

Suppression of breakers in stormy seas by an oil film

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Charles Cox

Abstract

The mechanism by which an oil film is able to still stormy seas has remained mysterious. Accounts by shipmasters of the effective use of oil collected by the US Hydrographic Office in the 1880s contain little quantitative information. In only one episode was the time of response to a sudden application of oil recorded. In this case, storm breakers were annulled by use of fish oil to enable a small open boat to rescue the crew of a sinking vessel. The cessation of breaking seas occurred only after the oil had spread over a large area to windward of the ships. It appears that wave growth stopped in this oiled region. The reaction of regulatory bodies and public responses to the rescue illustrate features of the political and social contexts in which shipping and trading activity was conducted in the late nineteenth century.

Keywords

Load line, oil films on the sea surface, Plimsoll mark, rescue of crew of *Grecian*, Ship *Martha Cobb*, suppression of storm breakers

Introduction

It has been known since antiquity that oil can still the angry seas,¹ but how it does so has remained mysterious. In the 1880s, the US Hydrographic Office collected information on the use of oil by mariners to reduce the dangers of storm breakers. The data were published on pilot charts of the day, and some have been collected in a magazine article,² and in an

1. See, for instance, James Beresford, 'Oil on Troubled Waters: A Reappraisal of the Storm Tactics Described in Acts 27', *International Journal of Maritime History*, 26 (2014), 752.
2. W. H. Beehler, 'The Use of Oil to Still the Waves', *The Century Illustrated Monthly Magazine*, 37, new series 15 (1888), 705.

Corresponding author:

Charles Cox, Scripps Institution of Oceanography, UCSD-0213, 9500 Gilman Drive, La Jolla, CA 92093, USA.
Email: cscoc@ucsd.edu

essay published by the Hydrographic Office.³ Unfortunately, members of the Hydrographic Office believed that an oil film immediately surrounding a ship could prevent waves from turning over in breakers, so they thought the only important questions were the locations on the ship where the oil was dispensed and how much was used.⁴ Records of wind speed, wave heights and time of response were disregarded. Many ship masters seem also to have been similarly mistaken. A more percipient view was expressed by Wyckoff, also of the Hydrographic Office: ‘In using oil for this purpose, it is evident that it must be spread well to windward in order to be efficacious’.⁵ All these workers were aware of Benjamin Franklin’s demonstration that oil films prevented the growth of short wind waves in a one-acre pond near London.⁶ They assumed the oil acted mechanically on the sharp crests of waves to prevent storm breakers from forming. An expression of this viewpoint by a well-educated seaman is provided by Admiral C. de Cuverville, commander of the French naval vessel *Naiade*: ‘it appears that the oil takes effect on the breakers due to horizontal translation produced by the wind, leaving the orbital motion or swell unaffected’.⁷ Because of the impossibility of such a major response, some fluid dynamicists have concluded that the phenomenon of ‘oil stilling the angry sea’ is illusory.

Use of oil to stop storm breakers

The only information recorded by the Hydrographic Office that sheds light on the actual processes at play is a brief mention of the saving of the crew of a sinking vessel by the ship *Martha Cobb* in 1883. This story is wrongly dated in Beehler’s magazine article,⁸ but I assume his text, derived directly from Thomas J. Greenbank, master of the *Martha Cobb*, is factually correct. I am grateful to Kelly Page, librarian and registrar at the Maine Maritime Museum in Bath, Maine for identifying the correct date, and Eileen Moran, librarian and historian at the Local History Centre of the Central Library, Dundee, Scotland, for identifying the British Newspaper Archive as a source of many other features of the episode. The log book of the *Martha Cobb* would be most useful, but has escaped discovery.

The sequence of events can be inferred from these many sources: on 7 November 1883, the barque *Grecian* (267 tons) left Philadelphia with a cargo of grain bound for Oporto in Portugal.⁹ The vessel shown in Figure 1, although of a larger barque, gives an

3. G. L. Dyer, ‘The Use of Oil to Lessen the Dangerous Effect of Heavy Seas’, US Hydrographic Office, Bureau of Navigation, No.82 (1886). Photocopied by Nabu Public Domain Reprint (2012).

4. Beehler, ‘The Use of Oil to Still the Waves’, 705; G. W. Littlehales, ‘Why a Film of Oil Can Calm the Sea’, *Popular Science Monthly*, 43 (August 1893).

5. A. B. Wyckoff, ‘The Use of Oil in Storms at Sea’, *Proceedings of the American Philosophical Society*, 23 (1886), 383.

6. Benjamin Franklin, ‘On the Stilling of Waves by Means of Oil’, *Philosophical Transactions of the Royal Society of London*, 64 (1774), 445.

7. Admiral C. de Cuverville, *New York Times*, 4 March 1893 (translated into English from *Revue Maritime* by *Nature London*).

8. Beehler, ‘The Use of Oil to Still the Waves’, 706.

9. *Dundee Courier and Argus and Northern Warder*, 18 December 1883, 2.

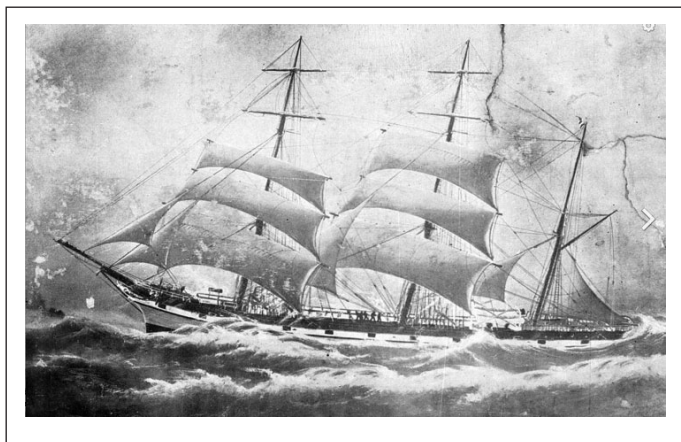


Figure 1. A painting of the barque *Louisa Craig* (formerly *Peru*, built of iron in 1876, 683 net registered tons). This vessel was several times larger than the *Grecian* (built of wood in 1867, 267 net), but of similar form and rig. Both were built in Dundee, Scotland.

Source: State Library of Victoria, Malcolm Brodie shipping collection. File: *Louisa Craig* (ship, 1876) - SLV H99.220-686.jpg.

idea of the appearance of the *Grecian*. She was overloaded because the principal owner, Alexander Banks of Dundee, Scotland, had refused to accept the judgment of the Lloyds' surveyor that the load line marked on the side of the ship was too high and that some above-water structural repairs were needed.¹⁰ As a consequence, the *Grecian* was removed from Lloyd's London registry in 1881. In 1876, the United Kingdom Merchant Shipping Act had made the marking of maximum load waterline compulsory, but the positioning of the mark was at the discretion of the shipowner, and not fixed by law until 1894. For this reason, Banks was able to purchase marine insurance for the voyage, with American Lloyds of New York accepting the risk at ½ percent higher premium. Banks' action was within the letter of the law in 1883, but it was a disastrous decision on his part. The cargo, 400 tons of Indian corn and wheat in bushel bags, loaded the vessel very heavily.

On 12 November, five days out of port, the *Grecian* was several hundred miles off-shore when a strong SSW gale blew up, and her decks were periodically submerged by breaking seas. By 2 a.m. on the next morning, the storm had worsened, two sails were blown away and the barque was hove to while listing heavily to leeward. After she righted water was found entering the hold. There was a major leak, and the entire crew had to man the pumps. Shortly before noon a heavy breaker carried away part of the starboard bulwarks and damaged the longboat. On 14 November, there was a lull in the wind, and the crew threw 400 bags of grain overboard to lighten the ship and thereby reduce the rate of leakage. At 5 p.m., the gale returned and increased in violence into the early hours of 15

10. Report of the Court of Enquiry into the Loss of the *Grecian*. A full copy of the Report was printed in *The Northern Warder and Bi-Weekly Courier and Argus*, 8 January 1884, 3.

November. Another breaking sea completed the destruction of the longboat and damaged a remaining boat.¹¹ The crew became exhausted, and water was gaining in the hold. At daybreak, by good fortune, a vessel appeared in sight and was overtaking the *Grecian*. After consultation with his crew, the master of the *Grecian* raised a signal to inform the oncoming vessel that his vessel was sinking and needed to be abandoned.

The oncoming vessel was the *Martha Cobb*, a 1249-ton full-rigged ship, registered in Rockland, Maine, and under the command of Thomas J. Greenbank. She was en route to London from New York with a cargo described as 'petroleum'.¹² In those days, it was common for refined products such as kerosene or heating oil to be dubbed 'petroleum', and it is probable that the cargo was one of these products rather than crude oil. It was extremely unlikely that the two vessels would come within sight of each other because the direct course from New York to the English Channel is never closer than 80 miles to the great circle course from Cape May to Oporto. However, fortunate timing and stress of weather somehow brought the vessels together and saved the lives of ten men. The location of the rescue is stated as 39° 54' N latitude, 56° 12' W longitude, far to the south of the direct course from Cape May to Oporto and even further south from the usual course from New York to London.

Communication between the two ships must have been carried out by signal flags. What was then known as the 'Commercial Code' had been issued by the British Board of Trade in 1857. It consisted of two, three or four letter flags hoisted as a single group to represent maritime expressions in coded form. There were 18 different flags representing the alphabetic consonants, omitting x, y and z. Vowels were omitted in order to avoid the possibility of spelling out objectionable words in any language. In addition to the alphabetic flags, a 19th (code pennant) was designated as an indicator that the subsequent flags were to be regarded as signals of the Commercial Code. This system of coded signals met an important need and was widely and rapidly adopted as 'The International Code of Signals for the Use of all Nations'.¹³ In modified form, now including the entire alphabet, plus numerals, it is known today as the 'International Code of Signals' under the jurisdiction of the International Maritime Organization.

We may assume that the requisite flags and code books were aboard both the *Grecian* and the *Martha Cobb*. The following is a possible sequence of events and messages in the code which enabled communications between the two ships:

Grecian hoisted the British ensign over the code pennant. This indicated her nationality and that subsequent flags would carry the meanings of the Commercial Code. On the same or separate hoist the flags N over C, meaning 'In distress; want assistance' were displayed;

After decoding these signals, *Martha Cobb* hoisted flags H over F, meaning 'We are coming to your assistance';

Grecian then hoisted flags N over V, meaning 'I am sinking', and then a subsequent hoist of H over J, meaning 'Boat or lifeboat cannot come';

11. *Dundee Courier and Argus and Northern Warder*, 18 December 1883, 2.

12. Beehler, 'The Use of Oil to Still the Waves', 707.

13. Great Britain, Board of Trade; United States Hydrographic Office; US Navy Department; US Bureau of Navigation, *The International Code of Signals for the Use of all Nations* (American Edition, 1894).

Greenbank states that he was puzzled as to how to rescue her crew. The *Martha Cobb* had also been damaged by the violence of the gale, again with some bulwarks washed away and the two deck boats both severely damaged. There remained intact a 16 foot dinghy, but there was no possibility that it could survive in the heavy, breaking sea (see Figure 2), so he may have hoisted the three flags B over C over N, meaning 'I will not abandon you', and stood by the *Grecian* for several hours hoping the wind and seas would die down.

During this time the vessels were continuing slowly on course eastward, but as night was coming on with no change in the weather, Greenbank decided to make an attempt to save the crew of the *Grecian*. He now luffed to sail the *Martha Cobb* to windward of her.

Some of the petroleum cargo of the *Martha Cobb* had leaked into the bilges. To still the waves Greenbank directed his crew to pump bilges. This made a noticeable smoothing of the wind-ruffled sea around the ships, but failed to stop the breakers. He then ran down across the *Grecian*'s stern, hauled up close under her stern, hove-to and started the pumps again. At this time, and crucially, he dumped a five-gallon can of fish oil in the scuppers of the *Martha Cobb* from which the oil dribbled into the sea. After 20 minutes, Greenbank recorded the result as 'magical'. The breakers disappeared around both vessels, and the dinghy was successfully launched. Two seamen under the command of the second mate rowed the dinghy upwind against the gale and over the mountainous waves.¹⁴ The entire crew of the *Grecian* (ten hands all told) was ferried back to the *Martha Cobb*. George Brown, chief mate of the *Grecian* testified that only three of his crew could be ferried back in each dinghy trip.¹⁵ If so, there must have been at least three trips.¹⁶ In Greenbank's words, as recorded by Beeler, 'the boat was deeply loaded and did not ship any water, although the sea was breaking fiercely outside the charmed space in which the vessels lay on oiled seas'.¹⁷ The second mate and the two rowers were exceptionally brave, because they had no reason to expect that the 'magical' effect of fish oil would continue while they made the rescue trips. The dinghy might have been swamped or overturned by a breaker, and many lives lost in the cold waters of the North Atlantic. Such a disaster occurred in a similar rescue attempt two months later. In this episode, without the magic of oil, a much larger shore boat was deployed from the rescue ship, *Medea* of Greenock, but was capsized by storm breakers before reaching the sinking vessel, the barque *Lauderdale* of Liverpool. The four rowers, and the first mate in command, all drowned.¹⁸

With present-day knowledge we can partly understand the 'magical' effect of the fish oil in the following ways:

14. *The Nautical Magazine*, 53 (1884), 420.

15. Report of the Court of Enquiry into the Loss of the *Grecian*.

16. Drawing upon the Board of Trade report, *The Nautical Magazine*, 53 (1884), 420, notes that the second mate commanded the dinghy for two trips. Perhaps he did not participate in the third trip to make it possible for the remaining four crew members to be conveyed from the *Grecian* without overloading the dinghy.

17. Beeler, 'The Use of Oil to Still the Waves', 707.

18. *The Nautical Magazine*, 53 (1884), 245.

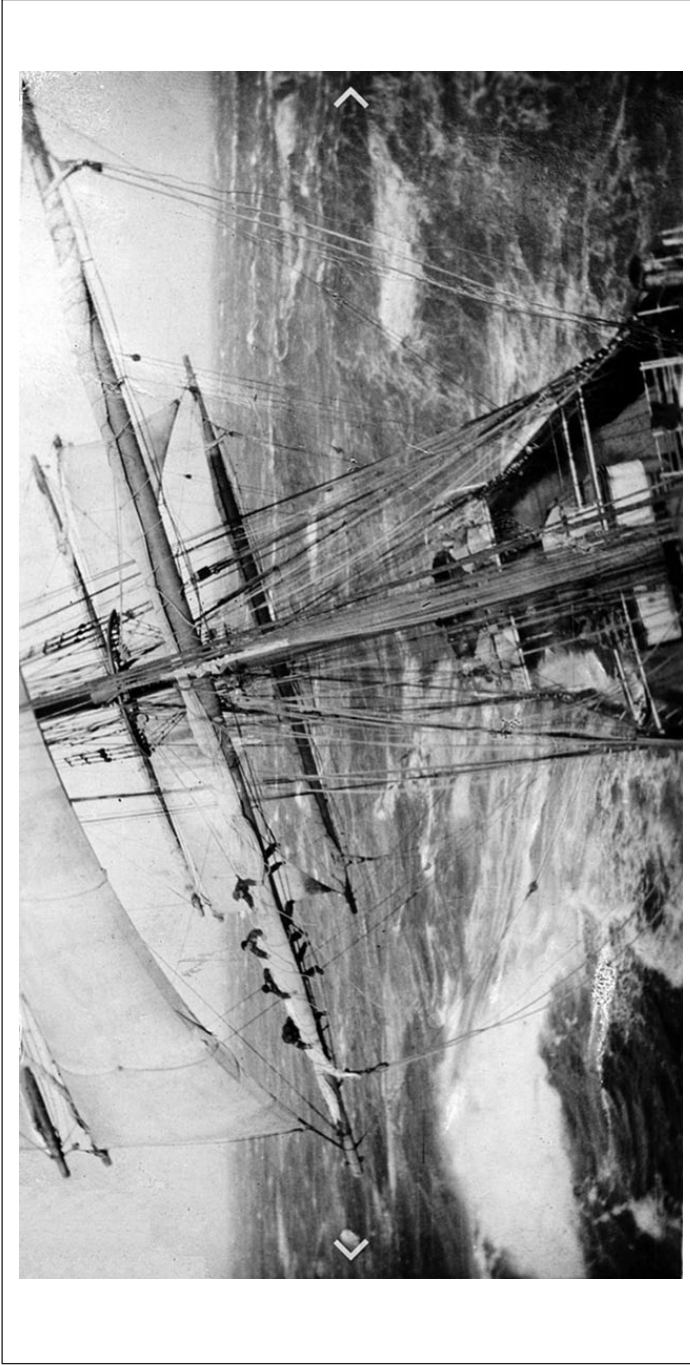


Figure 2. The barque *Garthsnaid* on a voyage from Iquique, Chile to Maputo, Mozambique by way of Cape Horn. The *Garthsnaid* (1318 net registered tons) was slightly larger than the *Martha Cobb* (1249 net). This view illustrates the difficulty Captain Greenbank faced in launching and recovering a small open boat in an attempt to rescue the crew of the *Grecian* in similar conditions, and the impossibility of such a boat surviving after launch. Original glass copy negative held in the De Maus Collection, Alexander Turnbull Library, New Zealand National Library. The photograph was taken in 1920 by 19-year-old Alexander Harper Turner, acting second mate, from the forward end of the jib-boom. It shows four men refastening gaskets around the furled foresail. The *Garthsnaid* is running with the wind on the port quarter under fore and main lower topsails. The wind force is estimated at Beaufort 9 or 10 from the appearance of the sea.

Source: State Library of Queensland, Australia, File: *Garthsnaid* - SLV H91.250-933.jpg. Photograph by Allan C. Green, titled *Garthsnaid Fore Yard*.

- 1) Molecules of fish (and vegetable) oils have one end in the form of a dipole that is strongly attracted to water. The other end is a triplet of hydrocarbons with no love for water. Consequently such oils spread readily over a water surface, and may thin themselves to a mono-molecular layer with molecules packed together. The dipole ends are stuck to the water and the hydrocarbons point upwards. The pure hydrocarbon oils in kerosene and heating oil are non-polar and do not behave in this way. They remain as lens-like clumps on the water. As a consequence, fish oil is far more effective than hydrocarbons in covering an extensive surface area of water and thereby damping roughness elements (capillary and short gravity waves) on the surface. Dilution of polar by non-polar oils reduces the spreading rate. But rapid spreading remains effective as long as the dilution is not too great.¹⁹ Alpers and Huehnerfuss have calculated the effects of a mono-molecular layer on the damping of wavelets.²⁰ They find that the elasticity of such a layer causes damping to extend from capillaries well into the short gravity wave regime, and even longer waves pour some of their energy into these lossy waves. But such a surface layer has no appreciable mechanical effect on the very long gravity waves (20 to 100 metre wavelengths) that form storm breakers.
- 2) When hove-to, sailing ships drift rapidly downwind because of the high wind-drag of their masts, rigging, sails, bulwarks and deckhouses. The resistance of hull and keel to leeway motion is reduced from its underway value because of flow separation, just as an aeroplane wing loses lift when it stalls. During the 20-minute delay following the dumping of fish oil in the scuppers, both vessels probably drifted one to three kilometres down wind, much faster than the oil, leaving an extensive coverage of the mixed fish oil-‘petroleum’ film on the water surface.
- 3) Because of turbulence in the stormy seas, and because of wave-driven diffusivities, the oil would have spread out in a fan-shaped slick in a broad area in the one to three kilometre region to windward of the vessels, with the apex of the fan at the vessels.
- 4) Present knowledge of growth and decay of wind waves under storm conditions indicates that waves having wavelengths up to 100 metres would decay rapidly in a one to three kilometre travel distance if their growth mechanism of energy input from the wind suddenly stopped. Such waves normally contribute to a major part of breakers on stormy seas (see Figure 2). If they are sufficiently reduced in size, no breakers will form.
- 5) Waves outside the fan-shaped area would continue to break. Such breakers would be visible from the hove-to vessels in directions normal to the wind, as described by Captain Greenbank.

All of these points are in agreement with the records of this incident, but what remains mysterious is why wave growth should suddenly stop in an oil-slicked area. Wave-breaking in the open sea occurs where the chance superposition of large waves creates an unstable mass. Oil films suppress capillary waves and other short wind waves. Apparently

19. David W. Camp and John C. Berg, ‘The Spreading of Oil on Water in the Surface-Tension Regime’, *Journal of Fluid Dynamics*, 84 (1987), 445.

20. W. Alpers and H. Huehnerfuss, ‘The Damping of Ocean Waves by Surface Films’, *Journal of Geophysical Research*, 94, (1989), 625.

this changes the air flow over large storm waves in such a substantial way that the large and long waves fail to grow. The normal processes of dissipation and energy transfer continue while they run through a large area of oil film. In storm conditions these processes are very rapid, and therefore waves of wavelengths up to 100 metres become so weakened that they no longer can superpose to the point of breaking.²¹

Social and political aspects

After the rescue, the *Martha Cobb* continued on her voyage and reached London on 14 December. There were social and political ramifications in the responses to the news of the rescue:

Social: In its 1884 report, the Board of Trade stated:

The Board of Trade have awarded a piece of plate to Captain Thomas J. Greenbank, master of the American ship *Martha Cobb*, of Rockland USA, in acknowledgment of his humanity in standing by the British barque *Grecian*, of Dundee, which was in a sinking condition, for several hours in a heavy sea and finally rescuing the crew. The Board have also awarded a Gold Medal to Mr. Dominick Gardiner, the second mate of the *Martha Cobb*, in recognition of his gallantry in taking the command of a small boat and making two trips to the *Grecian* for the purpose of taking off the crew.²²

The action of the Board of Trade justifiably rewarded Captain Greenbank. He was responsible to the owners of the *Martha Cobb* for the delay in delivery of the cargo, but he did not hesitate to use all his power to effect a rescue. The second mate was heroic in risking his and the rowers' lives in taking the dinghy to the *Grecian*. He certainly deserved a gold medal.

The *Martha Cobb* did not return to the USA until March 1884. The *Bath Daily Times* (Maine) of 27 March 1884 reported:

Ship *Martha Cobb*, of Rockland, Greenbank, which recently arrived at New York from London, on her voyage out picked up the crew of a sinking British vessel. For this service Capt G. has just received from the British government a piece of plate, the mate a gold medal and sum of money, and each man of the crew of the rescuing vessel a sum of money.

The two documents exhibit a social commentary on the times. Officials of the Board of Trade were upper-class Britons. In their report, there is no mention of the bravery of the two rowers of the dinghy, only the 'gallantry' of its 'command' is noted. Moreover, there is no mention of the money awards. Evidently officers of vessel are recognized but sailors and money are not. By contrast, the *Bath Daily Times* recognized the money awards, an expression of the American respect for money over class distinctions.

21. The author is preparing a manuscript describing the hypothesis that the changed windspeed profile over slicked water surfaces in storms annuls the normal energy input into storm waves. Normal dissipative processes then reduce waves of wavelengths up to 100 metres as they run through the oil slick to such an extent that they are no longer able to form breakers.

22. *The Nautical Magazine*, 53 (1884), 420.

Political: A court of enquiry in Dundee into the loss of the *Grecian* ruled that the abandonment was justified.²³ The shipowner was at fault for failing to accept the judgment of Lloyds' surveyors on structural repairs and the position of the load line on the *Grecian*. The captain and mate were held blameless, but were criticized for leaving the hatches uncovered when they left the ship. They had done so with the expectation that this would speed up the sinking of the *Grecian* and thus reduce the danger of collision to other shipping.

Samuel Plimsoll, Liberal Member of Parliament for Derby, had been horrified at the continuing loss of life at sea caused by the sinking of overloaded and unseaworthy vessels in the 1860s. He struggled to get Parliament to require that maximum load lines be painted on vessels, but was opposed by shipowners, some of whom served in Parliament. Plimsoll was effective in rousing public opinion and finally the Merchant Shipping Act (1876) was passed, which made the marking of the maximum load line mandatory, but its position was at the discretion of the shipowner. The defect of this rule was strenuously pointed out by Samuel Plimsoll, but he was forced to accept this version to get anything passed by Parliament because of the power of shipowners, who were supported by Disraeli, the Tory Prime Minister.²⁴ The loss of the *Grecian* and many other incidents finally strengthened public opinion so much that Parliament brought forward the improved Merchant Shipping Act of 1894, in which it was stipulated that the position of the load line, now known as the Plimsoll mark, was to be fixed by a rating agency, such as Lloyd's Register. It is now a regulation under the auspices of the International Maritime Organization.

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Author biography

Charles Cox was educated at the California Institute of Technology, Pasadena, and the Scripps Institution of Oceanography (SIO) of the University of California, San Diego. He undertook post-doctoral studies at the National Institute of Oceanography, Wormley, Surrey, and the Geophysical Institute of the University of Tokyo. His researches have concentrated on water waves, the turbulent transfer of heat through the sea and electromagnetic processes in the sea and underlying rocks. He is a member of the National Academy of Sciences, the American Geophysical Union and the Royal Astronomical Society. He is now Professor Emeritus at SIO.

23. Report of the Court of Enquiry into the Loss of the *Grecian*.

24. Nicolette Jones, *The Plimsoll Sensation: The Great Campaign to Save Lives at Sea* (London: Little Brown, 2006).

Correction to legend of figure 2

The legend should read:

Figure 2

The barque *Garthsnaid* on a voyage from Iquique, Chile to Maputo, Mozambique by way of Cape Horn. The *Garthsnaid* (1318 net registered tons) was slightly larger than the *Martha Cobb* (1249 net). This view illustrates the difficulty Captain Greenbank faced in launching and recovering a small open boat in an attempt to rescue the crew of the *Grecian* in similar conditions, and the impossibility of such a boat surviving after launch.

The photograph was taken in 1920 by 19-year old Alexander Harper Turner, acting second mate, from the forward end of the jib-boom. It shows four men refastening gaskets around the furled foresail. The *Garthsnaid* is running with wind on the port quarter under fore and main lower topsails. The wind force is estimated at Beaufort 9 or 10 from the appearance of the sea.

Source: State Library of Queensland, Australia. File: *Garthsnaid* -SLV H91.250-933.jpg