An astronomer's summer outing to the Lizard, Cornwall, 1769

Carolyn Kennett

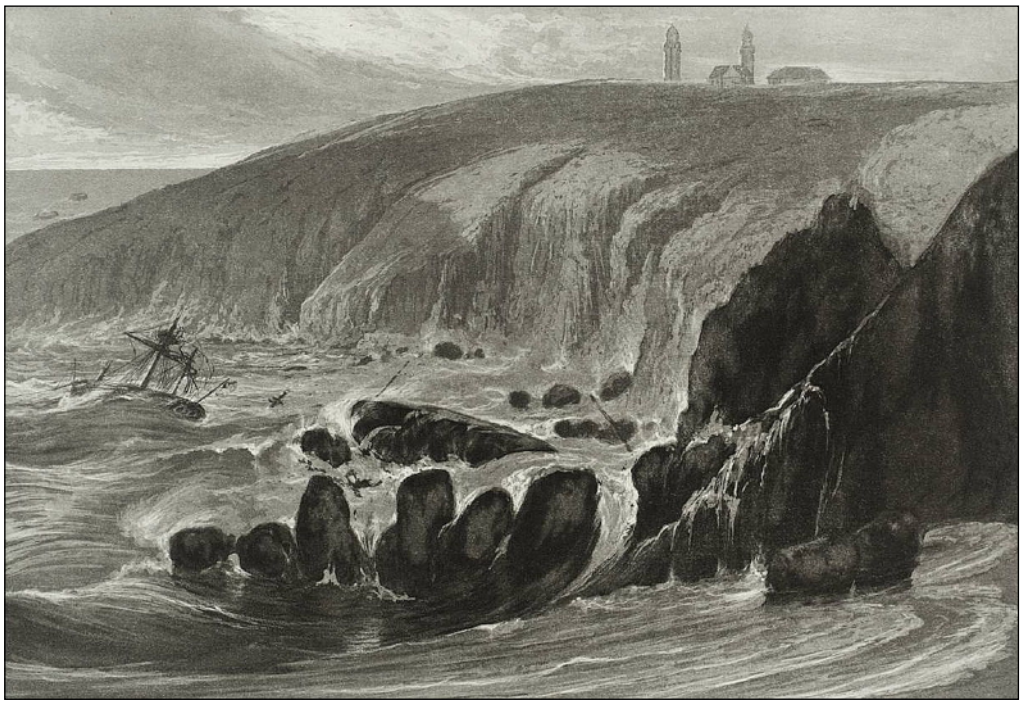


Fig. 1: *The Lizard Light-houses, Cornwall, by William Daniell (1769–1837). Date unknown. The twin towers of the lighthouses stand high on the cliff top, while a wrecked ship languishes on the rocks below. (Tate Gallery)*

In the summer of 1769 John Bradley (1728–1794), astronomer, mathematician, and nephew of the third Astronomer Royal James Bradley, was instructed by the Board of Longitude to travel to the Lizard Point on the south coast of Cornwall. There he was to record the transit of Venus on June 3 that year, and make other observations that would help to derive an accurate longitude of the Lizard for the benefit of shipping. What follows is a account of the man, his journey, and the work he accomplished during his summer visit to the Lizard Point.

1. Introduction

June 1769 presented 18th-century astronomers with the last chance to observe a transit of Venus within their lifetimes. Transits were at that time the best available way to measure the size of the Solar System. Efforts had already been made to observe the preceding transit in 1761, but results were disappointing because of the unexpected 'black drop' effect around the disk of Venus that affected the accuracy of timings. Determined to do better for the 1769 transit, the international astronomical community organized a mass-participation event far greater in scale than anything attempted before.

Another pressing need at that time was for a solution to the problem of finding longitude at sea, as increasing numbers of ships floundered and sank through lack of knowledge of their true position. One particularly treacherous section of coastline was the Lizard Point in Cornwall, the most southerly point in mainland Britain, which sticks out into the English Channel. Jutting out farther still from the Lizard Point are the Stag Rocks and a reef which extends up to half a mile into the Channel.

All ships departing or arriving at English ports from the Mediterranean and the Atlantic pass the Lizard Point, making it a major hazard. Accurate coordinates for the Lizard Point would be of great value for mariners, for at that time all they had to rely on were rough estimates and bad charts.

Nevil Maskelyne, the Astronomer Royal, recommended to the Board of Longitude in 1768 November that the forthcoming transit of Venus would be a good opportunity to make observations at the Lizard that would pin down its latitude and longitude once and for all, 'as the observation of the transit itself affords one of the best methods of determining the longitude of places'.[1] In addition, there was to be a partial solar eclipse the morning following the transit, which would provide an independent check on the measurements.

John Bradley, nephew of the former Astronomer Royal James Bradley, was chosen for the job.[2]

2. Life and work of John Bradley

John Bradley was born in 1728. There are few records of his early life but in the summer of 1742, at age 14, he was taken on as Assistant (as the post was officially termed) to his uncle, the newly appointed Astronomer Royal James Bradley, in the Royal Observatory at Greenwich.[3] He was paid £26 a year.[4]

Although all mathematical instruction would have been coming from one of the best astronomers at the time, the role would have required a certain level of intelligence, diligence, and the ability to work long hours at night by oneself. It was during his time at Greenwich that John Bradley would have grown from a schoolboy into a man with excellent mathematical abilities.

Among the more notable work John undertook as Assistant to the Astronomer Royal was the computation of the path of the Great Comet of 1744, popularly known as Comet de Chéseaux.[5] This comet was notable for developing a fan of six tails and reaching a apparent magnitude of −7 in the early months of 1744. He also observed an occultation of Venus by the Moon in 1751.[6]

In addition, while James Bradley was away in Oxford fulfilling his other duties as Savilian Professor of Astronomy, John was left in charge at the Observatory. One such occasion in 1752 saw John testing a new transit instrument to measure the differences in right ascension between pairs of bright stars. John also dealt with day-to-day correspondence and visitors.[7] Through this he would have built up a reputation for reliability and trustworthiness.

2.1. *John Bradley and lunar distances*

In September 1756, after working as Assistant to the Astronomer Royal for 14 years, John Bradley made his last observational entry at the Royal Observatory and left his post.[8] He had been offered the chance to travel with Captain John Campbell (1720–90) on *HMS Essex* to test out new tables of the Moon's position calculated by the German astronomer Tobias Mayer (1723–62).

These tables, in conjunction with observations made using Mayer's newly invented device known as a reflecting circle, could in theory be used to find longitude by the method of lunar distances. This technique involved observing the distance between the moving Moon and certain fixed stars to determine the time.

No doubt James Bradley would have influenced his nephew's decision, since Bradley sat on the Board of Longitude and was an enthusiastic supporter of Mayer's technique. Bradley had compared Mayer's tables of the Moon's position with his own observations and found them 'exact enough for the purpose of finding at sea the longitude of a ship'.[9] Encouraged by this recommendation, the Board of Longitude at its meeting of 1756 March 6 decided to conduct shipboard trials to test the lunar distances method.[10] Campbell's ship was one of those chosen for the trials.

John Bradley and Campbell already knew each other, as Campbell had been a regular visitor to the Royal Observatory after becoming friendly with James Bradley in 1747 through their mutual interest in the method of lunar distances.[11] Campbell, a very able astronomer in his own right, observed lunar distances at Greenwich with the Astronomer Royal, and no doubt young John was involved too. Campbell was elected to the Royal Society in 1764 and became one of its Visitors to the Royal Observatory the following year.

John Bradley spent three years working with Captain Campbell on HMS *Essex* in 1757–59. During this time he made a great many observations to test the lunar distances method both with Mayer's reflecting circle and an octant of the type invented by John Hadley.[12] This led to further refinements of the lunar tables and improvements in the equipment used, in particular the development of the marine sextant to supersede the octant.

By 1763 John Bradley was still working at sea, this time as a purser on the ship the *Dorsetshire*, another of Campbell's commands.[13] In this role he would have handled all the money on board, as well as supervising the ship's supplies.

2.2. *John Bradley and the Board of Longitude*

With his reputation for trustworthiness, allied to his background in astronomy, John Bradley was a natural choice by the Board of Longitude to play a role in the trials of John Harrison's H4 chronometer in 1764. Other than the lunar distances method, chronometers were considered the most likely solution for finding longitude at sea.

John Harrison had been designing and perfecting chronometers for many years and H4 was the

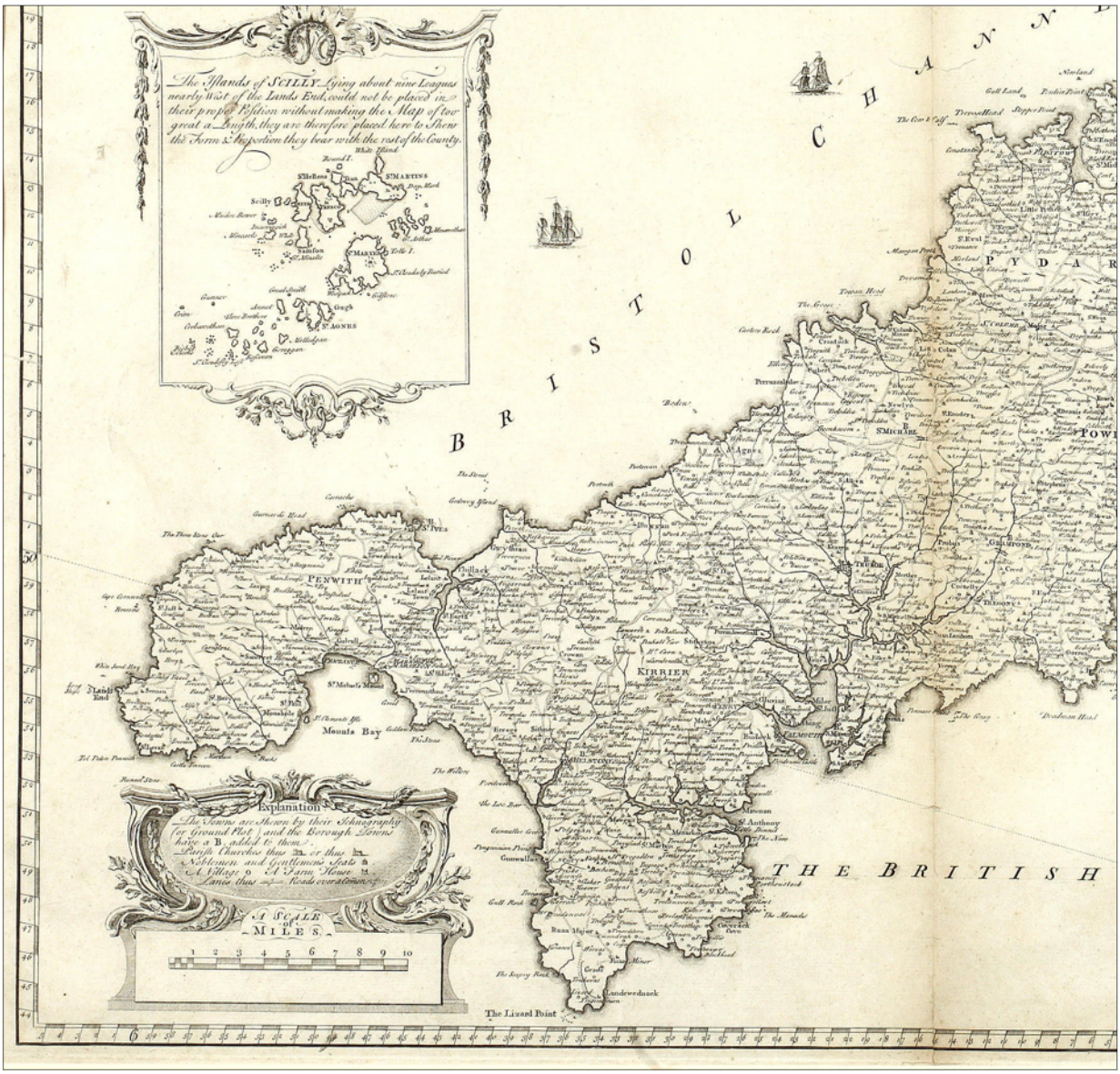


Fig. 2: *Thomas Martyn's map of Cornwall was considered the most accurate at the time of its publication in 1748. However, as the astronomical observations of 1769 found, its longitude for the Lizard Point, 5° 36' west, was some 23' too large. (Bonhams)*

culmination of his efforts. In 1764 it was due to be trialled for a second time to confirm the outcome of its successful first test. With a large reward at stake, the Board of Longitude wanted to ensure that no tampering could occur before the clock left for Barbados, so H4 was kept in a box with three separate locks, each with a different key holder. John was appointed one of the three shore-based key holders at Portsmouth who would ensure the security of H4 before its sea trials.[14]

In addition, John was instructed by the Board to make observations of Jupiter's moons and the altitude of the Sun at noon to establish the local time at Portsmouth as a reference for the trials. John asked for a small wooden observatory to be built on the South Bastion of the garrison at Portsmouth. This request was agreed by the Board.[15] It was around this time that John would have met Nevil Maskelyne, the future Astronomer Royal, who was simultaneously testing out the rival method of lunar distances in competition with Harrison's chronometer.

In 1767, after completion of the longitude trials, John was appointed second mathematics master at the Royal Naval Academy in Portsmouth under George Witchell FRS.[16] It seems likely that a shared appreciation for the lunar method of measuring longitude, along with John's earlier work at Greenwich, would have led Maskelyne to recommend to the Board of Longitude that John would be an ideal person to lead the planned trip to the Lizard for the 1769 transit of Venus.[17]

The money for this expedition was provided entirely by the Board of Longitude. This was the first time that a expedition was paid for directly by the

Board, demonstrating the importance they attached to this task. All other ventures of the time, including Cook's to the Pacific, were funded by the Crown.[18]

A total of £67 17s was released, £36 7s of which was for travel to and from the Lizard and Bradley's expenses while there. A further £21 was for his time and efforts, while his assistant Nehemiah Hunt, master of the ship *HMS Arrogant*, was to receive half that amount, viz. £10 10s.[19] Hunt was chosen as he was shore-bound while the *Arrogant* was being refitted at Portsmouth dockyard. As a ship's master he would have had responsibility for the navigation of a vessel and so had the skills needed for mapping accurately the Lizard Point and the treacherous Stag Rocks. Also accompanying them on this venture were two of the Portsmouth Dockyard's house carpenters, Nicholas Vass Jr and John Doughty.[20]

3. 1769 trip to the Lizard Point

During his sojourn on the Lizard John wrote directly to Nevil Maskelyne rather than to the Board of Longitude. His letters contain a relaxed tone which possibly shows a level of friendship that comes through previous dealings between the two men. What follows is an account of John Bradley and his time at Lizard Point, taken primarily from letters John wrote to Nevil Maskelyne which can be found in the papers of the Board of Longitude preserved at the University of Cambridge.[21]

3.1. *Preparations*

On 1769 May 4, just a month before the transit, John wrote from Portsmouth with an air of impatience, complaining that he had still received no order for a ship to take him and his equipment to the Lizard. 'I think it is a great pitty we were not at the Lizard now, for in all probability after the change of the Moon we may have change of weather... I have been in expectation for some time to receive my instructions & orders... I keep myself in readiness to go at an hour's notice so there shall be no delay on our account'.[22]

His observatory at Portsmouth, which had stood for five years since the H4 chronometer trials in 1764, had been dismantled and was to be taken to the Lizard for reassembly. The accompanying instrumentation included an equal-altitude and transit instrument (in one), an astronomical quadrant, and a reflecting telescope of 2-ft focus, all made by John Bird, plus an astronomical clock with a gridiron pendulum by John Shelton.[23] He also took a brass sextant belonging to the Naval Academy.

His assistant Nehemiah Hunt had a watch which, John reported, 'keeps time very well. If we have a quick run [I] am of [the] opinion it will give us the difference of longitude between Portsmouth and the Lizard within ¼ of a degree.'[24]

3.2. *Arrival at the Lizard*

Late in the evening of 1769 May 12 Bradley and his team finally arrived in Falmouth after a two-day voyage from Portsmouth on the ship *HMS Seaford* captained by John Macbride. Captain Macbride had just returned from securing an inaugural settlement in the Falkland Islands and was commissioned at that time to patrol the English Channel, so would have been on hand to transport the small party and their equipment to Falmouth. Not caring to disembark that late in a strange town, Bradley decided to spend the night on board the ship.

The following morning he and Captain Macbride ventured ashore. John's main concern was to find the best means of transporting his equipment, observatory, assistants, and himself to the Lizard Point. He had originally hoped to get as close as possible to the Lizard by sea, but this idea was soon quashed by the locals who, in John's words, informed him that 'it was impossible for us to land our things with safety within 10 miles of the Lizard... we were told there was a passable road in the summer from Falmouth to this place but I could not prevail on the carryer to engage to take our things till he was certain he could go through with them.'[25] Clearly, the local people were not making things easy for their heavily laden visitor, or perhaps were trying to make extra money out of him by exaggerating the transport difficulties.

Not being able to find anyone who would assure him that he could get to the Lizard by road, John set out in a horse-drawn carriage to scout the way himself, returning in the evening 'having found the road pretty good, a few dangerous places excepted'.[26]

On May 19 John wrote to Maskelyne: 'After a good deal of trouble & care we have got our observatory and instruments safe to the Lizard at a great expense for carriage etc; our observatory is errected and we have just set up the clock.'[27] He was no doubt grateful for the expenses that the Board had advanced him to pay for all this. However, his earlier fears about the weather were well founded. 'We have seen neither Sun or horizon with any distinctness since we come here.'[28]

3.3. *The Lizard lighthouse and its owner*

There were further difficulties for the party. Set atop a tall cliff with no trees in the vicinity, the Lizard is particularly remote and exposed to the elements. Hence John felt fortunate that he had made a passing acquaintance with an unnamed gentleman in Falmouth who gave him an introduction to the proprietor of the lighthouse on the Lizard, Thomas Fonnereau (1699–1779).

Fonnereau was not a local man. He originated from Suffolk and was primarily a businessman but also had political leanings, becoming MP for Sudbury in 1741. His father, Claude Fonnereau, was a merchant of Huguenot extraction. With wealth inherited from his father, Thomas Fonnereau had bought up large

Fig. 3: *The Eastern tower of the Lizard lighthouse, seen from the shore side. Next to it was the cottage in which the overseer lived, and where John Bradley and his expedition lodged during their time at the Lizard. (Trinity House)*

swathes of the Lizard,[29] including the land that the Lizard lighthouse was built on in 1751 under licence from Trinity House. Officers in nearby ports would charge ships a toll for passing the Lizard lighthouse, thereby funding its operation and making a tidy profit for Fonnereau.

The Lizard lighthouse was unusual in that it had twin towers which were both kept alight by coal fires. Between them was a small overseer's cottage which would have been the only shelter outside a small cluster of houses at the Lizard village itself about three-quarters of a mile away (Fig. 3). The overseer lived on site while the workers who kept the fires lit lived in the nearby Lizard village.

John reported in his letter of May 19: 'At our first coming here we found no small difficulty to get some little shelter for ourselves in one of the appartments belonging to the light houses. I believe we should not have been permitted to have come on their ground had I not been recommended by a gentleman of Falmouth who is acquainted with Mr Fonnereau the proprietor of the light houses.'[30]

As John and his assistants settled into the spartan lighthouse buildings they would have realized that this was a working environment. The overseer had a couch in the cottage from which he could see both towers through opposing windows. At night, when he felt the light from the fires had become too dim, the overseer would blow a cow horn to tell the firemen to pump the bellows harder.

Although parts of Cornwall were becoming industrialized because of tin mining, the effect on the Lizard would have been minimal. There would have still been pockets of people speaking the traditional Cornish language, along with separate customs that would have made the environment feel very different and remote from what John had been used to. 'I find we are got into an odd part of the Kingdom,' he wrote.[31]

The visitors would have been reliant on the overseer and locals not only for their food but also their water for there is no running fresh water on this part of the Lizard. John bemoaned that he could not buy a joint of meat 'within less than 10 Cornish miles' (a Cornish mile being equivalent to about 1.5 standard miles). He was also hoping for a change in the weather and complained of the cold (Fig. 4). Evidently they were not allowed to use coal from the lighthouse for he remarked: 'We can get scarce any thing to burn but straw and turf.'[32]

3.4. *Building the observatory*

Despite the somewhat austere living conditions, John professed himself optimistic about their observing prospects. 'I believe our observatory will do very well here, but when our observations are finished it will not be worth while to remove it from hence as it will not be fit to put up again & it will cost six times more than it is worth to get it carried back to Falmouth.'[33]

John instructed his carpenters to site his observatory 180 yards north of the lighthouse.[34] Here it would be located away from the seaward side of the lighthouse, possibly gaining protection from the wind due to the shelter of the cottage and twin towers.

With his equipment installed, John started to make measurements whenever possible even though the rain and cloud remained pretty persistent. The measurements at this point concern regulating his clock through zenith distances of the Sun and pole star; meridian observations of bright stars including Arcturus and Spica; and an observation of Jupiter's second satellite.[35]

As the next week dragged on, with poor weather limiting his ability to complete many measurements, he complained that he was suffering from a 'rheumatism' that hindered his ability to move about. Meanwhile, the transit of Venus on June 3 was approaching.

4. The transit and partial solar eclipse

By the day of the transit John felt that, despite what he termed 'very dirty weather', he had managed to make enough measurements to determine the latitude and longitude of Lizard Point.[36] For the latitude he had used the Bird quadrant of one-foot radius to take several sets of observations: nine meridional altitudes of the Sun's limb giving a latitude of 49° 57′ 35″; six meridional observations of the Pole Star giving a latitude of 49° 57′ 23″.2; thirteen observations of Arcturus, α Coronae Borealis, and α Serpentis giving a latitude of 49° 57′ 29″; and fifteen observations of α, β, and γ Draconis giving a latitude of 49° 57′ 33″. Back at Greenwich, Nevil Maskelyne combined all 44 measurements to derive a mean latitude for the Lizard Point of 49° 57′ 30″.[37]

The longitude was to be primarily determined by the transit of Venus on June 3 and the partial solar eclipse the morning after.

4.1. *Observing the transit*

Only the initial phase of the transit was visible from the UK as it began late in the evening and the Sun set while the transit was in progress. Fortunately the sky was clear enough for John to observe the entry of Venus onto the Sun's disk.

The following day he wrote to Maskelyne:

> 'The first external contact of Venus was very exact as my eye was fixt on that part of the Sun where she first touch'd, but I saw no shade precede the body of the planet. The internal contact is doubtful 4 or 5″ [as] near the time of that contact there appeared a confused sort of a light on the edge of Venus just coming on the Sun's limb, but whither it was the effect of an atmosphere, or occasioned by the great undulation in the air I do not pretend to know. A flying cloud at that instant hindred my sight for about 5″ in time.'[38]

He continued his description in his next letter two weeks later:

> 'I saw no shade precede the external contact, that the limb of Venus appear'd well defined at first coming on the Sun for 3 or 4 minutes time, when it began to appear a little jagged and continued so increasing till the internal contact; when quite in the Sun it made a very irregular figure, no part of the limb of any sensible length being a true circle, but branched[?] out in many different forms, that a very odd stricking[?] motion of light appeared about 10″ or 12″ before, & near the point of the internal contact such as I never saw before, neither do I know how to discribe it; but at the time [I] thought it might have proceeded from a great undulation in the air.'[39]

Had John seen what was to become known as the black drop effect? Similar effects to those he described had been reported by the Swedish scientist Torbern Bergman at the previous transit of Venus in 1761, and were attributed to an atmosphere around Venus.[40] Yet John's letters make clear that this phenomenon was new to him, and he struggled to explain it.

He considered the apparent time of the external contact of Venus with the Sun to be exact, at 6h 47m 58s in the afternoon, while the internal contact was recorded as 7h 6m 18s with an uncertainty of 4 or 5 seconds due to the 'flying cloud' which had intervened.

4.2. *Observing the solar eclipse*

The following morning he was able to observe the partial solar eclipse through gaps in the cloud. At maximum, the Sun was just over 50% eclipsed as seen from Cornwall and London. He reported in his letter to Maskelyne of June 4 that his measurements of the beginning and end of the eclipse had been very good, but confessed himself 'extreamly fortunate' to get a gap in the cloud at the right time.[41]

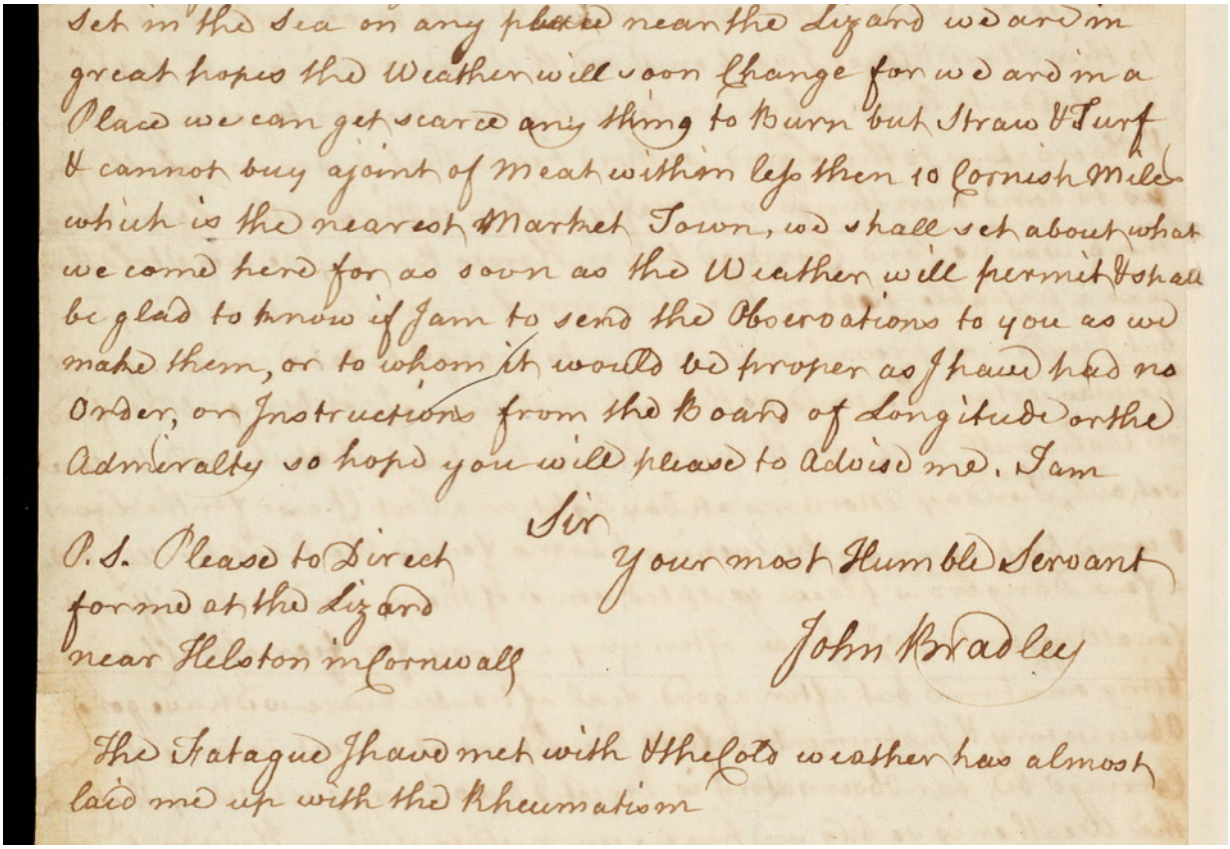
He recorded the apparent time for the beginning of the eclipse as 06h 14m 54s and the end as 07h 57m 17s, giving a duration of 1h 42m 23s. The measurements were made with the two-foot reflector and ×120 magnification.[42]

5. Final weeks at the Lizard

Other measurements he had been trying to make during his stay were hindered by the persistent bad weather.[43] These included the dip of the horizon to determine his height above sea level, observations of Jupiter's satellites, and meridian transits of the Moon. 'We have not had one day since we have been at the Lizard without some rain,' he informed Maskelyne on June 4, but promised to continue work as weather permitted until they left the Lizard, which his letters make clear he was keen to do as soon as possible.[44]

'I cannot get rid of my rhumatism,' he added, but struck a more satisfied note than before about living conditions: 'We live very well, having a very good market 12 miles from hence where we send for what we want.' Here he is referring to the market town called Helston. Daniel Defoe during his grand tour of Britain had paid a visit to Helston 44 years prior and was similarly impressed, describing it as 'large and populous, and has four spacious streets, a handsome church, and a good trade'.[45]

Maskelyne's reply expressed satisfaction with the observations that John had sent to London. On June 18 John wrote again to inform Maskelyne that the weather remained poor. He continued to hope for an improvement so he could finish his work, but complained that he was still suffering in the cold, damp conditions: 'I do assure you I am so lame with my old rhumatic complaint that I can scarce crawl about.'[46] Unfortunately for John there was as yet no order for him to return to Portsmouth.


Set in the Sea on any part near the Lizard we are in great hopes the Weather will soon change for we are in a Place we can get scarce any thing to Burn but Straw & Turf & cannot buy a joint of Meat within less then 10 Furnish Miles which is the nearest Market Town, we shall set about what we come here for as soon as the Weather will permit & shall be glad to know if I am to send the Observations to you as we make them, or to whom it would be proper as I have had no Order, or Instructions from the Board of Longitude or the Admiralty so hope you will please to advise me. I am

Sir

your most Humble Servant

John Bradley

P.S. Please to Direct for me at the Lizard near Helston in Cornwall

The Fatague I have met with & the cold Weather has almost laid me up with the Rheumatism

Fig. 4: *Letter from John Bradley to Nevil Maskelyne from the Lizard, dated 1769 May 19. After signing off he adds a complaint about his health that was to become a regular feature of his correspondence: 'The fatague I have met with and the cold weather has almost laid me up with the Rheumatism'. (Cambridge University Library)*

5.1. *More observations at the Lizard*

Despite his debilitating ailment, John continued to make routine observations during the following weeks, including more measurements regarding the dip of the horizon which he had not been happy with before. He also took timings of the transits of Jupiter's moons. 'I hope you have been so fortunate as to observe the same transits as I have & the emersions of the satellites & then I think the longitude of this place will be as well known as any headland need to be,' he informed Maskelyne on July 2.[47]

One unexpected difficulty in timing observations was hearing the ticking of the observatory clock above the background noise outside: 'When the wind blows anything fresh from the southward it is very difficult to hear the beat of the clock owing to the continual noise the surff of the sea makes among the Stag Rocks some of which are not more than half a mile from us.'[48]

While the party awaited their instructions to return, Nehemiah Hunt had plenty of time to chart the aspect of the Lizard and the location of Stag Rocks relative to the lighthouse. The two carpenters, Vass and Doughty, assisted in the surveying and astronomical work. As John wrote to the Admiralty afterwards, 'they were very servisable in removing the necessary stands etc from place to place in order to observe the dip of the horizon of the sea at different elivations, & the situation of the Stagg Rocks and the bearing of the principal head lands etc, and making a very exact survey of the coast for near three miles and when any astronomical observations were required to be made they were up most part of the night.'[49]

At last, nearly a month after the transit, John was relieved to receive a letter from Captain Robert Keeler of the sloop *HMS Cruizer* who had arrived in Falmouth harbour to take him back to Portsmouth. John wasted no time in arranging his departure. In a letter to Maskelyne on July 2 he wrote: 'We propose to set out for Falmouth early tomorrow morning with our clock and instruments.' His letter ended with the regular grumble: 'I am at present in a very hobbling condition but hope soon to get better.'[50]

5.2. *Leaving the Lizard*

So with little notice and after 51 days John Bradley and his assistants departed the Lizard Point. They left behind their wooden observatory building as a shed for the overseer since it was not worth the trouble and expense of taking it with them. They also left behind a meridian marker on the north face of the overseer's cottage. As John explained: 'It is a white spot about 4/10 of an inch in diameter painted round with black on the north side of a brick house which stands between the two light houses and distant from my

transit instrument just 518 feet; I have a lamp fixed in the same direction against the wall of the house by which I can adjust the instrument at night nearly as well as by day.'[51] Sadly the building on which the marker and lamp were fixed is now long gone.

At this point there was a breakdown in relations with the overseer (who John never names, referring to him only as 'the poor man'), since he had never received an official order from the Admiralty to admit the expedition as John had promised when they arrived. 'He said he would never trust to any ones word again,' according to John.[52] Evidently the overseer was worried that he would get into trouble with his employer, Thomas Fonnereau, for allowing the astronomers to stay in the lighthouse without his permission. John requested Maskelyne to write to Fonnereau 'both on my and the poor mans account' but there is no record that the letter of explanation was ever sent.

John's experience at the Lizard left its mark, both physically and psychologically. The day after his return to Portsmouth he wrote to Maskelyne: 'My rheumatick complaint is something better, but I have such a nervious complaint I can scarce write my hand shakes so much. I am afraid I shall find the effects of the Lizard taunt for some time.'[53] In the same letter he noted that if Maskelyne were determined that more observations be made at the Lizard he would write to the overseer to ensure that the observatory and meridian mark were left untouched, 'but on no condition go'.

6. Calculating the longitude

John sent his final measurements to Nevil Maskelyne for him to calculate the latitude and longitude of the Lizard Point. Maskelyne published his results in the *Nautical Almanac* for 1771.[54] From John's meridian altitudes of the Sun and pole star Maskelyne calculated that the latitude was 49° 57′ 30″ N, very close to the modern figure.

For the longitude, Maskelyne used the difference in times of the transit of Venus on June 3 and two emersions of the first satellite of Jupiter on June 8 and 15 which had been observed simultaneously at the Lizard and Greenwich. The differences in the times ranged from 20m 53s by the first contact of Venus to 21m 52s by the June 15 emersion of Jupiter's satellite. Maskelyne settled on a mean figure of 21m 00s of time, equivalent to 5° 15′ of longitude.[55]

The longitude figure was later revised in the light of further calculations by Nevil Maskelyne, George Witchell (John's superior at Portsmouth Naval Academy), and William Wales (who had recently returned from his own transit expedition to Hudson Bay, Canada).

As calculated by Wales, four transits of the Moon gave a time difference between the Lizard and Greenwich of 20m 30s.6, while the two emersions of Jupiter's first satellite gave 21m 14s.5. The time difference for the transit of Venus was calculated by Wales as 20m 57s.0, by George Witchell as 20m 56s.5, and by Nevil Maskelyne as 20m 57s.0. Finally the time difference for the eclipse of the Sun was calculated by Witchell as 20m 44s.5.

Additional calculations of the eclipse observations by the European astronomers du Séjour, Euler, and Lexell gave time differences of 20m 45s.1, 20m 59s.0, and 20m 51s.0, respectively. The mean of these was 20m 52s.12, equivalent to a longitude of 5° 13′ west of Greenwich, slightly smaller than the initial result.[56]

Today's figures have the Lizard point at latitude 49° 57′ 32″ N and longitude 5° 12′ 54″ W, confirming that the revised longitude calculations were admirably close to the modern determination.

7. John Bradley in later years

Once settled back at Portsmouth, John Bradley returned to his role as second master in residence at the Naval Academy under George Witchell. One of his roles was to instruct ships' masters in the Royal Navy how to use the methods of lunar distances. Among those he taught was Nehemiah Hunt, his assistant at the Lizard and still master of *HMS Arrogant*.[57]

Having taken his old observatory to the Lizard and left it there, John was in need of a replacement. Shortly after his return, John and George Witchell requested the governors of the Naval Academy to provide 'a proper building and stone pier' to be erected to house an astronomical quadrant made for the Academy by John Bird.[58] In addition to teaching at the Academy, John continued to do occasional consultancy work for the Longitude Board.

He remained in his post at the Naval Academy for 27 years, until his death on 1794 June 14.[59]

7.1. *John Bradley's children*

John Bradley had three sons and one daughter. Upon his death his youngest son, James (1765–1820), succeeded him as second mathematician at the Academy, having worked for his father since leaving school.[60]

John's second son, William (1757–1833), was an officer aboard the ill-fated *HMS Sirius* which was flagship of the first fleet to Botany Bay but was wrecked off Norfolk Island in 1790. He had a inquisitive and scientific mind which saw him keeping a journal documenting his time in Australia.[61] He charted much of the coastline around Sydney. A promontory called Bradleys Head on the north shore of Sydney Harbour is named after him.

William married Sarah Witchell, the daughter of John Bradley's superior at Portsmouth, George Witchell. As William was away at sea for years at a time, Sarah and the four grandchildren who lived in Portsmouth were on hand to look after John into his later years. By the time of John's death in 1794

William had reached the pinnacle of his career, having been promoted to command his own ship. Sadly there followed a descent into madness and attempt at postal fraud which led to his exile in France in 1814. William spent the rest of his life trying unsuccessfully to design and improve a longitude method using an hour-glass with the hope of being allowed to return to England.[62]

His eldest son, also called John, was born in 1755 while John senior was still at Greenwich. He worked in the storekeeper's office in Portsmouth from the age of 18 and died in 1788.[63]

A daughter, Mary, was born in 1771. Little is known about her, but she was still alive at the time of the 1841 census, aged 70, a spinster living in Portsea.

8. Concluding notes

Thomas Fonnereau's lease on the lighthouse was due to last 61 years but instead it was terminated just two years later, in 1771. Fonnereau had been cutting corners over the lighting of the twin towers. He continued charging people when they reached port even though the fires had not been visible from their vessels. This led to numerous complaints from ship owners and requests to the Crown for refunds. The Lizard lighthouse is the only lighthouse to have been removed from private ownership through court proceedings by Trinity House.[64, 65]

Trinity House continued with coal-lit towers until 1812 when they were changed to oil lamps. At this time the overseer's cottage was removed. New housing and offices with a covered passageway were installed, but the twin towers remain.

Despite the efforts of the astronomers to establish the precise coordinates of the Lizard, navigation past Stag Rocks remained treacherous. Visibility on that part of the coastline is often poor because of sea fog. Navigators would still have needed the instruments to make accurate observations and the skills to calculate their position, which many did not.

The next ship to hit Lizard point after John Bradley's visit was the *Hambro Arms* on 1769 August 7.[66] The ship and its cargo were lost. Many more vessels would follow its fate.

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References and notes

1. Confirmed minutes of the Board of Longitude 12th Nov 1768, RGO 14/5, p. 175.

2. Maskelyne, Nevil, *The Nautical Almanac and Astronomical Ephemeris for the Year 1771* (1769), pp. viii–ix. Maskelyne had given detailed guidelines for observing the transit in an appendix to the *Nautical Almanac* for 1769 (published 1768).

3. Rigaud, S. P. (ed.), *Miscellaneous Works and Correspondence of the Rev. James Bradley* (Oxford University Press, 1832), p. li.

4. Woolley, Richard, 'James Bradley, Third Astronomer Royal', *Quarterly Journal of the Royal Astronomical Society*, 4 (1963), p. 51.

5. Bradley, John, Letter to James Bradley dated 16th April 1744, RGO 3/43/6.

6. Bradley, John, and Short, James, *Philosophical Transactions* 47 (1751), pp. 201–202.

7. Rigaud (1832), p. 469.

8. Rigaud (1832), p. xcix.

9. Rigaud (1832), p. 84.

10. Confirmed minutes of the Board of Longitude 6th March 1756, RGO 14/5, p. 25.

11. Wales, William, and Bayly, William, *The original observations made in the course of a voyage to the south pole and round the world* (1777), p. xxxiv.

12. Wales and Bayly (1777), p. xxvii.

13. 'Letters from the Longitude Commissioners to the Navy Board', National Maritime Museum Manuscripts ADM/A/2551, page 4:1.

14. Ibid., p. 4:2.

15. Resident Commissioner's letter to the Navy Board dated 28th September 1763, ADM/106/1123/300.

16. Hollis, H. P., 'The Greenwich Assistants during 250 years', *The Observatory*, 48 (1925), p. 392.

17. Maskelyne (1769), pp. x–xi.

18. Howse, Derek, 'Britain's Board of Longitude: The Finances', *The Mariner's Mirror* (1998), 84(4), 400–417. Derek Howse delves into the Board of Longitude finances, offering insights over the whole period and showing how there becomes far more spent on expeditions after John Bradley's visit to the Lizard.

19. *Journal of the House of Commons* (1774), 34, pp. 662–663.

20. Bradley, John, Letter to Commissioner Hughes, 26th July 1769, ADM 106/1178/221.

21. Papers of the Board of Longitude, Cambridge Digital Library, readable online at http://cudl.lib.cam.ac.uk/collections/rgo14

22. Bradley, John, Letter to Maskelyne dated May 4th 1769, RGO 14/52, p. 6r.

23. Maskelyne (1769), p. xi.

24. Bradley, John, Letter to Maskelyne dated May 4th 1769, RGO 14/52, p. 6r.

25. Bradley, John, Letter to Maskelyne dated May 19th 1769, RGO 14/52, p. 7r.

26. Ibid.

27. Ibid.

28. Ibid.

29. Ratcliffe and Henderson, solicitors of Helston, 'Lease and release, Manors of Bochym, Trethevas, Lucyas or Rosewick', (4-5 Jan 1768), Cornwall Records Office RH/1/856.

30. Bradley, John, Letter to Maskelyne dated May 19th 1769, RGO 14/52, p. 7r.

31. Ibid.

32. Ibid., p. 7v.

33. Ibid., p. 7r.

34. Ibid., p. 7v.

35. Bradley, John, Observations made at the Lizard, RGO 14/52, pp. 8r, 8v.

36. Bradley, John, Letter to Maskelyne dated June 4th 1769, RGO 14/52, p. 14r.

37. Mudge, William, *An account of the operations carried on for accomplishing a trigonometrical survey of England and Wales*, vol. II (1801), p. 132.

38. Bradley, John, Letter to Maskelyne dated June 4th 1769, RGO 14/52, p. 14r.

39. Bradley, John, Letter to Maskelyne dated June 18th 1769, RGO 14/52, p. 146.

40. Bergman, Torbern, Letter to Benjamin Wilson dated 28 August 1761, *Philosophical Transactions* 52 (1761), pp. 227–230.

41. Bradley, John, Letter to Maskelyne dated June 4th 1769, RGO 14/52, p. 14r.

42. Maskelyne (1769), p. x.

43. On his return to Portsmouth John noted: 'In the seven weeks we were there we had but once 24 hours without rain, they have at the [Lizard] Point in general much worse weather than 4 or 5 miles inland on account of thick fogs etc hanging over it.' John Bradley, Letter to Maskelyne dated July 9th 1769, RGO 14/52, p. 20r.

44. Bradley, John, Letter to Maskelyne dated June 4th 1769, RGO 14/52, pp. 14r, 14v.

45. Defoe, Daniel, *A Tour Thro' the Whole Island of Great Britain* vol. 1 (1724), p. 349.

46. Bradley, John, Letter to Maskelyne dated June 18th 1769, RGO 14/52, p. 16v.

47. Bradley, John, Letter to Maskelyne dated July 2nd 1769, RGO 14/52, p. 18r.

48. Ibid., p. 18v.

49. Bradley, John, Letter to Commissioner Hughes dated July 26 1769, ADM 106/1178/221.

50. Bradley, John, Letter to Maskelyne dated July 2nd 1769, RGO 14/52, p. 18v.

51. Ibid., pp. 18r–18v.

52. Bradley, John, Letter to Maskelyne dated July 9th 1769, RGO 14/52, p. 20r.

53. Ibid.

54. Maskelyne (1769), p. x.

55. Ibid., p. xi.

56. Mudge, William, *An account of the operations carried on for accomplishing a trigonometrical survey of England and Wales*, vol. II (1801), p. 133.

57. RGO 14/18, p. 449r. This document lists 'the names of those masters of His Majesty's Navy who have been instructed in the use of the Nautical Almanac, quadrant, etc. at the Royal Academy in His Majesty's yard near Portsmouth by Mr George Witchell and John Bradley'.

58. Witchell, G., and John Bradley, letter to Commissioner Richard Hughes dated July 26th 1769, ADM 106/1178/210.

59. Dickinson, Harry W., *Educating the Royal Navy* (Routledge 2007), p. 36.

60. Rigaud, S. P. (ed.), *Miscellaneous Works and Correspondence of the Rev. James Bradley* (Oxford University Press, 1832), p. li (footnote).

61. Bradley, William, *A Voyage to New South Wales, December 1786–May 1792*. The original manuscript is held by the State Library of New South Wales and can be viewed online at The University of Sydney Australian Digital collections: http://purl.library.usyd.edu.au/setis/id/brajour

62. Hine, Janet D., 'Bradley, William (1757–1833)', *Australian Dictionary of Biography* (Melbourne University Press, 1966).

63. Greenaway, John, letter to the Admiralty dated 1773 August 28, ADM 106/1220/310. The letter recommends John Bradley, 'son of Mr Bradley 2nd Master of the Royal Academy', as a person qualified to fill the junior vacancy of a Clerk at the dockyard in Portsmouth. The letter states he is 18 years of age and had been a volunteer Assistant Clerk in the Commissioner's office for three years.

64. Stevenson, D. Alan, *The World's Lighthouses Before 1820* (Oxford University Press, 1959).

65. Larn, Richard, and Carter, Clive, *Cornish Shipwrecks – The South Coast* (David & Charles, 1969). One such incident involved a boat from the West Indies which was wrecked because the fires at the lighthouse had burnt so low.

66. Larn, Richard, and Larn, Bridget, *Shipwreck Index of the British Isles*, vol. 1 (Lloyds Register, 1995).

The author

Carolyn Kennett moved to the far west of Cornwall with her husband and son from London 11 years ago. When not helping to run the family business she spends time on astronomy and exploring the countryside. She has a keen interest in history, having worked for the Office of Public Works Heritage Services in Dublin for a time. She holds an Environmental Science degree (1996) from the University of Hertfordshire, and a PGDip in Environmental Management (1997) from Middlesex University. Currently she is undertaking a distance-learning astronomy degree with UCLAN.