



Letter

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The 1789 Christmas Eve collision of the *HMS Guardian* with an iceberg in the southwest Indian Ocean

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Abstract

In the evening of 24 December 1789, 2100 km southeast of Cape Town and after encountering three icebergs, the *HMS Guardian* under Captain Edward Riou collided with the submerged foot of a large iceberg. Despite severe damage to the ship and its abandonment by many of its crew and passengers, Riou sailed the hulk back to Cape Town, arriving on 22 February 1790. From present-day research and field studies, the formation of the foot in the collision is consistent with the above-freezing seawater temperatures inferred from Riou's commentary. Further, the observed 60 m iceberg height suggests that it calved from the Filchner Ice Shelf in the Weddell Sea. Comparison of the positions of Riou's icebergs with historic sightings, satellite observations and iceberg drift and fracture models also shows that they originated in the Weddell Sea and that their likelihood of occurrence in the collision region is small.

1. Introduction

On 11 December 1789, the *HMS Guardian* under command of 26-year-old Captain Edward Riou departed Cape Town for the new Australian colony. The ship sailed southeast to reach 44°S, the latitude of the strong westerly winds, then continued east in the Antarctic Circumpolar Current (ACC).

The *Guardian* was a Roebuck-class warship refitted as a supply ship. It had a 35 m deck length, a 43 m overall length, a 12 m width, a draft of 5–6 m and a main mast height of ~30 m (Best ship models, 2022; Model ship builder, 2022). The ship carried 1000 tonnes of supplies, and 124 people, including 88 crew, 25 convicts and 11 passengers and wardens. The only female was a 10-year-old girl, Elizabeth Schaeffer, daughter of colonist Phillip Schaeffer.

Eleven days after leaving Cape Town on 22 December, Riou was surprised to observe two icebergs that he recorded at the position of his noon sighting (Table 1). His dates were in 'nautical time,' with days running from noon to noon, and his positions determined at local noon. Before the collision, he determined latitude from sextant observations and longitude from a chronometer; after the collision, when his chronometers were stolen, his longitudes were from dead reckoning and less accurate. The first iceberg was saddle-shaped and measured ~10 m high and 300 m long at the waterline; the second was similarly sized and visible only from the masthead (Riou, 1790, 4–5). Thirteen years earlier during 1776–80, Riou sailed this course as a midshipman on Cook's third voyage without observing icebergs, and Cook during his 1772–75 circumnavigation of Antarctica saw no icebergs north of 51°S, which was seven degrees south of Riou's observations (Martin and others, 2022).

This letter describes Riou's encounters with these icebergs, and the physical interpretation of his observations. The next section gives a detailed description of the *Guardian* collision with the submerged foot of another iceberg and the resultant severe damage. The post-collision section describes the flooding of the ship, and the panic among the crew, some of whom with Riou's concurrence abandoned ship in five small boats, of which four were lost. It then describes how Riou sailed the ship back to Cape Town. The discussion section shows that the properties of the iceberg foot are consistent with contemporary research, and that from a comparison of historic ship collisions, iceberg positions from ships and modelling results, the likelihood of Riou's icebergs in the collision region is small. Finally, the 60 m freeboard of the collision iceberg suggests it calved from the Filchner Ice Shelf.

2. Collision

Two days after his first iceberg observations, in the afternoon of Christmas Eve, at 43.3°S, 42.7°E, Riou observed a third iceberg with a waterline length of ~200 m and hummocks at each end, the larger 60 m high, the smaller 15 m high. In the late afternoon, Riou deployed two boats in a downwind approach to the iceberg, which this letter calls 'Oasis,' to collect fragments of freshwater ice in the water around the iceberg (Fig. 1). As the boats approached the ice, he observed that tonnes of ice occasionally fell from the larger hummock, providing 'convincing proof of [its] rapid decay...' (Riou, 1790, 7–13). At 7:30 pm, the operation was complete, the boats were taken onboard, and the *Guardian* departed Oasis to the northwest.

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Table 1. The dates and positions of Riou's icebergs

December 1789	Latitude	Longitude	Comments
21	44.3°S	38.5°E	Two icebergs
24	43.3°S	42.7°E	The Oasis and collision icebergs
27	44.2°S	45.1°E	Single iceberg

At 7:45 pm, Sailing Master Thomas Clements wrote they 'were shut up in a thick close general mist...from this it was apprehended there were many more such islands of ice floating [around us], which appeared very dangerous, but being sensible that every precaution had been taken [extra lookouts had been posted], it was hoped our fears were imaginary' (Dickson, 2012, 31). The wind remained from the northeast (45°), and the ship was sailing east-south-east (112°) at 12 km h⁻¹ (Fig. 1).

At 8:00 pm, after estimating that the *Guardian* had cleared Oasis to the south, Riou went to his cabin. Half an hour later, he felt the ship move 'with instantaneous and unaccustomed velocity.' He immediately left his cabin and started to run toward the bow, when he observed from 'the countenances of horror of the men on the forecastle that the danger [was] on the lee [downwind] bow...they screamed out "put the helm down" [meaning turn into the wind]' (Riou, 1790, 14–15).

Riou ordered this done. He then ran aft to the quarter deck, looked forward and on the downwind side, saw 'a sight which will admit no description – a body of ice full twice as high as our masthead, showing itself through the thickest fog I ever witnessed' (Fig. 2a; Dickson, 2012, 23).

As the ship continued its turn, Riou thought it was entering 'a vast cavern...large enough to receive her completely' (Dickson, 2012, 23). He watched the jib-boom, the forward extension of the bowsprit, which he expected to be the first part of the ship to collide with the ice. Instead, a minute later, the downwind submerged part of the bow struck 'a piece of ice, which projected out from main body underwater,' leaving the jib-boom intact, but shaking the ship (Fig. 2a; Dickson, 2012, 23, 31).

Riou was relieved that the ship survived the encounter. Since the ship had rotated such that the wind was now incident on its

starboard [right] side, he ordered the foresails set so that the rotation would continue. Quoting Riou, 'the wind blowing fresh around a projecting precipice which acted upon the head sails that were aback and thereby enabled her to tack completely' (Dickson, 2012, 23). The ship continued turning until the wind was 'abaft the beam' or ~110° off the bow (Fig. 2b).

The stern of the *Guardian* drifted back over the foot (Fig. 2c). As Clements observed, the propagation over the shallow foot of the ocean swell and its reflection from the iceberg wall increased its amplitude and the flow of water on and off the foot. This meant as the water flowed off, the ship 'was dashed with great force' onto the submerged foot, severely damaging the hull. The ship 'had her rudder carried away, the tiller broke in two places, three of the [deck] planks were raised a foot [0.3 m] higher...and she shook from stem to stern in so violent a manner we expected her to part in every joint...,' following which the ship grounded on the foot (Dickson, 2012, 31).

Riou, looking out over the port [left] or the new downwind side, described the ship as being in the cavern, with ice overhanging the mizen [aft] mast (Dickson, 2012, p. 23). Given the ice they had seen falling from the Oasis iceberg, both Riou and Clements were greatly concerned about whether the ship would survive. After ~6 min, there was sufficient wind on the foresails to carry the ship off the foot. As Clements observed, the ship '...began to forge off and the same instant stuck a third time with greater force if possible than before, nearly abreast of the main chains [mid-ship], [then] kept crashing for some time along the ice under her, [until] entirely clear of it' (Dickson, 2012, 31). Finally, the ship sailed free (Fig. 2d).

3. Post-collision

As the ship took on water, Riou ordered the men to start pumping, but the water level continued to rise. He ordered heavy objects such as cannon, anchors, supplies and livestock thrown overboard. He then worked on fothering the hull. This complicated process involved lowering a sail underwater and wrapping it around the

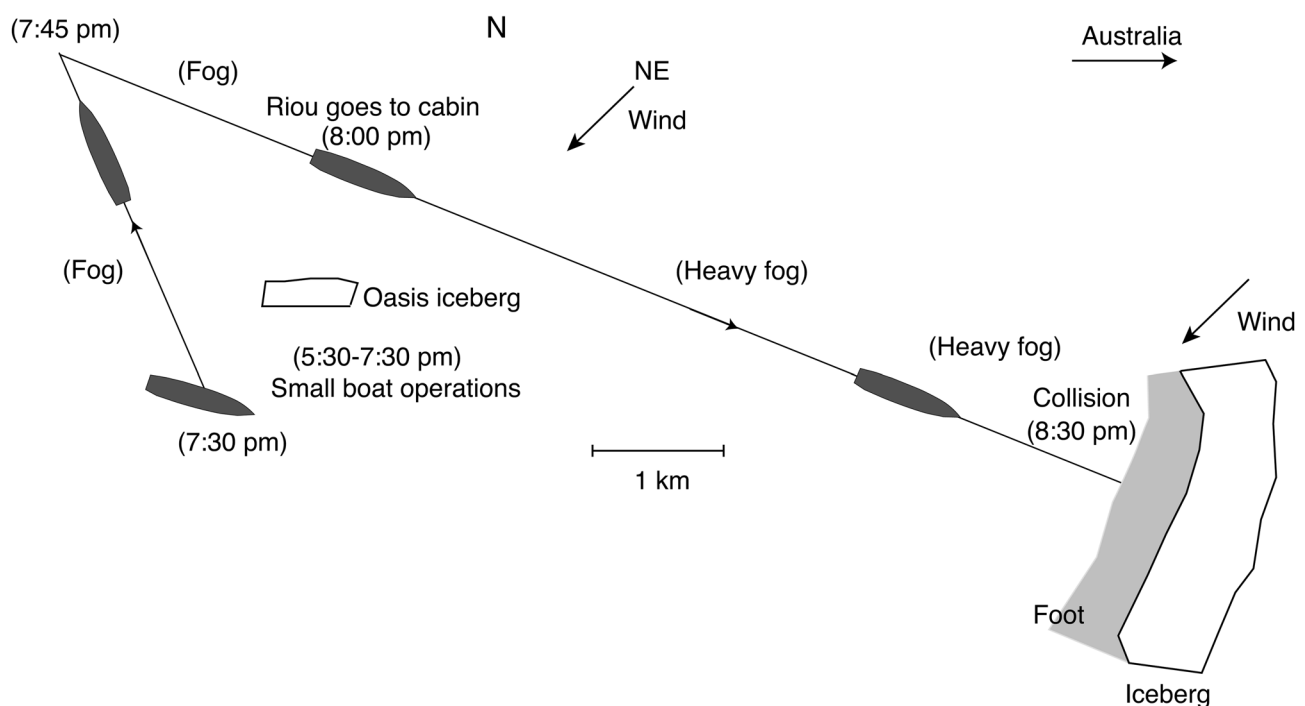


Fig. 1. Schematic of the *Guardian* location from the late afternoon recovery of freshwater ice at the Oasis iceberg to the 8:30 pm collision.

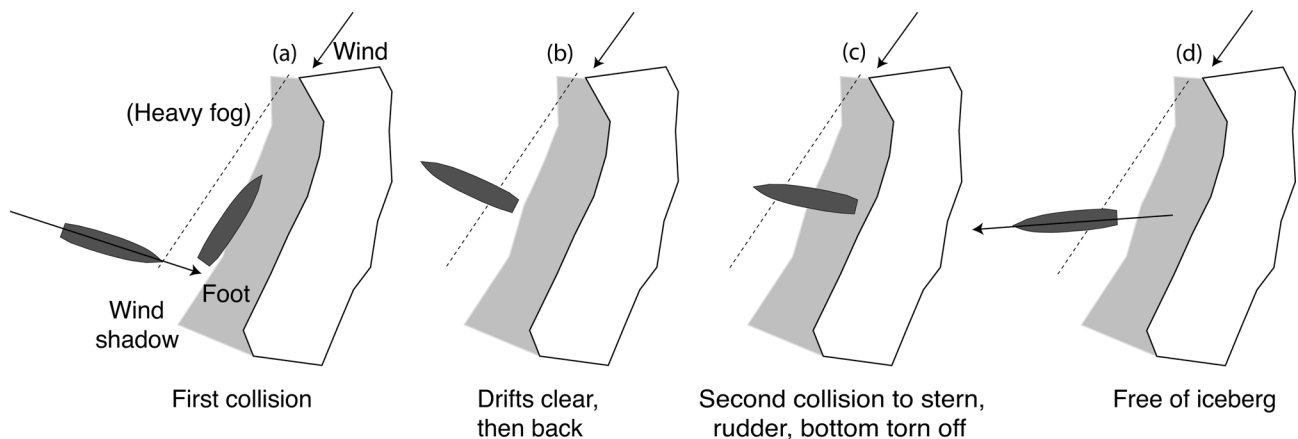


Fig. 2. The four stages of the *Guardian* collision with the iceberg foot.

damaged hull. Since increasing winds and heavy seas caused the ship to pitch and roll, this was a nearly impossible operation.

On Christmas Day, although Riou felt that the ship would remain intact and afloat for at least another day, the crew gained access to the spirit room and a panic fueled by their excessive alcohol consumption ensued (Dickson, 2012, 26). Riou, firm about his desire to remain on the *Guardian*, supported those who wished to abandon it and deployed five boats. He asked Clements to command the 11 m long launch, and to carry a letter to the Admiralty.

Sixty-three men abandoned ship. As Riou described, 'at least twenty people had jumped overboard' into the swell to reach the boats, of whom two may have drowned immediately (Dickson, 2012, 28). Figure 3 shows a fanciful illustration made in London of the abandonment, with the stern sinking, ice chunks in the water and ice overhanging the ship. Of the five boats and 63 men, only the 19 men in Clements' launch survived. They were picked up 9 days after leaving the *Guardian* by a French merchant ship and transported to Cape Town.

In the evening of 27 December, Riou saw his last iceberg, 'a large island of ice' on the port bow ~8 km distant (Table 1). Because all Riou's watches were stolen in the panic, he could only determine longitude from dead reckoning. Riou hoped that the remaining crew would not see this iceberg, since 'I was not a little alarmed at the effect this sight might have on their minds...' For safety that night, he reduced the ship speed so that the iceberg remained in sight during the next day (Dickson, 2012, 39).



Fig. 3. Period image of the collision, attributed to 'possibly Robert Dighton.' Out of copyright, courtesy of the Mitchell Library, State Library of New South Wales (Mitchell Library, 2022).

The theft of his watches meant that he was unable to navigate the ship to the nearest land, the Prince Edward and Marion Islands (46.9°S, 37.7°E), ~600 km to the southwest. Instead, he sailed the ship 2100 km back to Cape Town. He accomplished this by sailing northwest until he reached a latitude above the southern tip of Africa, continuing west until he encountered the coast, then following the coast until on 22 February 1790, they reached Cape Town. Of the 124 people initially on board, 80 survived (Dickson, 2012, 30, 55–67).

Elizabeth Schaeffer was among them. Her father said that 'the ship's captain, Edward Riou, behaved like a savage for the whole nine weeks... My poor child had to stand all night in water and serve the men with liquor when they rested from the pumps and do other work as well. ...[At Cape Town] my poor child and I were left with nothing but our lives...' (Schaeffer, 1790).

4. Discussion

4.1. Formation of the underwater foot

The formation and growth of an iceberg foot is important to understanding not only the *Guardian* collision but also the mechanism through which Riou's icebergs arrived at their locations. As England and others (2020, Fig S3) describe, the foot grows from the presence of warm surface water and ocean waves, which through wave-induced melting, cuts a notch into the iceberg at its waterline. After the notch grows in several meters, the ice above the waterline becomes unstable and sloughs off, leaving the underwater foot intact. For an above-freezing seawater temperature, the growth rate of the notch into the iceberg is $\sim 1 \text{ m day}^{-1} \text{ } ^\circ\text{C}^{-1}$, so that a 5°C temperature elevation yields 35 m week⁻¹ (Wagner and others, 2014).

The growth of the buoyant foot on a large iceberg exerts an increasing torque, which when it becomes large enough, fractures the iceberg (Scambos and others, 2005; Wagner and others, 2017). This process, called edge wasting, can repeat multiple times, leading to a relatively rapid disintegration (Scambos and others, 2008). The properties of the foot with which the *Guardian* collided are consistent with the observations of Wagner and others (2014; Fig. 2b). From a multi-beam sonar survey of the underwater portion of a 100 m long, 70 m thick iceberg, they found a 26 m long, 60 m thick foot located ~5 m below sea level.

Although Riou did not measure seawater temperature, on 22 December, he reported air temperatures of 50° to 60°F (10–15°C), and on Christmas Day, his observation of 20 men in the water also suggests the seawater was above freezing. These inferred above-freezing water temperatures combined with the ocean swell satisfy the necessary conditions for ice-foot formation and for edge wasting to occur.

4.2. Iceberg frequency in the southwest Indian Ocean

Several datasets address the likelihood of icebergs at the *Guardian* sites. Shipwrecks (2022) lists 775 shipwrecks on the route between the UK and Australia. Before the 1869 opening of the Suez Canal, the route from the UK went around the Cape of Good Hope and across the Indian Ocean; after that time, some ships continued traveling on the Cape-to-Australia route. Between 1789 and 1922, on this route, four ships including the *Guardian* were reported lost to or severely damaged by icebergs in the southwest Indian Ocean. This small number, which ignores ships that simply disappeared, shows that the passage from the Cape to Australia was much safer than the Europe-to-North-America route on which the *Titanic* was lost.

Second, the iceberg dataset maintained by the Scientific Committee for Antarctic Research (SCAR) for 1978 through 2012 contains the positions of 374 142 icebergs (Orheim and others, 2022). In box 44°–52°S and 30°–40°E of their Figure 1, corresponding to Riou's first and western-most observations, they report two to three icebergs, while farther east toward Australia and north of 44°S, there were no icebergs.

Third, the Brigham Young University/National Ice Center (BYU/NIC) Antarctic Iceberg Tracking Database is derived from satellite scatterometer observations taken during 1978 and from 1992 to the present (Stuart and Long, 2011; Budge and Long, 2018). The low scatterometer resolution also means that their smallest observable iceberg has a length of 5–10 km. Further, because of the loss of scatterometer contrast in summer when the iceberg surfaces become wet, their dataset consists of several hundred complete and fragmented trajectories. Examination of their data shows that the two closest BYU/NIC trajectories to Riou's icebergs originate from the Weddell Sea and lie respectively 1000 and 3000 km to their west in the ACC (Fig 2 in Martin and others, 2022).

Since the BYU/NIC icebergs continue to drift when their size falls below the scatterometer resolution, England and others (2020) apply a combined drift and fracture model based on the ice-foot mechanism to these trajectories. Their model extends the icebergs represented by the two BYU/NIC trajectories to the site of the *Guardian* icebergs, so that for the ~600 trajectories in the 2020 BYU/NIC dataset, only two reach the positions of Riou's icebergs. Each of the datasets and the England and others (2020) model results show that the likelihood of icebergs in the collision region is very small.

During the collision, Riou reported that the iceberg had a cavern large enough to receive the ship and towered two mast heights above the ship, implying that the iceberg had a 60 m freeboard and 500 m thickness. Even though Riou's observations were made under conditions of extreme stress, they imply that the iceberg had a much greater freeboard than the others. Its large freeboard and thickness suggest it calved from the Filchner Ice Shelf, the thickest in the Weddell Sea, drifted along the Antarctic Peninsula to the ACC, which carried it to the site of the collision (Lambrecht and others, 2007, their Fig. 3c).

5. Conclusions

The collision of the *HMS Guardian* with an iceberg foot provides a dramatic story in a region of sparse icebergs. The properties of the iceberg foot with which the ship collided are consistent with modern theory and the warm seawater inferred from Riou's observations. His estimated 60 m height of the collision iceberg suggests it originated from the Filchner Ice Shelf in the Weddell Sea. Existing ship iceberg and collision datasets plus the low-resolution scatterometer data show the small likelihood of his sightings. The model for iceberg drift with fracture

allows for theoretical tracking of their drift at sizes below the resolution of the scatterometers, also shows that they originated in the Weddell Sea, provides a mechanism for icebergs to reach the site and is consistent with the small likelihood of Riou's icebergs in the collision region.

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