Department for Environment Food & Rural Affairs

Environment Agency

Centre for Environment Fisheries & Aquaculture Science

Marine Management Organisation

Joint agency investigation into Teesside and Yorkshire Coast Crab and Lobster mortalities

Investigation summary

Date: May 2022

Contents

1. Executive summary

Between October and December 2021, dead and dying crabs and lobsters were washed ashore in unusually high numbers along parts of the north-east coast of England.

Animals displayed ‘twitching’ and lethargic behaviour as well as an inability to self-right. Crabs and lobsters appeared to be predominantly affected in large numbers.

Environment Agency led the initial emergency response, with Defra taking responsibility for the ongoing investigation in December 2021 and, in doing so, coordinating a multi-agency response involving the Environment Agency, Centre for Environment, Fisheries & Aquaculture Science (Cefas), North-East Inshore Fisheries and Conservation Authority (NEIFCA), Marine Management Organisation (MMO), Food Standards Agency (FSA) and the UK Health Security Agency (UKHSA). The investigation concluded in March 2022.

The Environment Agency, MMO and Cefas investigated a range of potential causes including licensed dredging activity, chemical contamination, activities related to offshore windfarms, presence of algal blooms and aquatic animal disease.

No single, consistent causative factor was identified. However, a harmful algal bloom present in the area coincident with the event was identified as of significance.

The presence of a harmful algal bloom was indicated by satellite imagery and confirmed by the consistent detection of lipophilic algal toxins (specifically the diarrhetic shellfish toxins okadaic acid and dinophysistoxin 2) in washed up dead crab and lobsters, confirming that animals had been exposed to algal toxins.

The significance of these algal toxins in the context of the mortality event is not yet fully understood. This will be explored in Defra funded research at Cefas.

Healthy crabs and lobsters are now being caught in the region and, while crab and lobster stocks will continue to be monitored, the investigation was closed in March 2022.

2. Incident summary

In early October 2021, the Environment Agency received reports that crabs, and lobsters were washing up dead and dying on Teesside beaches. The Environment Agency immediately launched an emergency investigation, working with a range of UK government agencies including, Cefas, MMO, FSA, UKHSA, and Defra. The roles of each agency were as followed:

- Environment Agency – Investigating pollution related incidents
- Defra – Coordinating the investigation from December 2021 onwards.
- Cefas – Investigating disease and biosecurity threats
- MMO – Investigating whether licensable activity, including dredging and disposal, cabling and offshore windfarm activity, might have caused the mortality event
- NEIFCA – Liaison with local fishing community and intelligence on stranding
- Food Standards Agency – Advising on food safety implications
- UKSHA – Advising on any threat to human health
- Local councils – Local outreach and advice on local areas

Reports of dead and dying crabs and lobsters found washed up on beaches and in fishing pots continued throughout October and into December 2021. The most significant wash-ups occurred in October. The incident affected a stretch of coastline stretching approximately from County Durham and Teesside to Robin Hoods Bay, with the fishing community reporting a significant drop in catches to at least 4 nautical miles offshore.

Defra took on overall responsibility for the Investigation from the Environment Agency in December 2021.

Affected moribund crabs and lobsters displayed clinical signs including lethargy, inability to self-right (turn off their backs) and a twitching behaviour before dying. The event seemed to affect crabs and lobsters only, and this was supported by the Environment Agency in situ observations through survey of the area - no other taxonomic groups appeared to be impacted either intertidally (observations made around rockpools) or sub tidally (vessel grab samples and trawls).

Several primary causes were considered including:

- licensed activities – dredging and disposal of sediment from local ports
- chemical pollution from land-based source including from sewage or industry discharge, and contaminants potentially released from dredging or offshore activities in the Tees area
- aquatic animal diseases
- harmful algal blooms and associated algal toxins
- seismic activity
- electromagnetic fields from undersea power cables
- unusual environmental conditions such as sudden drops in temperature and storm events

3. Investigation summary

The following were reviewed.

3.1 Licensed activities (including dredging)

Capital and maintenance dredging activities in English waters require a marine licence, unless exempt under Section 75 of the Marine and Coastal Access Act 2009, where a Statutory Harbour Authority have their own powers to carry out dredging provided specific criteria are met. The MMO, as the licensing authority, are responsible for issuing marine licences to cover all relevant activities not covered by exemptions.

Some marine licences will, therefore, include both dredging and disposal, while others may only licence particular activities of the wider project, such as disposal to sea. As part of the licensing process, the MMO consider all relevant legislation and policies, potential impacts, and carry out consultation with key stakeholders.

Further information on the impact assessments and the licensing process can be found on GOV.UK.

Following the reports of the incident, the MMO reviewed marine licensed activities within the area which supported the conclusion that based on the evidence available the licensed activities including cabling and offshore windfarm activity and dredging or disposal of sediment to designated disposal grounds was not likely to be the cause of the decapod mortalities.

Prior to considering options for the disposal of sediment to sea, dredged material undergoes rigorous regulatory testing, in line with international guidance, to ensure that deposit of such material will not cause significant harm to marine life. Uncontaminated material from dredging operations on the Tees is deposited at the designated Inner and Outer Tees disposal grounds off Teesmouth.

As part of the initial response to the incident, the Environment Agency tested environmental media for a wide range of contaminants (see section 3.2) including contaminants that are routinely tested to support marine licence applications for the disposal of dredged material to sea.

This additional screening undertaken by the Environment Agency as part of this investigation supports the conclusion that the licensed disposal of dredged sediment to designated disposal grounds was not likely to be the cause of the mortalities.

You can find more Information on marine licence on the Marine Managements Organisation's (MMO) Public Register by searching for it using the reference number.

Additionally, Cefas completed an indicative 2D tracking model of the potential sediment plume from the designated Tees dredge material disposal site. The model indicated that any plume extents were relatively confined along the tidal excursion at the disposal site

and did not have the same geographic extent that would be consistent with the known mortalities.

3.2 Chemical pollution

Analysis of water, sediment, and biological tissue samples detected no indicative chemical cause that could explain the scale of impact observed. Following extensive investigations, the Environment Agency did not consider chemical pollution or sewage as a likely cause of the mortalities.

The Tees Estuary has both current and historical industry activity, with a century of the iron, steel, and chemical industry activity in the area. Given the location of the initial findings of moribund and dead crabs in and around the Tees Estuary, a possible contaminant cause was the focus of the Environment Agency's investigation at the earliest stage.

However, it was essential that all analysis results were put into context of the pre-incident period, to differentiate between identified chemicals present in samples from this area and a chemical, or group of chemicals, which could cause the mortalities observed at this time.

A range of possible sources of contamination were considered such as industrial and wastewater discharges, as well as sediment disturbance activities (dredging). Environment Agency regulatory officers checked for any unusual activity in industry or water companies that discharge into the Tees Estuary and immediate coastal area. No abnormal site activities or non-conformances with numeric permit conditions at any of the sites were noted.

Furthermore, no significant sewage or surface water outfall incidents were reported to the Environment Agency. As the spatial scale of the incident became more obvious and mortalities occurred over several weeks, it became highly improbable that there was a point source contaminant cause as there was no indication of dilution mitigation over time and space.

The Environment Agency analysed water, surface sediment and blue mussel and crab tissue, considering over 1,000 different chemicals (The Environment Agency's scheduled contaminant sample data can be found in the Water Quality Archive on data.gov.uk as part of the public archive). As well as processing samples using their standard, fully established laboratory methods, the Environment Agency's laboratory service modified their water screening methods to look for unusual traces of contamination in the sediments and crab flesh.

Although these matrices have not previously been analysed using these methods, it was hoped that they could provide an indication that could then be investigated in more detail. This was the case with the pyridine findings.

The Environment Agency's analysis focused on organic pollutants, including pesticides, based on the behaviour of the dying crabs and the targeted nature of the impact. However,

Cefas also conducted metal analysis (including for chromium, nickel, copper, zinc, arsenic, cadmium, lead, selenium, manganese, iron and mercury) of the soft tissues from crabs. The concentrations of all metals analysed in the body tissues were consistent with baseline levels for healthy brown crab.

Cyanide was not initially analysed for as, had this been the cause, a highly visible impact would have been observed from the start of the incident across the whole biological community rather than the more targeted impact on the crabs and lobsters.

However, at the request of the fishing sector, sediment, and water samples, collected by the Environment Agency from the impacted area around Teesside in early October, were subsequently screened for free cyanide. Results from these samples were below the detection limit of the test.

In summary, no chemicals tested were identified at levels which would consistently explain the cause of the mortality event over the spatial and temporal scale observed.

3.2.1 Pyridine

Pyridine was identified in the crab soft tissue using the investigative, semi-quantitative screening technique. However, concentrations could not initially be put into context as this analysis had not previously been carried out on crab tissue and background levels were unknown.

To provide some immediate comparison, healthy crab tissues from outside the area of impact (St. Mary's Lighthouse, South Shields, Norfolk Wash and Cornwall) were analysed, and they were also found to contain varying amounts of pyridine. It is also thought that pyridine could be being formed naturally post-mortem in the crab tissue. It has been reported amongst other amines monitored as indicator of freshness in fish.

The pyridine finding illustrates how the Environment Agency further explored investigative findings from the screening results to provide potential lines of enquiry. Upon the initial pyridine findings in the first crabs analysed, follow up steps were immediately taken to explore whether this was the cause:

- on the assumption that pyridine was causal, a potential source of the contaminant was sought. This included taking a formal water discharge sample from a possible industrial source. Using validated, fully quantifiable, tests no pyridine was present in water samples. No source could be identified. (As the impacted area and length of time of the incident increased, with no dilution mitigation, a contaminant source became increasing improbable)
- literature searches for information including the ecotoxicology and background levels of, and impact of, pyridine in crabs and lobsters, were carried out
- comparison crabs from outside the known impacted area were sourced to provide an indication of the 'background' levels of pyridine in crab tissues. Comparison crabs were obtained from St. Mary's Lighthouse, South Shields, Norfolk Wash

(Eastern IFCA), Cornwall, and analysed using the same indicative screening technique. Levels found ranged from low to medium

- Pyridine was analysed for in other materials in the area includinh water, sediment, and blue mussels. Pyridine was detected at low levels by the screening method in blue mussels but not in the sediment samples. Pyridine was generally not detected in the water samples (historically we do see some positive detects of pyridine in saline wasters, including in the Tees). Pyridine is readily soluble in water, considered to be 'mobile' in soil and sediments, and has a low potential for bioaccumulation in aquatic habitats
- a laboratory pyridine standard was obtained to validate that the screening technique was identifying pyridine. It has been confirmed that the substance detected was pyridine but the 'concentrations' remain indicative only

Taken together the findings from the different parts of the investigation could not support the hypothesis that pyridine was the cause of the mortalities.

3.3 Aquatic animal disease

The Fish Health Inspectorate (FHI) at Cefas is responsible for investigating suspected outbreaks of listed and emerging aquatic animal diseases under the Aquatic Animal Health Regulations (England and Wales) 2009. The FHI, working with partner agencies including the Environment Agency and NEIFCA, took a number of samples from the affected area through October and November 2021.

There was no evidence of the major listed disease of crustacea, White Spot Syndrome Virus (WSSV) in any of the samples. Bacteria were detected in a number, but not all samples, bacteria were identified as *Vibrio* spp. and *Marimonas aquiplantarum.* Many *Vibrio* spp. are autochthonous members of marine environments and thus detection is not uncommon.

Vibrio spp. were likely to be either commensal flora or opportunistic and not expected to be linked to primary mortalities. Likewise, *Marimonas aquiplantarum* is regularly found in marine environments, often associated with seagrasses and has not been implicated in crustacean mortalities previously. In summary, it was concluded that an infectious disease agent was not responsible for the mortalities observed.

In March 2022, an additional report of 2 unhealthy lobsters in pots was received amongst an otherwise healthy commercial catch. On examination at Cefas, both animals were found to be heavily parasitised by the 'lobster louse' *Nicothoe astaci ,*which has been linked to impaired respiratory function. *Nicothoe astaci* is commonly found in samples of lobster from around the UK.

It was not observed in any other sample as part of the investigation and is not considered the cause of the wider mortalities reported in the Autumn of 2021.

3.4 Harmful algal blooms and algal toxins

As the investigation continued, consideration was given to the possible involvement of a harmful algal blooms (HAB). Sea temperatures in the Tyne and Tees were higher than normal (more than 15 °C until 26 September) in the run up to the incident (Figure 1) and potentially conducive to the formation of a HAB. It was also noted that the autumnal decrease in temperatures were severe in 2021, as shown in Figure 1.

Over the period 26 September to 7 October, the water temperature dropped by more than 2ºC, following discussion, this rapid temperature perturbation was considered unusual.

Figure 1: Tyne and Tees WaveNet Site seawater temperature, August to December 2021

Data from the Environment Agency routine phytoplankton samples showed that HAB were occurring in early September in high densities in the north-east region (Detection and enumeration of *Karenia mikimotoi* bloom of 385,000 cells per litre in Beadnell Bay, Northumberland, 50 nautical miles (nm) north of the Tees). Multiple other phytoplankton species were identified, and cell densities measured, including various potentially toxic genera such as *Dinophysis* and *Cyanobacteria* in the north-east region.

Data from the Environment Agency monthly routine phytoplankton sampling programme provided a ‘snapshot’ of phytoplankton assemblages and abundance during September but, because of monitoring frequency (monthly), not an inclusive systematic record of all HAB presence. These data are not available; therefore, a relatively short-lived algal bloom would not have been confirmed during the period.

However, harmful algal bloom was indicated by satellite imagery across multiple platforms, which appeared to be of significance given the apparent timing of the potential bloom as well as spatial scale.

Satellite data from 2 online platforms, the Cefas Eutro Viewer and the s-3 EUROHAB appeared to indicate that an algal bloom occurred along the coastal area in question prior to the onset of mortalities from 20 to 26 September 2021.

The Plymouth Marine Laboratory was also contacted as part of the investigation and provided a separate report detailing *K. mikimotoi* HAB risk around the Tees Estuary in September to October 2021 using Earth observation data (NERC Earth Observation Data Acquisition and Analysis Service (NEODAAS)).

The report showed an elevated risk of HAB in the region at different times through September and October 2021 (Figure 2).

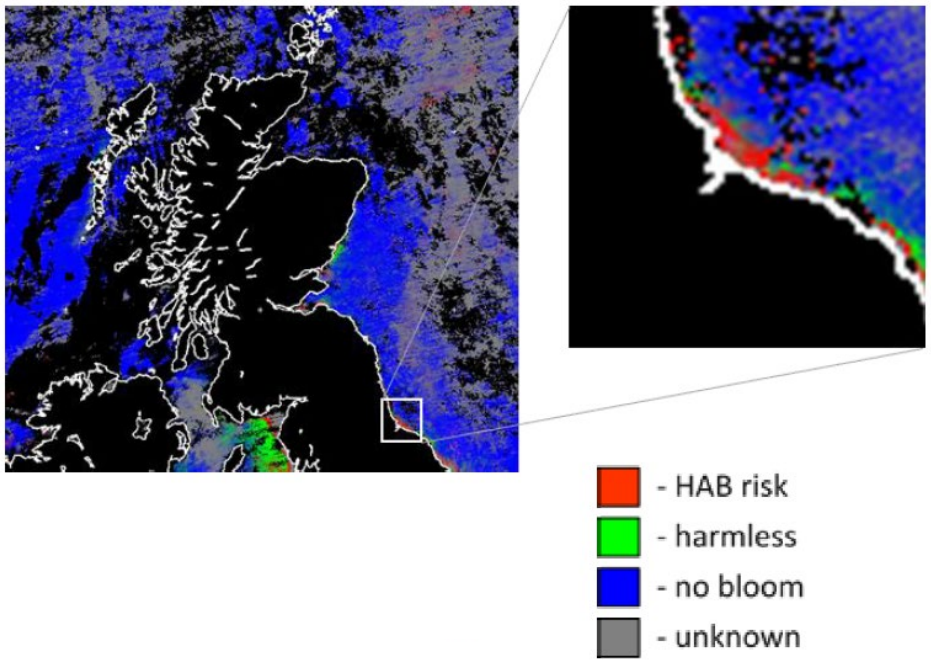

Figure 2. Karenia mikimotoi HAB risk map, 7-day composites, Suomi VIIRS sensor (9 to 15th October 2021) Courtesy of Plymouth Marine Laboratory and NEODAAS data.

Furthermore, *Karenia mikimotoi* was also identified (albeit at low concentrations) at depth on Teesside in Environment Agency samples taken as part of the investigation in November 2021 (approximately 1 and half months after the onset of the mortality event). This species of algae has previously been implicated in mortality events in crustaceans in the USA. For more detail, read the WBUR news article '2 years ago, lobsters started dying in their traps. Now scientists think they know why.

Where putative cause was reported to be reduced oxygen and hypoxic conditions at depth following microbial breakdown of dead algal blooms. *K. mikimotoi* species have also been linked to negative impacts on aquatic animal health.

Gill damage in farmed fish exposed to *K. mikimotoi* was reported in Scotland in 2006 as well as mortalities in benthic organisms (Davidson et al., 2006). It should be noted however that no evidence of hypoxia or consistent gill pathology was confirmed in this event.

Whilst satellite data indicated algal bloom formation in the region at the time of the mortality event it is important to recognise the limitations of this approach. Uncertainties mainly relate to interpretation of satellite data in near shore waters, where it can be difficult to confidently identify species composition and bloom density.

Further supporting evidence relating to HABs in the region, was confirmed however through detection of algal biotoxins (produced by certain species of HAB) in dead and moribund animal tissues sampled during, but not after, the event.

Initially, samples of frozen dead crab and lobster were screened for 2 classes of marine algae-produced neurotoxins (ASP and PSP) which are known to have impacts on animal health within the marine food web. There was no evidence for these marine neurotoxins (domoic acid and saxitoxins) being present in the samples received at levels which would cause a concern.

However, further samples of dead crab and lobster from the early wash-ups on 8 October were sent to the Cefas laboratory to be screened for additional algal toxins in light of the new information on the presence of *Karenia* algal blooms in the broader vicinity.

Analysis of these tissues was conducted for toxins in the crab tissue (hepatopancreas and brown meat). Samples were subjected to methanolic extraction to assess the potential presence of brevetoxins – natural lipophilic toxins which have been reported in other countries as produced by various *Karenia* species of phytoplankton.

Whilst brevetoxins were not detected, other lipophilic toxins, either okadaic acid and dinophysistoxin 2, were detected and quantified in all samples. Lipophilic toxin concentrations, in some instances, exceeded the regulatory limits applied for bivalve molluscs.

This finding was reported to the FSA. The consistent detection and quantitation of these compounds, sometimes at high concentrations, in washed up dead crab and lobster tissue confirmed exposure to algal toxins.

Two lobsters sampled in March 2022 (see section 3.3) were also tested for a full suite of algal toxins, only trace levels were detected. Further work is underway to explore the potential physiological impact of high levels of okadaic acid and dinophysistoxin 2 on crustacea.

4. Cefas investigation

The Defra led investigation into the mortality event was stood down in March 2022. Subsequently Defra have commissioned Cefas to further investigate a number of lines of enquiry to:

1. Ensure better preparedness for any future incident.
2. Further investigate the indicative results relating to pyridine, particularly in relation to its formation as part of a 'normal' biological process during decomposition.
3. Examine the physiological impacts of high levels of algal toxins on crustacean physiology.

5. Sources of further information

Throughout the incident investigation information was collected and variously communicated to stakeholders:

- Update on investigation into the deaths of crabs and lobster in the North East
- Environmental scientists and experts investigate Teesside crab deaths
- Environment Agency rules out chemical pollution as likely cause of Teesside crab deaths

In addition, to assist the public and other stakeholders during the investigation a series of frequently asked questions is included in Annex 1.

6. Annex 1

Is this an ongoing issue? Should levels of catch, more instances of dead or dying shellfish, and other issues continue to be reported and how?

Anecdotal evidence suggests that dead and dying crabs and lobsters are no longer being found in significant numbers, but local industry and the public should continue to report any instances. This will help us get a better picture of what is still happening by:

- The public calling the Environment Agency's helpline on 0800 80 70 60
- Local industry can do this through the NEIFCA office

Has dredging been ruled out as the cause? What testing has been done to reach this conclusion?

Dredging has been ruled out as a likely cause. Samples of dredge material must meet the highest international standards protecting marine life before it is permitted to be disposed of at sea. If samples analysed for contaminants do not meet the standards, the disposal to sea of that material will not be licensed.

Nothing in the testing of sediment prior to disposal or evidence from Environment Agency sampling suggests a chemical contaminant is a cause. Testing of sediment at the Inner Tees disposal site has already taken place in April 2021 and there was no evidence of significantly elevated contaminants in sediment at locations around and within the disposal site.

Sediment that is proposed to be dredged in the Tees Estuary is tested and sampled across the footprint of the area to be dredged at least every 3 years prior to disposal.

Cefas completed an indicative 2D tracking model of the potential sediment plume from the dredge disposal site. The model indicates that the plume extents are relatively confined along the tidal excursion at the disposal site and do not have the same geographic extent that would be consistent with the reported scale of mortalities.

Will the disposal of dredged sediment be stopped?

No, The MMO uses the best available evidence to inform its decision making. There is no evidence to suggest that the disposal of dredged sediment responsible for the crab and lobster mortality, this has been tested in accordance with international (Oslo and Paris convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR)) obligations.

Has cyanide in the sediment and water been tested for?

Sediment and water samples collected by the Environment Agency from the impacted area around Teesside in early October have now been screened for free cyanide. Results from these samples were below the detection limit of the test.

Is it only crabs and lobsters affected, what about other species?

The incident only appears to have affected crabs and lobsters. Reports of other animals, including octopus, limpets and shrimp found dead in the area appear to be unconnected and are more likely to be a result of storms and bad weather in the area.

Continue to report instances of dead or dying animals through the helpline or NEIFCA representative so we can investigate.

Are there links to seabird deaths reported earlier in the year?

The seabird death incidents were during late August and September and cases have significantly reduced since then. Samples of liver and kidney from guillemots and razorbills were analysed at Cefas for the neurotoxic marine biotoxins (saxitoxins and domoic acid), but only trace concentrations of saxitoxin detected in some samples.

Which provided very little evidence for any natural toxin impacts on bird health, assuming samples provided were representative of the affected bird population and toxin levels remained in tissues post death and sample shipment.

Further samples will be received at Cefas for analysis late March 2022, and will be assessed for ASP, PSP as well as DSP toxins.

What about dogs which have been reported as falling ill recently?

We are aware that there has been an increase in reports of vomiting and diarrhoea in dogs in the north-east, and across England. The University of Liverpool Small Animal Veterinary Surveillance Network (SAVSNET) have been investigating and found no link to the affected dogs and the incident.

While they cannot definitively point to a common cause, they do suggest this is a transmissible infection rather than contact with the beach area or sea water.

What about seals which have been reported as falling ill recently?

There is no evidence linking reports of dead seals to the investigation on crab and lobster deaths in the north-east.

If you are a member of the public and you observe a seal in danger or distress, you should contact an appropriate helpline for advice and assistance (for example, the RSPCA helpline in England and Wales, SSPCA helpline in Scotland and USPCA in Northern Ireland, or the British Divers Marine Life Rescue on 01825 765546).

The APHA Disease of Wildlife Scheme in conjunction with a network of collaborators from across Great Britain undertake surveillance for new and emerging diseases in seals, however, large die-offs can occur for many reasons, including storm surges, food shortages, trauma, predation or disease outbreaks.

The APHA Wildlife Expert group has commented that they have carried out post mortems on seal samples, taken from a range of sites in Great Britain, over the last year and not seen any evidence of an emerging disease.

We will continue to engage with wildlife experts and remind the public not to approach dead or sick seals.

How are you measuring the impact on shellfish stocks in the area?

We are continuing to work with fishers in the areas. Any information provided especially in comparison to previous years' catch, will help us get a better picture of the impact on stocks. You can provide us with further information by contacting your NEIFCA representative.

Are you sure that crabs and lobsters are safe to eat and sell? What about eating species which feed on crab and lobster?

There is currently no evidence of food safety risk from fishery products caught off the north-east coast. Businesses should continue to ensure that food placed on the market is safe and meets the relevant legislative requirements in relation to food safety and hygiene.

How are you sure that disease is not the cause?

Cefas has taken further samples from the area recently, to investigate whether an aquatic animal disease is the cause of this incident. There is no evidence in the samples analysed that there is an infectious disease agent responsible for the mortalities.

What about compensation or support for the industry?

The priority of the UK government is to investigate and understand the cause of the issue. At this stage, while investigations into the cause are ongoing, we are not considering financial support.

What about the possibility of natural causes?

Mass crustacean mortality events can occur from natural causes. For example, a mortality event was evident off the Kent coast in December 2011 that was linked to unseasonal low temperature.