaweed beds and the way the area of seaweed beds in Sotoura decreased are covered in R7-B08 "Shallow seaweed beds dried out by uplift, and the decrease in the area of seaweed beds in Sotoura". [S5]

Region (Sotoura): the rocky shores that became land, and what is covered in other papers

The former intertidal zone that was left dry has begun to change into a place for the living things of the land. According to a report (March 2026) of a survey carried out in October and November 2025 by the Biodiversity Center of Japan of the Ministry of the Environment, at Minazuki Bay and Yoshiura in Wajima City, Kinoura in Suzu City, and Sodegahama and Kamogaura in Wajima City, the dead remains of sessile organisms (living things that are attached to rock and do not move) that had been below the former intertidal zone remain white on the rocks, and the positions of the former shoreline and sea surface can be seen. At Kinoura, a wetland had formed on the low ground between the embankment and the water's edge that is thought to have once been intertidal zone. In every district, few plants were seen on the uplifted rocky areas themselves. The uses of the land that newly became land are covered in R7-B06 "The uses of the land that newly became land and of the coast". [S7]

The uplift also affected the fisheries of the rocky shores. The Association's report states that the ground was left dry down to the holes that purple sea urchins had bored in the rock and lived in, and that the deaths of abalone and sea urchins inside the holes were also confirmed. The effect on the rocky shores where rock nori (iwanori) and wakame are gathered is covered in R7-B14 "The rocky shores for rock nori and wakame (drying out of the nori beds, footing, and processing sites)"; the piling up, on the fishing grounds of the rocky shores, of mud entering from river mouths is covered in R7-B09 "The mud and turbidity that keep entering from river mouths (the seaweed beds and rocky-shore fishing grounds of the Wajima coast)"; and the decline of the seaweed beds on the offshore side of the Sotoura coast of Suzu is covered in R7-B10 "The decline of the seaweed beds on the offshore side of the Sotoura coast of Suzu (tsunami or winter waves?)". The fishery of the ama (women divers), who dive on the rocky shores, is covered in R7-B25 "The ama diving fishery of Wajima (numbers of people, reopening, and the passing on of skills)". [S5]

3. Existing measures, and how they are assessed

The living things of the rocky shores are thought to have died all together immediately after the earthquake uplift. The efforts given in the materials this paper looked at are three: recording the communities of living things that died, continuing to watch the changes after that, and giving consideration to living things in the plans for the coast. Overseas, there are also efforts to stop taking and wait for recovery. For Sotoura, we found neither any treatment to bring back the living things of the intertidal zone (such as transplanting or releasing) nor any assessment showing which effort worked and how much. A survey to confirm recovery in numbers began in April 2025. The fishery for abalone and turban shells is covered in R7-B13, and the local activities that protect the seaweed beds of Wajima in R7-B26 "Rebuilding the local activities that protect the seaweed beds of Wajima".

Recording the communities of living things that died

The living things of the rocky shore before the earthquake were reconstructed from the dead remains. The group from Kanazawa University and the other institutions surveyed Kaiso from 66 days after the earthquake, and left the species and numbers for each frame in a paper. The paper treats this record as baseline data for watching the changes in living things after the uplift, including changes in the climate. The paper states that the dead remains are expected to be washed away little by little by rain, but that the shells of the bivalves that bore holes

in rock will probably remain as a marker of the intertidal zone before the earthquake. The Association's report writes that for Kaiso there are no findings from surveys before the earthquake. [S1, S2, S5]

Prefectural bodies, too, surveyed the 10 sites that correspond to this paper's Sotoura in May–June 2024 by the same method as before the earthquake, and left a record for each site (Table 3 in chapter 2). In Wajima City, from February 2024, fishers centred on the ama divers used the Fisheries Agency's support project for measures to restore fishing grounds to survey the seaweed beds of Wajima together with Ryoko Ishikawa, and recorded the damage. The numbers of dead remains and the matter of abalone and turban shells are covered in R7-B13 "The mass die-off of abalone and turban shells, and the fall in catches that continues for some years". Among the 6 survey sites surveyed in fiscal 2025 by the national government's long-term survey of rocky shores (the Monitoring Sites 1000 project of the Ministry of the Environment; since fiscal 2008), there is no site on the Sea of Japan side (this paper's judgement from the locations of the survey sites). [S15, S14, S25]

Continuing to watch the changes

The surveys are being continued by universities and prefectural bodies. The Ishikawa Prefecture Noto Marine Center added 6 sites after the earthquake to its fixed sites surveyed once every 5 years. The Center's research report (March 2025) states that from now on it is necessary to continue surveys that count numbers using frames of a fixed size, and to confirm the process of recovery of the living things of the intertidal zone. The Center's material gives, as the surveys needed from now on, monitoring (keeping continuous watch) of the changes in the living things of the intertidal zone, differences between sites due to how the waves strike and other factors, and the effects on the culture of the satoumi, such as seaweeds and shellfish. The group of Kanazawa University also states that it is continuing the survey of Kaiso. The Association's report states that it is desirable to continue regular monitoring of the shallow places and, as necessary, to consider creating seaweed beds and releasing shellfish seed. [S3, S15, S2, S6, S5]

From April 2025, a survey that keeps watching the same places has also begun. According to an explanatory article by a researcher of Tohoku University (November 2025), the researcher, the Noto Marine Center and others, after preliminary visits in November 2024 and February 2025, chose seven coasts in Sotoura with different sizes of uplift. The sizes of uplift given in the article are 0 m at Akasumi, 4 m at Kaiso, 1.7 m at Hikariura, 1.9 m at Sosogi, 2.3 m at Nagahashi, 1.7 m at Kinoura and 1.3 m at Noroshi. In April 2025, plots of 25 cm × 25 cm were placed at places of different heights, at 5 points on each coast. So that the same places can be surveyed every time, the locations of the plots were fixed by driving anchors into the rock; these are called permanent quadrats. The plan is to confirm by statistics, in comparison with Akasumi, which had no uplift, how long the effects of the uplift continue and whether their length and the way they change differ with the size of the uplift. It states that the data of the Center's surveys so far will be used for the comparison of before and after the earthquake. The 1st survey was in June 2025, and at the time of the article the results are left for "another occasion". It states that the survey was designed so that local people can also take part in it. [S16]

This researcher has also obtained national research funding (KAKENHI, Grants-in-Aid for Scientific Research; April 2025 to March 2028) to study, on rocky shores affected by the 2011 Tohoku earthquake and the 2024 Noto Peninsula Earthquake, what characteristics make living things susceptible to the effects of an earthquake, and the differences in the time until communities return to their original state. The record of the research funding does not state the places to be surveyed. [S17]

The results of the surveys have not yet been brought together in one place. At the review committee for the prefecture's basic plan for coastal protection (5 November 2025), a member gave the opinion that various surveys of biodiversity and ecosystems are being carried out on the Noto Peninsula after the earthquake, but that they are being carried out separately, so the member would like them to be put in order in coordination

with the Environment Department and others. The chair asked that they be put in order in coordination with the Environment Department as well, and that useful data also be shown at future meetings of the committee. [S4]

Giving consideration to living things in the plans for the coast

The prefecture touches on the changes in living things in the course of remaking its plan to protect the coast. The material of the review committee (5 November 2025) states that, in light of the changes in the environment caused by the earthquake, it is necessary to develop coastal protection facilities suited to the characteristics of sandy beaches, rocky reefs, seaweed beds and so on. It also states that the previous environment was lost in the earthquake and tsunami, and that an ecosystem is in the process of forming in the new environment. The content of the plan is covered in R7-B05 "Remaking the basic plan for coastal protection (uplift and growing waves)". [S4]

Stopping taking and waiting for recovery (an example from overseas)

In Kaikōura, taking was stopped, and the reopening was decided on the results of surveys. Because pāua, bull kelp and others suffered great damage in the earthquake, the taking of shellfish and seaweeds was stopped as an emergency measure (the pāua fishery was closed from November 2016), and this was still continuing at the time of the report of March 2021. One of the main purposes of the survey of the rocky shores was to provide material for the decision to reopen the fishery, and the results were explained repeatedly to local groups, the indigenous Māori people, pāua fishers and others. The pāua fishery was reopened on 1 December 2021, for the 1st time after the closure, for only 3 months. The report, having stated that recovery had been expected to be slow, expects that the communities rich in seaweeds will continue to change. [S12, S13]

4. What is changing

The living things of the rocky shores are thought to have died all together immediately after the uplift of 1 January 2024. The changes after that are still continuing (as of 4 November 2026). Most of what this chapter covers is the surveys by researchers and the prefecture, and the schedule of the plans.

Changes in living things

Living things have come to be seen at the new water's edge. At Sodegahama in Wajima City, it was reported that at the end of March 2024 wakame and rock nori were sprouting at the new water's edge, and that there were more dead remains the further towards the land from the water's edge. In the survey by prefectural bodies in May–June 2024, urauzugai and purple sea urchins (Kaiso) and turban shells (Sodegahama), which had originally been in the subtidal zone, and seaweeds of the subtidal zone were seen in the new intertidal zone. On the uplifted coasts, snails that live in the intertidal zone, such as ishidatami and sugai, were hardly seen, and narasamo and umitoranoo had all withered. 50 or more individuals of the cap-shaped shell yomegakasa were found at 3 of the 8 uplifted sites (chapter 2). [S24, S15, S3]

In June 2024, about half a year after the earthquake, it was reported that seaweeds were not growing on the rocks at a water depth of 3–4 m around Kaiso fishing port, and that a researcher said that there were no sea urchins or turban shells either. The Center's outreach magazine (March 2025) states that rock nori (in Noto, almost all of it is uppurui-nori, Pyropia pseudolinearis) has been confirmed to be growing vigorously in the new intertidal zone. The rocky shores where rock nori is gathered are covered in R7-B14 "The rocky shores for rock nori and wakame (drying out of the nori beds, footing, and processing sites)". In the preliminary figures of the 2025 survey, yomegakasa was said to be relatively numerous and unoashi very scarce. In the shallow sea at Kaiso, turban shells have been seen since then (the Association's diving survey of June 2025 and the press

release of March 2026). We found no outlook that showed, with its grounds, which species will return when (chapter 5). [S21, S23, S6, S5, S2]

The Kaiso paper states that, because the uplift far exceeds the tidal difference of the Sea of Japan, the living things from the intertidal zone to the very top of the subtidal zone on the west coast of the Noto Peninsula will probably go through changes the same as, or larger than, those in the examples of other earthquakes. Other changes also overlap with the changes to come. The press release of Kanazawa University and the other institutions gives warming and changes in topography, and states that the species that return will not necessarily be the same as before the earthquake. The water temperature of the shallow sea of Sotoura is covered in R7-B12 "High water temperature in summer (the shallow sea of Sotoura)". The Association's report considers that, on the offshore rocky reefs that emerged from under the sand because of the uplift, new seaweed beds will form over time, while being subject to the deposition of sand and erosion by waves (the movement of the sand of the beaches is covered in R7-B03 "The sandy beaches that keep moving even after the uplift, and the silting up of fishing ports"). In Kaikōura, the erosion of soft rock and the movement of gravel were given as major reasons hindering recovery. [S1, S2, S5, S12]

Schedule of surveys and plans

- 7 March to 11 July 2024: the group from Kanazawa University and the other institutions surveyed Kaiso fishing port, the Kaiso rocky reef and the Kuroshima coast on 7 occasions (the frame survey on 21 April). [S1]
- 10 May to 28 June 2024: the Ishikawa Prefecture Noto Marine Center brought forward its survey held every 5 years, and surveyed the 10 sites of this paper's Sotoura and 6 sites in Uchiura and Nanao Bay. The results are in the research report of March 2025. [S15]
- 20 November 2024: the Ishikawa Prefecture Noto Marine Center and the Fisheries Research Center presented the results for Kinoura and Kaiso. [S3]
- 2025: the recovery survey of Kanazawa University (the preliminary figures are of 31 January 2026). [S6]
- April 2025: a researcher of Tohoku University, the Noto Marine Center and others placed permanent quadrats on seven coasts of Sotoura. The 1st survey was in June 2025, and the results have not yet been shown (as of the explanatory article of November 2025). [S16]
- April 2025 to March 2028: the KAKENHI project of the researcher of Tohoku University, "Predicting the response of rocky intertidal communities to earthquakes: vulnerability and speed of recovery as understood from functional traits". It covers rocky shores affected by the 2011 Tohoku earthquake and the 2024 Noto Peninsula Earthquake. [S17]
- 6–19 June 2025: the diving survey of the Kanazawa Association of Corporate Executives (5 sites in Sotoura and 2 sites in Uchiura). The report is of March 2026. [S5]
- October and November 2025: the survey of the natural environment of the Noto Peninsula by the Ministry of the Environment (the report is of March 2026). [S7]
- 5 November 2025: the review committee for the prefecture's basic plan for coastal protection (2nd meeting). The prefecture plans to hold the committee about 2 times in fiscal 2026 and to draw up the plan (the content is in R7-B05). [S4]
- 26 February 2026: the Kaiso paper was published online. On 3 March the university and the other institutions made their announcement. [S1, S2]

5. What is not yet known

Where there are no figures

- We found no numbers showing how much of the living things of the intertidal zone and shallow rocky reefs died, and how much returned, in Sotoura as a whole. There are numbers only for limited sites, such as the Kaiso rocky reef (the frame survey of the paper), the 10 sites that correspond to this paper's Sotoura (the research report of the prefectural body; a single survey in May–June 2024), and the densities of shellfish and sea urchins in the shallow sea at 5 sites in Sotoura (Kaiso, Wajimazaki, Nagahashi, Kinoura and Noroshi) (the Association's diving survey, June 2025). The Kuroshima coast was only observed and recorded by the paper, and there are no numbers. [S1, S15, S5]
- We found no source that showed the recovery from 2025 onwards in numbers set beside the values for the same place before the earthquake. The only numbers that set before and after the earthquake side by side are the numbers of species (2020 and 2024) at 4 sites (Oshima, Akasumi, Nagahashi and Kinoura) in the research report of the prefectural body. There are densities of turban shells seen by diving (the Association, June 2025), but they are not set beside values from before the earthquake. Neither the 2025 preliminary figures of Kanazawa University nor the press release's "the diversity has not reached the level before the earthquake" gives numbers. We also found no source showing the results of the permanent quadrat survey that began in April 2025 (chapter 3). [S15, S5, S6, S2, S16]
- For Shika Town, there are results for Oshima and Akasumi, which the Center's research report treats as coasts that were not uplifted (Table 3). We found no results of a survey, after the earthquake, of the living things of the rocky shores on the uplifted coasts in Shika Town. [S15, S3]
- We found no results of a survey, after the earthquake, of the living things of the rocky shores of Hegura Island and the Nanatsujima Islands. The Center's outreach magazine (December 2024) states that the Center's rocky shore surveys include 4 sites on Hegura Island, but these are not among the 16 sites of the 2024 research report. [S26, S15]
- We found no outlook that showed, with its grounds, in how many years the living things of the rocky shores of Sotoura will return. According to a news report, a researcher of Kanazawa University, after a dive about half a year after the earthquake, indicated the possibility that it would take at least 3–5 years for things to be as they were (June 2024; no grounds are given). The press release states that the lost living things are considered to return little by little from the surroundings, and the Association's report conjectures that the seaweed beds of the shallow places will eventually return to the original vegetation, but neither gives a number of years. In Kaikōura, in the survey at the point 3 years after the earthquake (November 2019), recovery is said to be far off. In the paper at the 4-year point, too, the return remained poor except in the low part of places where the uplift was less than 1 m. [S21, S2, S5, S12, S20]

Limits of comparison

- The survey methods differ from source to source. The paper took back and counted the dead living things inside the frames. The prefectural body checked along lines whether things were alive or dead, and recorded the living things at the water's edge at four levels. The Association dived and recorded 1 m on both sides of the line every 10 m. The times of the surveys also differ: March–July 2024 (the paper), February–March and May–June 2024 (the prefectural body), and June 2025 (the Association). [S1, S3, S15, S5]
- The number of species changes according to what was counted. The 92 species of the paper is the number of molluscs inside the frames, and the values in the research report of the prefectural body are the numbers found out of the 37 species decided in advance. These two cannot be compared. [S1, S15]

- The values of the tidal range also differ according to what they refer to. They are: "up to about 50 cm throughout the year" at Wajima (the press release); a width of the intertidal zone of about 60 cm at most and an average difference in 1 day of about 40 cm (the 2024 values that the paper gave from the tide tables of the Japan Meteorological Agency); a width of the intertidal zone of 20–30 cm (the figure of the prefectural body); and an average difference in 1 day of about 24 cm, a maximum of 40 cm, and a difference over 1 year of 67 cm (calculated by this paper from the 2024 predicted values of the Japan Meteorological Agency). The predicted values are the astronomical tide, and differ from the actual tide levels. [S2, S1, S3, S18]
- The table of results in the presentation slides of the prefectural body shows its columns by height of uplift (2 m and 4 m) and does not write the survey dates. The slides introduce Kinoura as an example of 2 m or less and Kaiso as an example of about 4 m, but it is not written whether the columns of the table are values for those sites alone. This paper used the tables of the research report for the values for each site. The 2025 preliminary figures of Kanazawa University do not write the place surveyed, but they are shown on the same page as the frame survey of the Kaiso rocky reef. [S3, S15, S6]
- The numbers in the research report of the prefectural body were recorded once per site, by eye, at four levels, and are not numbers of individuals. The ease of surveying also differs between sites, and the research report states that the subtidal zone was hard to see at Oshima because the tide level was high and at Akasumi because of wind and turbidity. [S15]
- The numbers of species in 2020 and 2024 at Nagahashi and Kinoura are values from fixed-site surveys by the same method. However, in 2024, because the uplift moved the shoreline forward by 44 m at Nagahashi and by 33 m at Kinoura, the survey location was moved to the new water's edge, and the values are not a comparison of the same rocks. The width by which the shoreline at Nagahashi moved forward is about 60 m in the Association's diving survey. [S15, S5]
- The overseas examples differ in both tidal range and method of measurement. We found no source that applied the Kaikōura rule of thumb of "a quarter of the tidal difference" to Sotoura and examined it. [S11]

Where the figures disagree

- The numbers of species in the Kaiso paper are 92 species of molluscs and 5 species of echinoderms. The symposium material from before the publication of the paper (31 January 2026; it describes the paper as "in press") gives 91 species of molluscs, 6 species of echinoderms and more than 6 species of arthropods. This paper used the values of the paper, which was peer-reviewed and published later. [S1, S6]
- The main text of the paper gives the difference in height between frame 2 and frame 4 as about 50 cm in the results section and about 40 cm in the discussion section. As for the survey dates, too, the dates listed in the methods section number 6 days, but it is written as 7 occasions, and 27 March also appears in the captions of the photographs. [S1]
- The presentation slides of the prefectural body give the sites as the original 12 and the 6 added after the earthquake, and give the numbers of sites for each level of uplift as 9, 7 and 1 (17 in total; this paper's calculation). The abstract of the same presentation and the research report give the sites surveyed in 2024 as 16 sites (the 10 sites from before the earthquake and the 6 sites added), and the research report states that, of the original 12 sites, Katano was not surveyed and Kounyu could not be reached. This paper uses 16 sites. [S3, S15]
- The abstract of the presentation of the prefectural body states that uplift was confirmed at 4 of the 10 sites from before the earthquake, but the only ones it names as uplifted sites are Nagahashi and Kinoura among them, and the remaining 2 sites are not written. The research report shows a height of uplift, among the sites from before the earthquake, only for Nagahashi and Kinoura, and treats Oshima, Akasumi and others as coasts that were not uplifted. [S3, S15]

- The summary in the presentation slides of the prefectural body lists fushisujimoku among the species that are not growing in the new intertidal zone, but in the slides' table it is given as "often found" in the 2 m column. [S3]
- The summary in the same slides states that, with both the 2 m and the 4 m uplift, turban shells and sea anemones had appeared in the new intertidal zone, but in the table there are no such marks in the 4 m column, and the marks there are for the 3 species urauzugai, purple sea urchin and reishigai. [S3]
- The numbers of species at the new water's edge differ between the two materials of the prefectural body. The table in the presentation slides gives 10 species of animals and 13 species of seaweeds in the 2 m column, and 3 species of animals and 13 species of seaweeds in the 4 m column, while the table of the research report gives 6 species of animals and 17 species of seaweeds at Kinoura (10 May 2024), and 4 species of animals and 17 species of seaweeds at Kaiso (27 June). The species listed in the slides' table number 20 each for animals and seaweeds, fewer than the 37 each of the research report, and the differences in the numbers of seaweeds and in the number of animals at Kaiso can be explained by the difference in the species listed (the result of this paper's checking of the two tables against each other). On the other hand, turban shell, purple sea urchin, himekubogai, aogai (Nipponacmea schrenckii) and the sea anemone midori-isoginchaku (Anthopleura fuscoviridis), which are in the 2 m column of the slides, are not in the Kinoura column of the research report. The reason for this difference is not known from the materials. This paper uses the values of the research report, in which the survey dates and method are written. [S3, S15]
- The result for Maura in the research report is 6 species of animals in the table, but the main text states that himekubogai, ishidatami and urauzugai, which are given as "not found" in the table, were also found. Table 3 of this paper used the values of the table. [S15]
- The paper gives, from the tide tables of the Japan Meteorological Agency, the average tidal difference in 1 day at Wajima in 2024 as about 40 cm, but when this paper calculates from the predicted values of the same tide tables, the average is about 24 cm, and 40 cm is the maximum of the difference in 1 day. The maximum width of the intertidal zone of about 60 cm is also 67 cm in this paper's calculation (the difference between the highest high tide of August and the lowest low tide of March). [S1, S18]
- The seaweeds at Nagahashi decreased from 24 species to 13 species in the table of the research report of the prefectural body. On the other hand, the Association's diving survey (June 2025) states, in comparison with the same survey of June 2020, that there was no large change in the mix of large brown algae and that umitoranoo had disappeared. The values of the research report are numbers out of the 37 species decided in advance, and the diving survey looked at large brown algae on lines down to a water depth of 8 m, so what was counted, the scope and the year differ (this paper's view). [S15, S5]
- The width by which the shoreline moved forward with the uplift differs between sources: at Kaiso, 116 m (the lines of the prefectural body) and about 100 m (the Association); at Kinoura, 33 m (the lines of the prefectural body and the research report), about 15 m (the Association) and about 60 m (the Center's outreach magazine, an observation of March 2024); and at Nagahashi, 44 m (the research report) and about 60 m (the Association). This is thought to be because the positions of the lines measured and the times differ (this paper's view). The values of uplift, too, are, at Kaiso, 3.6–3.9 m (the AIST value quoted by the paper), about 4 m (the prefectural body), 400 cm (the value that the research report took from a collection of photographs) and 4.1 m (the value used in the Association's report) (R7-B01). [S3, S15, S26, S5, S1]
- On the tsunami at Kaiso, the paper states that no conspicuous traces of a tsunami were seen in two field surveys, and that it can be read as about 1.5 m from a figure in a computational study as well (quotation). The Association's report considers that Kaiso was hit by a tsunami of about the same size, from the fact that at Tsurugiji, 9 km to the south, the height to which the tsunami ran up on land (the run-up height) was 2.4 m above mean sea level. The overall summary of the same report states that the effects of the tsunami were limited to the tip of the peninsula near the epicentre. The material of the prefecture's committee explains the change in the numbers of species of living things as the loss of the previous environment because of the

tsunami, but 3 of the 4 sites in that figure are outside Sotoura. The paper and the materials of the prefectural body give being left dry as the reason for death on the uplifted rocky shores of Sotoura. The research report of the prefectural body states that no conspicuous effect of the tsunami could be confirmed on the rocky reef coasts. On the rocky shores of Iwate Prefecture in 2011, too, the decrease caused by the tsunami was about the same as, or smaller than, that caused by the high waves of a large low-pressure system of the kind that comes once in several decades. [S1, S5, S4, S3, S15, S19]

Reliability and the standpoint of the sources

Reliability differs from item to item. That, on the uplifted rocky shores of Sotoura, almost all the living things of the dried-out intertidal zone and below it died is shown in the same way, by separate methods, by a peer-reviewed paper from universities, the surveys of the prefectural body, the report of the Ministry of the Environment and the diving survey of a business association, and its reliability can be said to be high. The mix of living things at Kaiso before the earthquake (the species and numbers inside the frames) comes from a peer-reviewed paper, and its reliability can be said to be high. The differences in the number of species by height, and the depth at which the species were most numerous, are based on the results of surveying, in 1 day, 18 frames placed on 1 line, and on an estimate from the height of the tide on that day, and the paper itself says "Preliminary assessment" in its title. For this reason, the reliability is medium. That the species of animals found decreased on the uplifted rocky shores is shown by the research report of the prefectural body, which surveyed the 10 sites that correspond to this paper's Sotoura by the same method and set side by side the sites that can be compared with before the earthquake and the sites that were not uplifted, and the reliability is medium. This is because it was a single survey recorded by eye at four levels, and only 4 sites can be compared with before the earthquake. As for the differences by size of uplift, the research report itself shows the possibility that survival is not decided by the height of uplift alone, and they cannot be separated from differences in how the waves strike and in topography, so the reliability can be said to be low. The state of recovery after the earthquake comes from material with preliminary figures and a press release, a single survey by the prefectural body in 2024, a single diving survey, and news reports and an outreach magazine; there are no numbers counted continuously at the same place, and the reliability can be said to be low. As for in how many years things will return, the only outlook for Sotoura is the remark of a researcher conveyed in a news report, with no grounds given, and the overseas examples also differ in tidal difference and in the conditions of the sea, so the reliability can be said to be low.

The standpoint of the sources also needs attention. The Kaiso paper, the press release of Kanazawa University and the other institutions, and the symposium material are from the same group of researchers, and are not independent confirmation. The researcher whose outlook was conveyed in the news report (June 2024) is also 1 member of this group. The research report of the Ishikawa Prefecture Noto Marine Center is a report edited by the Center and published by the prefecture, and it shows the method, the survey dates and tables for each site. Its submission rules state that whether to carry a contribution is decided by peer review by the editorial committee members. The slides of the presentation at the conference are not peer-reviewed, and the table of results does not state the survey dates either. The figure in the material of the prefecture's committee was made from this research report. The research report, the presentation, the figure in the committee's material, and the Center's outreach magazine are based on the surveys of the same Center, and are not independent confirmation. The explanatory article on the permanent quadrat survey was also carried in the Center's outreach magazine, and people of the Center take part in the survey. The report of the Kanazawa Association of Corporate Executives is the report of a survey carried out by a business association with a grant from The Nippon Foundation, and is not peer-reviewed. People from the prefecture's Fisheries Division and Fisheries Research Center took part in this survey as observers, and 1 of them is also a co-author of the presentation of the prefectural body. The report by Ryoko Ishikawa was carried in an academic society's journal, but it is not shown whether it was peer-reviewed. The example of the 1923 Kanto earthquake is cited by the Association's

report; the 2011 subsidence at Oshika and the changes in the subtidal zone after the disaster are cited by the Kaiso paper and the press release; and the 2007 uplift at Akakami is cited by the Center's research report; this paper has not checked the original materials. The example of the rocky shores of Iwate Prefecture in 2011 comes from an article written by researchers of Hokkaido University for a special feature in an academic society's journal. One of the authors of this article is the researcher who wrote the explanatory article on the permanent quadrat survey. The three papers on Kaikōura and the Fisheries New Zealand report on the survey of the rocky shores (March 2021) are centred on the same group of researchers at the University of Canterbury, and are not independent confirmation. This report was issued by the national fisheries authority, and the sites surveyed were first surveyed in 2017 as part of the programme for the recovery of the sea that the national government carried out after the earthquake. For the paper on the 1985 earthquake in Chile and the 2019 paper that summarised the effects of the Kaikōura earthquake, only the English abstracts were read.

The publisher of this paper (SeatecHIROSHIMA Ltd.) runs a business that controls the attachment of living things by surface treatment of materials. This covers both preventing fouling from attaching (antifouling) and making it easier for eelgrass (a kind of seagrass) to take root for the restoration of seaweed and seagrass beds. It is also developing a system that identifies the positions of oyster rafts and informs ships of them. This paper does not cover the company's own technology or results. This paper covers the death, because of the uplift, of the shellfish and seaweeds that live attached to rock, and the way living things are returning to the new water's edge, and also touches briefly on the shallow seaweed beds (R7-B08). Chapter 2 also touches on the paper's view that vertical port walls have fewer species than natural rocky reefs and that the difference is due to the unevenness of the surface of the rock. The attachment of living things and the restoration of seaweed and seagrass beds overlap with the publisher's field of business. The 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 for the prefecture's (Commerce, Industry and Labour Department, Industrial Policy Division) "survey project for attracting start-ups to Noto" (fiscal 2025 [Reiwa 7]) (September 2025). In this project, specialists accompany and support the selected companies in drawing up business plans and building connections in Noto (according to the prefecture's announcement). In October 2026, in the "Start-up Business Plan Contest Ishikawa 2026" run by Ishikawa Prefecture and the public interest incorporated foundation Ishikawa Sunrise Industries Creation Organization, the publisher received the top entrepreneur award for a plan on the theme of Nanao Bay (according to the announcement on the Organization's website). The Organization's website states that this award comes with a subsidy, the free use for 3 years of a facility that rents rooms to newly founded companies, and other benefits. In Noto, the publisher has concluded non-disclosure agreements and is working together with Nanaibe LLC and Yamaguchi Suisan of Nanao City, Atsumasa Nakamura of Kanazawa University, and the Noto council for raising fisheries earnings. With the Ishikawa Prefecture Fisheries Cooperative (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), there is the relationship that the publisher secured a site for its demonstration through Nanaibe LLC, its partner in the collaboration. The publisher is not a member of the Noto council for raising fisheries earnings. The area in Ishikawa Prefecture with which the publisher has been involved 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 that this paper draws on, researchers of Kanazawa University take part in the Kaiso paper, the press release of Kanazawa University and the other institutions, and the symposium material (researchers of the Natural History Museum and Institute, Chiba, and of Kyushu University also take part in the paper). The researcher whose outlook was conveyed in the news report is also a person of the same university. The explanatory article on the permanent quadrat survey also gives the name of a researcher of Kanazawa University as a person who is carrying the survey forward together. The chair and 1 of the members of the review committee for the prefecture's basic plan for coastal protection are also people of the

same university. The name of Atsumasa Nakamura does not appear among the authors or collaborators of these materials, in the news reports, or in the list of members of the committee. With Hiroshima University, the publisher has participated since October 2025, as one company in a consortium, in a research centre of the university (JST COI-NEXT). Michio Imai, the publisher's co-representative CEO, has served since 1 November 2026 as a researcher (part-time) at a research institute of the same university (the institute for the future of ocean and maritime affairs) (concurrently with his post as the publisher's co-representative CEO). In addition, the publisher joined joint research under the Town & Gown initiative of Kure City and Hiroshima University (an initiative in which the city and the university work together) (the research period is October 2025 to August 2026, with the contract concluded in March 2026). This joint research is funded by a research grant from Kure City, and the publisher received an allocation of research funds from that grant (April 2026). It has also been selected for the research grant from Kure City for the 2nd year (from September 2026). The explanatory article on the permanent quadrat survey that this paper draws on gives the name of a researcher of Hiroshima University as a person who is carrying the survey forward together, but that person is not a researcher who is the publisher's partner in the joint research. This paper does not use the data or results of this joint research. With Tohoku University, there is the relationship that, in October 2026, the publisher applied to a call for research of a research centre (COI-NEXT) centred on that university (the result had not come out as of 4 November 2026). The explanatory article on the permanent quadrat survey and the KAKENHI project that this paper draws on are those of a researcher of Tohoku University. Apart from the above, there are no relationships between the publisher and the organisations taken up in this paper (national government bodies, the prefecture and the cities and towns, universities and research institutes, overseas universities and institutions, news organisations, the companies and organisations named in this paper, and others) or the organisations active in Sotoura (fisheries cooperatives, local groups and others) that would affect the content of this paper. Relationships here means transactions, funding, joint research, and officers or employees of the publisher concurrently serving as employees or officers of the organisation. This is the publisher's judgement, made after checking the information the publisher has made public, the publisher's contracts and records, and the research for this paper.

6. Sources

We examined materials that had been published by 4 November 2026. We examined mainly peer-reviewed papers, materials of the national government and the prefecture, and reports of research institutes, and we used figures that were checked against the very materials listed as sources (for the papers S8 and S10, the English abstract only). Among the figures that papers and materials quote from other studies, there are some that have not been checked back to the original study, and these are marked "quotation" in the text. Values calculated by this paper are written as "this paper's calculation". Reliability: A = laws and regulations, statistics, materials of the national government and the prefecture; B = papers, reports of research institutes that state their method; C = explanatory materials for the general public, explanations by organisations, guidance with little description of the method; D = news reports.

ID	Source (publisher, year)	Type	Reliability	Chapters used
S1	Sato et al. (Kanazawa University; Natural History Museum and Institute, Chiba; Kyushu University): Onshore investigation of intertidal to subtidal mass benthic mortality assemblage: Preliminary assessment of the rocky reef coastline uplifted by the 2024 Noto Peninsula Earthquake (M7.6) (Plankton and Benthos Research 21(1): 25–35, 2026; accepted 9 December 2025, published online 26 February 2026; "the Kaiso paper" in this paper)	Paper	B	Chapters 1–5

ID	Source (publisher, year)	Type	Reliability	Chapters used
S2	Kanazawa University; Natural History Museum and Institute, Chiba; 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) (press release, 3 March 2026; the announcement of S1)	Explanatory	C	Chapters 1–5
S3	Higashide, Arakawa and Nakade (Ishikawa Prefecture Noto Marine Center) and 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) (presentation material of the 27th liaison conference of natural environment survey and research institutes [NORNAC27] and its abstract [page 27], 20 November 2024; the table of results does not state the survey dates)	Presentation	C	Chapters 1–5
S4	Ishikawa Prefecture: Review committee for the basic plan for coastal protection of the Noto Peninsula coast (2nd meeting, Document 3; 2nd meeting, summary of proceedings; list of committee members) (in Japanese) (5 November 2025; the figure of the numbers of species was made by the prefecture from Research Report No. 30 of the Noto Marine Center [S15])	Meeting	A	Chapters 2–5
S5	Kanazawa Association of Corporate Executives: Fiscal 2025 (Reiwa 7) report of the survey of the effects of the earthquake disaster on the coast of the Noto Peninsula (in Japanese) (March 2026; the report of a survey by a business association; a grant from The Nippon Foundation; not peer-reviewed)	Report	C	Chapters 2–5
S6	Robert Jenkins (Kanazawa University): Surveys of the seabed and marine ecosystems after the 2024 (Reiwa 6) Noto Peninsula Earthquake (in Japanese) (material of the Noto Satoyama Satoumi Future Creation Symposium, 31 January 2026; preliminary figures of the 2025 survey)	Explanatory	C	Chapters 1–5
S7	Biodiversity Center of Japan, Nature Conservation Bureau, Ministry of the Environment: Fiscal 2025 (Reiwa 7) survey report of the Noto Peninsula natural environment survey work (in Japanese) (March 2026; the survey was in October and November 2025)	Report	A	Chapters 2, 4
S8	Castilla: Earthquake-caused coastal uplift and its effects on rocky intertidal kelp communities (Science 242: 440–443, 1988; abstract checked)	Paper	B	Chapters 1, 2
S9	Castilla, Manríquez and Camaño: Effects of rocky shore coseismic uplift and the 2010 Chilean mega-earthquake on intertidal biomarker species (Marine Ecology Progress Series 418: 17–23, 2010; full text checked)	Paper	B	Chapter 2
S10	Schiel et al. (University of Canterbury and others): The Kaikōura earthquake in southern New Zealand: Loss of connectivity of marine communities and the necessity of a cross-ecosystem perspective (Aquatic Conservation 29(9): 1520–1534, 2019; abstract checked)	Paper	B	Chapters 1, 2
S11	Orchard et al. (University of Canterbury and others): Threshold effects of relative sea-level change in intertidal ecosystems: Empirical evidence from earthquake-induced uplift on a rocky coast (GeoHazards 2: 302–320, 2021; CC BY)	Paper	B	Chapters 2, 5
S12	Alestra et al. (University of Canterbury and Cawthron Institute): Rocky reef impacts of the 2016 Kaikōura earthquake: extended monitoring of nearshore habitats and communities to 3.5 years (New Zealand Aquatic Environment and Biodiversity Report No. 253, Fisheries New Zealand, March 2021; copy)	Report	B	Chapters 1–5
S13	McCowan and Neubauer: Pāua population monitoring in areas affected by the November 2016 Kaikōura earthquake, February 2023 update (New Zealand Fisheries Assessment Report 2023/26, Fisheries New Zealand, May 2023)	Report	B	Chapters 2, 3

ID	Source (publisher, year)	Type	Reliability	Chapters used
S14	Ryoko Ishikawa (sole-proprietor office Wajima Kaiso Lab): On the changes in sea-weed 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; received 27 March 2025 and accepted 31 March, with no statement of whether it was peer-reviewed; a survey under the Fisheries Agency's support project for measures to restore fishing grounds)	Report	B	Chapters 2, 3
S15	Higashide, Arakawa and Nakade (Ishikawa Prefecture Noto Marine Center): Monitoring survey of benthic invertebrates and of seaweeds and seagrasses on rocky reef coasts after the 2024 (Reiwa 6) Noto Peninsula Earthquake (in Japanese) (Research Report of the Noto Marine Center No. 30: 83–102, Ishikawa Prefecture Department of Living Environment, March 2025; the survey of 16 sites in May–June 2024; its category in the table of contents is original paper, and the submission rules state that whether to carry a contribution is decided by peer review by the editorial committee members)	Report	B	Chapters 1–5
S16	Iwasaki (Tohoku University): The effects of earthquakes on rocky intertidal organisms, and the project to monitor living things after the Noto Peninsula Earthquake (in Japanese) (the Noto Marine Center's outreach magazine "Noto no Kaichurin" [The undersea forests of Noto] No. 63: 2–5, November 2025; as people carrying the survey forward together, it gives people of the Noto Marine Center, Kanazawa University, the Noto Satoumi Education and Research Institute, Hiroshima University and Ishikawa Prefectural University)	Explanatory	C	Chapters 1–5
S17	National Institute of Informatics, KAKEN: Predicting the response of rocky intertidal communities to earthquakes: vulnerability and speed of recovery as understood from functional traits (in Japanese) (KAKENHI Grant-in-Aid for Early-Career Scientists 25K18539; principal investigator Aiko Iwasaki [Tohoku University]; 1 April 2025 to 31 March 2028)	Reference	A	Chapters 3, 4
S18	Japan Meteorological Agency: Tide tables (in Japanese) (the hourly and high-tide and low-tide predicted values for 2024 for Wajima and Tokyo; they are the astronomical tide, and differ from the actual tide levels; the differences in 1 day and over 1 year are this paper's calculation)	Reference	A	Chapters 1, 2, 5
S19	Noda and Iwasaki (Hokkaido University): The effects of earthquakes and tsunami on the benthos of the rocky intertidal zone (in Japanese) (Nippon Suisan Gakkaishi 83(4): 677–680, 2017; an article in a special feature of the academic society's journal, with no statement of the dates of receipt and acceptance; five rocky shores in central Iwate Prefecture that sank in the 2011 earthquake)	Report	B	Chapters 2, 5
S20	Schiel et al. (University of Canterbury and others): 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; accepted 28 October 2021, published 19 November; CC BY)	Paper	B	Chapters 1, 2, 5
S21	Chunichi Shimbun: A "world of death" along the coast of the coastal uplift; tsunami on top of uplift ... Kanazawa University biologist: "there are no sea urchins or turban shells either" (in Japanese) (27 June 2024; a dive by a reporter, a researcher and an underwater photographer)	News	D	Chapters 4, 5
S22	US Geological Survey (USGS): Plafker: Tectonics of the March 27, 1964, Alaska earthquake (Professional Paper 543-I, 1969)	Report	B	Chapter 2
S23	Higashide (Ishikawa Prefecture Noto Marine Center): The present state of "rock nori" on the uplifted coasts (in Japanese) (the Noto Marine Center's outreach magazine "Noto no Kaichurin" No. 62: 5, March 2025)	Explanatory	C	Chapter 4
S24	Hokuriku Chunichi Shimbun: 1000 dead turban shells, and a loggerhead turtle too ... ama divers "shocked"; survey of the uplifted fishing grounds of Wajima (in Japanese) (29 March 2024)	News	D	Chapter 4

ID	Source (publisher, year)	Type	Reliability	Chapters used
S25	Biodiversity Center of Japan, Ministry of the Environment: Monitoring Sites 1000, fiscal 2025 preliminary report of the rocky shore survey (in Japanese) (March 2026)	Reference	A	Chapter 3
S26	Higashide and Arakawa (Ishikawa Prefecture Noto Marine Center): The state of the damage from the Noto Peninsula Earthquake (in Japanese) (the Noto Marine Center's outreach magazine "Noto no Kaichurin" No. 61: 2–6, December 2024; the part on Sotoura is on page 5)	Explanatory	C	Chapter 5

Related materials: R2 Seaweed and seagrass beds and the living things of the sea, R6 What is changing (why now), R7-B01 Earthquake uplift on the Sotoura coast, R7-B03 The sandy beaches that keep moving even after the uplift, and the silting up of fishing ports, R7-B05 Remaking the basic plan for coastal protection (uplift and growing waves), R7-B06 The uses of the land that newly became land and of the coast, R7-B08 Shallow seaweed beds dried out by uplift, and the decrease in the area of seaweed beds in Sotoura, 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-B12 High water temperature in summer (the shallow sea of Sotoura), R7-B13 The mass die-off of abalone and turban shells, and the fall in catches that continues for some years, R7-B14 The rocky shores for rock nori and wakame (drying out of the nori beds, footing, and processing sites), R7-B25 The ama diving fishery of Wajima (numbers of people, reopening, and the passing on of skills), R7-B26 Rebuilding the local activities that protect the seaweed beds of Wajima, I1 List of assessments