

Recovery of Logbooks and International Marine Data
RECLAIM Project – 2012 (revised and updated 2014)

Sources of Historic Sea-Ice Observations for the Southern Hemisphere

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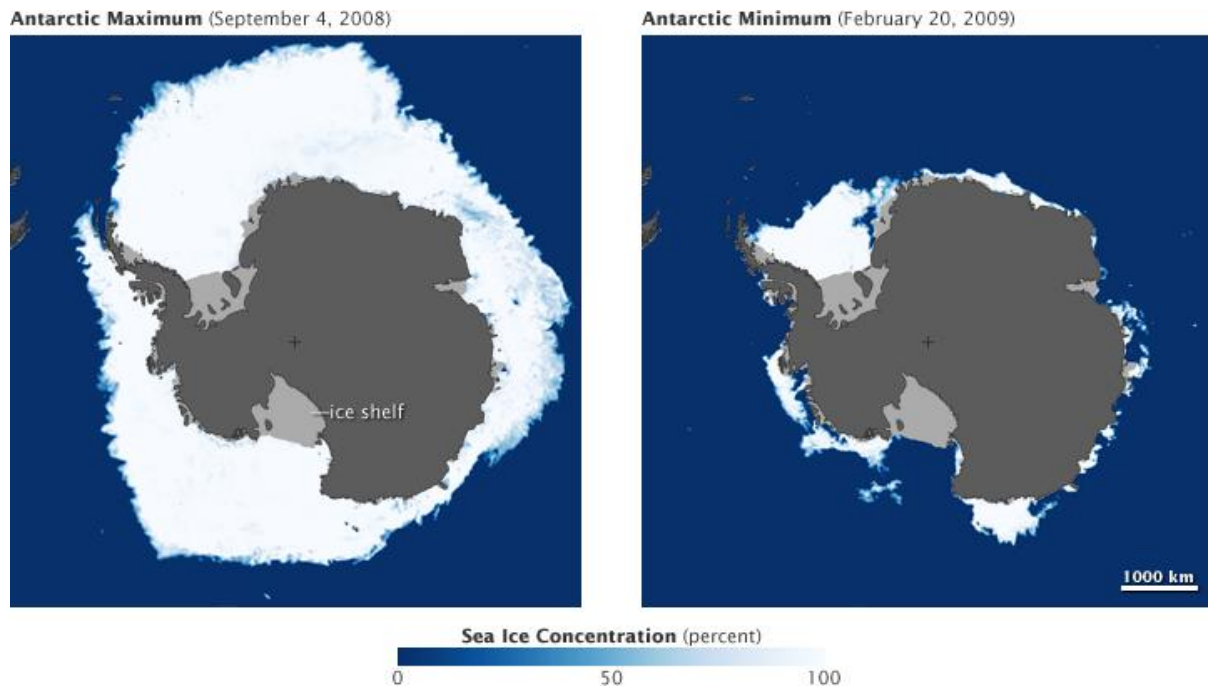
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Introduction

The extent of sea ice in the southern hemisphere is some 20% greater than the extent in the northern hemisphere, and is an important influence on the global energy balance. The maximum extent of the ice, in September, is about five times greater than the minimum extent in February. It follows therefore that much of the maximum ice extent is made up of new sea-ice. The ice consists of many different forms and descriptions, but can be broadly categorized into three groups, marginal, pack and coastal. Marginal ice is at the edge of the open ocean and is where most new ice will form. Pack ice is found between the marginal and coastal zones, and coastal ice, often the oldest and thickest, is found near the edge of the Antarctic continent. This report is concerned primarily with historic observations of sea-ice in the marginal and pack zones, and coastal ice in those areas such as the Indian and Pacific Oceans, where during the austral summer the ice edge can retreat to parts of the coast. This report is also concerned with observations of ice-free areas of the Southern Ocean where ice might otherwise be expected.



Sea Ice Concentrations (Max/Min) NASA Earth Observatory

This report and the accompanying inventory of historic sea-observations, adopts the convention found in the SAR Marine Users Manual in describing the geographic areas of the Southern Ocean surrounding the Antarctic continent. These are; Weddell Sea, 60°W to 20°E, Indian Ocean, 20°E to 90°E, Pacific Ocean, 90°E to 160°E, Ross Sea 160°E to 130°W, Bellingshausen-Amundsen Sea, 130°W to 60°W.¹

The report will discuss the sources of historic sea-ice observations in the context of the observing platform – usually a vessel, but sometimes a shore station, the

documentary source – usually a logbook, a journal, a dedicated scientific report such as a sea-ice report, or an ice chart, and other less usual reporting mediums such as a synoptic chart, air reconnaissance or radio transmission. Lastly the report will discuss the archives where sea-ice observations can be found in both Britain and abroad.

History and Background

The first sighting of the Antarctic continent is attributed to either the Russian Thaddeus von Bellingshausen or Edward Bransfield in 1820, although the South Shetland Islands were first sighted in 1819, by the merchant brig *Williams*, Captain William Smith. The Antarctic ice fields were encountered much earlier, notably by James Cook in January 1773, and even earlier in January 1739 by Jean-Baptiste Charles Bouvet, commanding a French expedition of two frigates, the *Aigle* and the *Marie*. These two vessels encountered what they described as pack ice in latitude 48.50S in the vicinity of Bouvet Island, now called Bouvetøya. These were the earliest sea-ice observations. Archives in Spain and in Lima (the administrative centre of the Vice-Royalty of Peru) may contain undiscovered sea-ice observations from ships taking passage around Cape Horn although recent research into iceberg records in Spanish archives suggests this is unlikely.²

Sea-ice observations in any significant quantity do not occur until the 19th century, first with the rise of sealing expeditions to the Weddell Sea area and the South Shetland Islands, and secondly the early phase of exploration of the Southern Ocean and the Antarctic continent. The early sealing vessels were American or British and the expeditions were seasonal, activity being confined to the southern summer. Some logbooks and journals from these vessels have survived and have been archived in whaling museums in the United States. Few British journals have survived. Those extant, either the original or a copy or a microfilm are mostly held by the Scott Polar Research Institute in Cambridge.

Observations from ships of exploration include Bellingshausen's circumnavigation of Antarctica 1819-1821, the expeditions of James Weddell in 1823, Dumont D'Urville 1838-1840, James Clark Ross, 1839-1842, and Charles Wilkes 1838-1842. After this period, polar exploration concentrated on the Arctic, until the 1890s and the beginnings of the so-called Heroic Age of Antarctic exploration. The early decades of the 20th century saw the scientific study of the Antarctic regions by Britain (Discovery Committee expeditions), the United States, France, Germany, Sweden, and Norway, as well as a renewed interest in whaling and sealing enterprises, most notably in the Weddell Sea and Indian Ocean sectors, by Britain, Norway and Argentina. These commercial activities continued after World War II, with the inclusion of vessels operated by Japanese and Russian companies. Post-war scientific study of the Antarctic continent and surrounding seas was conducted by the British Falkland Islands Dependency Survey (FIDS), various United States naval

operations mostly centred in the Ross Sea area, the Soviet Union, Norway, Japan, Australia, New Zealand, Chile, Argentina and others. All of these countries will have archived ice and meteorological data for the Southern Ocean from the 1940s onwards.

Observing Platforms and corresponding Documentary Sources

1. Naval Vessels on Voyages of Exploration

All naval vessels have logbooks and journals associated with them. It was a legal requirement for a ship's logbook or an officer's journal to be kept, and therefore almost all of these in the case of the British Royal Navy have been archived and are accessible to the public³. The same is applicable to the United States, Australia and New Zealand, and to a lesser degree France, and Spain. In other countries such as Chile, the logbooks of naval vessels, where extant, are still held by the naval service rather than a state archive. Public access to logbooks in Chile is permitted but subject to restrictions on access to logbooks of recent decades. As well as a ship's log or officer's journal, vessels of the Royal Navy and the United States Navy also produced a 'Remark Book'. This differed from the logbook in that it contained further observations usually of a hydrographic nature, rather than the daily routine documented in the logbook. It was not a legal requirement to keep a remark book, and not all vessels submitted one to the naval authorities. By the end of the 19th century, these remark books had become a detailed record of meteorological and oceanographic observations. It is the logbook and remark book that will contain sea-ice observations, although the number of naval vessels venturing into the high southern latitudes are few.

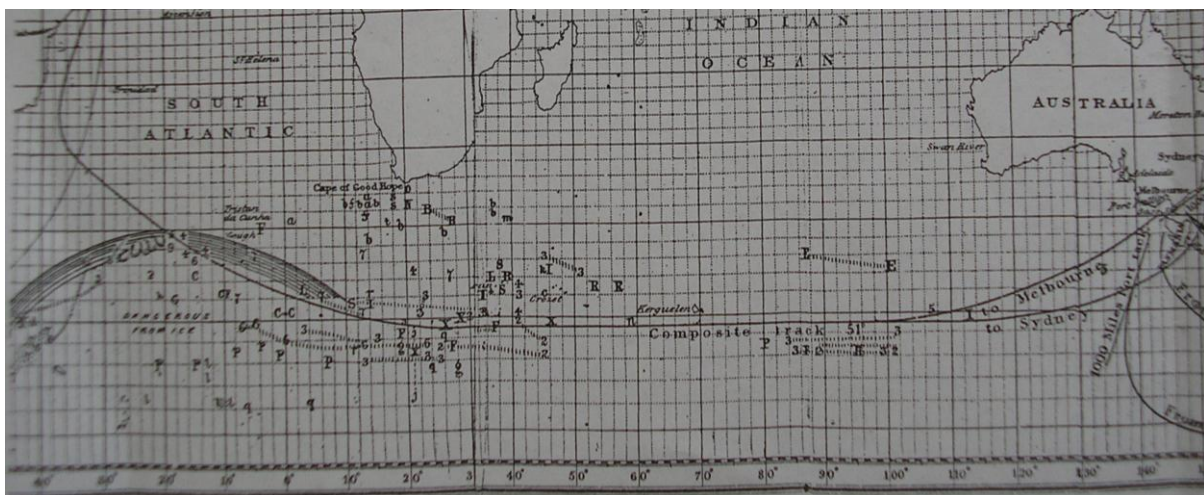
The naval vessels on southern voyages of exploration in the 19th century, originated from Britain, France, the United States and Russia. They were wooden vessels, of a construction to encounter ice but not to penetrate pack ice, depending instead on leads of open water to reach as southerly a position as possible. They tended to circumvent the ice, therefore the observations recorded give a good indication of the position of the edge of the sea ice. Many of these voyages have printed accounts for instance Ross and Bellingshausen, where many of the observations recorded in the logbooks are reproduced in whole or in part with additional comments. Observations are reliable as many of the officers involved in these naval expeditions had an interest in science and the vessels carried a range of barometers and thermometers (both air and sea). This interest was formalized by the publication in 1851, of the *Manual of Scientific Enquiry* under the authority of the British Admiralty.

Twentieth century naval interest in Antarctica and the Southern Ocean was revived in the 1940s, due primarily to competing territorial claims on the continent. The United States Navy conducted a series of military/scientific operations in the Ross Sea. Britain had competing claims to Antarctic territory with Argentina and Chile and

vessels of all three countries made frequent visits to the South Shetland Islands, the Weddell Sea and the seas to the west of the Antarctic Peninsular. The logs of the Chilean and British vessels have been archived and as well as ice observations contain detailed meteorological data and sea temperatures recorded every four hours. The US Navy logbooks are held at the National Archives in Washington.

2. Merchant Vessels

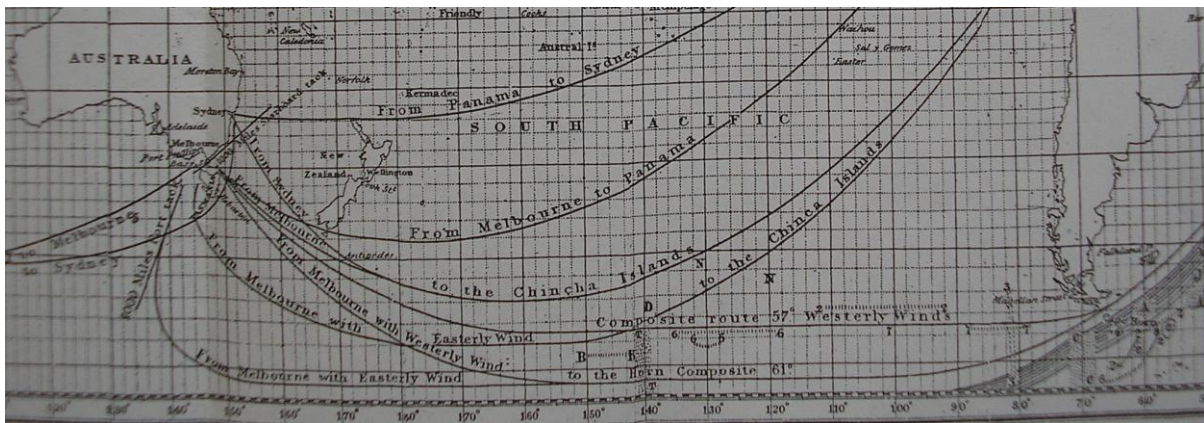
Merchant vessels, apart from whaling and sealing vessels, will not ordinarily stray into the high southern latitudes where sea-ice might be expected. Yet in the late 1840s, vessels bound to and from Australia started to explore more southerly routes. M. F. Maury demonstrated that after crossing the Atlantic equator in 30°W, the shortest (great circle route) to Melbourne intersected the Greenwich meridian between 70°S and 75°S (on the Antarctic continent).⁴ The route was clearly impractical but in 1849 John Towson published tables to calculate the best route, termed composite tracks, which combined the great circle route with parallel sailing (sailing along a line of latitude).⁵ Vessels were advised to sail in the latitude of 51°S or further south if practicable between the meridians of 20°E and 100°E to 110° E. This was far enough south to encounter icebergs but not sea-ice. The Swedish brig, *John*, did venture further south and observed 'immense fields of ice to the southward', at 56°.48'S in 83°.16'E on 19 January 1851.⁶ The observation is ambiguous but may indicate sea-ice.



Composite Track of Vessels to Australia - from Towson, 'Icebergs in the Southern Ocean'

The same principle of composite sailing was applied to the homeward voyage from Australia and New Zealand towards the Drake Passage. Here the composite route recommended sailing along the parallel of 61°S between the meridians of 150°E and

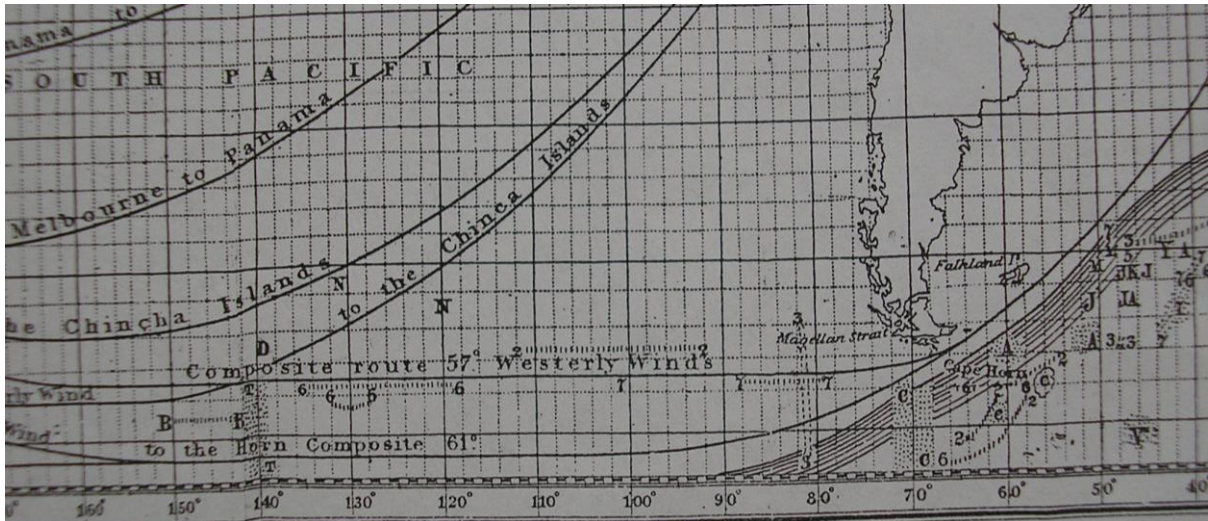
85°W. Along this route sea-ice was encountered. In June 1853, the *Marco Polo* encountered pack ice between the latitudes of 60°S and 57°S in longitude 141°W.⁷ In September 1854, pack ice was reported (*Golden Era*⁸) in the Drake Passage between the latitudes of 58°S and 63°S, between the meridians of 60°W and 72°W.⁹ Sea-ice in the vicinity of the Drake Passage was also reported by the *Arethusa* at 57°S, 93°46'W, between 4th and 24th of January 1833, being described as falling in with 'an almost impassable barrier, ... ice as far as the eye could see'.¹⁰ The examples above are from printed texts, rather than the original logbooks.



Composite Track of Vessels from Australia towards the Drake Passage - from Towson, 'Icebergs in the Southern Ocean'

The logbooks for some of the many vessels making this transit across the southern Pacific exist in the US Maury collection, the UK National Meteorological Archive (NMA) Exeter and probably in the marine meteorological logbooks held by Deutsche Wetterdienst (DWD) as well as archives in Australia and New Zealand.

It should be noted that an examination of 170 meteorological logbooks at the UK National Meteorological Archive, covering the years 1859 and 1881, found no observations of sea-ice and infrequent observations of icebergs and other ambiguous ice observations. In all 400 logbooks were identified for the period 1855 to 1895, kept aboard both sailing and steam driven vessels. The highest latitudes observed were usually between 56°S and 59°S and these latitudes were only reached on approaching the Drake Passage. John Towson's paper on 'Icebergs in the Southern Ocean' was apparently widely read and the appropriate avoiding action taken. On the other hand, these logbooks and the corresponding sets in the Maury and DWD collections, all of the same format and layout, have the merit of recording 4-hourly observations of pressure temperature and sea temperature, essential data for these high latitudes despite the lack of positive sea-ice observations.



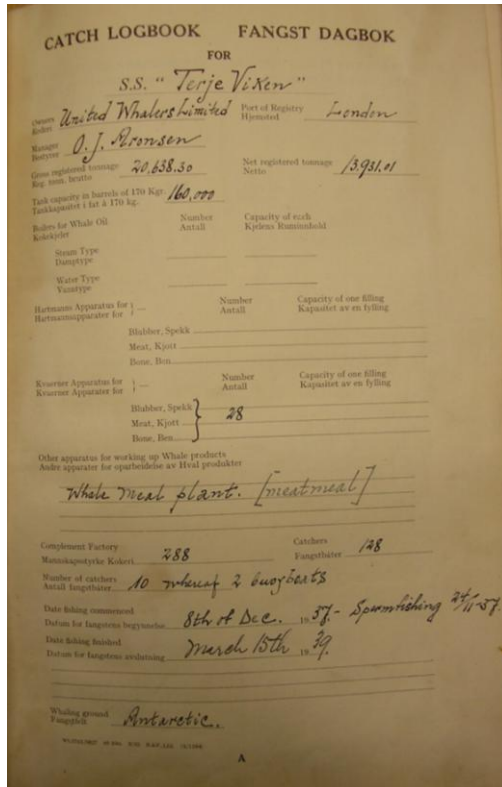
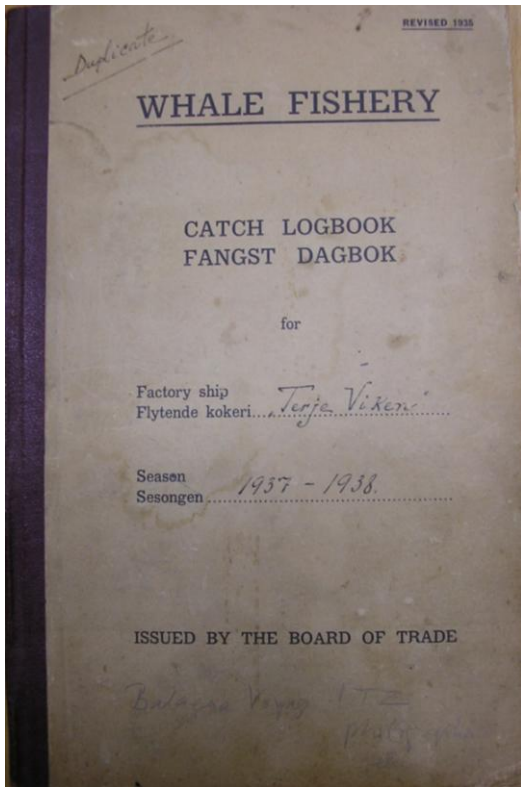
Detail of Chart – from Towson ‘Icebergs in the Southern Ocean’. Pack ice was reported at points ‘V’ (47W, June 1857), ‘e’ (61W, Sept. 1857), ‘C-C’ (69W-72W, Sept. 1854), ‘A’ (51W & 60W, August 1854) and ‘T’ (141W, June 1853)

3. Whaling and Sealing Vessels

Regular sealing expeditions to the very high southern latitudes began shortly after the discovery of the South Shetland Islands in 1819. Before this there had been sealing activity in South Georgia and the Magellan Strait. The vessels were either American or British, the US sealers sailing from Stonington, New London, New Bedford or Sag Harbor, New York. Sealing seriously depleted, local seal populations and the focus of activity shifted away from the Weddell Sea to the Auckland, Campbell and Maquarie Islands, in the western Pacific south of New Zealand, but well north of the ice regions of the Southern Ocean. Activity virtually ceased after 1830 until at least the 1880s.

Large scale whale hunting and processing by factory ships began in the Southern Ocean about the beginning of the 20th century, by British and Norwegian vessels. Activity centred mainly on the Weddell Sea and Indian Ocean sectors, and the establishment of whaling stations such as Grytviken in 1904 and Leith in 1909, on the island of South Georgia, and a shore station on Deception Island from 1912 to 1931. In the 1905-1906 season there was one factory ship, the *Admiralen*. Numbers of factory ships rose to 28 vessels in 1939-40. During WWII, the factory ships were withdrawn for several seasons, only 1 vessel (*Thorshammer*) operating in 1943-44. Post-war, annual numbers of factory ships rose to 21 during the 1960-1961 season, with an increasing number operated by the Japanese.¹¹

Apart from ship’s logbooks - many unlocated at the time of writing - the factory ships produced other documents containing sea-ice and meteorological data. These documents such as the ‘catch logbook’ or ‘fangst dagbok’ were issued by the British Board of Trade as factory ships operated under license from the British Government.



Catch Book Factory Ship *Terje Viken*, 1937-1938 (Climatic Research Unit, University of East Anglia)

| DAILY RECORD | | | | | | | | | | | | | | |
|-----------------------------|---------|-------------------------|-------------------------|---------------------|------------------|--------------|--------------|--------------|--------------------------------------|---------|--|---------|--|----|
| DAY | LOW No. | SUNDAY 28th | MONDAY 29th | TUESDAY 30th | WEDNESDAY 31st | THURSDAY 1st | FRIDAY 2nd | SATURDAY 3rd | PER HOUR TOTALS FOR WHALES AND SPERM | | | | | |
| LATITUDE | 1 | 58-48 S | 58-50 S | 58-15 S | 58-21 S | 58-26 S | 58-35 S | 58-43 S | 13.7 | | | | | |
| LONGITUDE | 2 | 45-20 E | 45-30 E | 45-37 E | 47-16 E | 48-12 E | 47-16 E | 45-33 E | 75.25 | | | | | |
| BAROMETRIC TEMPERATURE | 3 | 73.98 = 15°C | 73.80 = 15°C | 73.81 = 15°C | 73.77 = 15°C | 73.79 = 15°C | 74.11 = 15°C | 74.12 = 15°C | 75 | | | | | |
| WIND DIRECTION FORCE | 4 | NW - 5 | NNW - 4 | NW - 5 | SW - 2 | WNW - 4 | WNW - 3 | NE - 6 | 37.5 | | | | | |
| WEATHER | 5 | Breeze - somewhat foggy | Breeze - somewhat foggy | Small amount, clear | Clear - overcast | Snow - fog | Breeze - fog | Fog - snow | 37.5 | | | | | |
| PACK ICE BEARING DISTANCE | 6 | in the distance | S - close | S - close | S - close | S 20 | S 10 | S 20 | 37.5 | | | | | |
| BEING SCHEDULED | 7 | Some small | Some small | Some small | few small | Some small | few small | few small | 37.5 | | | | | |
| WHALES | 8 | B F H S | | B F H S | | B F H S | | B F H S | | B F H S | | B F H S | | 8 |
| DEAD AT MIDNIGHT - 00hrs | 9 | 8 | | 1 | | | | | | | | | | 5 |
| KILLED | 10 | 1 | | 14 | | 8 | | 3 | | 3 | | 3 | | 37 |
| SEX | 11 | 9 | | 15 | | 13 | | 3 | | 3 | | 3 | | 45 |
| WORKED UP | 12 | 8 | | 10 | | 13 | | 3 | | 3 | | 3 | | 45 |
| LOST, ETC. | 13 | | | | | | | | | | | | | |
| REMAINING AT MIDNIGHT 24hrs | 14 | 1 | | 5 | | | | | | | | | | |
| NUMBER OF WHALES | 15 | B F H S | | B F H S | | B F H S | | B F H S | | B F H S | | B F H S | | |
| NUMBER OF FILLERS | 16 | 16 | | 21 | | 24 | | 6 | | 6 | | 9 | | 88 |
| NUMBER OF TUBS | 17 | 16 | | 21 | | 24 | | 6 | | 6 | | 9 | | 88 |
| NUMBER OF TUBS | 18 | 16 | | 21 | | 24 | | 6 | | 6 | | 9 | | 88 |
| NUMBER OF TUBS | 19 | 16 | | 21 | | 24 | | 6 | | 6 | | 9 | | 88 |
| NUMBER OF TUBS | 20 | 16 | | 21 | | 24 | | 6 | | 6 | | 9 | | 88 |
| NUMBER OF TUBS | 21 | 16 | | 21 | | 24 | | 6 | | 6 | | 9 | | 88 |
| NUMBER OF TUBS | 22 | 16 | | 21 | | 24 | | 6 | | 6 | | 9 | | 88 |
| NUMBER OF TUBS | 23 | 16 | | 21 | | 24 | | 6 | | 6 | | 9 | | 88 |
| NUMBER OF TUBS | 24 | 16 | | 21 | | 24 | | 6 | | 6 | | 9 | | 88 |
| NUMBER OF TUBS | 25 | 16 | | 21 | | 24 | | 6 | | 6 | | 9 | | 88 |
| NUMBER OF TUBS | 26 | 16 | | 21 | | 24 | | 6 | | 6 | | 9 | | 88 |
| NUMBER OF TUBS | 27 | 16 | | 21 | | 24 | | 6 | | 6 | | 9 | | 88 |
| NUMBER OF TUBS | 28 | 16 | | 21 | | 24 | | 6 | | 6 | | 9 | | 88 |

REMARKS: *2 1/2 "T-2" left for Captain. She has cut her propeller shaft in collision with a buoy. Repair will be carried out at Capton.*

MANAGER *O. J. Bronsen*

NOTE: Headings B, F, H & S, indicate Blue, Fin, Humpback & Sperm.

Catch Book Page *Teje Viken*, 28 Nov-4 Dec 1937

| DAY | LINK No. | SUNDAY 28th | MONDAY 29th | TUESDAY 30th |
|--|----------|---------------------------------------|-------------|------------------------|
| LATITUDE | 1 | 58-48 S | 58-50 S | S 58-15 |
| LONGITUDE | 2 | 45-20 E | 45-50 E | E 46-37 |
| BAROMETER. THERMOMETER. <i>millibars Centigrade</i> | 3 | 73.98 ÷ 1.5°C. | 73.80 ÷ 1°C | 73.81 ÷ 1°C |
| WIND. DIRECTION. FORCE | 4 | NW - 5 | NNW - 4 | NW - 5 |
| WEATHER | 5 | drizzle-snowsqualls fog & snowsqualls | | Swell, overcast, clear |
| PACK ICE. BEARING. DISTANCE | 6 | in the proaice | S - close | S - close |
| BERGS. NUMBER. SIZE | 7 | some small | some small. | some small |
| | | S B F H S | B F H S | B F H S |

Detail from page showing meteorology and ice observations

An example catch book is illustrated above. *Terje Viken*, was operated by a British company, United Whaling Ltd.

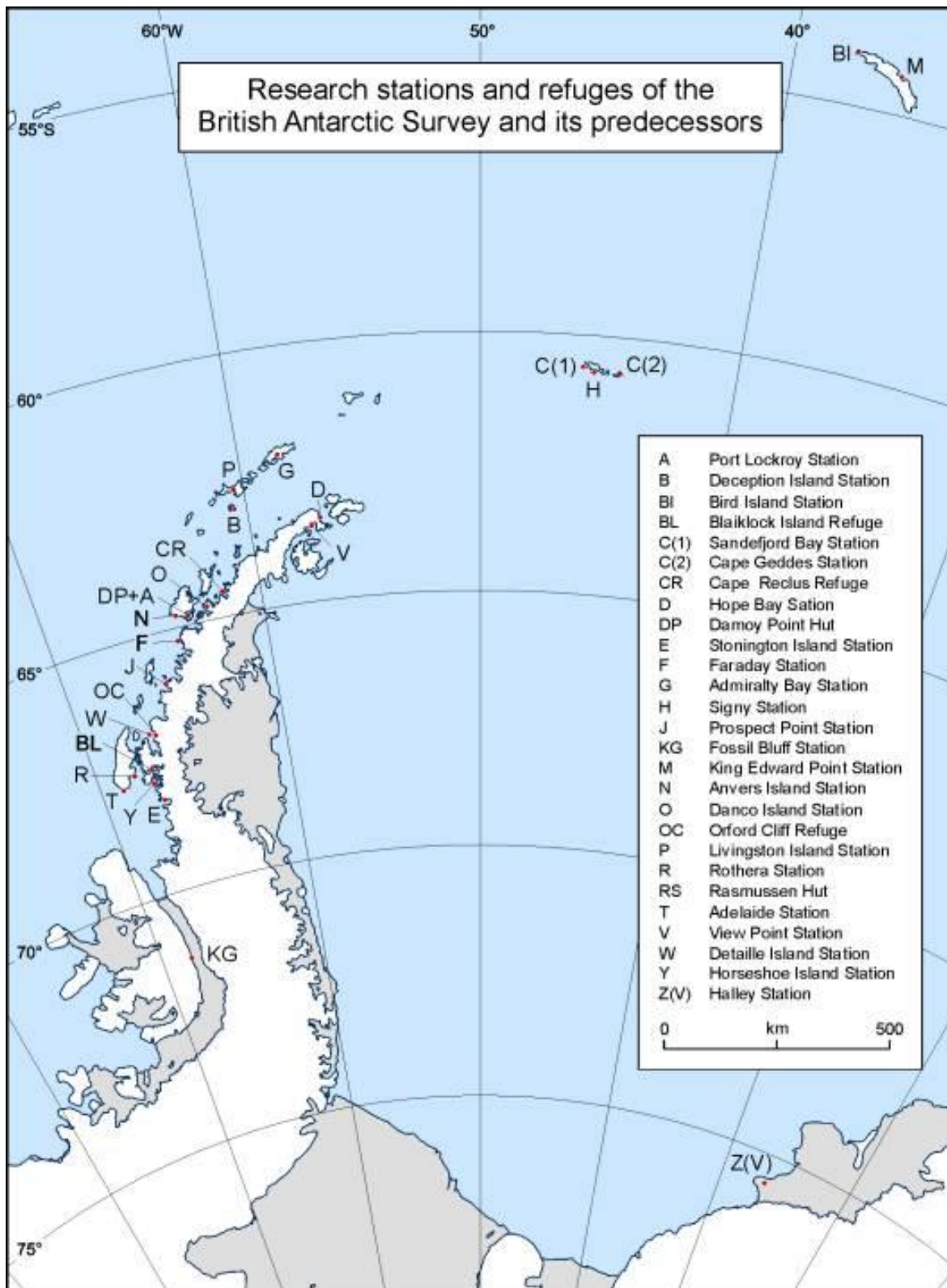
A significant number of catch books are held at St. Andrews University Scotland, in the records of the Sea Mammal Research Unit (SMRU) transferred there in 1996 from the British Antarctic Survey. The collection also includes Inspectors' diaries and field notes. These documents contain meteorological data, sea temperature and sea-ice observations. Most of the documents are from the 1930s, to the 1960s. A further source of British data from factory ships is held in the Special Collections at the University of Edinburgh. This is the archive of the Christian Salvesen Company, which operated many factory ships in the Southern Ocean. The relevant part of the archive consists of logbooks, catch books, daily reports, oil books, ice charts and US hydrographic Office H1-9 current reports.

Another source of data from factory ships operating in the Southern Ocean is the International Comprehensive Ocean-Atmosphere Data Set (ICOADS). Decks 761 and 187 contain data from Japanese whaling and factory ships (1946-1984 and 1946-1956). In addition ICOADS has data from Norwegian Antarctic whaling factory ships in Deck 188 (1932-1939). Furthermore, Deck 899 has reports from South African whaling vessels. This is discussed more fully in the 'Archives' section of this report.

4. Terrestrial Bases

As well as sea-ice observations from ships of Antarctic exploration, observations were also made from shore bases. The earliest of these observations were made in 1944 during 'Operation Tabarin' which sought to establish a permanent British presence in Antarctica, first at Deception Island and then at Port Lockroy. Observations from these points, and others as they were established, have

continued to the present day, first through the Falkland Islands Dependencies Survey (FIDS) and after 1962, the British Antarctic Survey (BAS).



Map courtesy of the British Antarctic Survey.

The map above indicates the geographic coverage of British stations on the Antarctic Peninsular. There are many more operated by Argentina and Chile and other countries (not shown) and this is the most intensively observed sector. There are scattered (non UK) bases eastward from the Weddell Sea to the Ross Sea, but no modern bases between McMurdo (USA) at 167°E to Rothera (UK) at 68°W.¹²

Observations consist of descriptions, either daily or monthly, of sea-ice conditions, often the year round. BAS has archived these reports along with the logbooks of the research and supply vessels supporting FIDS and BAS operations. The BAS archive is discussed in more detail in the next section. It is assumed that other Antarctic bases such as those operated by Germany, South Africa, India, Russia/Soviet Union, Japan, Australia, China, France, New Zealand, the United States, Argentina, Chile, Uruguay, Poland and Brazil will have archived similar reports. The sea-ice reports also have corresponding meteorological reports, although in the case of the British data, the historic met reports were sent to the UK Met Office and are no longer held by BAS.

Printed Sources of Sea-Ice Data

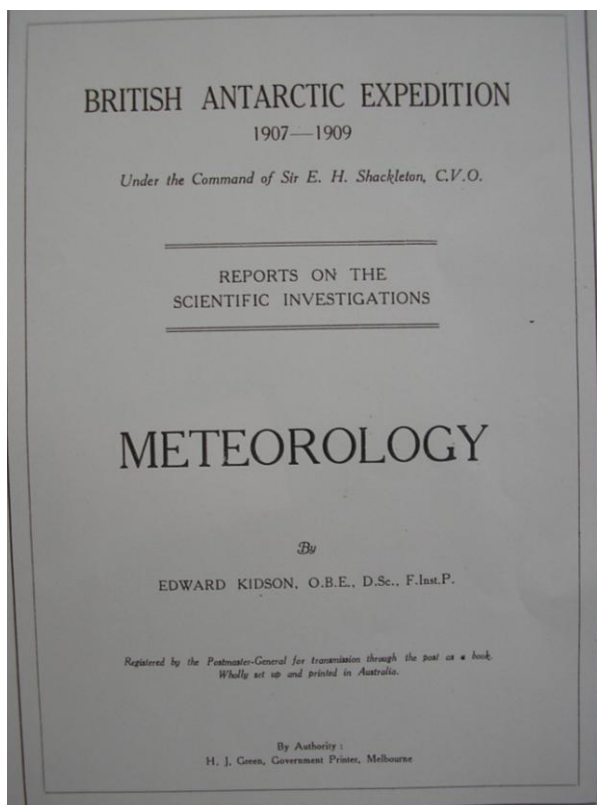
Printed sources of sea-ice data come in a variety of types and formats from books, published operational and scientific reports, periodic journals and charts. Sailing and hydrographic directions have traditionally included historic ice information although much of the data concerns sightings of icebergs as these are a hazard to navigation. Even so reports of 'fields of ice' and 'pack ice' are also recorded. M. F. Maury's, *Explanations and Sailing Directions* (1852) and Alexander Findlay's *Directory for the Navigation of the South Pacific* (1863) are typical examples having sections devoted to the hazards of ice and providing tabulated lists of observations with an approximate date and position, sometimes usefully providing the name of the vessel.

Printed accounts of voyages especially those of exploration will provide detailed accounts of weather and ice conditions where observed. The best contain an abstract of the ship's logbook, otherwise it is necessary to scan the narrative for ice observations. This is not as time consuming as one might think, as it is usually easy to determine the latitude of the vessel from the narrative and confines one's search to a relevant group of pages. Typical examples are Cook's journals, F. Debenham's translation of Bellinghausen's journal 1819-21, the printed journals of James Weddell and James Clark Ross and Morrell's *Narrative of Four Voyages 1822-1831*. The latter volume has been criticized for inaccuracies, but the criticism may not be justified. Many of the 19th century publications can be accessed via the internet through Googlebooks, Gallica or Archive.org.

Periodic journals such as the *Polar Record*, contain accounts of voyages and on-going Antarctic operations (at the time of publication). For instance volumes one and two of the *Polar Record* contain pack ice observations from the *Norvegia* in 1931.

The movements of Chilean naval vessels and their activities around the Antarctic Peninsular are described in various numbers of the *Polar Record* in the 1950s, providing clues as to which logbooks and reports in the archives are mostly likely to provide ice data. Nineteenth century journals such as the *Nautical Magazine* and *Mercantile Magazine and Nautical Record* have accounts of voyages usually of an unusual nature including encounters with ice. Philosophical journals such as the *Transactions of the Historical Society of Lancashire and Cheshire*, which in 1857 published John Towson's article on 'Icebergs in the Southern Ocean', or scientific journals such as the *Transactions of the Royal Society*, are worth looking through for ice data, and many are available as on-line scans.

Operational and scientific reports are often published in connection with expeditions or military operations. Abstracts of ships' logbooks and other sets of observations are usually included, with large amounts of information printed on each page making this an efficient medium for abstracting data. Illustrated below is the cover and a single page from the volume on meteorology produced by the British Antarctic Expedition 1907-1906. The data is from the meteorological logbook of the *Nimrod*. The data illustrated provides a date and time, four-hourly observations of barometric pressure, wet and dry bulb temperatures, sea temperature, wind force and direction with remarks containing the noon position, and ice observations.



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TABLE XXXII.—METEOROLOGICAL LOG OF S.Y. "NIMROD," VOYAGE I.—continued.

| Date | Time | Barometer | Temperature | | | Wind | | Position, Maximum and Minimum Temperature, Remarks, &c. |
|--------------------------|------|-----------|-------------|------|------|-----------|-------|--|
| | | | Dry | Wet | Sea | Direction | Force | |
| | | ° F. | | ° F. | | | | |
| January, 1908—continued. | | | | | | | | |
| 23 | 4 | 28.96 | 24.8 | .. | .. | SSE | 2 | Fine. |
| | 8 | 28.97 | 23.5 | .. | 28.5 | S x E | 1 | Overcast, St-Cu. 07.00, passed line of close pack, also several large bergs. Tilted berg shows discoloured bottom. "Sago" snow at 05.00. |
| | 12 | 29.01 | 21.8 | .. | 31.8 | ESE | 2 | 78° 27' S, 171° 54' W. Overcast; dull. Occasional snow previously. 09.00, sighted Ross Barrier, much distorted by mirage. 11.00, proceeding along face of Barrier. Bergs and broken ice seen. Large portion of Barrier appeared to have broken off in one place. |
| | 16 | 29.05 | 21.2 | .. | 32.0 | SE | 2 | Misty; overcast; St-Cu. Passing along Barrier 1.8 miles distant. Height by sextant 105 ft. |
| | 20 | 29.03 | 19.0 | .. | 29 | Calm | .. | Overcast; hazy. |
| | 24 | 29.06 | 20.8 | .. | .. | SE | 0-1 | Max. 28.4° F., Min. 18.3° F. Fine; clear. Much pack ice and bergs. Sighted strong indications of land, ridgy undulations to SSW. |
| 24 | 4 | 29.08 | 23.8 | .. | .. | Calm | .. | Clear in places to S, but chiefly overcast. Sea smooth. Passing bay in Barrier. Large cakes of sea ice all round. Much mirage. 02.15, encountered heavy pack; ship headed northward to skirt along edge. |
| | 8 | 29.09 | 24.0 | .. | .. | Calm | .. | Overcast, St-Cu. Steaming along Barrier through pack. |
| | 12 | 29.08 | 25.4 | .. | 30.0 | ESE | 1 | 78° 19' S, 162° 53' W. Sky clear, except at horizon. Proceeding W along Barrier. |
| | 16 | 29.07 | 23.1 | .. | .. | SW x S | 3 | Mainly overcast; sunshine at intervals. Cleared pack, sailing along Barrier face. 14.30, off head of large bay. Skirted along Ered ice. Observed hummocky bergs scattered and marooned in sea ice. Smooth sea surface as far as eye could see to S. To W, low-lying sloping hills extending at right angles to Barrier edge. |
| | 20 | 29.08 | 15.5 | .. | .. | Var | .. | Overcast; hazy. 18.15, frost smoke. |
| | 24 | 29.04 | 16.5 | .. | .. | SE | 1 | Passing through pack. |
| 25 | 4 | 29.09 | 19.5 | .. | .. | W | 2 | Clear. Passing through pack showing pressure. Ice blink to NW. Much refraction. |
| | 8 | 29.04 | 28.0 | 27.6 | 33.3 | Calm | .. | Clear overhead; Cu to N. Brought up by large field of bay ice extending all round S horizon. Left pack at 06.00. Cu moving slowly from NE at 06.00. |
| | 12 | 29.07 | 30.6 | .. | 32.0 | Calm | .. | 77° 32' S, 165° 44' W. Fine, clear weather. Smooth sea. 09.00, steering round heavy pack. 10.45, found opening in pack. |
| | 16 | 29.02 | 30.0 | .. | 32.0 | NNW | 2-3 | CU-S and St-Cu with patches of blue sky. Passing squalls of fine snow. Since noon, passing impenetrable pack to starboard. |
| | 20 | 29.05 | 28.3 | .. | 32.0 | NW | 4 | Overcast. Wind had previously freshened to gale with heavy squalls of snow and sleet. 18.30 to 20.00, vessel turned back towards W side of Ross Sea. Rapidly entering clear water; occasional bergs. |
| | 24 | 29.01 | 27.0 | .. | .. | WSW | 3 | 77° 32' S. Max. 33.4° F., Min. 15.3° F. Fine; clear atmosphere; dull, slowly sky. Occasional bergs. At 17.00 hrs., passed berg about 15 miles long, of land ice, about 20 ft. high. |
| 26 | 4 | 29.07 | 29.3 | .. | .. | WSW | 4 | Cloudy. Light swell. |
| | 8 | 29.04 | 26.1 | .. | .. | WSW | 3-4 | Overcast; dull. Clear sea; occasional bergs. |
| | 12 | 29.09 | 26.0 | .. | 33 | W | 4 | 77° 32' S, 160° 33' W. CU-Cu overhead; St-Cu below. Occasional bergs. |
| | 16 | 29.05 | 26.4 | .. | .. | WSW | 4 | Overcast, Cu. |
| | 20 | 29.07 | 21.5 | .. | .. | SW x W | 3 | Wind puff. Slight head sea. Occasional bergs. 17.00 hrs., observed blink of Barrier. Sea discoloured to light green. |
| | 24 | 29.07 | 16.6 | .. | 33.6 | SW | 2-4 | Max. 37.8° F., Min. 15.0° F. Wind unsteady in force and direction. Isolated tabular bergs. 22.30, sighted Barrier. |

Other scientific reports include for example the *Monthly Weather Review* supplement no. 41 'Meteorological Research of the Byrd Expeditions 1928-30, 1933-35' which contains a set of tables providing sub-daily meteorological observations taken on

board the *Jacob Rupert* in the Bay of Whales. A copy is held by the Scott Polar Research Institute, Cambridge. The extensive United States post WWII naval and scientific operations in the Ross Sea (High Jump and Deepfreeze) produced many reports. Scott Polar Research Institute has many of these but some are also available as on-line scans from Archive.org. Most of the operational reports are narrative in format but frequently contain sea-ice observations from several vessels. Archive .org can also provide the copies of the various *Discovery Reports*. *Discovery Reports vol. 28 (1957), Station List 1950-1951*, for example contains an observation of pack ice on 12/7/1951, at the position 57.05S/26.50W. Significantly this observation is not recorded in the *Marine Observer* 'Ice Reports' another source of ice data but clearly not an exhaustive one.

Books, reports and journals also contain ice charts. For example, *Field Report: Oceanographic Observations United States Navy Antarctic Expedition 1954-1955 USS Atka (AGB-3)* contains detailed ice charts, for the Ross Sea and Amundsen Sea, January 1955, the Bellingshausen Sea Jan-Feb 1955, and the Weddell Sea February 1955. A chart contained in the Scottish National Antarctic Expeditions reports – showing the track of the Scotia 1902-1904 – usefully illustrates some of the tracks of other expeditions back to the early 19th centuries noting the edge of the pack ice at that time (illustrated below).



Chart printed in the Scottish National Antarctic Expedition Report

An Argentine publication published in 1955, Luis Capurro, *Expedicion Argentina al Mar de Weddell*, contains two loose, very detailed ice charts of the Weddell Sea, for December 1954 and January 1955, with text in English, Spanish and German. A copy is held by the Scott Polar Research Institute and one of the charts is illustrated below.



Printed chart from Luis Capurro, *Expedicion Argentina al Mar de Weddell* (Buenos Aires, 1955). Copy held by the Scott Polar Research Institute, Cambridge

As well as providing ice data in a visual form, these ice charts are also useful for indicating the names, dates and positions of vessels making the observations, providing a means of tracing the original observations in logbooks and reports.

THE ARCHIVES

British Antarctic Survey <http://www.antarctica.ac.uk/>

The British Antarctic Survey (BAS) is located at High Cross, Madingley Road, on the outskirts of Cambridge. Visits to the BAS archive are by appointment only. The history of BAS and its predecessor, the Falkland Islands Dependencies Survey (FIDS) can be found on the BAS web pages. Documents containing sea ice

observations fall into several categories: Chief Officers' logbooks, deck log abstracts, ice reports from vessels, ice reports from terrestrial bases and ice charts.

Chief Officers Logbooks (AD5/7/)

These documents consist of individual log sheets, usually bound. The earliest logbooks commence in 1948 and the collection runs to the present year. The earliest log, AD5/7/JB1/1, *John Biscoe* (Mar 1948-Jun 1948) has, as well as ice observations, the full range of meteorological observations including, wind direction (true), wind force, weather and visibility, sea state and swell, barometric pressure (corrected), dry and wet bulb temperatures and sea temperature.

from *Admiralty Bay.* towards *Nope Bay.*

| ERROR | | WINDS | | BAROMETER | THERMO-METER | REMARKS, Etc. (Note carefully when boats are exercised). |
|-------|----------|-----------|-------|-----------|--------------|---|
| Gyro | Standard | Direction | Force | | | |
| | | W | 3. | mb | °F | Thursday 25 th day of March 1954 |
| | | Var | 1. | 998.2 | 27 | 0000. Rounded Pt. Henneguin. at 5 cables and set course 150°G. |
| | | E by | 2. | | | 0300. Allowed +2° set 152° |
| | | NE by | 2 | 1000.2 | 31 | 0317. Pack ice to southward. Various E by course to avoid same. Slight sea & swell fine & clear, becoming cloudy later. Courses various to avoid heavy pack. |
| | | E by S | 2/3 | 997.9 | 26 | 0730. Vessel turned to course 250°. Rippled sea, long swell. Not rolling easily. Overcast, vis fair. Various courses skirting heavy pack. Slight sea and swell. Heavy to southward. Overcast, light snow, vis fair. |

| Latitude | Longitude | Steaming Time | Speed | Distance per Log |
|----------------|----------------|-----------------|---------------|---------------------|
| S. | W | | | |
| By Ac't 62°41' | By Ac't 57°36' | This Day 12.-15 | Average 11.51 | Error, per cent. .. |
| Obs. | Obs. | Total | Total Average | Variation |

Remarks section of RRS *John Biscoe*, 25 March 1954, describing the sighting of pack ice. Noon position 62.41S, 57.36W. BAS Archive AD5/7/JB1/7.02.

By the 1970s/1980s, the log sheets are more detailed. As well as the 4-hourly meteorological observations there are separate columns for ice observations. AD5/7/BR/10, *Bransfield* for instance has columns for 'bergs', 'bergy bits', 'pack coverage', 'pack size', and 'pack thickness'. Log sheets for the year 2005, AD5/7/ES/2005, *Ernest Shackleton*, are the same format but with the addition of hourly GPS positions. The only significant divergence from the formats described

above can be found in the log sheets of the *Kista Dan* (for example AD5/7/KD5 & KD6, Nov 1963-Mar 1964 & Nov 1964-Mar 1965). These log sheets are printed in Norwegian, and completed in English. On examining a broad selection of log sheets it was noted that the logs of the *John Biscoe* (AD5/7/ JB2/19-20) recorded very few sea-ice observations in the seasons 1973-4, 1974-5 and 1975-6.

DATE 26th January 1980
DATE 25th January 1980
DAY OF YEAR ... 025

VIA
TOWARDS *SIGNY*

| WIND DIRECTION | FORCE | BAROMETER | AIR TEMP | SEA TEMP | REMARKS | BERGS | BERG BY BITS | PACK COVERAGE | PACK SIZE | PACK THICKNESS | |
|----------------|-------|-----------|----------|----------|---|--------------------------------|------------------------|---------------|-------------|----------------|--|
| | | | | | Friday G.I.T. - 3 | | | | | | |
| | | | | | 0000 Clocks started 1 hour to G.I.T. - 3 hours | 13 | 8 | | | | |
| | | | | | Compasses compared - gyro error unobtainable | 30 | 11/12 | | | | |
| | | | | | 0030 Sat Nav SSI for 66° 14.2'S 37° 38.8'W | | | | | | |
| | | | | | 0138 Sat Nav SSI for 66° 02.7'S 37° 28.4'W | 50 | 11/12 | | | | |
| | | | | | 0236 Sat Nav SSI for 65° 57.5'S 37° 27.8'W | | | | | | |
| | | | | | 0334 Sat Nav SSI for 65° 40.7'S 37° 26.6'W | 3,800 | 255 | 70 | 11/12 | | |
| | | | | | Overcast throughout. Vll getting in ceiling | D.R. LAT 65° 27'S | | | | | |
| | | | | | early to indicate SE ice on and south | D.R. LONG 37° 27'W | | | | | |
| | | | | | 0430 Sat Nav SSI 65° 26' 6.5 37° 26' 0'W | | | | | | |
| | | | | | Compasses compared. | 20 | 20 | | | | |
| | | | | | 0538 Sat Nav SSI 65° 05' 3.0 37° 23' 6'W | 20 | 30 | | | | |
| | | | | | 0652 Sat Nav SSI 64° 53' 6.5 37° 25' 4'W | | | | | | |
| | | | | | Clear and clear. Vll getting early to indicate SE ice | 3,800 | 255 | 15 | 20 | | |
| | | | | | 0730 Sat Nav SSI for 64° 30.8'S 37° 24' 1'W | D.R. LAT 64° 28'S | | | | | |
| | | | | | 0920 Sat Nav SSI for 64° 19.3'S 37° 23' 7'W | D.R. LONG 37° 26'W | 10 | 20 | | | |
| | | | | | 1016 Sat Nav SSI for 64° 08' 6.5 37° 24' 1'W | | | | | | |
| | | | | | 1030 A/c B. 2120 2150g) D.R. 64° 04'S 37° 26'W | | | | | | |
| | | | | | 1100 Sat Nav SSI for 63° 58.4'S 37° 33.5'W | 1/4 working pack ice | | | 3/8 | S/M | |
| | | | | | 1100 MAGNETOMETER RECOVERED | 4 | 8 | | | M | |
| | | | | | Cloudy but clear occasional light snow Vll | D.R. LAT 63° 54'S | | | 6/8 | S/M | |
| | | | | | mainly steady on low sea & small visibility good | D.R. LONG 37° 43'W | 1 | 4 | 3/8 | | |
| | | | | | 970.7 | | | | | | |
| | | | | | TOTAL DIST 365' | STEAMING TIME 25 HOURS | AV SPEED 12.52 KTS | SET | DIST BY LOG | | |
| | | | | | DIST TO GO | TOTAL STEAMING TIME 67.1 HOURS | T. AV. SPEED 12.00 KTS | DRIFT | LOG ERROR% | | |
| | | | | | | | | | | | |
| | | | | | Compasses compared - gyro error unobtainable | | | | | | |
| | | | | | 1250 Sat Nav SSI for 63° 46.7'S 38° 06.6'W | 3 | 3 | 5/8 | S | M | |
| | | | | | 1346 Sat Nav SSI for 63° 38' 0.5 38° 24.2'W | | | | | | |
| | | | | | 1440 Sat Nav SSI for 63° 27.3'S 38° 29.2'W | 0 | 0 | 3/8 | S | L+H | |
| | | | | | Vll working pack ice throughout. | 4,000 | 270 | 4 | 4 | 5/8 | |
| | | | | | Overcast throughout. snow hatching Vll | D.R. LAT 63° 24'S | | | | | |
| | | | | | | D.R. LONG 38° 04'W | 9 | 4 | 3/8 | S L+H | |

Section of log sheet RRS *Bransfield*, 25 January 1980 en route from Halley Base to Signy Island. BAS Archive AD5/7/BR/10

Deck Log Abstracts (AD5/9/)

Most of the deck log abstracts are a pre-printed 'Form 60'. A different form of similar format was used after 1999. Form 60, records noon position, air temperature, wind force and direction and brief remarks including ice observations. Note that barometric pressure and sea temperature is *not* recorded on Form 60. The later abstracts, from 1999, record pressure, air and sea temperatures winds, and ice observations in a remarks section. All the abstracts use the noon observations and this fact was checked by a comparison of the log sheets and the abstracts of the RRS *James Clark Ross* in 2001. The abstract logs are an efficient and cost effective way of imaging and collecting data with up to a month's observations on a single page. However as only the noon observations are recorded, sub-daily data,

including additional ice observations will not be captured. Some additional abstracts can be found in AD/3/.

DECK LOG ABSTRACT

FOR. 0

RRS S.S./M.V. "JOHN BISCOE" Voyage Number 3

From DECEPTION ISLAND (Place) 12th FEBRUARY 1959 (Date)

To PORT LOCKROY VIA MARGUERITE BAY AND MATHA STRAIT (Place) 7th APRIL 1959 (Date)

| DATE | NOON POSITION | | STEAMING TIME | | | STOPPAGES | | Distance Miles | Av. Speed Knots | Air Temp. °F | WIND | | REMARKS (Cause of Stoppage etc.) |
|----------|----------------|------------------|---------------|----|----|-----------|----|----------------|-----------------|--------------|-------|-------|---|
| | Lat. | Long. | D | H | M | H | M | | | | Force | Dir'n | |
| 22/2 | DECEPTION IS. | To DANCOS COAST | | | | 9 | 53 | 121' | 12.24 | 33 | 4 | NE | ARRIVED DANCOS 1503 SAILED DANCOS 1600 |
| 22/2 | DANCOS COAST | To PORT LOCKROY | | | | 2 | 30 | 27' | 10.80 | 34 | 4 | N.E. | ARRIVED LOCKROY 1830 SAILED LOCKROY 0510 |
| 23/2 | PORT LOCKROY | To CHARHAM COAST | | | | 13 | 00 | 155' | 11.92 | 36 | 2 | SW | ARRIVED "S" 1810 |
| 24/2 | 66° 26' | 67° 32' | - | 6 | 00 | - | - | 80' | 13.33 | 27 | 9 | SE | SAILED "S" 0600 |
| 25/2 | 66° 39' | 67° 29' | - | 2 | 30 | - | - | 17' | 6.80 | 27 | 3/4 | ESE | FAST ICE OFF "W" |
| 5/3 | 66° 42' | 68° 08' | - | 8 | 05 | - | - | 24' | 2.96 | 26 | 3/4 | SE | TOWARD MARGUERITE |
| 6/3 | 67° 25' | 69° 24' | - | 11 | 04 | - | - | 63' | 5.69 | 37 | 1/2 | SE | ARRIVED BAY IN HEAVY PACK |
| 7/3 | MARGUERITE BAY | | - | 8 | 20 | - | - | 50' | 6.02 | 18 | 3 | SE | FAST ICE 2020 1/4/3 |
| 10/3 | 67° 40' | 69° 33' | - | 7 | 56 | - | - | 35' | 4.41 | 33 | 4 | WNW | MARGUERITE BAY |
| 12/3 | 67° 39' | 69° 33' | - | 3 | 08 | - | - | 1' | - | 33 | 6/7 | NNE | To MATHA STRAIT IN 10 |
| 13/3 | 67° 38' | 69° 30' | - | 14 | 11 | - | - | 2' | - | 36 | 7/8 | N+E | HEAVY PACK ICE |
| 16/3 | 67° 42' | 69° 39' | - | 24 | 00 | - | - | 6' | - | 33 | 5/6 | N | HEAVY PACK ICE |
| 17/3 | 67° 39' | 69° 41' | - | 24 | 00 | - | - | 4' | - | 35 | 5/6 | NNE | HEAVY PACK ICE |
| 18/3 | 67° 39' | 69° 39' | - | 24 | 00 | - | - | 2' | - | 31 | 7/8 | NEN | HEAVY PACK ICE |
| 22/3 | 67° 39' | 69° 55' | - | 24 | 00 | - | - | 10' | - | 20 | 4 | SWW | HEAVY PACK ICE |
| 23/3 | 67° 21' | 70° 10' | - | 12 | 39 | - | - | 10' | - | 18 | 5 | SEW | HEAVY PACK ICE |
| 24/3 | 66° 38' | 67° 57' | - | 19 | 00 | - | - | 80' | 4.21 | 17 | 4/5 | ESE | IN MATHA STRAIT |
| 25/3 | 66° 40' | 67° 41' | - | 10 | 50 | - | - | 3' | - | 30 | 4 | NESE | IN MATHA STRAIT |
| 28/3 | 66° 38' | 67° 37' | - | 3 | 57 | - | - | 6' | - | 19 | 7 | ESE | FAST ICE NEAR BASE W |
| 1/4 | 66° 13' | 67° 15' | - | 7 | 00 | - | - | 28' | 4.00 | 12 | 2/3 | ENE | BASE W TO BASE A |
| 2/4 | 66° 03' | 66° 47' | - | 21 | 37 | - | - | 16' | - | 24 | 4/5 | ENE | HEAVY PACK ICE |
| 4/4 | 65° 59' | 66° 31' | - | 9 | 03 | - | - | 12' | 1.33 | 20 | 6 | SSW | HEAVY PACK ICE |
| 5/4 | 65° 07' | 65° 10' | - | 9 | 36 | - | - | 62' | 6.46 | 13 | 2 | ESE | MEDIUM PACK ICE |
| 6/4 | 65° 00' | 64° 50' | - | 10 | 45 | - | - | 26' | 2.42 | 19 | 4 | SSW | MEDIUM PACK |
| 7/4 | 64° 18' | 63° 08' | - | 11 | 00 | - | - | 73' | 6.64 | 22 | 4 | SSE | |
| 7/4 1735 | PORT LOCKROY | | - | 5 | 35 | - | - | 54' | 9.64 | 21 | | CALM | ARRIVED "A" 1735 |

| SEA PASSAGE | | | | DEAD-WEIGHT | Tons Leaving | Tons Arriving | DRAFT | | |
|-------------|--------------|--------|---------------|-------------|--------------|---------------|---------|----------|-------|
| Date | Ship Time | G.M.T. | Cargo | | | | Leaving | Arriving | |
| Commenced | | | Solid Ballast | | | | | | For'd |
| Completed | | | Water Ballast | | | | | | Aft |
| Steaming | Days | Hours | Mins. | Fresh Water | | | | | Mean |
| Stoppages | Days | Hours | Mins. | Bunkers | | | | | For'd |
| Distance | Slip % | | | Sundries | | | | | Aft |
| Av. Speed | Fuel per Day | | | TOTAL | | | | | Mean |

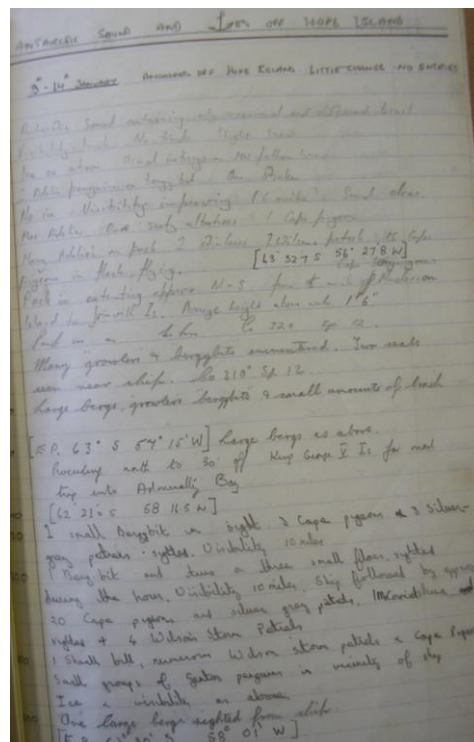
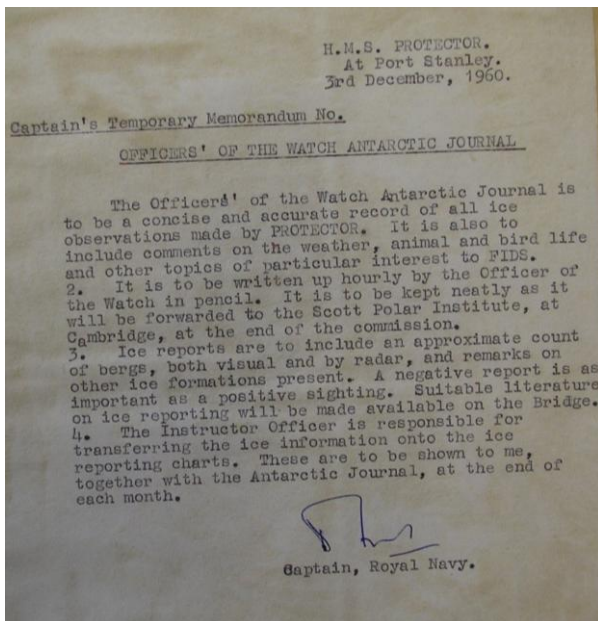
J. Russell
Navigating Officer.

Form 60: Deck Log Abstract RRS John Biscoe February-April 1959.
BAS Archive AD5/9/JB2/1-10

Sea Ice Reports

The sea ice reports are extremely varied in content and detail, some are narrative, others contain tabulated observations, and many include hand-drawn ice charts. The earliest reports, compiled during Operation Tabarin in 1944, are for Port Lockroy, and Deception Island. Both of these reports have corresponding meteorological reports. The met report for Port Foster and Deception Island contains only monthly averages but based on three-hourly observations. The reports with the original met observations are likely to have been sent to the UK Met Office.

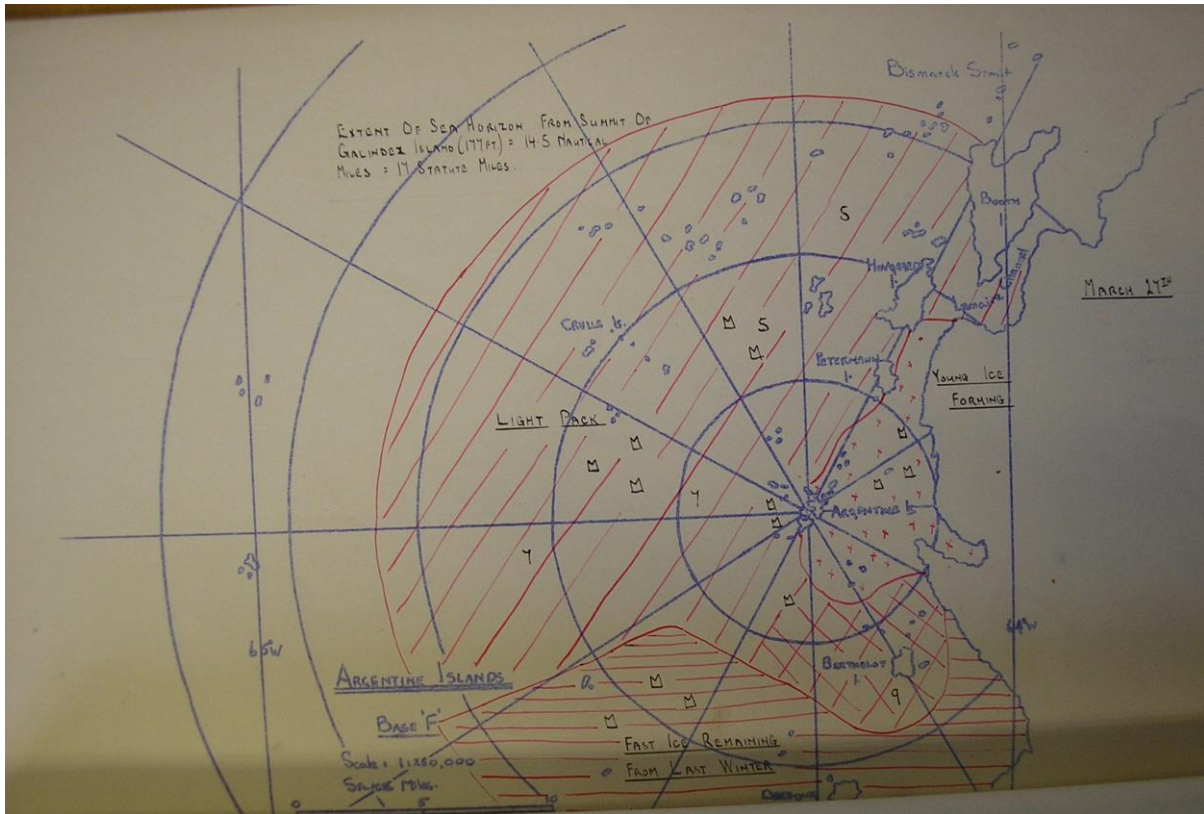
A few of the ice reports originate from vessels, such as AD6/2/1963/J. This is an ice report for the 1963/64 season from RRS *John Biscoe*, providing ice descriptions on different days and including some meteorological observations such as wind direction and force, barometric pressure and a few air temperatures. The format is narrative and not tabular. As only a few daily positions are provided, observations need to be referred to the original log sheets. An unusual item is AD6/2/1960/J, the Antarctic Journal of the ice patrol vessel HMS *Protector*, (Dec 1960-Mar 1961). This is a midshipman's journal adapted to record ice observations. It records the ship's position, time of day and ice sightings both visual and by radar. The report also contains a memorandum by the Captain giving strict instructions for completing the journal.



Antarctic Journal HMS Protector (Dec 1960-Mar 1961) BAS Archive AD6/2/1960/J

Land-based sea ice reports such as AD6/2B/1949/J 'Sea Ice conditions as observed from Deception Island' provide daily (but not every day) reports of ice conditions and

visibility. For example, '5 February 1949, Horizon 18 miles, pack ice appears on NE horizon round to East. Two tenths ice to South and SE. Pack appears to be fairly loose due East.' Many of the reports also contain small card-sized ice charts which have not been archived with the other BAS sea-ice charts. Other reports contain hand-drawn ice charts as illustrated below.



Ice Chart, Argentine Islands 27 March 1954. BAS Archive AD6/2F/1954/J

A few of the reports such as the one for the Argentine islands in 1978, AD6/2F/1978/J provide tabulated ice observations with the number of different types of ice seen each month. Other reports consist almost entirely of maps.

One unusual item is LS/BLI/6/1, 'Operation Tabarin, Monthly Sea-ice Conditions around the Coast of Graham Land' by JWS Marr. This 45-page document lists historic observations around the Graham Land section of the Antarctic Peninsular from 1819 to 1944, organized by month from October to August. Marr also provides a bibliography of sources. BAS also holds a large number of ice charts, many of which have been digitally imaged. All relevant BAS logbooks and reports to 1980 were imaged in early 2013, and an image catalogue is available.

British Geological Survey

The British Geological Survey has archived magnetic surveys and meteorological logbooks from a number of Royal Navy vessels. A complete list can be found at (http://www.geomag.bgs.ac.uk/data_service/data/survey/shipslogs.html). A relevant item is

the geomagnetic log of HMS *Pagoda*, (1844-1845) containing meteorological and other observations. The *Pagoda* penetrated to 67°38'S, in the Indian Ocean sector. Logbooks from this voyage are also held by the National Archives, Kew.

Christian Salvesen Archive, University of Edinburgh Special Collections

The Special Collections are housed in the Centre for Research Collections (CRC) on the sixth floor of the University Library located at George Square, Edinburgh, EH8 9L,. Consultation of the archive requires photographic ID, proof of address (dated within three months) and a passport sized colour photograph. Details of opening times and other information can be found at:

<http://www.ed.ac.uk/schools-departments/information-services/services/library-museum-gallery/crc/collections/special-collections/eua>

The archive holds 20 Chief Officers' Whaling Logbooks, 11 for the *Southern Harvester* 1950-1960 and 9 for the *Southern Venturer* 1951-1959. The logbooks contain data only for the operating period on the whaling grounds of the Southern Ocean and are completed in English. The logbooks have either four or six observations per day of wind direction and force, barometric pressure, air temperature and sea state. There are six *dagrapporter*, or daily reports from the factory ship *Sourabaya* 1932-36. These daily reports (month per page) record among other things daily barometric pressure and air temperature as observed at 8am.

The Archive holds 7 *fangstdagbok* or catch logs for the vessels *Sourabaya* 1932-35, *Salvestria* 1932-33, and *New Sevilla* 1932-34. The upper half of the left-hand page details the noon position (Middagsposisjon) followed by weather conditions (Vaerforhold) including observations of barometric pressure and air temperature. There is no indication of the time of day of the observations and it is assumed to be noon.

There are ten sets of H1-9 Current Reports for the vessels *Sourabaya* 1932-1934, *Salvestria* 1933-1936 and new *Sevilla* 1932-1935. Three of the reports associated with the *New Sevilla* have an additional report on weather and ice conditions. The H1-9 is a pre-printed form issued by the US Hydrographic Office. The usual data to be found on the H1-9 form is month/day/time, position, current set and drift, wind direction and force, sea temperature, either at the surface or at the injector, sometimes both, sea state, swell and specific gravity of seawater. In the case of sea temperatures measured at the engine room injector, the depth of the injector below the surface is given, in the section 'Additional Remarks' on the reverse of the form. This section is also used to record ice observations and the general situation of the vessel within the ice.

The archive holds eight ice charts for the vessels and whaling seasons *New Sevilla* (1933/4, 1934-5, 1935/6), *Salvestria* (1934/5, 1935/6) and *Sourabaya* (1933/4,

1934/5). There are also four sets of whale oil books or *Hval og Oljebok*, 14 books in total, all associated with the factory ship *New Sevilla* during four whaling seasons from 1932 to 1936. On the right hand pages are sections for remarks, describing the weather and ice conditions and the vessel's position at noon.

All of the documents except for the chief officers whaling logbook and the ice charts are in Norwegian. An inventory of relevant material and a detailed report are available.

Hydrographic Office <http://www.ukho.gov.uk>

The UK Hydrographic Office is located in Taunton. Visiting is by appointment only. The archive holds a collection of remark books' mostly kept on board Royal Navy vessels. The archive holds the remark book (71 BA3) of the *Eliza Scott*, which discovered the Balleny Islands in 1839. The vessel penetrated to 68°, 45'S. The Scott Polar Research Institute, Cambridge, has a microfilm copy of the *Eliza Scott's* logbook. All remark books held at the Hydrographic Office are gradually being transferred to the National Archives, Kew.

National Oceanographic Centre <http://www.noc.soton.ac.uk/>

The UK National Oceanographic Centre is located in Southampton. The archive holds the logbooks of the Royal Research Ships *Discovery* and *Discovery II* (1925-1985) and *William Scoresby* 1926-1938. *Discovery II* made a winter circumnavigation of most of Antarctica in 1932. In 1934, the same vessel made a close inspection of the ice edge in the South Pacific while en route from New Zealand to the Magellan Strait. The logbooks will contain sea-ice observations as well as a full range of sub-daily meteorological and oceanographic observations.

National Archives of the United Kingdom <http://www.nationalarchives.gov.uk/>

The National Archives at located at Kew in west London. The archive holds many thousands of ships' logbooks, captains' journals and masters' journals of Royal Navy vessels. These are catalogued under ADM 51, ADM 52, ADM 53, ADM 54, ADM 55 and ADM 173. There are about 310 logbooks that are relevant, spanning both the 19th and 20th centuries. Of particular interest is the log of the *Cora* (ADM 55/143), commanded by James Weddell, which visited the South Shetland Islands in 1820-21. The logbook was imaged by the CORRAL Project and the images are stored on the website of the British Atmospheric Data Centre (BADC) (<http://badc.nerc.ac.uk>).

The archives also hold the meteorological logbooks, in ADM 55, of HMS *Erebus* and HMS *Terror* - 1839-1843 - on their exploration of Antarctic seas under James Clark Ross. These logs were also imaged by CORRAL and the images are at BADC. Logbooks for the *Erebus* and *Terror* can also be found at the Scott Polar Research Institute in Cambridge. Two logbooks for HMS *Pagoda* (ADM 53/3652 & ADM 54/332) on her magnetic survey of the Indian Ocean in 1845, are held at Kew. The

Pagoda penetrated to 67°38'S. A meteorological and geomagnetic logbook is also held by the British Geological Survey.

The bulk of the relevant logbooks cover the 20th century. ADM 53/94415 is the logbook of the *Terra Nova*, 1903-1904. The Antarctic relief vessel *Morning* has logbooks for the period 1902-1904 in both ADM 53 and Adm 55. The ADM 55 logbooks were imaged by CORRAL and the images are held by BADC. Further logbooks of note are the cruiser HMS *Ajax*, which visited South Georgia and the South Shetland Islands in January 1937 (ADM 53/100975). In January and February 1941, HMS *Queen of Bermuda* (ADM 53/ 114914-16) visited South Georgia, the South Orkney Islands, Uruguay Cove, (27 Jan), penetrating to 66°S in 49°W, rounded Trinity Peninsular, the Bransfield Strait, the South Shetland Islands, Port Foster (5 March), returning to Port Stanley, Falkland Islands 8 March. The logbook contains sea-ice observations during February 1941, such as 23, February '11.00, sighted ice pack extending 210⁰ to 240⁰.' HMS *Caernarvon Castle* (ADM 53/ 117156-57) visited Deception Island in the South Shetland group in Jan/Feb 1943. The logs of both of these vessels were imaged under a project supported by the UK Met Office and NOAA's Climate Database Modernization Program (CDMP). While the meteorology was processed, none of the sea-ice observations were digitized. The images are held by the National Climatic Data Center (NCDC), Ashville, North Carolina.

Post World War II, HMS *Snipe* made hydrographic surveys off the South Shetland Islands and off Northern Graham Land. The logbooks are not in the National Archive but will exist elsewhere, possibly the UK Hydrographic Office, Taunton. HMS *Sparrow* was apparently trapped by ice in the South Shetland-South Orkney group in the 1948-1949 season. There are eight logbooks covering the period. The submarine HMS *Telemachus* conducted hydrographic surveys off Australian Antarctic Territory. The logbooks are held in the ADM 173 series. The Royal Navy frigates *Bigbury Bay* and *Burghhead Bay* were regular visitors to Antarctic waters in the 1950s, in or near the South Orkney and South Shetland Islands. *Burghhead Bay* was stopped by pack ice in May 1959, while attempting to reach the west coast of the Antarctic peninsular. All of the relevant logbooks are in the National Archives. Lastly, the logbooks of the ice patrol vessels, *Protector* and *Endurance* during the 1950s, 1960s and 1970s can all be found in the National Archives. As well as potential sea-ice observations, all of the 20th century logs and many of the 19th century ADM 53 logbooks will record sub-daily pressure, air and sea temperatures. All of the relevant logbooks at the National Archives were imaged in early 2013, and an image catalogue is available.

National Maritime Museum <http://www.rmg.co.uk/>

The National Maritime Museum is situated at Greenwich, south-east London. The Museum holds a microfilm copy of the logbook and journal of the *Quest*, 1921-1922,

(MRF/36). Both manuscript and microfilm copies of the meteorological logbook of the *Quest* are also held by the Scott Polar Research Institute, Cambridge.

National Meteorological Archive <http://www.metoffice.gov.uk/learning/library>

The National Meteorological Archive (NMA), a part of the UK Met Office, is contained within the Devon Record Office, situated nearby the Met Office in Exeter. The archive contains nearly 10,000 meteorological logbooks covering the years 1855 to 1904. At least 400 and possibly 500 of these include vessels making a circumnavigation during voyages from UK ports to Australia and New Zealand. The outward voyage was via the Cape of Good Hope, returning eastward across the southern Pacific towards the Drake Passage. (see section on merchant shipping above) All of these logs contain high latitude Pacific transits south of 55°S and in some examples south of 60°S. In the 1850s, the transit below 55S would start between 180°W and 125°W, and continuing on a parallel south of that latitude to the Drake Passage. Logbooks from later decades indicate that vessels were sailing a little further north, not going below 55°S until reaching the longitude of 100°W or further east. Sightings of sea ice are therefore rare, although sightings of icebergs are more common, in particular on approaching the Drake Passage. All of the logs have the merit of containing four-hourly observations of pressure, temperature and sea temperature at a high southern latitude. Most of the logbooks also contain a 'Form for Testing Logs' which provides details of the instruments used as well as comments on the quality of the observations.

Four logbooks were identified as being of particular interest. The four logbooks were for whaling vessels making an expedition to the Weddell Sea sector. These were the *Balaena* (8924), *Polar Star* (8944), *Diana* (8949) and *Active* (8961). The vessels penetrated to about 64°30'S in the region of the South Shetland Islands in January 1893 reporting sightings of pack ice.

The NMA holds 95,000 Form 911 'Ship's meteorological Report' a single log sheet (and later a booklet) that replaced the former meteorological logbook. The Form 911 dates from the first decade of the 20th century and the last part of the log sheet contains a section, 'report upon the position if ice etc.' The later form 911s do not have an ice section. Instead a form 912 ice report was produced. About 1930, the log sheet change format to a paper bound logbook.

Presently it is not possible to determine the number or date range of the archives holdings of Form 912 ice reports as they have not been catalogued. One of these forms has been examined, for the whaler *Ketos*, which observed pack ice 13-14 December 1948 between the positions 58°18'S, 36°50'E and 57°38'S, 34°00'E. This is potentially a rich source of ice data, once the extent of Form 912 holdings has been determined.

About 150 Form 911 meteorological logbooks cover Antarctic waters. Of these, 87 logbooks are for Christian Salvesen vessels during the late 1940s and 1950s, including the factory ships *Southern Harvester* and *Southern Venturer*. There are also Form 911 logs for the research vessel *William Scoresby* 1926-1931 and 1936-38.

Royal Geographical Society <http://www.rgs.org>

The Royal Geographical Society is situated at 1 Kensington Gore, London. Access to the library and archive is by appointment only. The Society holds a number of relevant items including John Biscoe's journal on board the *Tula* 1830-1833, a rough logbook of the *Terra Nova* in 1903-4, the logbook of the whaler *Active* 1892-93, and books concerning Antarctic expeditions.

**Sea Mammal Research Unit –
University of St. Andrews** <http://www.smru.st-andrews.ac.uk/>

The Sea Mammal Research Unit (SMRU) was formed in 1977 and housed at the British Antarctic Survey in Cambridge. It was moved to St. Andrews University in 1996. The archive includes catch books of British factory ships operating in the Southern Ocean in the 1930s, 1940s and 1950s. A catch book from the *Terje Viken* (1937-38), held by the Climatic Research Unit, Norwich, is illustrated in the section on whaling vessels at the front section of this report. As well as providing data on whale catches and processing, the catch books also provide a noon position of the vessel, pressure, temperature, weather and the bearing and distance of the ice pack. There are 96 catch books from 16 factory ships. The collection also includes Inspectors reports and field notes often containing sea-ice observations, meteorology and sea temperatures. Although a significant collection, the catch books and field reports represent a fraction of the material that should be available for the southern whale fishery from all sources.

The archive also contains several un-catalogued items of significance. One of these is a compilation in four volumes, of sea-ice observations from factory ships in the period 1930 to 1935. Another is a set of three photocopied charts from the voyage of the *Nissan Maru* 1947-48, showing the pack ice front in the region of the Balleny Islands. Additionally, the archive holds five folders (Box 642), containing daily logs of the first five commissions of the research vessel *Discovery II*, (1929-1939).

Scott Polar Research Institute <http://www.spri.cam.ac.uk/>

The Scott Polar Research Institute (SPRI) is situated on Lensfield Road in Cambridge. It houses the finest polar library in the world. Advance booking (on-line) to use the archive is required although the library requires no previous appointment. The library contains bound reports of all the major Antarctic expeditions, usually including a volume on meteorology, and a volume containing an abstract of a ship's

logbook. There are many bound reports from the US operations 'High Jump' and 'Deep Freeze' from the 1940s to 1960s, including ice charts and reports of ice conditions. An important printed item is *Extract from the journal of the voyage of Captain Powell to South Shetland during the years 1821 and 1822*. The book includes sea, sub-surface and air temperatures.

The archive contains many logs and journals either the original manuscript or a microfilm of material found in other archives, in particular US archives. Amongst the original manuscript materials is the archive of the Compañía Argentina de Pesca, a Norwegian venture established in Buenos Aires in 1904 that continued to operate until 1960. There are 20 sets of logbooks, mostly whalers rather than factory ships from 1925 to 1960. The log of the *Albatross* 1935-36 (MS 1213/18/1:D) uses a pre-printed form in Spanish. The log entries are written in Norwegian, are mostly text, with some positions, distances run and courses, entered in the first half of the logbook. On examination it was not confirmed if ice observations were present in this particular logbook or in any of the other 20 sets.

SPRI holds manuscript versions of the logs of the *Beaufoy* and *Jane*, (Weddell, 1820-24) and the *Erebus* and *Terror* (Ross, 1839-43) on their voyages of exploration. Amongst the microfilmed logbooks and journals are several for American sealing vessels 1820-1822 (*Hero*, *Hersila*, *Huntress* and *Huron*) the *Eliza Scott*, (Balleny) 1838-39, the *Gronland* 1873-74, German Antarctic Expedition, and the USS *Vincennes*, United States Exploring Expedition 1841-42.

A selection of the best manuscript logbooks were imaged in early 2013 and an image catalogue is available.

G. W. Blunt White Library <http://library.mysticseaport.org/>

The relevant parts of this collection, in the United States, consists of nine sets of microfilm containing eleven logbooks of sealing vessels sailing from New London and Stonington. Most of these are for the periods of the 1870s and 1880s with one set for the period 1836-1839. All the vessels operated in the area of South Georgia and South Shetland Islands.

International Comprehensive Ocean-Atmosphere Data Set (ICOADS)

<http://icoads.noaa.gov/>

The International Comprehensive Ocean-Atmosphere Data Set (ICOADS) offers surface marine data spanning the past three centuries, and as it contains observations from many different observing systems, encompassing the evolution of measurement technology over hundreds of years, ICOADS is probably the most complete and heterogeneous collection of surface marine data in existence. ICOADS contains reports from many vessels operating in the Southern Ocean and near the sea ice edge, but does not include the ice observations due primarily to translation

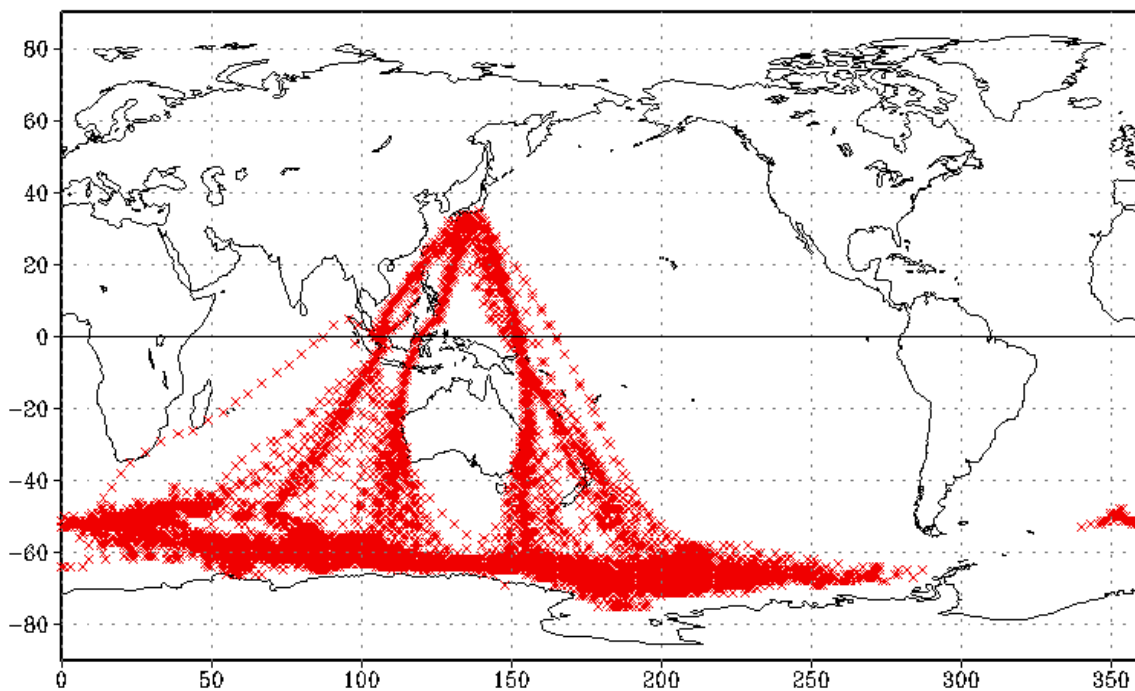
problems to modern units. This applies only to historic data before 1982, after which modern sea-ice codes were introduced. Other meteorological and oceanographic parameters are available in digital form, and the undigitized ice observations are still archived on the original images. Three of the ICOADS decks contain potential ice observations or, where not digitized, indicate sources of ice data.

1. ICOADS Japanese Whaling Ship Data <http://icoads.noaa.gov/japan.html>

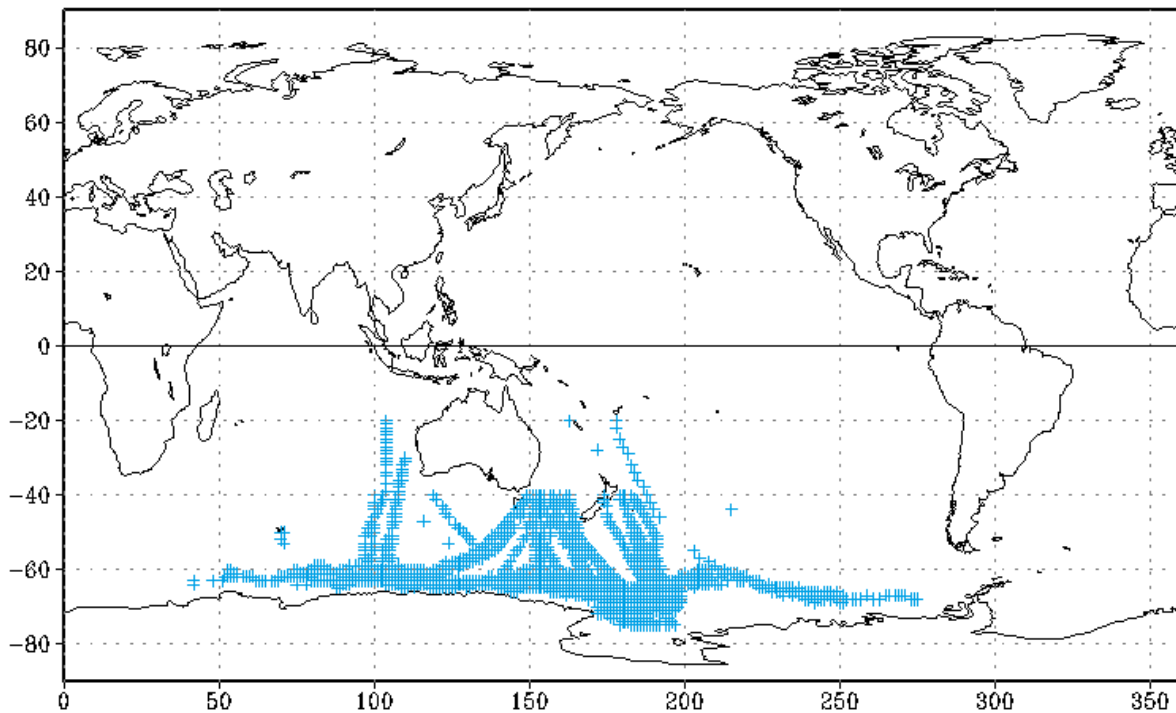
A. Deck 761, 'Japanese Whaling Ship Data' contains over 20K daily reports from 13 named vessels 1946-1984, using noon observations only. When the data was prepared, the original log sheets were not imaged due to proprietary fisheries information not being keyed or publicly released, and unfortunately the ice data was not included in ICOADS due to translation problems to modern units. The ice data is however available as 'supplemental data (as keyed)'.

B. Deck 187, 'Japanese Whaling Fleet' contains 10K daily reports from 11 named vessels 1946-1956 in the Indian and Pacific sectors of the Southern Ocean, consisting of six-hourly synoptic observations. These observations were part of the original COADS Release 1. Again sea ice observations were not included in but will be in the original documents if the provenance of the data can be traced.

Deck 761 1946-84



Deck 187 1946–55



The plots above indicate the spatial coverage of the Japanese whaling logs in decks 761 and 187.

2. Norwegian Antarctic Whaling Factory Ship data – Deck 188

Deck 188 contains reports from 11 named vessels operating in the Southern Ocean 1932-1939, in the Indian and Pacific Ocean sectors, reporting either six or three-hourly observations. The data was keyed in Oslo, and ice observations were not digitized, but will exist in the original documents if their provenance can be determined. The type of data recorded indicates that the original documents were most likely a deck log rather than a catch book. The original card deck reference manual containing codes and some metadata can be accessed at <http://icoads.noaa.gov/reclaim/pdf/dck188.pdf>.

3. South African Whaling – Deck 899

No information on this deck but the original documents should have ice reports

National Archives and Records Administration (NARA), Washington

<http://www.archives.gov/>

Forty-nine named US Navy or US Coast Guard vessels have been identified as operating at high southern latitudes up until 1970. **(awaiting further details)**

New Bedford Whaling Museum <http://www.whalingmuseum.org/>

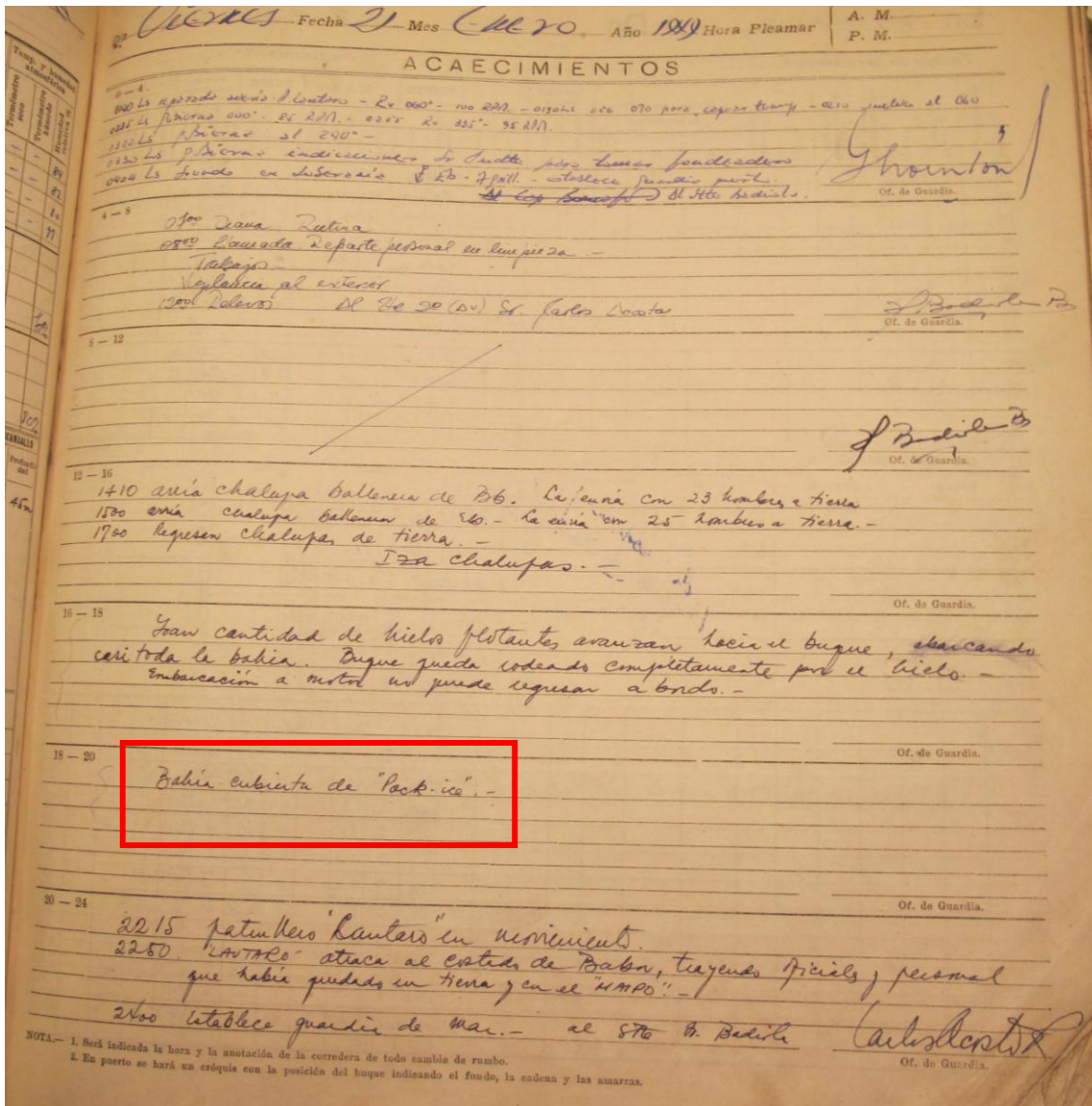
The Museum situated in New Bedford Massachusetts, holds 24 items, mostly microfilm sets, from fifteen named vessels operating in the Southern Ocean from about 1800 to the 1950s. Most of the logbooks are from American vessels in the 1850s, however for the 20th century there are microfilmed deck logbooks for two British, Christian Salvesen factory ships *Southern Princess* (1939-1940) and the *Southern Venturer* (1945-1946). There is also a microfilmed deck logbook for the Japanese factory ship *Hashidate Maru* (1950-1951). On notable item is the log of the *Levant* (1851-1854), reference ODHS 1075/Reel 1014. The *Levant* sailed from Chatham Island, passing through the pack ice to the Ice Barrier off Oates Land in January 1853, sailing thence to the Balleny Islands in February.

Museo Marítimo Nacional, Valparaíso Chile <http://www.museonaval.cl/>

The Museum located at Paseo 21 de Mayo, Cerro Artillería, Valparaíso holds logbooks (*bitácora*) for the Chilean Navy from the 1860s onwards. Of the 6-7,000 naval logbooks held at the Museum there are 79 sets of *bitácora* attached to 13 named vessels operating in Antarctic waters between 1947 and 1970. Most of the activity is centred on the South Shetland Islands, the Drake Passage and the seas to the westward of the Antarctic Peninsular. Ice observations are present in these logbooks for example on the logbook page illustrated below, the frigate *Covadonga* reported 'Bahía cubierta de 'pack ice' (the bay is covered in pack ice). This observation was made 21 January 1949, at Soberanía (now the Chilean Antarctic base 'Arturo Prat'). The bay mentioned is on the north side of Greenwich Island in the South Shetland group and facing English Strait. As well as ice observations, the Chilean logbooks have (often hourly), pressure, temperature, SST and humidity observations.

The Chilean naval logbooks are not only an important resource in their own right, but the observations within them can be combined with data from the logbooks of the Royal Navy (National Archive, Kew) and the logbooks of the Argentine Navy (if access can be granted). Argentina, Chile and the United Kingdom had competing territorial claims in the Antarctic Peninsular and the Weddell Sea area (claims presently in abeyance through the Antarctic Treaty, June 1961). On a few occasions, Chilean or Argentine naval forces would establish sovereignty by erecting a structure such as a hut, or by some other gesture, after which the Royal Navy would remove the structure, in turn asserting British rights. This led to periods where it would now be possible to link data from the different navies to form a longer record or to make comparisons between the different observations and observational methodology both for sea ice and for meteorological data. For instance on 24 January 1949, the log of the Chilean frigate *Covadonga* (ref. 2136) reported sighting HMS *Sparrow* (TNA, Kew - ADM 53/126967) and a British cutter. The latter vessel is

possibly the FIDS vessel *John Biscoe* although there are no logbooks for the *John Biscoe* covering January 1949



Museo Marítimo Nacional, Valparaíso – Bitácora 2136, Fragata Covadonga 21 January 1949.

Servicio Hidrográfico y Oceanográfico de la Armada de Chile, Valparaíso
<http://www.shoa.cl>

The Library and archive of the Hydrographic and Oceanographic Service of the Chilean Navy is situated at Errázuriz 254, Playa Ancha, Valparaíso. This is a defence establishment and visiting is strictly by appointment. Data from vessels engaged in hydrographic work including meteorological, and where appropriate, sea ice observations can be found in cruise reports and in the *Anuario Hidrográfico*, first published in 1875.

Archives Nacional, Paris <http://www.archivesnationales.culture.gouv.fr/>

The National Archives of France are situated at 11, Rue des Quatre Fils, 75003 Paris. The archive contains the journals of the French frigates *Aigle* and *Marie*, commanded by Lozier Bouvet. Here can be found the earliest sea ice observations in the vicinity of Bouvet Island where pack ice was encountered at 48°50'S in January 1739. The Archive also holds the journals of the *Astrolabe* and *Zelee* which under the command of Dumont d'Urville, approached the Antarctic Peninsular in January 1838 and again approached the continent from the direction of Hobart, in January 1840. The vessels penetrated to 65°, 20'S within the longitudinal range of 122° to 141°E.

National Archive of New Zealand, Wellington <http://archives.govt.nz/>

The National Archives of New Zealand are located at 10 Mulgrave Street, Thorndon, Wellington, New Zealand. There are regional archives situated at Auckland, Christchurch and Dunedin. The Wellington office hold logbooks of naval vessels including the research ship *Endeavour* (ex-FIDS vessel, *John Biscoe*) from 1956 to 1968. The logs of HMNZN frigates *Hawea* and *Pukaki* on their Antarctic cruises of 1956-1957 and the *Pukaki's* logs during 'Operation Deepfreeze' 1963-1965 are either not at this archive or are not presently on public access and these logs have not yet been located.

National Archive of Australia <http://www.naa.gov.au/>

The National Archives of Australia hold sea ice reports and logbooks of the research vessels *Magga Dan*, *Thala Dan* and *Wyatt Earp*, 1940s-1960s.

South African Weather Bureau <http://www.weathersa.co.za>

According to the website, the South African Weather Bureau only holds marine data from 1975 onwards. However 'ship reports' were re-broadcast by the Bureau from October 1952, from whale factory ships in the South Atlantic and Indian Ocean sectors. The broadcasts were received in the Falkland Islands and South Georgia.¹³ By the mid-1950s these reports were more extensive and were used to produce synoptic charts in S. D. Glassey's *Forecasting in the Falkland Islands and Dependencies*, published in 1961. Charts 6a through 6c (28 Feb-1 Mar 1956) indicate observations from RRS *Fitzroy*, HMS *Protector* and the factory ships *Olympic Challenger* and *Southern Venturer*, the latter vessel situated to the west of the Antarctic Peninsular at about 68°S and 76°W.¹⁴ As well as valuable meteorology, these vessels may also have reported ice conditions. It has not been determined if the South African Weather Bureau, or the authorities in the Falkland Islands have archived any of this data.

Vestfold Archive, Sandefjord, Norway <http://www.vestfoldarkivet.no>

The Vestfold Archive is located at Hinderveien 10, Sandefjord. The archive holds 83 logbooks including the factory ships *Antarctic* (1930), *Pelagos* (1935-7, 1945-62) and numerous whale catchers. Most of the logbooks are for vessels operating in Antarctic waters, but a significant number of logs cover whaling activities in the South Atlantic, off the coast of the former French Congo, and at least one vessel hunting on the Peruvian whaling grounds. An exhaustive search is required to determine what other relevant material may be found in this archive. It should be noted that all the logbooks are written in Norwegian, and most in old Norwegian, and in some cases with words similar to Danish. An inventory and a separate detailed report are available.

Whaling Museum (Hvalfangstmuseet), Sandefjord, Norway

<http://www.hvalfangstmuseet.no>

The Whaling Museum is located at Museumsgaten 39, Sandefjord. The archive of the Museum holds three relevant sets of documents. These are ships' logbooks (*dekkdagbok*), engine room logs, (*maskingdagbok*) and catch books (*fangstdagbok*). There are 171 logbooks of which 108 are for vessels in Antarctic waters, including factory ships, whale catchers and oil tankers. Ninety-three of these logbooks have been examined and all contain data of exceptional quantity and quality, including 4-hourly barometric pressure, wind force and direction, air temperature, sea swell and ice observations.. There are 74 engine room logs, some with sea temperatures, and at least 6 catch books. It should be noted that all the logbooks and other documents are written in Norwegian, and most in old Norwegian, and in some cases with words similar to Danish. An inventory and a separate detailed report are available.

Imaging

During 2013, imaging of all relevant material at the British Antarctic Survey 1944-1980, and the UK National Archives was undertaken. In addition, a selection of the best archive material held by the Scott Polar Research Institute was also imaged. The material from BAS included all 130 logbooks to 1980, selected voyage and ice reports from vessels, and sea ice reports (including some ice charts) from land stations at Deception Island 1944-1966 and Signy Island 1950-1978. At the National Archives, 131 logbooks were imaged, the earliest 1827/28, but most from Royal Navy vessels during the 1950s, 1960s and 1970s. At the Scott Polar Research Institute 76 logbooks and one ice chart were imaged. There are just over 26,000 images from these three archives awaiting the digitization of their observations. The images are held by the archives themselves, by the Met Office Hadley Centre and by the author. Detailed image catalogues and a report are available.

¹ R. G. Onstott, (2004) 'Antarctic Sea Ice and Icebergs' in C. R Jackson & J. R Aspel (eds.), *Synthetic Aperture Radar, Marine Users Manual* (NOAA), 397-400. <http://www.sarusersmanual.com/> Accessed October 2012.

² A. Maria del Rosario Prieto *et al.* (2004) 'Early Records of Icebergs in the South Atlantic Ocean from Spanish Documentary Sources', *Climatic Change*, 66, 29-48,

³ Royal Navy logbooks are subject to a thirty year restriction. Presently 2012, the National Archives at Kew hold logbooks up to 1976.

⁴ M. F. Maury (1859), *Explanations and Sailing Directions to accompany the Wind and Current Charts*, vol. 2, 587.

⁵ John T. Towson (1852), *Tables to Facilitate the Practice of Great Circle Sailing*.

⁶ Maury (1859), 581

⁷ John T. Towson (1854), 'Great Circle Sailing', *The Mercantile Magazine and Nautical Record*, Vol. 1, 106.

⁸ *Golden Era* sailed along the latitude of 63°S between the meridians of 112°W and 92°W without sighting any ice. A. G. Findlay (1863), *Directory for the Navigation of the South Pacific*, 759.

⁹ John T. Towson (1857), 'Icebergs in the Southern Ocean', *Transactions of the Historical Society of Lancashire and Cheshire*, Vol. IX, 250.

¹⁰ J. Boulton (1833), 'Route of the *Arethusa*', *Nautical Magazine*, 455.

¹¹ Robert Headland (2009), *A Chronology of Antarctic Exploration*.

¹² British Antarctic Survey (2010). Antarctica and the Arctic, 1:10,000,000 scale map Series BAS (Misc) Sheets 15A and 15B. Cambridge.

¹³ A.W. Mansfield & S. D. Glassey (1957), *FIDS Scientific Report no. 16, Notes on Weather Analysis in the Falkland Islands Dependencies, Antarctica*, 2-3.

¹⁴ S. D. Glassey (1961), *Scientific Paper No. 7, Air Ministry Meteorological Office Forecasting in the Falkland Islands and Dependencies*, 17-19.