R3-1 Oyster mortality (die-off)

In oyster aquaculture, how much loss is caused when the oysters being farmed die in large numbers, and how far are the causes and the countermeasures understood?

Readers

Fishery cooperatives and local governments (staff in charge of fisheries), research institutes, investors and others without specialist knowledge, who want to check in figures how much loss the mass death of oysters is causing and how far the causes and the countermeasures are understood.

Takeaways

1. In the national statistics since 1956, the largest harvest of farmed oysters in Japan was 270,858 tons in 1988. In 2024 it had fallen to 148,149 tons. Hiroshima Prefecture accounted for 63.6% of the national total in 2024. These are values counted by weight in shell.
2. In the autumn of 2025, farmed oysters died in large numbers, mainly in the Seto Inland Sea (mortality, or die-off). Hiroshima Prefecture's production in fiscal 2025 (July 2025 to June 2026) was 57% of a normal year. Because the unit price rose, the production value was 73% of the previous fiscal year and 87% of a normal year. We find no estimate of the amount of damage by the prefecture or the national government.
3. The national government and Hiroshima Prefecture see the main cause of the 2025 mortality as high water temperature that lasted for a long time. They state that, depending on the place, high salinity, lack of oxygen and other factors were added to it. All of these are provisional views, and the final opinion of the prefecture's expert panel is scheduled for March 2027. The possibility of disease is described as "extremely low".
4. In 2026, too, around 60–70% of the oysters died in some waters in the western and central parts of Hiroshima Prefecture. This is a share above the rough guide for mortality in an ordinary year (30–50% according to the Fisheries Agency). This value is in the October summary of what the Fisheries Agency heard from the prefectures, and it is not a counted value. The same summary states that there is no information that producers' oysters died "on a large scale". It does not say what it calls large scale. The 2026 season is still under way.
5. Measures against mortality include watching the sea and issuing warnings, improvements to seed, and attempts to increase the nutrients in the sea. We find no figures showing how much these have reduced mortality. The arrangements that support a fall in income are fishery mutual aid and loans and subsidies from the prefecture and the national government. In 2023, 91.3% of the management entities in Hiroshima Prefecture whose main business is oysters had joined some form of fishery mutual aid.

After reading

When you record oyster mortality in your own area, write down the following: the date of counting, the number of years of farming, whether the oysters are ordinary oysters (diploids) or triploids, the hanging depth, and the number alive and the number dead. A triploid is an oyster with 3 sets of chromosomes. Also write down how you counted (for example, that individuals with only the shell left were counted as dead). If you can measure them, also attach the water temperature, salinity and dissolved oxygen at the same depth. Dissolved oxygen is the amount of oxygen dissolved in seawater.

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1. Key points

- In the national statistics since 1956, the largest harvest of farmed oysters in Japan was 270,858 tons in 1988. In 2024 it had fallen to 148,149 tons. Hiroshima Prefecture accounted for 63.6% of the national total in 2024. These are values counted by weight in shell. [S1]
- In the autumn of 2025, farmed oysters died in large numbers, mainly in the Seto Inland Sea (mortality, or die-off). Hiroshima Prefecture's production in fiscal 2025 (July 2025 to June 2026) was 57% of a normal year. Because the unit price rose, the production value was 73% of the previous fiscal year and 87% of a normal year. We find no estimate of the amount of damage by the prefecture or the national government. [S2, S3]
- The national government and Hiroshima Prefecture see the main cause of the 2025 mortality as high water temperature that lasted for a long time. They state that, depending on the place, high salinity, lack of oxygen and other factors were added to it. All of these are provisional views, and the final opinion of the prefecture's expert panel is scheduled for March 2027. The possibility of disease is described as "extremely low". [S3, S4]
- In 2026, too, around 60–70% of the oysters died in some waters in the western and central parts of Hiroshima Prefecture. This is a share above the rough guide for mortality in an ordinary year (30–50% according to the Fisheries Agency). This value is in the October summary of what the Fisheries Agency heard from the prefectures, and it is not a counted value. The same summary states that there is no information that producers' oysters died "on a large scale". It does not say what it calls large scale. The 2026 season is still under way. [S3, S4]
- Measures against mortality include watching the sea and issuing warnings, improvements to seed, and attempts to increase the nutrients in the sea. We find no figures showing how much these have reduced mortality. The arrangements that support a fall in income are fishery mutual aid and loans and subsidies from the prefecture and the national government. In 2023, 91.3% of the management entities in Hiroshima Prefecture whose main business is oysters had joined some form of fishery mutual aid. [S4, S5, S6, S7, S8, S9, S25]

2. What is happening

Japan: how oysters are farmed, and how the figures are counted

The death of oysters that are being farmed is called mortality (die-off). A raft is a platform floating on the sea from which oysters are hung. Fouling organisms are living things that attach to and grow on the oysters and the rafts (for details, see R3-2).

Oysters are farmed either by hanging them in the sea or by putting them in baskets. A Fisheries Agency document divides the main methods into the hanging method (suspended culture, in which ropes with oysters attached are hung in the sea) and the basket method (single seed), in which oysters are grown one by one in baskets. The hanging method includes the raft method, in which the ropes are hung from a raft, and the longline method, in which they are hung from a long rope fitted with floats. The raft method allows the raft to be moved but is said to break easily and to be weak against waves, and it is used all over Japan, including Hiroshima, Miyagi, Okayama and Hyogo. The longline method is strong against waves and is used in some areas with strong wind and waves, such as Miyagi and Iwate. The basket method tends to give oysters of uniform shape, but because it uses the sea as a flat surface the production volume is limited, and it is used in some places such as Tokushima and Oita. No breakdown is given of how much is produced by each method (the sources of the table in the document include web pages that are not official). [S10]

Oyster aquaculture is work that takes more than 1 year, from collecting seed in summer to shipping from autumn to spring. The Fisheries Agency's check sheet (2026) shows the flow of work in the hanging method as

follows. In July–August, seed is collected by letting the oyster larvae drifting in the sea (the young that have hatched from eggs and have not yet attached to anything) attach to scallop shells (seed collection). After seed collection, there is a stage of growing the spat (small shellfish), and then, until the following spring (March–May), their growth is deliberately held back to make hardy seed (hardening). During that time the seed oysters (the small oysters from which farming starts) are inserted into ropes, and in March–May the spacing between the shells is widened to 20–30 cm. From around June they are hung in the sea in earnest (main hanging), and they are harvested from autumn (around October) onwards. The ways of hardening that are listed include using racks (hardening racks), hanging the oysters deep, and bundling the ropes and hanging them densely. In an example in another document of the same Fisheries Agency, seed is collected in May–September of year 1, hardening is in October–March, farming starts in April of year 2, and shipping starts in October of year 3. A leaflet from Miyagi Prefecture (2019) states that the oysters are landed after about one and a half to 3 years. Oysters are said to spawn in June–August, the larvae to drift for about 2 weeks before attaching to something, and the oysters to mature in 2–3 years (quoted from another national guideline). [S10, S11]

The quantity of oysters is counted either in shell or as shucked meat. In shell is the weight including the shell, and shucked meat is the weight of the meat with the shell removed.

The national statistics count the quantity of oysters by weight in shell, and assign it to the prefecture where the management entity is located. The Marine Fishery Production Statistics Survey of the Ministry of Agriculture, Forestry and Fisheries (a fundamental statistic under the Statistics Act [one of the national government's especially important statistics]) shows the harvest of oysters by weight in shell (up to 2011 both in shell and as shucked meat, and from 2012 in shell only). The category "oysters" includes, besides the Pacific oyster (magaki; the oyster species farmed in Hiroshima, Miyagi and elsewhere), the itabo oyster, the suminoe oyster and the rock oyster (iwagaki). The harvest is assigned to the prefecture where the management entity that did the farming (a household or company that engages in fishing or aquaculture for sale) is located, and the farming of seed for sale (the small shellfish from which farming starts) is excluded. The survey is a complete survey (a survey that covers every entity in scope), and in 2025 the response rate of the 1,363 survey units for marine aquaculture (aquaculture carried out in the sea) (this is not the number of oyster management entities) was 97.5% (in addition, there were 36 units in the collective survey, which surveys entities together and makes an estimate; no figures are entered for units that did not respond). Besides the calendar year (January–December), from the 2024 survey the figures are also compiled by aquaculture year (July of the previous year to June). The first report gives approximate figures (rounded preliminary values) by the end of May of the following year, and the final figures (confirmed values) come out around the end of February of the year after that. [S1]

The Census of Fisheries is a complete survey carried out by the Ministry of Agriculture, Forestry and Fisheries every 5 years (as of 1 November). In this paper, a management entity whose fishery with the largest sales value is oyster aquaculture is called a "management entity whose main business is oysters". [S5]

Japan: production volume and value

Seen over the long term, the national harvest of oysters is falling. In the national statistics (in shell, calendar year, final figures), the largest harvest in 1956–2024 was 270,858 tons in 1988, and the 148,149 tons of 2024 is 54.7% of that (this paper's calculation). It is 19.3% less than the 183,685 tons of 2014, but 2014 was a year about 12% higher than the years before and after it (164,139 tons in 2013 and 164,380 tons in 2015). Comparing 5-year averages, 2020–2024 (156,122 tons) is about 6% lower than 2012–2016 (166,449 tons) (both are this paper's calculations). In between, there were also years of increase, such as 2017–2018 (Table 1). Oysters in 2024 were equal to 18.5% of the 802,927 tons harvested by marine aquaculture (this paper's calculation; a rough guide, because the weight is in shell and the basis of weight differs from that for fish and seaweed). [S1]

The national harvest in 2025 fell further. The approximate figure in the first report is 134,400 tons, 13,700 tons (9.3%) less than the previous year, and the national government states that it fell in Hiroshima Prefecture and elsewhere (the amount and percentage of the fall are values that the Ministry of Agriculture, Forestry and Fisheries derived from approximate figures in units of 100 tons). Because it is a calendar-year value, the effect of the mortality from autumn 2025 is included only for July–December. The confirmed value is scheduled to come out in February 2027. [S1]

The output value (a national estimate made by multiplying the production volume by the wholesale price in the producing area) has not fallen as much as the volume. The national output value of oysters was 41.503 billion yen in 2024, 14% more than the 36.272 billion yen of 2014 (this paper's calculation), and in nominal terms, not adjusted for changes in prices, it was the 4th highest since 1960 (the highest is 42.723 billion yen in 1994). Comparing 5-year averages, 2020–2024 (about 37.3 billion yen) is about 9% higher than 2012–2016 (about 34.1 billion yen) (this paper's calculation), and since the volume is about 6% lower over the same period, the rise in unit price supported the value (this paper's interpretation). Year by year, the value was about 32.4–35.0 billion yen in 2017–2021, and from 2022 it rose to about 38.9 billion yen, about 40.9 billion yen and about 41.5 billion yen (Table 1). Seed for sale is not included in the output value, and the production value of oyster seed in 2024 was a separate 666 million yen. The output value for 2025 has not yet been published. [S12]

Table 1 National harvest and output value of oysters (t = tons)

Year	Harvest (t, in shell)	Output value (nominal)	Type of value and conditions
1988	270,858	30.953 billion yen	Final figures. The harvest is the largest in 1956–2024 (the highest output value is in 1994)
2012	161,116	30.438 billion yen	Final figures
2013	164,139	30.140 billion yen	Final figures
2014	183,685	36.272 billion yen	Final figures. The volume is about 12% higher than in 2013 and 2015 (this paper's calculation)
2015	164,380	38.424 billion yen	Final figures
2016	158,925	35.421 billion yen	Final figures
2017	173,900	33.447 billion yen	Final figures
2018	176,698	33.448 billion yen	Final figures
2019	161,646	35.032 billion yen	Final figures
2020	159,019	32.449 billion yen	Final figures
2021	158,789	32.989 billion yen	Final figures

Year	Harvest (t, in shell)	Output value (nominal)	Type of value and conditions
2022	165,590	38.905 billion yen	Final figures
2023	149,064	40.893 billion yen	Final figures
2024	148,149	41.503 billion yen	Final figures. The harvest is 54.7% of that of 1988 and 19.3% less than in 2014. The 2020–2024 average is about 6% lower than the 2012–2016 average (this paper's calculation)
2025	134,400	Not published	Approximate figure in the first report. The confirmed value is scheduled for February 2027

Note: The harvest is the weight in shell for the calendar year (January–December) and excludes the farming of seed for sale. The output value is a national estimate made by multiplying the production volume by the wholesale price in the producing area, and is a nominal amount not adjusted for changes in prices (it does not include seed for sale; the highest since 1960 is 42.723 billion yen in 1994). The 5-year averages of the output value (about 34.1 billion yen for 2012–2016 and about 37.3 billion yen for 2020–2024) are this paper's calculations from the values for each year in the same national table. [S1, S12]

Japan: mortality

Some oysters die even in an ordinary year. The Fisheries Agency gives the share of mortality in normal times as generally 30–50%, but it does not show the basis or the way of counting. The normal-year values in regional materials differ from this (Table 6 in chapter 5). [S3]

The mass mortality of autumn 2025 occurred mainly in the prefectures of the Seto Inland Sea. The summary of what the Fisheries Agency heard from each prefecture (as of 6 July 2026) states that mortality of 70–90% at the highest occurred in the prefectures of the Seto Inland Sea. Outside the Seto Inland Sea, there was mortality of 20–90% depending on the district in Miyagi Prefecture (20–90% in the north and 20–80% in the central to southern part), and of 90% of the 1-year oysters (oysters farmed for 1 year) in Kochi Prefecture (cause unknown). For Iwate Prefecture, it was roughly 10–60% depending on the district, described as broadly the same as in usual years although 2-year oysters and 3-year oysters died in some areas; Fukuoka Prefecture was described as the same as in usual years, and Mie Prefecture as the same as in usual years or lower. The figures are ranges from interviews, not counted values. The values for Ehime Prefecture (Imabari City and Ainan Town) are dealt with in R7-C29 (Seto Inland Sea side: oyster mortality in Imabari City) and R7-C06 (Uwa Sea: oyster mortality in Ainan Town) of this series, and so are not included in this paper. [S3] In the national statistics (approximate figures), the 2025 harvest of Miyagi Prefecture was about 17,200 tons, more than the 15,190 tons of 2024, and the national decrease in 2025 was concentrated in the prefectures of the Seto Inland Sea (this paper's calculation; the share of mortality and the harvest differ in timing and in the way of counting, and cannot be compared directly). [S1]

The national government estimates that the 2025 mortality was a compound event with high water temperature as the common factor. The Fisheries Agency's summary (as of 23 January 2026) estimates that high water temperature was confirmed in common in every sea area and that the mass mortality occurred when it combined with other factors specific to each sea area. It states that there are no reports that a known pathogen was the cause of death. The factors listed in the table are 6: high water temperature, hypoxia (a state in which the seawater does not have enough oxygen), lack of food, excessive farming density, high salinity (a state in which the salinity of the seawater is high) and red tide (a phenomenon in which plankton increase and the colour of the sea changes); fouling organisms are not among them. In the summary of the interviews with the

prefectures (July 2026), too, high water temperature is the common presumed factor, and high salinity, lack of food, hypoxia and others are also listed. [S3]

The national government's table of countermeasures lists the removal of fouling organisms as one of the ways of dealing with lack of food. The basis shown is 1 trial in Matsushima Bay, Miyagi Prefecture (2018), and the Fisheries Agency summarises this study as having found that removal was considered effective for the survival of oysters. However, no mass mortality occurred in the year of the trial in the original study, and no difference in survival due to the treatment is shown (chapter 3 of R3-2). In the national government's outline of efforts for 2026, the only response to lack of food is the supply of nutrients through the management of nutrient salts (the nutrients of phytoplankton, such as nitrogen and phosphorus) (an arrangement for increasing the nitrogen and other nutrients that enter the sea from sewage treatment plants and the like). [S3, S11]

On the other hand, the national government's explanatory material for the general public lists the increase in fouling as one of the reasons for mortality. The Fisheries Agency's "On the situation surrounding oyster aquaculture" (November 2025) states that poor growth and mortality are occurring because of the rise in seawater temperature in recent years, the increase in fouling and other factors. As countermeasures, it lists methods of removing the fouling by hot-water treatment (dipping in hot water for a short time), freshwater bathing (dipping in fresh water) and air exposure (exposing to the air), so as to improve growth and lower the risk of mortality. There is no statement of quantities or percentages, or of regions or years. In the same column, deep hanging (hanging the oysters deep) is also listed as a measure against high water temperature, and the use of triploids (oysters with 3 sets of chromosomes) as a measure against weakening caused by continued spawning. [S10]

No evidence has been found that disease was the cause in 2025. The Fisheries Agency states that there are no reports that a known pathogen was the cause of death, and Hiroshima Prefecture's expert panel also described the possibility that it was due to disease as extremely low. On the oyster herpesvirus (OsHV-1), there is a survey (2012) by national research institutes and others. Of 1,714 specimens, such as spat (small shellfish), of 3 oyster species including healthy Pacific oysters, collected in 2007 and 2011 in 6 prefectures including Miyagi, Hiroshima and Okayama, the gene was found in 123 (finding the gene does not mean that the disease has developed). The type found was different from the type (µVar) suspected of causing mass summer deaths in Europe, and no notable mortality had been reported at that time. However, a 2017 national report states that disease and death occurred in infection trials using strains from Japan (water temperatures of 23, 26 and 29°C). [S3, S4, S13]

For 2026, the Fisheries Agency's October summary (interviews with the prefectures) states that, following the mass mortality of autumn 2025, each prefecture strengthened its monitoring and carried out efforts to reduce mortality, and that "at present, there is no information that producers' oysters have died on a large scale". It does not say what it calls large scale, and the same summary also includes sea areas where mortality exceeded the rough guide for normal times (for Hiroshima Prefecture, see "The mass mortality of autumn 2025" in chapter 2). Also, in some waters of Iwate Prefecture, there is said to have been mortality of about 50% after fouling was removed by hot-water treatment (no conditions stated). The document does not link this mortality to the treatment, and there is no comparison with oysters that were not treated. 50% is the upper end of the Fisheries Agency's rough guide for normal times (30–50%). The liaison council of the Fisheries Agency, the Japan Fisheries Research and Education Agency (the national fisheries research institute) and others (14 October 2026) also summarises that, although there is no large-scale mortality, there was some mortality in several areas. The season is still under way. [S3, S14]

National research to find the cause is continuing. The Ministry of Agriculture, Forestry and Fisheries called for proposals for urgent research in January 2026, and the Japan Fisheries Research and Education Agency is carrying it out as the lead body, together with the Hiroshima Prefectural Technology Research Institute, in fiscal 2025–2026. The goal is to identify the cause of the mass mortality of autumn 2025 and to make a manual of

production management for avoiding mortality. The announcement of the call stated that deaths of 50–90% of farmed Pacific oysters had been reported one after another in the Seto Inland Sea, but that the cause had not been identified. An interim report was made at the liaison council of 31 August 2026, but that document could not be opened on 3 November 2026 (chapter 5). [S14]

Region (Hiroshima and the Seto Inland Sea): production volume and value

Hiroshima Prefecture is the prefecture with the largest oyster harvest in the national statistics. In the harvest by prefecture for 2024 (in shell, calendar year, final figures), Hiroshima Prefecture had 94,290 tons, 63.6% of the national total (the same as in chapter 2 of R1). It is followed by Miyagi Prefecture with 15,190 tons (10.3%), Okayama Prefecture with 14,671 tons (9.9%), Hyogo Prefecture with 7,348 tons (5.0%), Iwate Prefecture with 5,058 tons (3.4%) and Hokkaido with 3,682 tons (2.5%) (the percentages are this paper's calculations). For the aquaculture year (July 2023 to June 2024) in the same table, Hiroshima Prefecture has 94,656 tons, 62.5% of the national 151,414 tons (this paper's calculation). [S1]

Hiroshima Prefecture's share has stayed at roughly around 60%. In the final figures in shell for the calendar year, Hiroshima Prefecture's share of the national total in 2012–2018 was 70.8%, 64.6%, 63.5%, 65.0%, 60.2%, 59.5% and 58.9%. In 2019–2024 it is 61.3%, 60.4%, 58.5%, 58.5%, 59.8% and 63.6% (the percentages are this paper's calculations). In 2012–2013 Miyagi Prefecture was still recovering from the 2011 earthquake disaster (Miyagi Prefecture had 5,024 tons in 2012 and 11,581 tons in 2013), and Hiroshima Prefecture's share comes out high. Hiroshima Prefecture's harvest was 116,672 tons in 2014, 104,014 tons in 2018, 89,192 tons in 2023 and 94,290 tons in 2024. [S1]

There are 3 ways of counting the quantity of Hiroshima Prefecture's oysters, which differ in weight basis and period, and they cannot be mixed and compared (Table 2). The prefecture estimates the weight of shucked meat for each prefecture on the basis of the national in-shell statistics. In this estimate, Hiroshima Prefecture in 2024 (calendar year) has 17,051 tons, 65.3% of the national 26,108 tons. The method of conversion is not stated. Hiroshima Prefecture's share in the same estimate was 61.0–64.6% in 2018–2023, and in every year of 2018–2024 it is 1.7–3.3 points (a difference between percentages) higher than the share in the national in-shell statistics (the comparison is this paper's calculation). Working back from the prefecture's estimate, the weight of shucked meat is equal to 18.1% of the weight in shell for Hiroshima, 10.0% for Miyagi, 22.2% for Okayama and 25.0% for Hyogo, and it appears that a different ratio is used for the conversion for each prefecture (this paper's calculation and inference). The production of 16,900 tons in fiscal 2024 in the survey by the prefecture's Fisheries Division (the fiscal year is July to June of the following year) is a separate series from the calendar-year value in the prefecture's estimate (17,051 tons). [S1, S2]

Table 2 The 3 ways of counting the quantity of Hiroshima Prefecture's oysters (t = tons)

Way of counting	Period	Weight basis	2024 (fiscal 2024)	2025 (fiscal 2025)	Share of the national total
National statistics	Calendar year (January–December)	In shell	94,290 (final figures)	About 82,800 (approxi - mate figure)	63.6% in 2024, 61.6% in 2025 (this paper's calculation)
Prefecture's estimate (national statistics converted to shucked meat)	Calendar year	Shucked meat (estimate; the method of conversion is not stated)	17,051	—	65.3% in 2024

Way of counting	Period	Weight basis	2024 (fiscal 2024)	2025 (fiscal 2025)	Share of the national total
Survey by the prefec - ture's Fisheries Division	Fiscal year (July to June of the following year)	Shucked-meat equivalent (shucked meat, plus the quantity of in-shell oysters converted to shucked meat)	16,900	10,100	—

Note: The prefecture's estimate and the survey by the prefecture's Fisheries Division are both weights of shucked meat, but they differ in period and in how they are obtained. The weight basis of the survey by the prefecture's Fisheries Division follows a note in past editions of the prefecture's guidelines (the Hiroshima Oyster Production and Shipment Guidelines; a reference document on the production and shipment of oysters that the prefecture makes every year, and not an obligation based on law; chapter 3) (the table in the fiscal 2026 edition gives the unit only as "tons"). The national statistics for 2025 are the approximate figures of the first report (in units of 100 tons). "—" means that there is no value or that it was not examined in this paper. [S1, S2]

Hiroshima Prefecture's production in fiscal 2025 fell below 60% of a normal year. In the survey by the prefecture's Fisheries Division, production (shucked-meat equivalent) in fiscal 2025 (July 2025 to June 2026) was 10,100 tons. This is 60% of the previous fiscal year (16,900 tons) and 57% of a normal year (the fiscal 2015–2024 average of 17,610 tons) (the same as in chapter 2 of R1). Oysters for the fresh market were 3,000 tons (45% of a normal year) and oysters for processing were 7,100 tons (64% of a normal year). Production in fiscal 2018–2024 was 16,100–18,200 tons. The prefecture states that, because of the mortality that occurred throughout the prefecture from September 2025 onwards, production was below a normal year in both the earlier and the later part of the season. [S2]

The production value did not fall as much as the volume, because the unit price rose (Table 3). The production value in fiscal 2025 was 16.2 billion yen, 73% of the previous fiscal year (22.2 billion yen) and 87% of a normal year (the nominal fiscal 2015–2024 average of 18.7 billion yen), and it fell below 20.0 billion yen for the first time in 4 years. The production value in the most recent 3 fiscal years was 21.3 billion yen in fiscal 2022, 23.7 billion yen in fiscal 2023 and 22.2 billion yen in fiscal 2024, and compared with the average of these 3 fiscal years, about 22.4 billion yen, it is 72% (this paper's calculation). The average unit price was 1,604 yen per 1 kg, 151% of a normal year (1,064 yen) and 122% of the previous fiscal year (1,311 yen). Since the volume was 57% of a normal year and the unit price 151%, multiplying them gives a value of about 86% of a normal year, which almost matches the actual 87% (this paper's calculation). By use, the unit price of oysters for the fresh market was 2,094 yen per 1 kg, 153% of a normal year (1,365 yen) and 120% of the previous fiscal year (1,743 yen), and that of oysters for processing was 1,397 yen, 157% of a normal year (887 yen) and 126% of the previous fiscal year (1,113 yen). By use, the production value was 6.3 billion yen for the fresh market and 9.9 billion yen for processing. The prefecture's guidelines state that the fresh market was 32 points below the previous year and 29 points below a normal year, and that processing was 23 points below the previous year but 1 point above a normal year (differences when the previous fiscal year and a normal year are each taken as 100). The meat condition (how plump the meat is) was below a normal year in the earlier part of the season and above a normal year in the later part, so that the average weight of the shucked meat of the surviving oysters was 16.4 g, above a normal year (15.9 g). The Fisheries Agency's summary (as of 6 July 2026) also states that in every sea area of the prefecture, western, central and eastern, the meat condition is worse than in usual years but has been improving little by little since the latter part of January. [S2, S3]

Table 3 Production volume, production value and unit price of Hiroshima Prefecture's oysters (survey by the prefecture's Fisheries Division)

Fiscal year	Production (t, shucked-meat equivalent)	Production value (100 million yen, nominal)	Average unit price (yen/kg, nominal)	Number of management entities
2018	17,400	169	970	326
2019	16,100	151	934	310
2020	17,200	160	929	296
2021	18,200	190	1,042	296
2022	17,100	213	1,246	289
2023	17,800	237	1,330	288
2024	16,900	222	1,311	290
2025	10,100	162	1,604	288
Normal year (fiscal 2015–2024 average)	17,610	187	1,064	—

Note: The fiscal year is July to June of the following year. Production is shucked meat plus the quantity of in-shell oysters converted to shucked meat (according to a note in past editions of the prefecture's guidelines). The production value and the unit price are nominal values not adjusted for changes in prices. The values for fiscal 2018–2025 are from the table in the statistical materials of the fiscal 2026 edition of the prefecture's guidelines (production and other figures by fiscal year). The normal year is the value given by the prefecture; the values for each of fiscal 2015–2017 and the number of management entities in a normal year ("—") were not examined in this paper. No definition is given of how the management entities are counted (they cannot be mixed and compared with the census numbers). [S2]

The figure of 87% compared with a normal year works in the direction of making the loss look smaller. This is because the normal-year value is an average of nominal amounts and includes the years before the unit price rose (the unit price fell from 970 yen in fiscal 2018 to 929 yen in fiscal 2020 and then rose; in fiscal 2024 it was 1,311 yen, 35% higher than in fiscal 2018 and 41% higher than in fiscal 2020; this paper's calculation). Also, the production value is sales, not income. Many producers landed 1.5–2 times the amount of a normal year, and oyster shells also increased by about 28,000 cubic metres from the previous year (see the section "The mass mortality of autumn 2025"), but that labour and cost do not appear in the production value. The difference in production value (2.5 billion yen less than a normal year) is not an estimate of the amount of damage either. [S2, S15, S16]

Most of Hiroshima Prefecture's oysters are for processing. Of the production of 16,900 tons in fiscal 2024, oysters for processing (mainly frozen) were 11,600 tons (68.6%, this paper's calculation) and oysters for the fresh market were 5,300 tons. Oysters for eating raw are limited to oysters from the sea areas designated by the prefecture (where the most probable number [a statistically estimated number] of coliform bacteria per 100 ml of seawater is 70 or less) and the like. In the prefecture's processing flow, the in-shell oysters are washed, stored or artificially purified, and then shucked, and the shells are carried to temporary piling sites in the sea and elsewhere. The date of the start of shipping for fiscal 2025 was set by the Hiroshima Oyster Production Measures Council on 20 October 2025, and the prefecture gives the 2025 season as late October 2025 to the end of May 2026. [S2]

The fall from autumn 2025 can also be seen in the national statistics. In the approximate figures, Hiroshima Prefecture's harvest (in shell) in July–December 2025 was about 6,700 tons, about half (49%, this paper's

calculation) of the 13,579 tons of July–December 2024 (final figures). In the same period, Okayama Prefecture had about 600 tons (2,942 tons in 2024), Hyogo Prefecture had about 400 tons (1,450 tons in 2024), and the national total was about 21,000 tons (30,709 tons in 2024). Hiroshima Prefecture's harvest for the 2025 calendar year was about 82,800 tons, about 12% less than in 2024 and 61.6% of the national total (this paper's calculation). Of this decrease of about 11,500 tons, about 4,600 tons is a decrease in January–June, before the mortality (January–June was about 76,100 tons in 2025 and 80,711 tons in 2024; this paper's calculation). Because approximate figures are being compared with final figures, the differences are a rough guide. The national value for the whole season of July 2025 to June 2026 will not come out until the 2026 statistics (the first report is expected around May 2027). [S1]

Hiroshima Prefecture's output value is about half of the national total, a smaller share than its share of the volume. The 2024 output value of oysters was 20.364 billion yen for Hiroshima Prefecture, 49.1% of the national total. It is followed by Hyogo Prefecture with 4.572 billion yen (11.0%), Okayama Prefecture with 3.168 billion yen (7.6%), Miyagi Prefecture with 3.030 billion yen (7.3%) and Hokkaido with 2.924 billion yen (7.0%) (the percentages are this paper's calculations). Oysters made up 95.2% of the output value of Hiroshima Prefecture's marine aquaculture (this paper's calculation). The reason why the share of the value (49.1%) is smaller than that of the volume (63.6%) is not stated in the materials. This output value is a national estimate for the calendar year. It is a separate series, different in both origin and period, from the production value of 22.2 billion yen for fiscal 2024 (July to June of the following year) in the survey by the prefecture's Fisheries Division (Table 3), and they cannot be mixed and compared (chapter 5). [S2, S12]

Since 2019, the oyster harvest of the Seto Inland Sea as a whole can no longer be known from the national statistics. The last value for the Seto Inland Sea fishery district (a sea-area division used by the Ministry of Agriculture, Forestry and Fisheries, which combines the Seto Inland Sea side of the prefectures facing the Seto Inland Sea) is for 2018, when it was 130,965 tons (74.1% of the national total) (it was 144,209 tons and 78.5% in 2014, and 128,846 tons and 74.1% in 2017; the percentages are this paper's calculations). From the 2019 survey, publication by sea-area division was abolished, and the aquaculture tables are now by prefecture only. The total for the 3 prefectures of Hiroshima, Okayama and Hyogo in 2024 is 116,309 tons (78.5% of the national total, this paper's calculation), but because these are values for the whole of each prefecture and the scope differs, it cannot be compared with the value for the Seto Inland Sea fishery district. [S1]

In neighbouring Okayama Prefecture, too, the number of management entities is falling. In a report by Okayama Prefecture's research institute, Pacific oyster aquaculture in fiscal 2024 had 121 management entities and 1,954 rafts, production was 3,311 tons as shucked meat, and the production value was 4.0 billion yen (115% of the previous fiscal year). In fiscal 2018 there were 144 management entities and 2,013 rafts. The number of management entities in fiscal 2019–2023 was 138, 134, 132, 127 and 124, and production was 3,380, 3,053, 3,605, 2,670 and 3,149 tons. In fiscal 2024, main hanging was mainly from mid-April to early June, moving offshore (moving the rafts to the offshore farming grounds) was from mid-September to late October, and shipping was from 5 November 2024 to 20 May 2025. As a reason for the high unit price, the report gives the poor production of producing areas outside the prefecture. [S17]

Region (Hiroshima and the Seto Inland Sea): rafts, years of farming, seed

There are no official statistics on the number of rafts in Hiroshima Prefecture; there is only the statement "about 10,000 rafts" in research reports. A report by the Hiroshima Prefectural Technology Research Institute (2020) gives the number of oyster rafts on the farming grounds in the prefecture as about 10,000, but it does not state how or as of when the number was obtained. A 2009 report by the same institute has the same statement, which appears to be a repetition (not an independent confirmation; this paper's inference). The prefecture's guidelines ask that rafts be marked and that the number of rafts and the number of hanging lines set in the rules for exercising fishery rights (a fishery right is the right to fish or farm in a fixed area of water; these rules are rules in

which a fishery cooperative sets how the fishery right is to be used) be observed, but the total number of rafts is not published. [S2, S18]

The raft commonly used in the prefecture is made by assembling bamboo lengthwise and crosswise, tying it with wire and fitting expanded polystyrene as floats. According to the same report (2020), after about 5 years of use a raft becomes industrial waste, except for some of the expanded polystyrene. From 1 raft, a little under 700 hanging lines are hung, each made by threading about 35 sets of scallop shells with oysters attached and plastic tubes (spacers) alternately on a wire. [S18]

In Hiroshima Prefecture, oysters farmed for 2 years and for 3 years are shipped separately. The prefecture's Fisheries Division calls the oysters shipped from the start of the season "3-year-farmed oysters (nokoshi)", and the oysters whose shipping starts after the New Year "2-year-farmed oysters (yokusei, ikisu and others)" (the definition of how "2 years" and "3 years" are counted is not stated). As of December 2025, what was being shipped was mainly 3-year-farmed oysters. In the material that the Fisheries Agency compiled from interviews with the prefecture, there is no 3-year farming in the eastern sea area of Hiroshima Prefecture (as of July 2026). However, a prefectural document states that as of April 2026 the prefecture's "central and eastern district" was still landing mainly 3-year-farmed oysters, so the sea areas are divided differently. [S3, S15]

The seed for Hiroshima Prefecture's oysters is collected mainly from wild larvae in Hiroshima Bay. The larvae spawned in summer by the oysters being farmed are secured by letting them attach to scallop shells. The prefecture's fiscal 2026 guidelines call the ability to collect wild seed the "greatest advantage" of the prefecture's oyster industry, and state that the introduction of seed from outside the prefecture, which may hinder production, is to be kept to the necessary minimum. A 2008 public relations magazine of the prefecture's research institute stated that seed on roughly 200–300 million scallop shells was secured every year in Hiroshima Bay. [S2, S6]

Wild seed collection fails in some years. According to reports of the prefecture's research institutes, there was a large-scale seed collection failure in 2004, and there were also large-scale failures in 2013 and 2014. According to Hiroshima City, in fiscal 2013, fiscal 2014 and fiscal 2017 there were seed collection failures in which almost no spat could be secured anywhere in the prefecture. The prefecture's Fisheries and Marine Technology Center states that in 2014 only 16% of the required quantity of spat could be secured. A 2008 document of the same Center makes a trial calculation that, in a year of seed collection failure, the cost of buying seed to cover the shortfall alone would be up to 2.5 billion yen, and the wasted costs of labour, materials, fuel and so on would be 900 million yen or more, but the method of calculation is not stated (it is an estimate made to show the effect of research, not an actual purchase amount). [S19, S6]

Most of the seed that is sold comes from Miyagi Prefecture. In the national statistics, the seed sold (excluding seed for the producer's own use) in 2024 was 488,000 strings nationally (1 string is 60 scallop shells), of which Miyagi Prefecture had 295,000 strings (60.5%), Hiroshima Prefecture 71,000 strings (14.5%) and Mie Prefecture 33,000 strings (the percentages are this paper's calculations). In 2017 the national total was 646,000 strings, of which Miyagi Prefecture had 548,000 strings (84.8%, this paper's calculation). The national totals for 2018–2023 are 677,000, 676,000, 663,000, 722,000, 499,000 and 469,000 strings. The statistics do not show to which regions the seed was sold, and Hiroshima Prefecture's sales volume for 2020–2023 is marked as withheld (the national government does not publish a figure, in order to protect the confidentiality of individuals, companies and the like). Miyagi Prefecture states that seed oysters produced in the prefecture are also shipped to other prefectures and support aquaculture in many places (the prefecture's document gives 1 string as about 70–80 shells, a definition different from that of the national statistics). Okayama Prefecture's research institute gives the shortage of seed caused by the seed collection failure in Hiroshima Prefecture as one of the causes of the low survival in fiscal 2018 (others were heavy rain, red tide and so on). [S1, S11, S17]

Region (Hiroshima and the Seto Inland Sea): the mass mortality of autumn 2025

In Hiroshima Prefecture, oyster mortality occurred throughout the prefecture from September 2025 onwards. In the preliminary results of interviews that the prefecture held in February–March 2026 with 72 oyster producers in the prefecture, the mortality began around mid-September and was at its highest in early October. There were several reports that, just before the mortality, the oysters were in a mature state (or had just spawned) and their meat was plump. Offshore farming grounds had a higher mortality rate than coastal farming grounds; on the coast the mortality rate was higher in the lower layer, and offshore there was no difference by hanging depth. The shorter the period of farming, the lower the mortality rate. These are points in common among the interviews, not the results of counting. [S4, S15]

The share of mortality differed greatly by district and by years of farming, and also changed with the point in time (Table 4). In the prefecture's interviews (as of 5 February 2026), it was 20–90% in the west of the prefecture and 80–90% (mainly for 3-year farming) in the central and eastern part of the prefecture. In the interviews as of 3 April, the ranges for each district had changed; for example, 2-year farming in the Otake district was 10–20%, and 3-year farming in the Etajima district was 20–80%. The Fisheries Agency's summary (as of 6 July 2026) gives 10–90% for 2-year oysters and 20–80% for 3-year oysters in the western sea area, 20–90% for 2-year oysters and 70–90% for 3-year oysters in the central sea area, and 60–90% for 2-year oysters in the eastern sea area (no 3-year farming). All of these are shares based on interviews with producers and fishery cooperatives, not values from counting samples. We found no average mortality rate for the prefecture as a whole. [S3, S15]

Table 4 Share of mortality in Hiroshima Prefecture in autumn 2025 (by district, from interviews with producers and others)

District	3-year farming (5 February)	2-year farming (5 February)	Interviews of 3 April
Otake	60–80%	20–60%	2-year 10–20%
Hatsukaichi	70–90%	50–70%	2-year 30–40%
Hiroshima	70–90%	50–90%	2-year 30–90%
Saka Town	80–90%	80–90%	2-year 70–80%
Etajima	50–90%	30–70%	3-year 20–80%, 2-year 30–80%
Western Kure	80–90%	60–90%	2-year 30–90%
Eastern Kure	80–90%	40–90%	3-year 70–90%, 2-year 20–90%
Higashihiroshima	90%	90%	3-year 90%, 2-year 90%
Onomichi and Fukuyama	No 3-year farming	60–90%	2-year 60–90%

Note: The shares are the approximate shares of individuals that died, and are values from interviews with producers, fishery cooperatives and related bodies and the like (not counted values). The 2 columns for 5 February are the values shown on the prefecture's map as of that date (read from the figure). The column for 3 April is the values shown on the prefecture's map as of that date (read from the figure). Values for 3-year farming were shown for Etajima, Eastern Kure and Higashihiroshima, and 3-year farming in Otake, Hatsukaichi, Hiroshima, Saka Town and Western Kure was marked "finished" (shipping had ended). 3-year farming is "nokoshi", shipped from the start of the season, and 2-year farming is "yokusei", "ikisu" and others, shipped from after the New Year. [S15]

To make up for the small shipments, many producers landed more than usual. In the prefecture's document (as of 3 April 2026), shipments of shucked meat were about half of a normal year in the west of the prefecture and about 30% of a normal year in the central and eastern part of the prefecture, and many producers were landing

1.5–2 times the amount of a normal year (about 1.5 times in the west and about 2 times in the central and eastern part). Because the shells of the dead oysters also come out, the amount of oyster shell generated in the 2025 season was about 201,000 cubic metres, an increase of about 28,000 cubic metres from the previous year because of the mortality. [S15, S16]

There were also cases in which triploid oysters (oysters with 3 sets of chromosomes) died in large numbers. In the prefecture's interviews and survey of shucked meat in November 2025 (among some producers who had started shipping, mainly 3-year farming), not only diploids (ordinary oysters) but also triploids had died in large numbers. In an example from the Osakikamijima district, 70% or more of the diploids, 50% of the triploids bought in the spring of the previous year and about 10% of the triploids bought in the autumn of the previous year had died, so that somewhat fewer of the triploids died. However, the triploids also differed in when they were bought (in size), and this cannot be separated from the effect of being triploid or not. No mass mortality was seen in the seed oysters placed on racks. In the Fukuyama district, water temperatures of 30°C or more are said to have occurred repeatedly until mid-September and to have fallen suddenly from late September (the place, depth and method of measurement are not stated), and there was no difference by where the seed was bought (private businesses, and the sea-farming association that produces seed). In Hatsukaichi, the lower part of the hanging lines is said to have been wiped out by hypoxia in early October, and in Saka Town, too, there was information of oxygen shortage on shallow farming grounds. The figures of about 50% in the Otake district and about 40% around Atata Island are described as "the same as a normal year". [S15]

The prefecture and the national government give environmental factors that differ by district, and do not give fouling organisms. In its documents of November–December 2025, the prefecture estimated that the main cause in the central and eastern part of the prefecture was a physiological disorder (a disorder of the workings of the body) due to simultaneous exposure to high water temperature and high salinity (an estimate based on the literature). For the west of the prefecture, it infers that hypoxia had an effect in addition to high water temperature (to be verified). The table by fishery cooperative that the Fisheries Agency compiled from interviews with the prefecture (January 2026, "Presumed factors (from interviews with the prefecture)") is as follows. [S3, S15]

- Prolonged high water temperature and hypoxia: the farming grounds of Hatsukaichi City, Hiroshima City and Saka Town [S3]
- High water temperature and high salinity: 7 fishery cooperatives in Kure City (Hayase, Aga, Kurahashi Seibu, Hiro, Ondo, Yasuura and Kurahashijima), Higashihiroshima City, Takehara City and Osakikamijima Town, Onomichi City and Fukuyama City, and 4 fishery cooperatives in Etajima City (Oki, Kanokawa, Fukae and Ogaki-cho) [S3]
- Prolonged high water temperature only: Otake City, 6 fishery cooperatives in Etajima City (Mitaka, Toe, Mino, Etajima, Uchinomi and Kirikushi), and Yoshiura and Tahara in Kure City [S3]

In no district are fouling organisms listed as a factor. Fouling organisms do not appear either in the tables for Okayama, Hyogo, Yamaguchi, Kagawa, Tokushima and Osaka in the same material. [S3]

The prefecture's expert panel put together a provisional opinion in May 2026, and it does not mention fouling organisms (the same as in chapter 5 of R1). The panel has 6 members: 1 each from Fukui Prefectural University and Hiroshima University, 3 from the Japan Fisheries Research and Education Agency, and 1 private-sector consultant. The meetings are held in person and are closed to the public (only the opening is public), and the prefecture publishes a summary. The provisional opinion of 26 May 2026 gave the possibility that external factors had an effect. These were the long period of high water temperature, the low rainfall in the rainy season (said to be the 4th lowest in the past 50 years, but the location and the period are not stated), the resulting change in the food environment, and hypoxia and high salinity in particular sea areas. As factors on the side of the oysters, it gives the possibility that the mature state continued because there was little rain and little

stimulus to spawn, and the fact that oysters with a larger soft body (the meat inside the shell) die more easily. The possibility that it was due to red tide or disease is described as "extremely low", and the final opinion is scheduled to be put together in March 2027. The summaries of the 4 meetings from January to September 2026 contain no statement about fouling organisms. [S4]

Lack of food is treated not as a direct cause but as one of the environmental stresses. At the meeting of 25 March 2026, there was a report that the risk of mortality rises when the weight of the oysters increases during the period of high water temperature. In the light of this, the experts advised that lack of food should not be treated as a direct factor in the mortality but as one of the environmental stresses. At the same meeting, it was stated that sufficient grounds had been assembled to rule out the possibility of disease and of red tide. The word "fouling" does not appear either in the production and shipment measures of the prefecture's fiscal 2026 guidelines (in the guidelines as a whole, it appears only as "fouling residue" [the remains of fouling matter] in the table of waste). [S2, S4]

No data have been found showing the amount of fouling on the farming grounds in 2025 (chapter 5 of R3-2). The fact that fouling is not among the official factors is not evidence that fouling was not involved.

The summer of 2025 had especially little rain in July and was a year of high water temperature. In the observations of the Hiroshima Local Meteorological Office of the Japan Meteorological Agency, the precipitation in July 2025 was 64.0 millimetres (mm), about 23% of a normal year (the 1991–2020 average of 279.8 mm) (this paper's calculation). June, at 229.0 mm, was about the same as a normal year (226.5 mm), August was 273.0 mm and September 214.5 mm, both more than a normal year, and the total for June–July was 58% of a normal year and the total for July–October 94% of a normal year (this paper's calculation). This is rainfall on land at 1 point in Hiroshima City, not a value for the salinity of the sea. In the observations of the prefecture's Fisheries and Marine Technology Center, the surface water temperature in the west of the prefecture in 2025 was "extremely high" in July and September, and in the central and eastern parts it was also "extremely high" in September. "Extremely high" is a category used by the Center, meaning a difference from a normal year (fiscal 1991–2020) of 2 or more times the standard deviation (a rough measure of the size of the spread) (the Center describes it as a frequency of about once in 22 years). [S6, S20]

In the observations of the Hiroshima Prefecture Fisheries and Marine Technology Center (fixed points in the west and in the central and eastern part of the prefecture), Heterocapsa (a kind of plankton that causes red tides), which has caused great damage to oysters in the past, was not found in 2025 (Osaka Prefecture lists an increase in Heterocapsa among the presumed factors; see the note to Table 5). In the east of the prefecture, a warning for another red-tide plankton (Chattonella) was in force from 22 July to 16 November 2025. [S3, S6]

In the other prefectures of the Seto Inland Sea, too, heavy mortality occurred in autumn 2025 (Table 5). A written opinion of the Hyogo Prefectural Assembly (March 2026) gives roughly 80% in almost all districts of the farming waters as of mid-November. The Governor of Okayama Prefecture stated at a press conference in December 2025 that there had been no damage on this scale in about 30 years of monitoring. On the other hand, he also stated that the water temperature had been about as high in other years but that there had been no such damage. [S3, S21, S22]

Table 5 Mortality in the prefectures of the Seto Inland Sea in autumn 2025 (Fisheries Agency interviews, as of 6 July 2026; excluding Ehime Prefecture)

Prefecture	Share of mortality	Conditions
Hiroshima	West: 2-year oysters 10–90%, 3-year oysters 20–80%; central: 2-year oysters 20–90%, 3-year oysters 70–90%; east: 2-year oysters 60–90%	Differs by district. There is no 3-year farming in the east

Prefecture	Share of mortality	Conditions
Okayama	1-year oysters 10–70%, 2-year oysters 70–80%	Differs by district
Hyogo	Roughly 70–90%	Differs by district
Kagawa	Roughly 70–80%	From interviews with fishers and others
Osaka	70–90%	—
Tokushima (Seto Inland Sea side)	Roughly 30–90%	Differs by district
Yamaguchi	Roughly 30–60%	Differs by district

Note: All are ranges from interviews with the prefectures, not counted values. 1-year oysters, 2-year oysters and 3-year oysters refer to the number of years of farming. In the "summary of information heard from each prefecture" in the Fisheries Agency's summary (as of 6 July 2026), the column of presumed factors gives high water temperature, high salinity and decreased precipitation for Okayama; high water temperature and lack of food for Hyogo; high water temperature, lack of food and decreased precipitation for Yamaguchi; high water temperature, lack of food and hypoxia for Kagawa; high water temperature, hypoxia and lack of food for Tokushima; and high water temperature and an increase in Heterocapsa for Osaka. Fouling organisms are not listed for any prefecture, and the material concludes that high water temperature is common to all. On the map in the same material, the factor for Osaka is given only as an increase in Heterocapsa, Kagawa as "high water temperature and others" and Tokushima as "high water temperature, lack of food and others", which differs slightly from the table. In the table by fishery cooperative of January 2026, of the 10 fishery cooperatives in Osaka, 3 gave Heterocapsa only and 3 gave unknown. The column on sea conditions states that in Okayama the water temperature from late June to mid-September ran 2°C higher than in the previous year (from mid-September onwards it was about the same as the previous year), and that in Hyogo chlorophyll (a rough measure of the amount of phytoplankton) was low in summer. Mortality in normal times is 30–50% by the Fisheries Agency's general rough guide (no statement of basis or way of counting), and 20–30% at harvest in a report of Hiroshima Prefecture's research institute (the definitions differ; Table 6). The values for Ehime Prefecture in the same table are dealt with in R7-C29 and R7-C06 of this series and so are not included. [S3, S6]

In 2026, too, some sea areas had mortality above both the Fisheries Agency's rough guide for normal times (30–50%) and the normal year of Hiroshima Prefecture's research institute (20–30% at harvest). In the Fisheries Agency's October 2026 summary of what it heard from each prefecture, there was mortality ranging from the same as a normal year to around 60% in some places in the western sea area of Hiroshima Prefecture, and from the same as a normal year to around 70% in some places in the central sea area. In the eastern sea area, there are no reports of heavy mortality. There was mortality of about 50–60% in some waters of Osaka Prefecture (the presumed factor is hypoxia), and of about 20–50% for both diploids and triploids in some waters of Kagawa Prefecture. At the prefecture's expert panel (10 September 2026), it was stated that no large-scale mortality had been confirmed at that point and that the rain in the 2026 rainy season was more than in 2025. Because the 2025 mortality was concentrated in late September to October, the 2026 season is still under way. [S3, S4]

Region (Hiroshima and the Seto Inland Sea): mortality in the past

About 20–30% of Hiroshima Prefecture's oysters die even in an ordinary year. A report by the prefecture's research institute (2006) states that normally 20–30% of the oysters in the prefecture have died by harvest (this differs with the period and place of farming), and that when mortality of 40–50% or more occurs over a wide area it is called mass mortality. A 2011 report also states that in recent years mortality of 20–30% at harvest has

been seen almost every year. In a survey from summer to autumn in 2004–2006, the final mortality rate was 34.1% (2004), 28.0% (2005) and 23.5% (2006), which was considered to be within the normal range. This survey examined 1 raft each inside Etajima Bay and at Nagahama, taking an average of 27.2 oysters per layer, mainly oysters that had been put out for main hanging in the spring of the previous year, and "final" is the value on the last survey date, not at harvest. [S6]

In Hiroshima Prefecture, mass mortality has occurred before now in years of high water temperature and little rain. The 2006 report gives 1979, 1994, 2001 and 2002 as the years of mass mortality since 1970. Except for 2001, these were years with many days on which the sea-surface water temperature exceeded 20°C (152 days in 1979, 146 days in 1994 and 152 days in 2002, against an average for the period of 137.2 days), and years with little rain in July–October (the water temperature is that of the surface layer of the waters just off the Center [the sea in front of the Center] [1970–2004], and the rainfall is that of the Hiroshima Local Meteorological Office for July–October [1941–2004]). The report estimates that in years of high water temperature and little rain, mass mortality occurs with high probability. 2001 is described as a special year in which seed from Miyagi was used because of the seed collection failure of 1999, and 2002 as a year in which a red tide (Karenia mikimotoi) in July and hypoxia were also added. [S6]

However, high water temperature alone does not bring about mass mortality. In the data of the same report, 1990, 1998 and 1999 also had 145 or more days above 20°C, but there are no reports of mass mortality. Nor were there any in 1977, 1978, 1984 and 1988, when there was little rain. The conclusion is based on a correlation (a relationship in which, when one thing increases, the other also changes) in 3 cases (1979, 1994 and 2002). The report treats as years with a low-rainfall tendency those in which the rainfall over the 4 months of July–October is at or below, or close to, 442.5 mm, which is the average minus the standard deviation (the 1941–2004 average is 677.9 mm and the standard deviation 235.4 mm), and it includes 1979 (476 mm) among the "close" years. A high-water-temperature tendency is defined as a year in which the number of days with a water temperature above 20°C is 146.8 days or more, which is the average plus the standard deviation (9.7 days) (however, Figure 1 of the same report gives 146.9 days, and also includes 1994, with 146 days, in the high-water-temperature tendency). The rainfall for July–October 2025 was 643.5 mm (94% of a normal year [the 1991–2020 average]), far above the threshold, and by this indicator it does not count as a low-rainfall year. 2026 (508.5 mm, 74% of the same normal year) is also above the threshold, but the difference from the 476 mm of 1979 is 32.5 mm, and the report does not state how far "close" extends (both are this paper's calculations). In 2026, there was mortality of around 60–70% in some waters in the western and central parts of Hiroshima Prefecture. The Fisheries Agency's October summary states that there is no information that producers' oysters died on a large scale, but it does not say what it calls large scale. This paper has not checked whether the water temperatures of 2025 and 2026 meet the condition for high water temperature. This indicator cannot be checked with 2 years alone (a rough guide). [S3, S6, S20]

The view that oysters with heavier meat die more easily is also found in earlier research in Hiroshima Prefecture, but it is a result for some layers only. In the 2011 report, among the oysters of the middle and lower layers, the heavier the meat (the soft body), the higher the risk of mortality, and when the upper layer was included no clear relationship was seen. The report states that mortality is seen when the water temperature exceeds 20°C, and recommends that oysters with heavy meat should not be kept over the summer. It also states that farming extra oysters in anticipation of each year's mortality is considered to be a cause of overcrowding of the farming grounds. [S6]

The record of damage in the prefecture's guidelines lists typhoons, Heterocapsa red tides and shellfish poisoning (a phenomenon in which shellfish accumulate toxins). The amount of damage from typhoons (the combined amount for rafts, facilities and oyster products) was 5.401 billion yen in 1991 (Typhoon No. 19), 3.776 billion yen in 1999 (Typhoon No. 18) and 7.386 billion yen in 2004 (the total for Typhoons No. 10, 16, 18, 21 and 23). The amount of damage from Heterocapsa red tides was 275 million yen in 1995 (6.10 million shells

damaged), 222 million yen in 1997 (4.94 million shells) and 3.833 billion yen in 1998. In 1998 it occurred throughout Hiroshima Bay and in Kure Bay and Hiro Bay, and 85.18 million collectors (the scallop shells used for seed collection) with oysters attached were damaged. In the prefecture's records, no Heterocapsa red tide occurred from 2014 to 2025. This table is a record from 1991 onwards; it has no item for damage from fouling organisms, and the mass mortality of 2025 is not listed either (the same as in chapter 2 of R1). [S2]

What the publisher of this paper heard from producers, who say that oysters die because of fouling, is in chapter 2 of R3-2. The damage of 1969, when the fouling organism kasane-kanzashi (a serpulid tube worm) broke out in great numbers in Hiroshima Bay, and the views on its cause are also dealt with in chapter 2 of R3-2. [S23]

3. Existing measures, and how they are assessed

Measures against mortality include the prefecture's guidelines, watching the sea and issuing notices, seed, and efforts on nutrient salts. The arrangements that support losses are fishery mutual aid and public support. The size of the effect of the measures to reduce mortality has hardly been confirmed.

Measures against mortality: the prefecture's guidelines, and watching and notices

The prefecture's guidelines are not an obligation based on law but a reference document for production and shipment. The Hiroshima Oyster Production and Shipment Guidelines are a document that the prefecture makes every year in time for the shipping season, and in the document reporting the fiscal 2021 edition to the Prefectural Assembly, the column for the legal basis was "-" (none). However, there are also items that copy out obligations under other rules, such as labelling, the rules for exercising fishery rights and the waste laws (the meaning is that the guidelines themselves have no basis in law). They are reported every autumn to the Prefectural Assembly's Agriculture, Forestry and Fisheries Committee. [S2]

The fiscal 2026 guidelines give priority to measures against mortality. They set out the aim of returning the production of shucked meat to 17,000 tons (lowered from the 20,000 tons of the fiscal 2021–2025 editions), and ask producers to use the monitoring results on the prefecture's website for producers, the "Fisheries Platform", and the "Oyster Aquaculture Environmental Risk Report". When a warning is issued at one of 3 levels according to the degree of danger of mortality, "caution", "alert" and "high alert", they ask producers to check the condition of the oyster meat and then to move the rafts and take other steps promptly and appropriately (the criteria for the warnings were not found). They recommend trying the moving of rafts, the adjustment of hanging depth and the review of farming density in the prefecture's demonstration project, and state that a shift to a scale of farming that matches the productive capacity of the farming grounds will also be pursued. [S2]

The reason for reducing 3-year farming has changed from profit to the danger of mortality. The guidelines ask for 3-year farming to be reduced, on the grounds that the danger of mortality is high and that it also leads to a worsening of the environment of the farming grounds. The reason in the fiscal 2022 and 2023 editions was "the rate of return is low", and "the risk of mortality is high" appears from the fiscal 2024 edition. The finding in the interviews with 72 producers, that the shorter the period of farming the lower the mortality rate, is consistent with this policy. The Fisheries Agency's check sheet also lists the possibility that oysters are being farmed beyond the carrying capacity of the sea area as a risk of lower productivity. [S2, S4, S10]

The item on measures against red tide in the guidelines gives joining mutual aid as a way of preparing for losses, and also shows a rough guide for hypoxia. Within fishery mutual aid (an insurance by which fishers help one another), it gives joining aquaculture mutual aid (mutual aid that compensates according to the quantity that suffered damage) as a means of reducing economic losses. In the same item, the guidelines give the rough guide for hypoxia as 4.3 mg or less per 1 litre of seawater (3 ml as a volume of oxygen). [S2]

The prefecture has observations of the sea that have continued for more than 50 years, but fouling organisms are not among the things measured. To monitor red tides and shellfish poisoning, the prefecture's Fisheries and Marine Technology Center regularly measures water temperature, salinity, nutrient salts (the nutrients of phytoplankton, such as nitrogen and phosphorus), chlorophyll (a rough measure of the amount of phytoplankton) and plankton in the west of the prefecture (11 fixed points for red tide and 12 fixed points for shellfish poisoning), in the central and eastern part (8 fixed points for red tide and 4 fixed points for shellfish poisoning) and elsewhere. The results from fiscal 1971 onwards are compiled in a database. The water quality results are published on its website, the plankton results are given to the bodies concerned through the prefecture's Fisheries Division, and in summer information for oyster farmers is also issued. [S6]

Since fiscal 2021, the prefecture has been putting in place sensors for water temperature and other items and a website for producers. Under the "Project to Promote Smart Fisheries (Oysters)", at the end of December 2022 there were 20 water temperature sensors and 3 food sensors in Hiroshima Bay. At the end of December 2024 there were 15 water temperature sensors and 5 food sensors at 15 locations in the central and western part of the prefecture. The budget of the project was 20 million yen in each of fiscal 2022 and fiscal 2023 (part of it national funds) and 15 million yen in fiscal 2024. The project in fiscal 2024 covered the 262 oyster-producing management entities in the central and western part of the prefecture, and about 100 management entities were producers using digital technology (the prefecture's target is 130 management entities). For the survey of larvae for seed collection, a method of finding larvae by AI from photographed images has been adopted. The name and the budget of the project for fiscal 2026 could not be confirmed. [S7]

The effect of watching is shown only by producers' reports and questionnaires. In the prefecture's document of February 2024, 20 producers acting as monitors looked at the information from the water temperature sensors and judged when to change the hanging depth and when to move rafts to farming grounds where the meat condition was good. It writes that there was a report that in fiscal 2022 the share of mortality was about 10% lower than the average for the sea area (the number of people, the way of comparing and the meaning of "about 10%" are not stated). In response, the prefecture issued information on the danger of mortality and on countermeasures to all producers in fiscal 2023. In the producer questionnaire of November 2024, producers who had taken measures on the basis of the data or the prefecture's danger information tended to have a lower share of mortality, but there are no figures. Whether or not to take measures was chosen by the producers, and this cannot be separated from other differences such as farming ground and scale. The results for fiscal 2023 were marked "under investigation", and no later publication was found. [S7]

In 2026, monitoring was strengthened and trial warnings were issued. In 2026 the prefecture added items such as dissolved oxygen (the amount of oxygen dissolved in seawater) to the observation buoys on the main farming grounds. It also started an arrangement for checking the survival of the oysters and the condition of the meat together with fishery cooperatives and producers, and it posts the "Oyster Aquaculture Environmental Risk Report" on the Fisheries Platform on a trial basis. On 9 September 2026, a "high alert" warning for dissolved oxygen was issued. As of the expert panel of 10 September, no large-scale mortality had been confirmed, and the members said that the system by which producers can know the situation on their own farming grounds "can be rated very highly". On that basis, they advise checking the effect of this year's efforts and giving guidance based on actual cases. However, the rain in the 2026 rainy season was more than in 2025, and the difference in the weather cannot be separated from the effect of the measures. [S4]

Hiroshima Prefecture's efforts in 2026 differ by sea area. In the Fisheries Agency's October 2026 summary, the west has density, moving of rafts, pumps, improvement of the bottom sediment (the state of the mud and sand on the seabed) and monitoring. The central area has density, moving of rafts, air exposure, improvement of the bottom sediment, strengthening of seed (high-temperature treatment) and monitoring, and the east has strengthening of seed (high-temperature treatment and air exposure) and monitoring. In the prefectures' plan of efforts (October edition), strengthening of seed by air exposure is being carried out by 5 fishery cooperatives,

and raising dissolved oxygen with seawater circulation pumps by 2 fishery cooperatives. The spreading of bottom-sediment improvers such as oyster shell and seabed tilling (digging over the seabed) are being carried out over roughly 3 square kilometres. In the prefecture's demonstration project, 8 fishery cooperatives are to use a total of 986 tons of oyster shell to try to improve the bottom sediment of the farming grounds. For none of these efforts has the size of the effect yet been shown. [S3, S16]

The national government's table of countermeasures lists existing methods for each factor. For high water temperature, selective breeding (selecting and raising parents that are resistant to high water temperature) and deep hanging; for hypoxia, seabed tilling and improvement of the bottom sediment; for excessive farming density, the setting of an appropriate density; for red tide, monitoring and the moving of rafts; and for lack of food, the removal of fouling organisms. The heading of the table is "effective cases in the literature or actually being practised", and the size of the effect is not shown. The basis for both deep hanging and the removal of fouling organisms is research on growth and meat condition, not a comparison of survival in a year of mass mortality. [S3]

The evidence on whether deep hanging and the removal of fouling organisms reduce mortality is dealt with in chapter 3 of R3-2.

Measures against mortality: seed

Wild seed collection is supported by the sharing of information and by rafts of parent oysters. Since fiscal 2015, the prefecture, Hiroshima City and others, together with the industry, have placed rafts of parent oysters for spawning (broodstock rafts) at the head of Hiroshima Bay (there is no mention of this in the fiscal 2026 edition of the guidelines, and we have not checked whether it still continues). In 2016, the prefecture and Hiroshima City surveyed the larvae every week from mid-June to late August and passed the results to the fishery cooperatives on the same day through the prefectural federation of fishery cooperatives (the federation of the fishery cooperatives in the prefecture). In 2016, heavy rain lowered the salinity and there were few larvae in July, but many attached inside the bay in late August, and 96.4% of the required quantity was secured (the figure for the required quantity is not shown). The report says that this "seems" to be the effect of the rafts of parent oysters, but there is no control to compare with. [S6]

Recent seed collection has secured the required quantity. According to the prefecture's guidelines, seed collection in 2018–2022 secured the required quantity for 5 years in a row. In 2022–2024, the required quantity was secured by the end of July through the placing of broodstock rafts in the northern part of Hiroshima Bay, where food is plentiful, and the sharing of the results of the larval surveys. In 2025, too, it was secured by the end of July through the sharing of the results of the larval surveys. The fiscal 2026 edition of the guidelines has no mention of broodstock rafts, and refers to the information on the distribution of larvae on the Fisheries Platform. In 2025 seed collection was secured, but mortality occurred in the autumn that followed. [S2]

Research on making spat stronger is also progressing. In Hiroshima Prefecture, hardening is practised, in which the collected spat are hung on racks on tidal flats (hardening racks) and exposed to the air by the rise and fall of the tide so as to hold back their growth, and there are 151 tidal flats with hardening racks in the prefecture. Research by the prefecture's Fisheries and Marine Technology Center (in the fiscal 2025 report, a summary of several years of results) confirmed that the length of air exposure and the temperature during air exposure are the main factors that determine the growth and survival of the spat. It also confirmed that when the spat are exposed to the air in the daytime the genes for heat shock proteins (proteins that protect the body from heat) become active, and that this treatment reduces mortality after hardening, but the summary does not give a figure for how much it was reduced (publication of some of the results is being withheld). The same research also confirmed that isogani-type shore crabs (small crabs) eat the spat, and that shaking them off in early

October reduces the loss. It also states that, with recent changes in the environment, the reliability of conventional hardening is falling. [S6]

Triploid seed and the method of growing oysters one by one in baskets have existed in Hiroshima Prefecture since the 2000s. The prefecture developed the triploid "Kaki Komachi" and spread the method of growing artificial seed one by one in baskets (single seed). In the prefecture's fiscal 2009 follow-up evaluation (an evaluation by the very institute that developed it), because of the production capacity of the prefectural sea-farming association (the body that produces seed), the seed that could be distributed was limited to 700,000 a year. Applications from fishery cooperatives were about 1.51 million in fiscal 2008 and about 1.46 million in fiscal 2009, more than 2 times the limit. The share of the distributed seed that becomes product was about 30% (an estimate), the seed was sold at 5 yen each, and the guidance on the method of growing in baskets also included how often to wash off the fouling on the baskets. The development research ran from fiscal 2001 to fiscal 2005, and the total of research costs and personnel costs was 61,916,000 yen. We found no figures in published materials for the present production volume and cost of triploids or single seed. [S6]

Even with triploids, the 2025 mortality could not be avoided. As stated in chapter 2, in Hiroshima in 2025 there were cases in which triploids also died in large numbers (in the Osakikamijima example somewhat fewer than the diploids; this cannot be separated from the difference in when they were bought), and in some waters of Kagawa Prefecture about 20–50% of both diploids and triploids died in 2026 as well. The Fisheries Agency lists the use of triploids as a measure to reduce weakening caused by continued spawning, and the national policy package supports the introduction of artificial seed such as triploids. Among the prefectures' efforts for 2026 there are prefectures that list triploids, but Hiroshima Prefecture's efforts centre on methods of management. In the call for public comments on the prefecture's plan for 2030 there was a comment asking for the introduction of triploid seed, and the prefecture replied that it would continue to consider this as one of the specific measures. [S3, S10, S24, S25]

Measures against mortality: nutrient salts

Attempts to improve the meat condition by increasing nutrients are still at the demonstration stage. In a baseline survey that the prefecture carried out from December 2022 to March 2023 in 4 districts of the prefecture (Kusatsu and Eba in Hiroshima City, Jigozen in Hatsukaichi City, Hiro in Kure City, and Matsunaga Bay), total nitrogen (the total amount of nitrogen in seawater) at all points was at or below 0.2 mg per 1 litre (mg/L), the level at which biological productivity is considered low in the Water Quality Criteria for Fisheries (a rough guide to the water quality desirable for aquatic living resources, issued by a fisheries body). Chlorophyll a, which represents the amount of food, was also below 4 µg per 1 litre (micrograms; 1 µg is 1/1,000 of 1 mg), the level at which stable growth of oysters is expected. Since fiscal 2023 the prefecture has been carrying out a demonstration in which the operation of sewage treatment plants is changed to increase the nitrogen in the effluent. In fiscal 2025, in addition to the 4 sites of the prefecture's demonstration (Hiro in Kure City, Hatsukaichi, western Hiroshima City, and Matsunaga in Fukuyama City), a demonstration was also carried out in January–March 2026 at 8 facilities in Hatsukaichi City and Etajima City, at the request of these cities. [S8]

The prefecture states that chlorophyll a and the weight of the oysters in the test waters were greater than in the control fiscal year, and expresses this as "the possibility was high" that there was a good effect on growth. The weight of the oysters is a relative value, with the weight of oysters grown from the same seed on the raft of the prefecture's Fisheries and Marine Technology Center taken as 1. What was compared was a before-and-after comparison with the control fiscal year, the 1 year of fiscal 2022, and no statistical test or number of replicates is stated. The value for the control fiscal year for Fukuyama City (Matsunaga) is not in the figure, and the amount of total nitrogen in the effluent at Matsunaga was below that of the control fiscal year in January–March 2026. Chlorophyll a in fiscal 2025 exceeded 4 µg/L at Hatsukaichi, western Hiroshima City and Matsunaga, and at Hiro in Kure City it was close to 4 µg/L at the coastal point. It is stated that there were no signs such as discolouration

in the surrounding sea and that no red tide occurred. Fiscal 2025 coincides with the year of mass mortality, but the report does not mention any relationship with the mortality. [S8]

The draft of the prefecture's nutrient management plan (October 2026; chapter 4) states that the effect on oysters will be checked through production volume once a year, and the prediction made before starting covers water quality only. The way of examining the effect in the draft is to measure DIN (dissolved inorganic nitrogen; the part of the nitrogen dissolved in seawater that is in a form phytoplankton can take up as it is) and chlorophyll a around the target sea areas once a month in the shallow-sea fixed-line water quality survey (a survey that regularly measures the water quality of the sea at fixed points), to examine the production volume of oysters, nori (laver) and wakame once a year through the Marine Fishery Production Statistics Survey and the like, and to compare each with past results. In the prediction made before starting, a numerical model made by the Ministry of the Environment (a method of reproducing the currents and water quality of the sea by calculation) was used to calculate the water quality of the sea when sewage treatment plants and the like discharge total nitrogen at 30 mg per 1 litre (the concentration regarded, from the results of the demonstration, as the maximum that can be discharged). The items predicted were 3: total nitrogen, total phosphorus (the total amount of phosphorus in seawater) and COD (chemical oxygen demand; a rough measure of the amount of pollution in water); chlorophyll a and the growth of oysters are not included (this paper's check). The result was that, although the concentrations of total nitrogen and total phosphorus rise at some points, the achievement of the environmental quality standards (standards of water quality set by the national government as desirable to maintain in order to protect human health and conserve the living environment; in the sea, a category and values are set for each water area [an area of sea marked off for applying the standards] according to its use; these are separate from the Water Quality Criteria for Fisheries mentioned earlier) is maintained in all of the 8 target water areas (chapter 4) (judged by the average for each water area). For COD, too, the concentration rises at some points, but the state of achievement of the environmental quality standards was found not to change (for total phosphorus and COD, there are points that already exceed the standards now). [S8]

The research institute of neighbouring Okayama Prefecture shows the relationship between nutrients and oyster meat by correlation. In March 2026 the institute wrote that a fall in the concentration of nutrient salts has been pointed out in the Seto Inland Sea, but that its effects on the amount of phytoplankton, which is the food, and on the growth of oysters have not been made clear. On that basis, it states that, in data from the oyster farming grounds in the prefecture for fiscal 2015–2023, the weight of the soft body of the oysters in December showed a statistically significant positive correlation (a relationship in the same direction that is hard to explain by chance) with the concentration of particulate organic nitrogen (PON; the nitrogen contained in small particles in the sea, a rough measure of the amount of food) in September–November and with the water temperature in October–November. The correlation coefficients are 0.49 and 0.23 respectively (the sample size is not stated). 0.23 is a weak relationship, explaining only about 5% of the variation in weight (0.49 explains about 24%; this paper's calculation). The measured value for December 2025 was below the prediction, and the institute gives the possibility of an effect of the mass mortality thought to be due to the high water temperature of summer 2025 and other factors. The institute also writes that in general the larger a Pacific oyster is, the more easily it dies. [S17]

Fishery mutual aid and public support

Fishery mutual aid is an insurance, based on law, by which fishers help one another. Fishery mutual aid is an arrangement under the Fishery Disaster Compensation Act in which fishery mutual aid associations compensate losses out of the premiums collected from fishers. The national government subsidises part of the premiums, but it does not compensate the damage directly. The main mutual aid schemes for oysters are aquaculture mutual aid, which compensates according to the quantity that suffered damage, and specified aquaculture mutual aid, which compensates a fall in production value (from April 2026, specified aquaculture mutual aid is

"catch and specified aquaculture mutual aid", merged with catch mutual aid; chapter 4). When specified aquaculture mutual aid is combined with Tsumitate Plus (a top-up arrangement into which fishers and the national government pay reserves), a fall in income can be compensated up to a level of 90% at most. To use Tsumitate Plus, a contract share above a certain level (30–40% or more, depending on the species and the scale) and participation in a farming ground improvement plan (a plan that sets farming density and the like) are required. [S25, S26, S27]

In a national example of December 2025 (before the merger), the mutual aid payment under aquaculture mutual aid when the oysters are completely wiped out is about 500,000 yen at most per 1 raft (24,000 collector shells). The example for specified aquaculture mutual aid is a case in which the production value in a normal year is 30 million yen, the producer has joined the type that compensates 50% of the loss, and income has become 0 yen. The mutual aid payment of 9.6 million yen and the Tsumitate Plus refund of 3 million yen give a total of up to 12.6 million yen. Both are illustrations, and the level of compensation changes with the type and share of the contract. The national government states that, in cooperation with the prefectures and the bodies concerned, it will promote joining and moving to specified aquaculture mutual aid. [S25]

Almost all of Hiroshima Prefecture's oyster producers had joined aquaculture mutual aid (the association's explanation in 2020). According to an introductory document of the Hiroshima Prefecture Fishery Mutual Aid Association (March 2020; mainly on the state of membership in fiscal 2018), oysters made up 72% of the association's underwriting (the contracts accepted as mutual aid, including facilities) (it is not stated whether this is a share of the amount or of the number of contracts). Almost all of the roughly 300 farmers of the 34 fishery cooperatives in the prefecture involved with oysters had joined aquaculture mutual aid on most of their farming grounds. According to the same document, aquaculture mutual aid at that time was arranged so that a contract could not be made unless each farmer put in all of the oysters being grown. It was also arranged so that the national subsidy for premiums was paid in full when everyone farming in a membership district (the unit area for joining mutual aid; broadly, the area of a demarcated fishery right, which is the right to farm in a fixed area) had joined. It appears that one of the reasons why almost everyone had joined lies in this arrangement (this paper's view; the document does not state the reason; we have not checked whether this arrangement continues after the revisions of the system in 2025–2026). The unit price for underwriting was 45 yen per 1 collector shell, and as a rule the mutual aid payment is made when, for each farming ground entered by each contract holder, there has been damage of 15% or more of the quantity just before the incident. The premium for the red tide rider is borne 2/3 by the national government and the rest by Hiroshima Prefecture, with no burden on the member. Facilities such as bamboo rafts are covered by fishery facilities mutual aid, and joining it at the same time as aquaculture mutual aid is recommended. On 4 occasions, Typhoon No. 19 of 1991, the Heterocapsa red tide of 1998, Typhoon No. 18 of 1999 and Typhoon No. 18 of 2004, mutual aid payments of more than 1.0 billion yen were made in each of those years. [S27]

In the national statistics, too, a little over 90% of the management entities in Hiroshima Prefecture whose main business is oysters had joined some form of fishery mutual aid in 2023. In the 2023 Census of Fisheries (as of 1 November), 241 (91.3%) of the 264 management entities in Hiroshima Prefecture whose main business is oysters had joined fishery mutual aid, and 160 of the 264 (60.6%) had also joined Tsumitate Plus (66.4% of the 241 that had joined mutual aid). Those that had not joined were 23 (8.7%). Of the 1,846 management entities in Japan whose main business is oysters, 1,147 (62.1%) had joined, 756 (41.0%) had also joined Tsumitate Plus, and 699 (37.9%) had not joined. The percentages, both for Hiroshima Prefecture and for Japan, are this paper's calculations. "Fishery mutual aid" in the census is any of catch mutual aid, aquaculture mutual aid, specified aquaculture mutual aid and fishery facilities mutual aid, and includes cases of joining through a fishery cooperative or a group, so the rate of joining aquaculture mutual aid alone is not known. All of these are values from before the 2025 mortality and the revisions of the mutual aid system, and we found no public material showing the rate of joining after that. [S5, S27]

We found no material showing the amount of mutual aid payments made for the 2025 mortality. The National Federation of Fishery Mutual Aid Associations wrote in December 2025 that it is working to pay mutual aid payments quickly. It states that in the areas where damage occurred, too, there were farmers who had not joined mutual aid or whose compensation was not sufficient (no statement of numbers or shares). For reference, the mutual aid payments made for "oysters and pearls" under aquaculture mutual aid nationwide in fiscal 2024 were 961 million yen (the fiscal year before the 2025 mortality, and not including specified aquaculture mutual aid). Payments in fiscal 2025 were 24.0 billion yen for all fisheries, and we found no breakdown by species. The mutual aid system was revised in 2025–2026, but the new rider cannot be used for oysters (chapter 4). [S26, S27]

The national government's Fishery Management Safety Net Construction Project is an arrangement that compensates only for rises in the price of fuel oil and of compound feed for aquaculture (fish feed), and does not compensate losses from mortality (this paper's reading from the statement of what is covered by the compensation). What concerns oyster aquaculture is the fuel oil part (this paper's reading). The provisionally decided budget for fiscal 2026 is 203 million yen (850 million yen in the previous fiscal year), and in the fiscal 2025 supplementary budget it was 23.193 billion yen (amounts for all fisheries), and the project is continuing. [S26]

After the 2025 mortality, the prefecture and the national government prepared financing and support for resuming production. In the prefecture's list of support (as of 1 April 2026), the prefecture's interest-free working capital is for businesses that the mayor of the city or town has certified as having had oyster farming income in the fiscal 2025 season 10% or more lower than in the same period of the previous year. The repayment period is within 10 years (with a grace period of up to 2 years), and the interest is covered half each by the prefecture and the cities and towns. The loan facility was 3.0 billion yen in December 2025, and 2.0 billion yen was added in June 2026, for a total of 5.0 billion yen (the amounts of the facility are from a prefectural document of July 2026). For the costs of resuming production, such as re-hanging on rafts, the prefecture subsidises 1/2, up to a limit of 500,000 yen per 1 raft. For demonstrations in which a fishery cooperative as a unit tries out methods of preventing mortality, it gives a fixed-amount subsidy of up to 6 million yen per fishery cooperative (5 million yen for the cost of the measures in the demonstration and 1 million yen for the cost of assessing the effect). It also lists a subsidy for the joint purchase of materials and equipment under a national project, and a measure by which technical intern trainees who have become unable to continue their training can work in another occupation for a fixed period, up to 28 hours a week. Fishery mutual aid is not on this list. [S9]

In the prefecture's budget, the "measures against oyster mortality" in the supplementary budget of December 2025 were 5.005 billion yen (including the loan facility). This amount matches the total of the loan facility of 3.0 billion yen, the costs of resuming production of 2.0 billion yen and the fact-finding survey of 5 million yen (this paper's calculation). The "Emergency Project to Stabilise Oyster Production" was 89,737,000 yen in the February supplementary budget for fiscal 2025 (24,228,000 yen for the change of farming methods and 65,509,000 yen for improving the bottom sediment of farming grounds using oyster shell). The initial budget for fiscal 2026 is 259,163,000 yen (20 million yen for analysis of the cause, 238,631,000 yen for the change of farming methods and 532,000 yen for seed collection and seed management). The prefecture's target for fiscal 2026 is to bring to 36 the number of fishery cooperatives that work on measures against mortality in cooperation with the prefecture. On the interest subsidy, the prefecture's list of matters expected to be proposed (December 2025; an outline of the bills to be submitted to the Prefectural Assembly) showed a debt burden authorisation, which promises future payments (a limit of 412.42 million yen) (this paper has not checked the amount that was approved). We found no material showing how many loans and subsidies were actually used and for how much. [S9]

On 11 December 2025, the national government put together, across 9 ministries and agencies, the "Policy package for damage from oyster mortality due to high water temperature and other causes" (partly amended on 17 December, in line with the passing of the supplementary budget). The short-term measures are support for

farmers and others to continue their businesses, and the medium- to long-term measures are finding the cause and sustainable oyster aquaculture that responds to changes in the marine environment. It includes cash flow, mutual aid, the joint purchase of materials and equipment, support for introducing artificial seed such as triploids, and support for technical intern trainees to change their place of training. For the related businesses affected, such as restaurants, it states that they will be informed of the employment adjustment subsidy and the like. As the title shows, it gives the cause as "high water temperature and other causes". We found no figure for the number of cases actually used. [S25]

Most of the support is loans and subsidies that support the fall in income and the resumption of production in the next season (this paper's assessment). Support for reducing mortality is also included. This is the prefecture's demonstrations that try out methods of reducing mortality (up to 6 million yen per fishery cooperative), the change of farming methods (238,631,000 yen in the fiscal 2026 initial budget) and the analysis of the cause (20 million yen in the same budget), and the national government's finding of the cause and support for introducing artificial seed such as triploids. However, the effect has not yet been shown. Much of it is loans that have to be repaid, and the subsidies have upper limits. There is no item of support linked to fouling organisms, which is consistent with fouling organisms not being included in the official summary of factors. [S25, S9]

4. What is changing

Around oyster aquaculture, the marine environment, laws and systems, and the market are changing at the same time, but much of this is at the stage of plans, prospects, provisional views and drafts (as of 3 November 2026). Of the things dealt with in this chapter, the changes in law that have come into force are the amendment of the Setouchi Act (2022) and the amendments of the Fishery Disaster Compensation Act (2025 and 2026). The rest are plans, strategies, policy packages, guidelines, drafts, opinions of meetings, budgets, future schedules and so on of the national government and the prefecture.

The marine environment

The water temperature of the seas near Japan is rising more than the world average. In the Japan Meteorological Agency's analysis, the annual mean sea-surface temperature of the seas around Japan has risen at a rate of 1.36°C per 100 years in the statistics for 1908–2025, a larger rise than the world average of 0.63°C (about 2.2 times, this paper's calculation). A document of the Fisheries Agency's council (April 2026) also describes it as rising at a rate more than 2 times the world average. The difference of the annual mean from a normal year (the 1991–2020 average) was +1.44°C in 2024, +1.10°C in 2023 and +1.00°C in 2025, and these 3 years are the top 3 of the years with data (this paper's calculation). The difference from a normal year for July–September was +1.84°C in 2025, the largest value among the years with data (this paper's calculation). The difference from a normal year for October–December (autumn in the Japan Meteorological Agency's classification for sea-surface temperature; it is shifted by 1 month from autumn for air temperature [September–November]) was also +1.49°C in 2024, +1.30°C in 2025 and +1.16°C in 2023, and these 3 years were the top 3 of the 108 years with data in 1908–2025 (the 4th is 2022 with +0.76°C; the ranking is this paper's calculation). However, the Japan Meteorological Agency's division of sea areas has no Seto Inland Sea, and the trend for the Seto Inland Sea cannot be known from these figures. [S28, S20]

The long-term values for the water temperature of Hiroshima Bay are records from single points. In the prefecture's analysis, the annual mean water temperature of the surface layer (water depth 0–0.5 m) at the water quality measuring point "Hiroshima Bay 14" in Hiroshima Bay is rising at a pace of 0.17°C per 10 years. The period of the analysis is not stated in the text, and the figure shows values from around 1977 to around 2022. As reasons why the rise appears to slow from 2007 onwards, the prefecture gives 2 possibilities: the effect of the

surface water temperature off Shikoku and Tokai, and the effect of the time of measurement having become earlier from 2007 onwards. The prefecture describes this value as higher than the national value, while stating that they cannot simply be compared because the periods over which the data were taken differ. [S29]

In the observations at Kure, the highest water temperature of the year and the number of days above 20°C are increasing. The prefecture's plan for 2030 shows the results of the fixed-point observations (observations continued at the same point) in the waters just off the prefecture's Fisheries and Marine Technology Center (Kure City). It states that the maximum water temperature of each year rose by 1.8°C in 1980–2025 and that the number of days with a water temperature above 20°C increased by 19.5 days (about 13%). Both are values from trend lines fitted as straight lines, and the depth and time of the observations, how the maximum was obtained and the original data cannot be checked in the public materials. Nor is it stated what "about 13%" is a percentage of (it is about 13% if taken against the roughly 152 days on the 2025 side, and about 15% if taken against the roughly 133 days on the 1980 side; read from the figure and this paper's calculation). In the figure, the number of days above 20°C in 2025 is lower than in 2024. The same plan states that the rise in seawater temperature is raising the basal metabolism of the oysters (the energy used to stay alive) and that the time at which they switch from spawning to fattening is becoming later (the prefecture's view). [S24]

The summers of 2025 and 2026 differed in how the rain fell. The rainfall at the Hiroshima Local Meteorological Office was low in July 2025, at about 23% of a normal year, and in 2026 the total for June–July was 119% of a normal year (this paper's calculation). In 2026, there was mortality of around 60–70% in some waters in the western and central parts of Hiroshima Prefecture. The Fisheries Agency's October summary states that there is no information that producers' oysters died on a large scale, but it does not say what it calls large scale. The prefecture's expert panel has shared the fact that the rain in the 2026 rainy season was more than in 2025 (chapter 2). [S3, S4, S20]

Laws and systems

- 25 February 2022: The Basic Plan for the Conservation of the Environment of the Seto Inland Sea was changed by Cabinet decision (a plan for roughly 10 years, reviewed every 5 years). It states that the response of living things to changes in the environment, such as nutrient salts, is complex and that much has not been made clear, and that the extent and degree of the effects of the rise in water temperature and the change in how the rain falls due to climate change have not been sufficiently made clear either. [S30]
- 25 March 2022: The current Basic Plan for Fisheries was adopted by Cabinet decision. Oysters are mentioned in only 1 place, where they are given as an example of "marine products for which an expansion of exports is expected in future" in the section on export efforts, and there is no numerical target for oysters alone (this paper's check). Oysters are not among the strategic aquaculture items (yellowtails, red sea bream, bluefin tuna, salmon and trout, new fish species such as groupers, scallops, and pearls) of the national Comprehensive Strategy for Making Aquaculture a Growth Industry (drawn up in 2020, revised in 2021). [S28]
- 1 April 2022: The amended Setouchi Act (Act on Special Measures concerning Conservation of the Environment of the Seto Inland Sea) came into force. The governors of the prefectures concerned became able to set nutrient management plans and to supply nutrient salts to some sea areas. The viewpoint of climate change was also added to the basic principles. [S30]
- Promulgated 14 May 2025: Amendment of the Fishery Disaster Compensation Act. The abolition of the type of contract in which a fishery cooperative contracts for its members collectively, and other items, came into force on 1 October 2025, and the creation of "catch and specified aquaculture mutual aid", merging catch mutual aid and specified aquaculture mutual aid, and other items, came into force on 1 April 2026. The newly added rider, which pays even for heavy damage to an individual aquaculture facility (80% or more of the quantity just before the incident), is limited by the Enforcement Order to the farming of fish grown in net

pens (pens enclosed by nets), such as young yellowtail (hamachi) and sea bream, and oyster aquaculture is not covered. [S26]

- 30 May 2025: In the revision of the national "Strategy for Expanding Exports of Agricultural, Forestry and Fishery Products and Food", oysters and processed oyster products were added to the priority export items. [S31]
- 11 December 2025: The national policy package (partly amended on 17 December). In December 2025, the Prefectural Assembly passed a supplementary budget including measures against oyster mortality (chapter 3). [S25, S9]
- 20 April 2026: The Minister of Agriculture, Forestry and Fisheries consulted the council on the next Basic Plan for Fisheries (aiming for a Cabinet decision in late March 2027). [S28]
- 26 May 2026: Provisional opinion of Hiroshima Prefecture's expert panel (the final opinion is scheduled for March 2027; chapter 2). [S4]
- 1 October 2026: Hiroshima Prefecture's guidelines for fiscal 2026 were posted (with the production target set at 17,000 tons of shucked meat). [S2]
- 9 October to 9 November 2026: Call for public comments on the draft of the Hiroshima Prefecture nutrient management plan (aiming for adoption within fiscal 2026; not yet adopted as of 3 November 2026). In the draft, the target is 8 water areas (within the area of Hiroshima Prefecture): the waters off Otake and Iwakuni, western Hiroshima Bay, northern Hiroshima Bay, southern Hiroshima Bay, the waters off Kure, the waters off Akitsu and Yasuura, north-western Hiuchi-nada, and Bisan Seto (Ro); and the target living things are oysters, wakame and nori. For the time being only total nitrogen is to be increased, and 33 sewage treatment facilities and the like are to discharge effluent with more nitrogen left in it, within the effluent standards, roughly from October to March. The upper limit of the target values is given as the environmental quality standards (total nitrogen of 0.3 mg or 0.6 mg per 1 litre, depending on the category of the sea area). In summer, operation is to be normal because of concern about red tide, and trial operation at the facilities that plan to take part is being arranged for October 2026 to March 2027. [S8]
- 31 October 2026: Hiroshima Prefecture adopted the "2030 Hiroshima Prefecture Agriculture, Forestry and Fisheries Action Programme" (fiscal 2026–2030) (see the section on the market and plans below). [S24]
- Future schedule: the next meeting of the prefecture's expert panel (mid- to late November 2026); the next meeting of the national liaison council on the mass death of Pacific oysters (at the 5th meeting on 14 October 2026, it was stated that it would be held about 1 month later); the confirmed values of the 2025 survey of trends in fishery structure (December 2026); the final figures of the 2025 Fisheries and Aquaculture Production Statistics (February 2027); the final opinion of the prefecture's expert panel and the detailed tables of the 2025 fishery management statistics (March 2027); the next Basic Plan for Fisheries (late March 2027); the start of Employment for Skill Development (1 April 2027); the end of the national urgent research (the end of fiscal 2026); and the expiry of the demarcated fishery rights for oysters (31 August 2028). [S1, S4, S32, S33, S34, S28, S14, S35]

The market and plans

Oyster exports have been falling since their peak in 2022. In the tabulation of the Ministry of Agriculture, Forestry and Fisheries (based on the Ministry of Finance's trade statistics), the export value of oysters (excluding processed products) rose from 890 million yen (776 tons) in 2015 to 5.01 billion yen (4,083 tons) in 2022 (the weight is the quantity in the trade statistics, which does not distinguish between in shell and shucked meat). After that it was 4.46 billion yen in 2023, 4.83 billion yen in 2024 and 4.24 billion yen in 2025 (3,229 tons, down 12.2% from the previous year). The 2025 figure is a revised final figure [a value before the confirmed value] and may be changed in the confirmed value. The main export destinations in 2025 are Hong Kong (1.51 billion yen), Taiwan (1.37 billion yen) and Singapore (450 million yen). Exports of processed oyster products were 1.27 billion

yen (703 tons) in 2025. Of the 3,229 tons in 2025, "live, fresh or chilled" was 79.9 tons (about 2.5%, this paper's calculation), and the rest is "frozen or smoked". The Fisheries Agency states that the large-scale mortality in the Seto Inland Sea in 2025 affected the capacity to export, and that exports to Hong Kong have tended to fall since 2023. The quantity of exports of oysters from Hiroshima Prefecture alone cannot be known from the trade statistics. [S2, S31]

The unit price of Hiroshima Prefecture's oysters has been rising since its low in fiscal 2020. In the survey by the prefecture's Fisheries Division (the fiscal year is July to June of the following year; nominal), the average unit price per 1 kg fell from 970 yen in fiscal 2018 to 934 yen in fiscal 2019 and 929 yen in fiscal 2020, then rose to 1,042 yen in fiscal 2021, 1,246 yen in fiscal 2022 and 1,330 yen in fiscal 2023, and was 1,311 yen in fiscal 2024 (slightly below the previous fiscal year) and 1,604 yen in fiscal 2025 (Table 3). Fiscal 2025 is 73% higher than fiscal 2020 and 65% higher than fiscal 2018 (this paper's calculation). Over the same period, the number of management entities fell from 326 in fiscal 2018 to 288 in fiscal 2025. In Okayama Prefecture, too, in fiscal 2024 the unit price was high because of poor production in producing areas outside the prefecture, and the production value was 115% of the previous fiscal year (chapter 2). [S2, S17]

The prefecture's new plan sets maintaining the production volume as its target. The "2030 Hiroshima Prefecture Agriculture, Forestry and Fisheries Action Programme" (fiscal 2026–2030), adopted on 31 October 2026, makes "rebuilding a sustainable system of oyster production and shipment" one of the pillars of the fisheries sector. The target for oyster production is 17,000 tons in fiscal 2030, a level that maintains the 16,900 tons of fiscal 2024 (the weight basis is not stated in the plan, but the fiscal 2024 value is the same as the shucked-meat equivalent value in the prefecture's guidelines). The prefecture states that the farming grounds have the capacity to support production of 20,000 tons a year, but that because the effects of the rise in seawater temperature and the oligotrophication of the sea (a decrease in nutrients) are becoming serious, it aims to maintain the present level. The target for production per 1 raft is 2.3 tons (the same as fiscal 2024; the weight basis is not stated in the plan), and the target for the export volume of oysters is 2,500 tons (1,760 tons in fiscal 2024; the basis of weight and of fiscal year is not stated). The efforts include a review of farming density and of the production schedule, a reduction of long (3-year) farming, and support for demonstrations of the mechanisation and joint operation of shucking work. [S24]

5. What is not yet known

Things for which there are no figures

- For the 2025 mortality, we found no estimate of the amount of damage by the prefecture or the national government, no amount of mutual aid payments, and no rate of joining mutual aid after the mortality (in the 2023 census, 91.3% [this paper's calculation] of the management entities in Hiroshima Prefecture whose main business is oysters had joined some form of fishery mutual aid; chapter 3). In November 2025 a private credit research company (Tokyo Shoko Research) forecast the effect on 60 related businesses in the prefecture, engaged in oyster farming, sales and so on, at a scale of about 30.0 billion yen. This is the effect on businesses, based on their most recent sales of about 28.0 billion yen, and is neither the amount of damage to the product nor an official amount of damage (checked in news reports; the announcement itself has not been checked). [S5, S27, S36]
- We found no counted mortality rate for the prefecture as a whole (the shares by district are all from interviews). We also found no official figures for water temperature, salinity and dissolved oxygen on the farming grounds in 2025 (such as the difference from a normal year), no location and period for the "low rainfall in the rainy season (the 4th lowest in the past 50 years)", and no criteria for the 2026 warnings. The

document of the interim report of the national urgent research (31 August 2026) could not be opened on 3 November 2026. [S4, S14]

- The national statistics (in shell) for the whole season of July 2025 to June 2026 will not come out until around spring 2027. The output value for 2025 has not yet been published either. [S1, S12]
- The present number of rafts in Hiroshima Prefecture, the definition of how 2-year and 3-year farming are counted and the production volume of each, how much seed moved from prefecture to prefecture, the present production volume and cost of triploids and single seed, and the method of conversion by which the prefecture estimates the weight of shucked meat have not been published. [S1, S2, S18, S15, S6]
- The oyster harvest of the Seto Inland Sea as a whole has not appeared in the national statistics since 2019. The Japan Meteorological Agency's division of sea areas has no Seto Inland Sea, and we found no official long-term trend for the water temperature of the Seto Inland Sea either (the prefecture's values are for single points). [S1, S20, S29]
- The basis and the way of counting for the "30–50%" mortality in normal times (Fisheries Agency) are not stated. The pathogenicity of the types of oyster herpesvirus, and its treatment as a disease designated under national law, could not be confirmed (the 2017 national report states that disease and death occurred with strains from Japan). [S3, S13]
- The mass mortalities in Hiroshima in 1946–49 and 1960–64, and the death rate and amount of damage in 1969 (chapter 2 of R3-2), are values from old materials cited by a paper, and the original materials have not been checked. A statement made at a press conference by a reporter, to the effect that a similar mass mortality also occurred in Hiroshima in 2019, could not be confirmed. The prefecture's fiscal 2020 guidelines describe the poor results from the earlier to the middle part of the fiscal 2019 season as "poor growth due to the effect of high water temperature". [S2, S23, S6, S22]
- We found no figures for how much the prefecture's monitoring, warnings, demonstrations, rafts of parent oysters, strengthening of spat, nutrient salt demonstrations and triploids reduced mortality (the statements of effect that we found are only self-reports or comparisons without a control). [S4, S6, S7, S8]

Limits to comparison

- The shares of mortality are all ranges from interviews with producers and fishery cooperatives, and they also changed with the point in time (there are districts where 5 February and 3 April differ greatly). District, years of farming and the time of counting are not aligned, and the prefecture and the national government also divide the "sea areas" differently. [S3, S15]
- The effects of the prefecture's monitoring, warnings and demonstrations have not been confirmed by comparison with a control. In 2026 there was much rain in the rainy season, and the difference in the weather cannot be separated from the effect of the measures. [S4, S7]
- The indicator that mass mortality tends to occur in years of high water temperature and little rain (rainfall in July–October) is based on a correlation in 3 cases, and it cannot tell 2025 and 2026 apart (looking at rainfall alone, 2026 had less; in 2026, too, there was mortality of around 60–70% in some waters in the western and central parts of Hiroshima Prefecture, but the Fisheries Agency's October summary states that there is no information that producers' oysters died on a large scale and does not say what it calls large scale; the threshold for low rainfall is July–October rainfall at or below 442.5 mm or a value close to it, which the 643.5 mm of 2025 does not meet, and although the 508.5 mm of 2026 is above the threshold, the range of "close" is not stated; the threshold for high water temperature [146.8 or more days above 20°C] has values that differ slightly within the report, and we have not checked whether 2025 and 2026 meet this condition; a rough guide). [S3, S6, S20]
- Hiroshima Prefecture's production value in fiscal 2025 was 87% of a normal year because the unit price rose (73% of the previous fiscal year and 72% of the fiscal 2022–2024 average; the 72% is this paper's calculation)

(the volume was 57% of a normal year). However, the normal year is an average of nominal amounts that includes the years before the unit price rose, and the 87% works in the direction of making the loss look smaller. The production value is sales, not income, and does not include the costs of the large landings (1.5–2 times a normal year) or of the increase in oyster shell (about 28,000 cubic metres). The national output value, too, rose by about 9% while the volume fell by about 6% in terms of 5-year averages (2012–2016 and 2020–2024, nominal, this paper's calculation). [S2, S12, S15, S16]

Figures that disagree

- The share of mortality in a normal year (an ordinary year) differs from one material to another (Table 6). Because the way it is determined, the years of farming and the time of counting are not aligned, when the size of the 2025 damage is compared with a normal year it is necessary to show which normal year is meant.

Table 6 Share of mortality in a normal year (an ordinary year) (differences between materials)

Material	Share	Scope and conditions
Fisheries Agency (2026)	30–50%	General rough guide for Japan. No statement of basis or way of counting
Hiroshima Prefecture's research in - stitute (2006)	20–30%	Within Hiroshima Prefecture, at harvest. Differs with the period and place of farming
Hiroshima Prefecture's research in - stitute (2011)	20–30% (23.5–34.1% in the 2004–06 survey)	Hiroshima Bay. The survey was of 2 rafts, and the values are those on the last survey date
Governor of Hiroshima Prefecture (press conference of November 2025)	30–50%	Oysters with many years of farming, on heavily damaged farming grounds in the sea areas east of Kure
Governor of Okayama Prefecture (press conference of December 2025)	20–30%	A usual year in Okayama Prefecture
Hiroshima Prefecture's interviews (November 2025)	Otake district about 50%, around Atata Island about 40%	Values described as "the same as a normal year". Mainly 3-year farming
Research report of Fukuoka Prefecture (1999)	Less than 40%	A usual year in October in the Buzen Sea

Note: The shares are as worded in each material. The Governor of Okayama Prefecture also stated that even with mortality of 70–80%, if the 20–30% of a usual year is deducted, the actual decrease is about 60%.
[S3, S37, S15, S6, S22]

- The year in which the national output value of oysters was highest is 1994 (42.723 billion yen) in the table of the Ministry of Agriculture, Forestry and Fisheries, but a Fisheries Agency document states that "the peak was 42.7 billion yen in 1995" (1995 in the table of the Ministry of Agriculture, Forestry and Fisheries is 40.855 billion yen). This paper used the table of the Ministry of Agriculture, Forestry and Fisheries. [S10, S12]
- Hiroshima Prefecture's share of the national total of oysters is 63.6% in the national in-shell statistics (2024) and 65.3% in the estimate in which the prefecture converted the national statistics to the weight of shucked meat (the same as in chapter 5 of R1). The figure for Hiroshima Prefecture for 2024 in the prefecture's estimate (17,051 tons, calendar year) also differs from that for fiscal 2024 in the survey by the prefecture's Fisheries Division (16,900 tons, July to June of the following year). [S1, S2]
- The value of Hiroshima Prefecture's oysters in 2024 is 20.364 billion yen in the national output value (calendar year; an estimate made by multiplying the production volume by the wholesale price in the

producing area) and 22.2 billion yen in the production value in the survey by the prefecture's Fisheries Division (fiscal 2024, July to June of the following year). They are separate series, different in both origin and period, and cannot be mixed and compared. [S2, S12]

- Hyogo Prefecture's production in 2024 is about 8,500 tons in the written opinion of the Prefectural Assembly (March 2026) and 7,348 tons in the national statistics. The Fisheries Agency's document of November 2025 gives 8,400 tons for 2023, and the value in the written opinion may be the value for 2023 (this paper's conjecture; not checked). [S1, S10, S21]
- The prefecture's plan for 2030 states in its text that production since 2018 (Heisei 30) has "stayed at 17–18 thousand tons", while in the prefecture's guidelines (Table 3) fiscal 2019 is 16,100 tons, and in the table in the plan, which gives figures from fiscal 2020, fiscal 2024 is also 16,900 tons. [S2, S24]
- The name of the prefecture's demonstration project is written "Oyster Production Improvement Demonstration Project" in the guidelines and the list of support, and "Oyster Production Measures Demonstration Project" in the summaries of the expert panel and elsewhere. The guidelines call the May 2026 conclusions of the expert panel an "interim summary", and the summary of the meeting calls them a "compilation of the provisional opinion". The Fisheries Agency's document of October 2026 writes the values of the statistics for the calendar year 2024 as "production in fiscal 2024 (Reiwa 6)". [S2, S3, S4, S9]

Reliability and the standpoint of the materials

Reliability differs from item to item. Production volume, output value and the census are national statistics, and their reliability can be said to be high (however, 2025 is approximate figures, and the output value and the prefecture's shucked-meat values are estimates). That the official view for 2025 is one of compound factors centred on high water temperature, and that it does not list fouling organisms, is a fact of high reliability. However, the cause itself is provisional, and the final opinion is due in March 2027. The size of the mortality by district comes from interviews, so its reliability is medium. The effect of the existing measures in reducing mortality and costs, and the effect of the prefecture's monitoring and warnings, have not been confirmed by comparison with a control (self-reports, comparisons without a control, overlap with the weather), and their reliability can be said to be low.

Care is also needed about the standpoint of the materials. The agreement between the old research in Hiroshima and the present view includes a line running through the same expert. The person who was a co-author of the 2006 report and the author of the 2011 report was also the person in charge of the 2014 measurement of residue (the measurement that R3-2 used as a clue to the amount of fouling). This person is 1 of the 6 members of the prefecture's present expert panel, and this cannot be called independent confirmation (the panel also has members from universities and from the Japan Fisheries Research and Education Agency). The national government's table of countermeasures relies on 1 study each as the basis for the removal of fouling organisms and for deep hanging, and its summary goes beyond the range that the original study showed. The prefecture's follow-up evaluation of triploids is an evaluation by the very institute that developed them. The 2020 explanation of mutual aid membership (almost everyone) is that of the mutual aid association itself (the membership numbers in the 2023 census are national statistics), and the figure of about 30.0 billion yen is the forecast of a private company (news report).

The publisher of this paper (SeatecHIROSHIMA Ltd.) runs a business that controls biofouling by surface treatment of materials, and is in a position that may compete with the existing measures covered in this paper. It is also developing a system that tracks the positions of oyster rafts and informs ships of them. This paper does not cover the company's own technology or results. The publisher's relationships with the bodies taken up in this paper are as follows (as of 3 November 2026; based on information the publisher has made public, the publisher's contracts and records, and the research for this paper). With Hiroshima Prefecture, there is the relationship of having been selected in fiscal 2022 and 2023 for the prefecture's start-up support programme

"HIROSHIMA UNICORN 10" (the same as in R2). With Hiroshima University, the publisher has taken part since October 2025, as one company in a consortium, in a research centre of the university (JST COI-NEXT). Michio Imai, co-representative CEO of the publisher, has served since 1 November 2026 as a researcher (part-time) at an institute of the university (its research institute for the future of the ocean and maritime affairs) (concurrently with his post as co-representative CEO of the publisher). The publisher also joined a joint research project 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, and the contract was made 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 Kure City's research grant for year 2 (from September 2026). The costs of the demonstration work that the publisher asked the partner company in the joint research to do also include honoraria for the fishers who helped with the work (2026). This paper does not use the data or results of this joint research. The statements about the number of rafts (chapter 2) and about the moving of rafts and the prefecture's watching arrangements (chapter 3) are based on public materials. Note that 1 of the 6 members of the prefecture's expert panel taken up in this paper (chapter 2) is from Hiroshima University. With Kure City, there is also the relationship that from June 2021 to April 2025 the publisher was a tenant of the city's incubation facility (a facility that rents rooms to companies that have only recently been founded) and paid the city a fee for the use of the room. Of the regions in which the publisher is involved, the figures for Ishikawa Prefecture (Nanao Bay) and Ehime Prefecture are dealt with in R7-A (Nanao Bay) and R7-C (Ehime) of this series and are not included in this paper. Apart from the above, there is no relationship between the publisher and the bodies taken up in this paper (national bodies, prefectural and city research institutes and foundations, fishery cooperatives and fishery mutual aid bodies, companies named in this paper and so on) of a kind 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 body. This is the publisher's judgement, made after checking the information the publisher has made public, the publisher's contracts and records, and the research for this paper.

6. Sources

We examined materials that had been published by 3 November 2026. We examined mainly national statistics and laws and regulations, materials of the national, prefectural and city governments, reports of prefectural research institutes and peer-reviewed papers, and we used figures that a separate researcher had checked against the very materials listed as sources (where a value that has not been checked was used, the text says so). Among the figures that review articles and national materials quote from other studies, there are some that we have not checked back to the original study, and the text marks these as "quoted". Values read from figures are marked "read from the figure". Reliability: A = laws and regulations, statistics, materials of the national government and prefectures; B = papers, reports of research institutes that state their method; C = explanatory materials for the general public, explanations by organisations, guidance with little statement of method; D = news reports.

ID	Source (publisher, year)	Type	Reliability	Chapters used
S1	Ministry of Agriculture, Forestry and Fisheries: Fisheries and Aquaculture Production Statistics (long-term time series, Table 6; 2024 (Reiwa 6) final figures, oysters; same, sales volume of seed; 2017 (Heisei 29), seed; final figures for each year; 2018 (Heisei 30), by sea-area division; 2025 (Reiwa 7) first report; tables of the first report; outline of the survey) (in Japanese) (2013–2026; 2025 is approxi - mate figures)	Statistics	A	Chapters 1, 2, 4, 5

ID	Source (publisher, year)	Type	Reliability	Chapters used
S2	Hiroshima Prefecture: Hiroshima Oyster Production and Shipment Guidelines, fiscal 2026 (Reiwa 8) (introduction; production and shipment measures; state of shipments; statistical materials; processing flow; complete edition), past editions (fiscal 2020 (Reiwa 2); Prefectural Assembly document for fiscal 2021 (Reiwa 3); fiscal 2022 (Reiwa 4); fiscal 2023 (Reiwa 5); fiscal 2024 (Reiwa 6); fiscal 2025 (Reiwa 7)) (in Japanese) (2020–2026)	Guidelines	A	Chapters 1–5
S3	Fisheries Agency: information on oyster aquaculture; presumed factors and countermeasures (January 2026); presumed factors in each part of the Seto Inland Sea; state of mortality (July 2026; October); the prefectures' plan of efforts (August; October) (in Japanese) (summaries of interviews with the prefectures)	Material	A	Chapters 1–5
S4	Hiroshima Prefecture: expert panel on oyster mortality (summaries: January 2026; March; May; September) (in Japanese) (summaries compiled by the prefecture of meetings closed to the public)	Meeting	A	Chapters 1–5
S5	Ministry of Agriculture, Forestry and Fisheries: Census of Fisheries (for 2023, by class of management entity; by region; oyster aquaculture; people engaged in work at sea; work on land (by fishery ranked 1st in sales value); work on land (individual management entities); number of people in work on land (individual management entities); successors; time series of fishery workers; fishery workers by sex and age group; fishery workers by own-household fishery only and employed in fishery; membership of fishery mutual aid (by fishery ranked 1st in sales value); explanation of terms, and the same tables for 2018), Hiroshima Prefecture: prefectural results of the 2023 Census of Fisheries; prefectural statistical tables; tables by city and town (in Japanese) (2020–2025)	Statistics	A	Chapters 1–3, 5
S6	Hiroshima Prefectural Technology Research Institute, Fisheries and Marine Technology Center: Akashige et al.: mass mortality and water temperature and precipitation (2006); Hirata: mortality in 2004–06 (2011); annual project reports (fiscal 2014; fiscal 2016; fiscal 2020; fiscal 2024; fiscal 2025; list); list of research reports; follow-up evaluation (2009, self-evaluation); public relations magazine (No. 11; No. 12, 2008); research results on seed collection (2008); technical support (2016) (in Japanese)	Report	B	Chapters 1–3, 5
S7	Hiroshima Prefecture: use of digital technology in oyster aquaculture (Prefectural Assembly documents: January 2023; February 2024; January 2025) (in Japanese)	Material	A	Chapters 1, 3, 5
S8	Hiroshima Prefecture: call for public comments on the draft nutrient management plan; draft (October 2026); results of the fiscal 2025 (Reiwa 7) survey on nutrient salt measures (September 2026; a report of the results of the prefecture's demonstration, B) (in Japanese)	Plan	A	Chapters 1, 3–5
S9	Hiroshima Prefecture: main support measures for damage from oyster mortality (as of 1 April 2026); outline of policies and projects for fiscal 2026 (Reiwa 8) (April 2026; July); matters expected to be proposed (December 2025), Hiroshima Prefectural Assembly: Prefectural Assembly newsletter No. 82 (2026) (in Japanese)	Policy	A	Chapters 1, 3–5
S10	Fisheries Agency: On the situation surrounding oyster aquaculture (November 2025); check sheet for the proper management of Pacific oyster aquaculture (March 2026) (in Japanese) (explanations for the general public; the sources of the tables include pages that are not official)	Explanatory	C	Chapters 2, 3, 5
S11	Miyagi Prefecture Fisheries Technology Institute: Ito and Oshino: fouling organisms in Matsushima Bay and methods of removing them; Tanabe et al.: induction of spawning by hot-water treatment (2018), Miyagi Prefecture: points to note in the production management of raw oysters (2002, C); Miyagi Fisheries Day (oysters) (2019, C) (in Japanese)	Paper	B	Chapter 2
S12	Ministry of Agriculture, Forestry and Fisheries: Fishery Output Value (long-term time series, Table 3; 2024 (Reiwa 6), by prefecture) (in Japanese) (2026; an estimate of production volume × wholesale price)	Statistics	A	Chapters 2, 5

ID	Source (publisher, year)	Type	Reliability	Chapters used
S13	Shimahara et al.: survey of the oyster herpesvirus in Japan (Fish Pathology, 2012), Ministry of Agriculture, Forestry and Fisheries: summary of the report of the fish - eries epidemic prevention project (in Japanese) (2017)	Paper	B	Chapters 2, 5
S14	NARO (National Agriculture and Food Research Organization): urgent research project 07026c5 (2026), Ministry of Agriculture, Forestry and Fisheries: announce - ment of the call for proposals (2026), Fisheries Agency: liaison council on the mass death of Pacific oysters (2025–26) (in Japanese)	Research	A	Chapters 2, 4, 5
S15	Hiroshima Prefecture: documents of the Prefectural Assembly's Agriculture, Forestry and Fisheries Committee, "State of mortality of Hiroshima oysters" (19 November 2025; 9 December; 16 February 2026; 17 April) (in Japanese) (interviews and survey of shucked meat)	Material	A	Chapters 2, 5
S16	Hiroshima Prefecture: on the use of oyster shell (February 2026); state of the piling up of oyster shell and efforts to use it (July 2026, Prefectural Assembly document) (in Japanese)	Material	A	Chapters 2, 3, 5
S17	Okayama Prefectural Technology Center for Agriculture, Forestry and Fisheries, Research Institute for Fisheries Science: overview of oyster aquaculture (fiscal 2018; fiscal 2021; fiscal 2024); water quality environment and growth of Pacific oysters; figure of results (in Japanese) (2020–2026)	Report	B	Chapters 2–4
S18	Hiroshima Prefectural Technology Research Institute, Western Region Industrial Research Center: development of an oyster farming raft using PE pipes (2020); gripping and fixing mechanism for automatic oyster shucking; research results sheet (in Japanese) (2025; in cooperation with companies)	Report	B	Chapters 2, 5
S19	Hiroshima City Agriculture, Forestry and Fisheries Promotion Center: annual re - ports (fiscal 2018 (Heisei 30); fiscal 2019 (Heisei 31); fiscal 2020 (Reiwa 2); fiscal 2021 (Reiwa 3); fiscal 2022 (Reiwa 4); fiscal 2023 (Reiwa 5); fiscal 2024 (Reiwa 6); list), Hiroshima City: guidance on the farming of Hiroshima oysters and related matters (in Japanese) (2020–2026)	Report	B	Chapter 2
S20	Japan Meteorological Agency: monthly precipitation at Hiroshima (2025; 2026); normal values; long-term trend of sea-surface temperature (seas around Japan); time-series data (in Japanese) (released March 2026, viewed November 2026)	Observation	A	Chapters 2, 4, 5
S21	Hyogo Prefectural Assembly: Written Opinion No. 89, measures against the mass mortality of farmed Pacific oysters in Harima-nada (in Japanese) (March 2026)	Assembly	A	Chapters 2, 5
S22	Governors' press conferences: Hiroshima Prefecture (18 November 2025); Okayama Prefecture (25 December 2025) (in Japanese)	Press	A	Chapters 2, 5
S23	Arakawa: damage to farmed oysters by the serpulid tube worm kasane-kanzashi, which broke out abnormally in Hiroshima Bay in 1969 (VENUS 30(2), 1971; the death rate and the amount of damage are quoted from prefectural materials)	Paper	B	Chapters 2, 5
S24	Hiroshima Prefecture: 2030 Hiroshima Prefecture Agriculture, Forestry and Fisheries Action Programme (Chapter 4, Fisheries) (in Japanese) (adopted October 2026)	Plan	A	Chapters 3–5
S25	Fisheries Agency and others, 9 ministries and agencies: Policy package for damage from oyster mortality due to high water temperature and other causes (in Japanese) (December 2025)	Policy	A	Chapters 1, 3, 4
S26	Fisheries Agency: explanation of fishery mutual aid; outline of the amendment of the Fishery Disaster Compensation Act; Safety Net Construction Project (2026), House of Representatives: outline of the bill (2025), e-Gov: Fishery Disaster Compensation Act; Enforcement Order of the same Act (in Japanese)	System	A	Chapters 3, 4

ID	Source (publisher, year)	Type	Reliability	Chapters used
S27	National Federation of Fishery Mutual Aid Associations: Topics (December 2025); present state of fishery mutual aid, fiscal 2025 (Reiwa 7); state of payments (April 2026), Hiroshima Prefecture Fishery Mutual Aid Association: introduction to its business (2020) (in Japanese) (the mutual aid bodies' own explanations)	Organisation	C	Chapters 3, 5
S28	Fisheries Agency: Basic Plan for Fisheries (2022); documents of the Fisheries Policy Council (consultation; schedule; background) (2026); on the reform of fisheries policy (July 2026, summary of the comprehensive strategy) (in Japanese)	Plan	A	Chapter 4
S29	Hiroshima Prefecture (Hiroshima Climate Change Adaptation Center): sea level and seawater temperature of Hiroshima Prefecture (in Japanese) (2024)	Material	A	Chapters 4, 5
S30	Ministry of the Environment: outline of the amendment of the Setouchi Act; announcement of the change to the basic plan; Basic Plan for the Conservation of the Environment of the Seto Inland Sea (in Japanese) (2022)	Law	A	Chapter 4
S31	Ministry of Agriculture, Forestry and Fisheries: exports of agricultural, forestry and fishery products and food in 2025 (by item) (2026, revised final figures), Fisheries Agency: the situation surrounding exports of marine products (in Japanese) (August 2026)	Statistics	A	Chapter 4
S32	Ministry of Agriculture, Forestry and Fisheries: statistical survey of fishery management, final figures of the survey of individual management entities (outlines: 2021 (Reiwa 3); 2022 (Reiwa 4); 2023 (Reiwa 5); 2024 (Reiwa 6), and for 2024 (Reiwa 6) state of operations; expenditure; list of tables); 2025 (Reiwa 7) first report (in Japanese) (2023–2026; for 2024 the Seto Inland Sea is a simple average of 17 management entities, and the average of the 5 main producing areas is a weighted average)	Statistics	A	Chapter 4
S33	Ministry of Agriculture, Forestry and Fisheries: 2025 (Reiwa 7) survey of trends in fishery structure; outline of the survey (in Japanese) (2026, approximate figures from a sample survey)	Statistics	A	Chapter 4
S34	Immigration Services Agency: number of foreign residents with Specified Skilled Worker status (end of June 2026); table by municipality; outline of the Employment for Skill Development system, Minister of Justice and others: operational policy for the fisheries field (2026), Ministry of Health, Labour and Welfare: occupations eligible for transition in technical intern training (2026); examination criteria for Pacific oyster farming work (2017), e-Gov: Technical Intern Training Act (after amendment its title is the Employment for Skill Development Act; in force from 1 April 2027) (in Japanese)	System	A	Chapter 4
S35	Hiroshima Prefecture: on the Hiroshima sea-area fishing ground plan and related matters (in Japanese) (separate volumes 4–6, demarcated fishery rights, posted October 2026)	Plan	A	Chapter 4
S36	Kyodo News: oyster damage in Hiroshima Prefecture, 30.0 billion yen (forecast by Tokyo Shoko Research) (in Japanese) (November 2025, reprinted on another site; the announcement itself has not been checked)	News	D	Chapter 5
S37	Fukuoka Fisheries and Marine Technology Research Center: Sato: control of Mediterranean mussels in oyster aquaculture (1999); Naito and Matsui: reduction of waste from oyster aquaculture (2013), Buzenkai Laboratory of the same Center: oyster aquaculture information (15 September 2023; 20 October; 17 November; 11 October 2024; 6 November; information for producers, A) (in Japanese)	Paper	B	Chapter 5

Related materials: R1 The burden of biofouling at sea, R2 Seaweed and seagrass beds and the living things of the sea, R3-2 Fouling organisms on oysters, R3-3 The workforce and manual work of oyster aquaculture, R5-2 How the positions of oyster rafts are communicated, R6 What is changing (why now), R7-A08 Mass mortality of Noto oysters, R7-A09 Feeding damage to oyster spat by black sea bream, R7-A10 Dependence on other prefectures for

oyster seed, R7-C06 Uwa Sea: oyster mortality in Ainan Town, R7-C29 Seto Inland Sea side: oyster mortality in Imabari City, I1 List of assessments