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ARTICLE

The window of opportunity: Linking climate history and storms

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Abstract

High magnitude storms have impacted coastal maritime communities, instigating national government responses. Storm catastrophes can open a 'window of opportunity' that enables the implementation of new long-term disaster risk reduction measures. Analysis of historical storm events using written newspaper records identified the *Royal Charter* storm of 1859 as a catastrophe that opened a window of opportunity. The resulting actions prompted the first national (UK) storm early warning systems which continue today as the Meteorological Office forecasts. This historical case study demonstrates how the effective use of the window of opportunity can instigate beneficial long-term change that decreases vulnerability. However, policies emerging from such windows of opportunity must consider the diverse cause of catastrophe and avoid overreliance on top-down technocracy, instead promoting community engagement and autonomy for sustained success. Environmental history can contribute to improving the understanding of the limitations of technocracy and the importance of community agency in enhancing hazard understanding and effective early warning systems.

KEYWORDS

climate history, disaster, risk, storms, weather, 'window of opportunity'

1 | INTRODUCTION

This research outlines new ways of thinking about environmental hazards and disasters. It utilises the explicit link between storms and climate history by using an environmental history case study approach to analyse how major storm events changed storm subcultures in the nineteenth century. The concept of storm subcultures draws on Anderson's (1965) term 'disaster subcultures', defined as enduring trends of community and government response arising from an awareness of repeated hazards. The research focuses on the key historical event, the *Royal Charter* storm of 1859 and evaluates its major impacts on communities and the government.

Coastal storms pose an increasing threat to British communities (Lewis et al., 2011; Lowe et al., 2018; Wadey et al., 2014). Although knowledge of past storms is variable, geological and historical archival evidence indicates that storms have periodically impacted coastal environments and the human communities that inhabit them (Chaumillon et al., 2017; Garnier et al., 2018; Swindles et al., 2018). This threat persists and is predicted to grow with climate-change driven sea level rise (SLR) and increases in atmospheric storminess (Lowe et al., 2018; Palmer et al., 2018), potentially resulting in the loss of valuable coastal environments as well as cultural assets. Although there have been previous attempts to reconstruct past coastal storms in order to assess their consequences in the twenty-first century, the emphasis has primarily been placed on storms after 1950 as they are considered to have had the greatest social impacts (Haigh et al., 2016; McEwen et al., 2014; Villiger et al., 2017). There are some valuable studies that consider lessons to be drawn from earlier storms (e.g. Freitas & Dias, 2013; Hallin et al., 2021; Hawkins et al., 2023). However, in general, understanding is limited of the nature and impact of past coastal storms, despite the availability of abundant archival and geomorphological storm evidence.

On October 25–261,859, a storm occurred off Anglesey, North Wales, that caused the loss of the ship *The Royal Charter* and the death of 459 people (Villiger et al., 2017). Two years later, Admiral Robert Fitzroy, the founder of the Meteorological Department of the Board of Trade (later the Meteorological (Met) Office) introduced official 'storm warnings' based on barometric and telegraph information from throughout the UK and Western Europe. The new Met Office warnings represented the first formalised national early warning systems (EWS) (Walker, 2011). However, despite scientific development, storms have continued to have significant socio-economic and political impacts in Britain: recently Storms Ciara and Dennis in February 2020 resulted in estimated losses of £425 m (Partridge, 2020).

Although modelling of storm and climatic variability is important in informing storm response, an environmental history approach examining case studies of extreme weather-related disasters can improve the understanding of the social, political and cultural effects of storms (Knight et al., 2015). Such events can present a 'window of opportunity' which may result in policy change (Jones, 2015, p. 2; Penning-Rowsell et al., 2017). Tortajada et al. (2021) note how major flooding in Singapore in 2010 and 2011 opened a window of opportunity and catalysed key flood management policy transitions in the state. The devastating impacts of Hurricane Mitch on a Tawahka community in Honduras were also shown to enable the vulnerable poor to initiate an institutional change enhancing long-term resilience (McSweeney & Coomes, 2011). Window of opportunity adaption requires an acceptance of natural hazard events as catastrophes that are influenced by social and political frameworks, enabling an ability to learn from past storm events (Wisner et al., 2015).

In Britain, historical newspaper reports can provide key insights into hazard events that catalysed major long-term policy change. They record the publicly available information that shaped the knowledge and understanding of the catastrophe (Macdonald et al., 2010). Newspapers can bridge the gap between science, governments and the public, providing a unique insight into changing public hazard perception. As public hazard understanding fundamentally influences community vulnerability and resilience, newspapers are a valuable source for analysing the broader public and policy implications of historic storms (Rowe et al., 2000; Hove et al., 2014). The present study uses archival newspaper records following the *Royal Charter* catastrophe to elucidate the effects of the opening of a window of opportunity.

2 | CASE STUDY SELECTION

To identify the case study, a detailed review of archival newspaper material concerning storms, storm responses and implications between 1800 and 2020 was undertaken using the GALE and ProQuest online repositories. Fourteen newspapers that regularly included storm reporting were used, including *The Bristol Mercury*, *Caledonian Mercury*, *Liverpool Mercury*, *Observer & The Guardian*, and *Western Times*. Following the analyses of the 1524 storm reports in the period, it was possible to appraise trends in storm effects, specifically fatalities and socio-economic losses, and select a case study. The most devastating event was the *Royal Charter* storm of 1859, which caused 469 deaths (459 on ship). It had the greatest human impact of any British storm during the nineteenth century but remains largely unstudied. Therefore, the documented evidence of the actions and responses in the window of opportunity following the *Royal Charter* storm is assessed to determine the subsequent long-term effects (Birkmann & von Teichman, 2010).

The specific newspapers used in the case study are the *Bristol Mercury*, *Glasgow Herald*, *Liverpool Mercury*, *Morning Chronicle* (London) and *Western Times* (Exeter). These papers were considered liberal in the period, with a strong focus on community and societal issues. The newspapers firstly focus on the immediate catastrophe and its effects off Point Lynas, Anglesey. They also include important information relayed from the Met Offices in London. This study therefore reveals the wider implications of the event and the window of opportunity.

3 | CASE STUDY ANALYSIS

3.1 | 'A more complete annihilation of a ship was never seen': The royal charter storm, October 1859

The reports published immediately after the storm revealed the extent of loss and devastation. On the *Royal Charter* vessel, reports indicated that only 39 of 498 were saved. An estimated £500,000–£800,000 (equivalent to £63,300,000–£101,300,000 in 2020) worth of valuables was lost (Western times, 1859). A combination of the strong north-westerly winds estimated as 12-16 ms^{-1} (23–32 knots) and the rocky shore of Lynas Point led to the rapid destruction of the 72 m long vessel (Villiger et al., 2017).

The *Western Times* accounts stated that the ship dragged anchors creeping ever closer to the shore. Despite the initial containment of anxiety, the ship was thrown broadside on impact and great panic ensued. The *Bristol Mercury* reports showed that great consternation ensued with the ship's officers unable to control the terrified passengers. Such was the sense of desperation that a clergyman began to pray before 'his exhortations were interrupted by the violent thumping of the vessel on the rocks and the heavy seas which came dashing into the cabin' (Bristol Mercury, 1859, p. 2).

The pitiful situation was documented in the *Morning Chronicle* which exclaimed there was 'scarcely a vestige of the *Royal Charter* remaining'. A graphic scene was depicted of 'frightfully mutilated' bodies filling the local churchyard. Although survivors were treated with compassion, there was scant mention of any organised welfare provision nor had storm warnings been issued. The devastation led a correspondent to exclaim 'that a more complete annihilation of a ship was never seen' and the storm was pronounced the most 'memorable and destructive gale' for a generation (Bristol Mercury, 1859, p. 5; Glasgow Herald, 1859, p. 6).

Such human suffering and loss brought the threat of coastal storms to the forefront of public consciousness among coastal and inland communities. The societal repercussions were best communicated by a poem named 'Royal Charter' published on 5 November 1859. The poet exclaims: 'the winds awoke the other day, / And from their couches leaping / Cried out, 'We'll have a tragic play, / And set the world a weeping' (Bristol Mercury, 1859, p. 6). This poem made the grievance of the nation profoundly clear whilst conceptualising the storm as a powerful external enemy. There is no attribution of blame, with the elements themselves being condemned for their deeds. This perception was not unanimously shared, however, and this sense of inescapable storm vulnerability was to change.

Admiral Robert Fitzroy, a strong Christian humanitarian, was devastated by the reports and became convinced that a more effective warning system could have prevented the catastrophe (Burton, 1986). As a result, formal storm and weather Early Warning Systems (EWS) in Britain were introduced, with the first of Fitzroy's new 'storm warnings' issued in 1861. The introduction of government-issued storm warnings marked a major change catalysed by the window of opportunity following the storm. The actions resulting from the window of opportunity were to change the contributions of maritime coastal communities and the national governments to storm EWS.

3.2 | Initial storm warning systems, February 1861

The Met Office storm warnings, transmitted by telegraph, were published in newspapers from August 1861. However, this was six months after the first use of storm warnings at ports in February 1861. These warnings were mandatory in the sense that, once issued, the relevant authorities had to display appropriate signs (storm cones and lights) to alert mariners (Burton, 1984). The new storm warnings prioritised 'storm telegraphy', based on local observation and measurement made at various stations and transmitted to the Met Office, over more generalised statistical barometric pressure data, which had previously been given more importance when devising warnings (Cerveny et al., 2020; Dry, 2008; FitzRoy, 1863). The theory was that these observations would prove easier to interpret, enabling the Met Office in London to produce the rapid predictions and warnings that Fitzroy desired. At the time, such rapid results could not be provided by the statistical analysis of barometric pressure variability as pressure gradients had to be calculated manually and then the consequences determined. The new storm telegraphy warnings were, however, only issued to ports chosen by London-based officials after the Met Office had analysed all human weather observations and selected relevant barometric readings (Waal, 2020). This centralised and formalised approach, combined with the limited scientific basis of storm telegraphy warnings due to their ultimate dependence on Fitzroy's individual judgement, proved problematic.

Even before the warnings had made print, there was reported evidence of their effects on coastal communities following the storm of 9–10 February 1861. An extract written by Fitzroy on 13 February 1861 reveals the first recognition of the

new storm warnings across Britain. The message read 'Caution: Gale threatening from south-west and then northward. Show signal drum' (Liverpool Mercury, 1861, p. 3). A detailed explanation of signal interpretation was then provided. Prominently, Fitzroy stated 'these cautionary warning signals advert to winds during part of the next following two or three days; and therefore due vigilance should prevail' (Liverpool Mercury, 1861, p. 3). As Fitzroy had also supplied free barometers at most key ports in the 1850s, further guidance was given concerning barometric change and storms before he concluded that storms were often 'shown by instruments some hours, if not days, before the actual alteration is visible to ordinary notice' (Dry, 2007; Liverpool Mercury, 1861, p. 3). Despite the eloquent explanation, the rigorous justification highlighted the issues facing Fitzroy. Although initial reactions to the forecasts did not indicate that scientific and coastal communities were opposed to them, the change in the source, nature and communication of knowledge was an issue.

In 1854, Fitzroy had introduced barometers into coastal ports and provided interpretation instruction. The barometers were independent of the Met Office's formal storm signalling system, which enabled communities to successfully use meteorological science to inform their fishing and sailing choices. However, the 1861 adoption of mandatory and centralised storm warnings, heavily reliant on Fitzroy's personal judgement, changed the dynamic between the government and communities. While the 1854 Met Office insertion of barometers had fostered scientific integration that complemented local expertise, the 1861 storm warnings somewhat removed this maritime community input. During a stormy period, mariners were no longer able to use and interpret barometrical information to deploy when they wished and were instead subordinate to the centralised Met Office.

Despite the great developments in meteorology and hazard communication, the issues of stakeholder engagement equality and communication still resonate in twenty-first century Britain. Studies in England have highlighted that communication issues induce doubt in flood risk management agencies and EWS. In particular, engaging with community perceptions of risk is vital in managing flooding and other environmental hazards (Bang & Burton, 2021). Effective community stakeholder engagement enhances understanding of hazard exposure and vulnerability, as well as improving hazard observation and analysis and improving EWS effectiveness (Thaler & Leven-Keitel, 2016).

Fitzroy's problems, therefore, represent an early and important example of the issues concerning hazard understanding, stakeholder equality and knowledge communication. Despite significant meteorological advances, key issues resulted as storm prediction changed from a process that involved local community expertise and statistical barometric pressure data to a more centralised approach that was largely dictated by the judgement of the Met Office and Fitzroy in particular.

Although storm warning communication remained an issue, early predictive successes heightened Fitzroy's credibility and he became a hero among many mariners who entrusted him with their safety. However, the predominant reliance on storm telegraphy, based ultimately on his personal judgement, rather than statistical barometric information or local expertise began to erode his credibility. Signs of criticism appeared in the *Liverpool Mercury* on 28 September 1861. The correspondent noted instructions issued in key ports during the recent storms had been attracting 'a good deal of attention among seafaring people'. Fitzroy was quoted in the article as emphasising that 'only the greater and more general disturbances of the atmosphere are to be made known by this method (warning signals) not merely local, or sudden changes'. The prediction of localised changes was instead the responsibility of local observers. Storm signs were noted by Fitzroy as including 'much inequality of atmospheric pressure or temperature, great depression or elevation of the barometer'. This emphasis on local interpretation seemed at odds with the increased emphasis Fitzroy and the Met Office had placed on centralised storm telegraphy. Despite the assured statements, a period defined by inaccurate forecasts and political turmoil had a tragic effect on Fitzroy's health. The pressure intensified as fishing owners, now partially stripped of their independence by the new centralised storm warnings system, began to object due to losses resulting from inaccurate and centralised predictions that sometimes dissuaded them from going out to sea.

Although Fitzroy attempted to improve the transparency of the new storm warnings, negative consequences ensued due to the rapid change in forecasting policies provoked by the *Royal Charter* storm. While Fitzroy clearly sought to use the resulting window of opportunity to beneficial effect, his actions of supplying barometers to ports contradicted his previous measures to improve community engagement and knowledge.

Fitzroy's situation was further compounded by the fact that more criticism also came from within the Met Office and wider scientific community. Most prominently, Francis Galton, who headed the Royal Society, was heavily critical of using relayed weather observations to form storm warnings. Unlike fleet owners who wished for the reinstatement of their autonomy, the Royal Society opposed storm telegraphy as they considered it unscientific and a hindrance to progress. Galton noted the imprecise nature of the new forecasts and condemned Fitzroy, who had boasted how his forecasts were calculated mentally, placing the most emphasis on telegraphed weather observations and using barometric pressure readings as he saw fit. In the Royal Society's (along with the Admiralty and Board of Trade) subsequent April 1866 report

on the Met Office, it was stated how forecasts were devised 'after a simple inspection of the list of weather returns [received from coastal observers]. No notes or calculations upon paper are made. The operation occupies about half an hour, and is conducted mentally' (quoted in Dry, 2008, p. 49). Despite the technological innovation represented by storm forecasting's use of telegraphy, its reliance on the judgement of a single individual (Fitzroy) was in tension with the developing idea in the period that the weather should be the object of rigorous and robust scientific knowledge (Anderson, 2005).

Storm telegraphy inaccuracies also led to the rebuking of wider modern meteorology by astrologists who amassed great public prominence to the point that figures such as 'Zadkiel' were seen by many as genuine rivals to meteorologists. This relentless pressure and criticism sadly culminated in Fitzroy's suicide in 1865. The death of the most prominent advocate of storm warnings and storm telegraphy would fundamentally change meteorology and storm prediction. The Met Office changed its approach to forecasting and thereby changed the relationships between storms, the national government and coastal communities.

3.3 | Post-fitzroy revision of approach, August 1866

Following five years of storm warnings of variable accuracy and effectiveness, August 1866 marked a sea change in British weather forecasting and storm perception. On 22 August, the *Liverpool Mercury* featured an article concerning a pivotal Royal Society meeting about the future of forecasting. Much of the emphasis was placed upon Fitzroy's contentious system of 'weather telegraphy'. The review occurred as it had 'long been recognised that it would be desirable to collect and digest, upon a uniform plan' (Liverpool Mercury, 1861, p. 3).

For Fitzroy, the science of meteorology provided a practical way to save lives at sea. However, Galton prioritised the advancement of science and the improvement of meteorological understanding. For Galton, public and practical use was merely a secondary benefit and his report published in April 1866 evaluating the work of the Met Office virtually demolished everything Fitzroy had accomplished. It was therefore unsurprising that the fellows of the Royal Society in attendance at the meeting suggested 'phenomena as ocean currents, magnetic variations, the fluctuations of temperature in the atmosphere and in the sea ... might be investigated with advantage on a much larger scale' (Waal, 2020). This more generalised approach was to be given precedence over storm telegraphy based on localised information. The new approach instead aimed to 'map out all the accessible parts of the ocean, to provide accurate instruments for the use of officers in the navy and merchant services'. According to the committee, a 'firm statistical basis ... would be laid for the science of meteorology and the art of navigation'. The article noted that this statistics-driven method of barometric data had been the initial approach of the department and the data was 'mostly, if not entirely, of good quality'. However, the *Royal Charter* storm had changed this. Fitzroy's impatience with the slow progress of statistics-driven barometric meteorology resulted in him utilising the window of opportunity to divert the focus of the Met Office towards providing daily forecasts with a reliance on telegraphy. According to the Meteorological Department, between 1860 and 1866 weather telegraphs in Britain had been 75% accurate regarding force alone and 36% correct regarding direction. The wreck department statistics were more damning, however, stating that 78% of telegraphy predictions were incorrect. The Royal Society, therefore, reached the conclusion 'there is no sound basis on which they are founded' and storm warnings were to be immediately discontinued (Waal, 2020).

With this decision, the Royal Society adopted an almost entirely technocratic and science-focussed long-term approach to storm warnings. Although warning cessation now gave fleet owners the ability to deploy as they pleased, the decision effectively eliminated the ability of coastal communities to access weather information from different locations. While barometers were still present in ports, the decision reduced free access to barometric and reported weather observations from elsewhere. This left maritime communities often dependent on one barometric reference point and a select number of localised weather observations. While in hindsight the evidence suggests the Royal Society were pursuing a more scientifically valid long-term meteorological approach, the decision was contentious as early storm warning and forecasting success had fostered a relationship between the Met Office and coastal communities built around information sharing and predictive assistance. Therefore, to many maritime communities, the decision reversed years of valuable state assistance upon which they had become partially dependent.

A *Liverpool Mercury* correspondent postulated that seafarers would 'generally consider weather from elsewhere' but, given the evidence, they concluded 'we cannot but concur in the view of the committee, that official prophecies of weather should be abandoned'. Fitzroy's 'ill-founded pretences' were denounced, and it was agreed the state should not 'publish formal opinions every morning which science does not warrant and which experience generally confutes'. Storm warnings were abandoned with a return to devising scientific barometrically-informed storm warnings in the longer

term. This drastic change directly contradicted Fitzroy's reaction following the opening of the *Royal Charter* window of opportunity. To many, however, the radical actions of the Royal Society represented the relinquishment of Met Office support for coastal maritime communities and such actions were met with a major national response.

3.4 | Criticism and the return of storm telegraphy, September–December 1867

A year after the cessation of reported storm warnings, an account of the 'sectional meetings of the British Association' was published in the *Liverpool Mercury* on 11 September 1867. Importantly, the British Association for the Advancement of Science (BSA) was a rival scientific association to the Royal Society, formed in 1831 by 19 scientists who had become disillusioned with the elitist and conservative attitude of the Royal Society. Unlike the Royal Society, the BSA sought to enhance scientific involvement and knowledge throughout wider society. Unusually for the period, it enabled women to engage in debates and lectures which were held in both urban and rural centres to enhance inclusivity. The BSA meeting revealed the strong opposition against the cessation of the storm warnings and forecasts. The focus was a debate concerning the paper of the prominent naturalist and MP Colonel W H Sykes, entitled 'Storm Warnings, their Importance and Practicability'. Sykes demonstrated that it was widely felt that both the State and communities now had a responsibility for coastal storm resilience. (All quotations from Sykes's paper and the subsequent discussion are taken from the account in the *Liverpool Mercury* on 11 September, 1867).

The paper began with a background to meteorological development and an appraisal of Fitzroy's contribution. Between 1862 and 1865, 'Admiral Fitzroy gave 405 warnings, 305 of which were correct, representing, it was quite safe to infer, a saving from shipwreck of 305 ships and nobody knew how many lives'. Following this questionable inference, Sykes exclaimed 'such results were surely a sufficient justification for the continuance of the storm warnings'. Most poignantly Sykes had no hesitation in stating that the cessation was the 'pedantic affection of science – literally, the coxcombry of science', which was greeted by laughter and applause.

In response, a scientific committee from the Royal Society stated their proposal of 'a continuance of the system of warnings, to establish eight observatories for the purpose of making records which fifteen years hence they expected would furnish such data as would enable them to promulgate storm warnings philosophically and not empirically'. Sykes' response was that, if meteorologists had not been able to do this in 50 years, then 15 would make little difference. After referring to the opinions in favour of storm signals, he reinforced his support for storm telegraphy stating: 'Storm signalling was really practicable; it had been proved so'. He concluded by asking whether the Met Office would 'rest its actions on individual convictions and continue the suspension of the signals, or listen to the claims of humanity and the just claims of the public interest'. Sykes effectively voiced the major concern of coastal communities who were without any official weather forecasting. After widespread support from prominent members of the audience, Dr. Balfour Stewart, the secretary of the meteorological committee of the Royal Society, stated that despite 'some misapprehension about the amount of valuable information ... the committee would be prepared to establish telegraph stations all over the country, more particularly in the west'. With this information, the meteorological department would rapidly telegraph warnings to concerned ports.

This view among the audience is further echoed by Christopher Cooke's (1867) published letter to the President of the Scottish Meteorological Society. Cooke, the former (1860–62) solicitor to the Astro-Meteorological Society, referenced both Sykes' paper and addresses Fitzroy's progress and limitations, as well as the findings collated by the Royal Society, to express a widely held consensus best captured by the letter title: 'Admiral Fitzroy: His Facts and Failures'. After referring to a range of statistics produced by Sykes, Fitzroy and the Royal Society, Cooke stated 'These specimens show that Admiral Fitzroy had, at least, one foot in the path which leads to the truth' but 'sometimes he seems to have erroneously doubted the indications of the barometer' (Cooke, 1867, p. 6). This forms a crucial part of the argument about community support for storm warning telegraphy. Cooke's letter also featured a list of testimonies in support of the reintroduction of storm warnings from major ports, pilot associations, custom collectors and marine boards and importantly frequently highlighted the seafaring communities' strong support for storm warnings.

Sykes' paper and the wide consensus supporting the reintroduction of science-guided warnings had a tangible effect on government policy. This was evidenced on December 21 1867, when the *Liverpool Mercury* published an announcement declaring the 'renewal of the system of storm-signals' from T. H. Farren of the Board of Trade (comprised the Met Office). Farren proclaimed that the Board of Trade 'are now prepared to issue, free of cost, to ports or fishing stations which are accessible by telegraph, notices of serious atmospheric disturbance'. The first of these was issued on 10 January 1868 and a storm-warning service and forecasting has continued ever since. The extracts did not state that the new storm

warnings were mandatory. Therefore, communities and fleets could use a combination of the national Met Office information with their own barometric and local observations to collectively inform their decisions.

Farren's announcement essentially marked a somewhat paradoxical triumph of public knowledge over scientific dedication, but was in line with Fitzroy's initial humane impetus that prompted the scientific development that led to storm prediction. Sykes championed a well-supported cause that prioritised knowledge accessibility and inclusivity as it once again gave maritime communities agency in decision-making processes. Sykes' public cause triumphed over an approach defined by top-down technocracy in which scientific progress and elitism were prioritised. In this era of meteorological development, Sykes and his supporters demonstrated a desire to reduce vulnerability through enhancing community autonomy, engagement and knowledge dissemination.

Whilst many present at the BSA meetings would have likely been from the societal elite and have had incentives to restart storm warnings, a genuine desire to reduce community storm vulnerability is evident. Most prominently Admiral Sir E. Belcher voiced the desires and concerns of coastal communities: 'even birds, fishes, reptiles, gave warning of gales; and a man of intellect, assisted by the barometer and the electric telegraph, could have no difficulty in affording to mariners most valuable information'. Moreover, the focus on community vulnerability reflects the more inclusive approach of the BSA which further suggests those in attendance largely believed that a combination of storm telegraphy and barometer-informed storm warnings could ultimately aid coastal communities.

The reintroduction campaign highlights that for many of the societal elite and coastal maritime communities, Fitzroy's storm warnings made the Met Office an integral part of storm EWS and risk understanding. Despite the initial resistance and variable accuracy of Fitzroy's 1861 storm telegraph, the campaign illustrates the broad consensus over a range of demographic groups that coastal communities valued the Met Office storm warnings alongside their local knowledge/weather observations and autonomous barometric observations. While it was acknowledged that Fitzroy's mandatory storm warnings were imperfect and perhaps too reliant on his personal judgement, the documented evidence indicates that Fitzroy's use of the window of opportunity to initiate storm warnings had an overwhelmingly positive long-term effect. The sudden removal of storm warnings by the Royal Society, which prioritised scientific progress over public hazard awareness and EWS, was based largely on technocratic feedback from elite British scientists. This action evidently removed what had become an important and widely valued EWS between 1861 and 1866. The decision left coastal ports and communities with only localised weather observations and barometer readings, crucially restricting the flow of valuable barometric and weather observations from elsewhere. Therefore, communities were unaware of incoming storms, despite the government's ability to provide a wealth of wider meteorological data.

The subsequent developments and reinstatement of warnings in 1867 highlights the government's recognition of their value. However, their non-mandatory nature indicates that the government learnt from Fitzroy's past failings and respected coastal communities' needs for a degree of autonomy in decision making processes. This partially represented a return to what Dry (2008) in her work on barometer introduction in ports in the 1850s termed the 'outsourcing of judgement', but crucially also gave communities access to general and barometric weather observations so that more informed decisions were made to reduce vulnerability.

Fitzroy's use of the window of opportunity clearly had a beneficial long-term impact as it prompted the first national EWS from which modern forecasts originate. However, the case study highlights how decision making resulting from the opening of a window of opportunity must fully consider the variable causes of catastrophe before marked changes to a strategy are implemented. The mandatory centralised nature of warnings coupled with the overreliance on one man's judgement were the main downfalls of 1861 storm warnings, demonstrating the importance of community engagement and autonomy in EWS. Similarly, the Royal Society's top-down technocratic decision to stop storm warnings was also met with strong widespread resistance as it did not consider the wishes of coastal maritime communities and deliberately restricted public information with an approach that entirely focussed on scientific advancement. The cessation crucially ignored the importance that the window of opportunity had provided to nurture a new relationship connecting storms, the UK government and coastal communities.

4 | CONCLUSIONS

This historical case study focused on the *Royal Charter* storm and subsequent forecasting developments. It demonstrates how the effective use of the window of opportunity can instigate beneficial long-term change that decreases hazard vulnerability. Evidence of this change remains present in the form of the Met Office's highly advanced storm warning and forecasting network. However, mitigation policies resulting from the opening of a window of opportunity must

consider the diverse causes of catastrophe and avoid an overreliance on top-down technocracy. Perhaps most importantly, window of opportunity policies must enable community autonomy and engagement if they are to be highly effective in the long-term.

Although improvements in forecasting and mitigation have reduced storm catastrophes, recent events, such as the 2014 Somerset Levels Flooding (Thorne, 2014) and Storms Ciara and Dennis in 2020 (Partridge, 2020), illustrate the need for further integrated community and government action if storm and flood vulnerability in Western Britain is to decrease. The conclusions further resonate with the IPCC, (2019) findings which highlight that governments must understand the vital importance of wider community agency and autonomy when addressing climate hazards (IPCC, 2019, pp. 694–699). This article has shown how the *Royal Charter* Storm catastrophe evoked long-term social, political and cultural responses. An understanding of environmental history can highlight the limitations of technocracy and the importance of community agency with important contemporary implications for governments, ultimately contributing to enhancing future community resilience to natural hazards.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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