# Science at Sea: voyages of exploration and the making of marine knowledge, 1837-1843.

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## Abstract

This thesis is about the historical geography of scientific knowledge production at sea. It focuses on three expeditions of exploration and discovery undertaken, respectively, by France, the United States of America, and Britain, that in the late 1830s sailed into the southern oceans. These voyages marked the last such expeditions to travel by sail alone and came before an acknowledged period of specialized interest in investigating the oceans and the marine environment, exemplified by the sailing of HMS *Challenger* in 1872. The expeditions share a commonality of period and of destination: their study together provides a hitherto overlooked opportunity to analyse practices of experimentation on, and investigation of, the natural history and physical properties of the marine environment that were integral to the construction of scientific knowledge about the oceans at that time.

By attention to archival records, personal correspondence, diaries, published travel narratives and representations of marine phenomena in the form of illustrations, sketches, preserved specimens and displays of numerical material, this thesis examines quotidian shipboard practices to show how the production of scientific 'facts' was a matter of constant negotiation between people, weather, instruments and vessels – that occurred as a by-product of the running of the ship as well as of more defined programmes of study by civilian naturalists and naval staff. Informed by work in the history of science, Science and Technology Studies (STS) and Actor-Network Theory (ANT), this thesis highlights how attending to practice in the ambiguous, heterotopic space that was the expedition vessel can reveal the origins of a new, specialized, discipline: what I call here a proto-oceanography. This covers those scientific practices undertaken primarily at sea and from the ship: depth measurement, sea temperature and chemistry, the height of waves, collection of marine specimens and coastal topography, but not those primarily land-based activities such as astronomy, meteorology and terrestrial magnetism. By focusing on work carried out on board ship rather than on land, this thesis offers new insights into the practices of marine investigation and experimentation and the complexities of interrogating a space which was visualised primarily through instruments. This thesis examines how at-sea cultures of collection, measurement and representation can inform geographically nuanced analyses of the production of scientific knowledge.

## Acknowledgements

I would like, above all, to thank Charlie Withers for his patient, unceasing help with the thesis. It is no overstatement to say without his support this would not be the product it is today. The most poignant aspect of finishing this research is that it brings an end, for now, to our collaboration.

Grateful thanks to Fraser Macdonald for offering much needed encouragement and a different, challenging, and rewarding point of view.

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To Colin, Oscar, Niall, and Lyra: I hoped to make you proud – you are my constant motivation and my greatest pleasure, always.

**Declaration**

I hereby declare that this thesis has been composed by me and is entirely my own work. No part of this thesis has been submitted for any other degree or professional qualification

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# Contents

**Figures**

# Chapter 1 The Mysteries of the Deep: constructing knowledge on the deep seas through expeditionary voyages, 1837-1843.

> I [Joseph Dalton Hooker] have doubled both Capes now, & am not to be sneezed at in any society. We want to go to the Southward once more in Weddell's Track, where the French have been twice beaten under the redoubted Admiral d'Urville, whom we regard with great scorn & hardly ever mention his name on board but as a boaster. As to poor Wilkes, & his Yankee Fleet, they are extinguished.[1]

When the French corvettes, *Astrolabe* and *Zélée*, captained by the Pacific explorer Jules Dumont d'Urville, set sail from Toulon on 7 September 1837, the journey marked the beginning of a period of intense interest in the Southern Ocean and the Antarctic continent that would be quickly augmented by American and British exploring expeditions. Dumont d'Urville sailed with the approval of France's King Louis Philippe, who had guaranteed that each sailor would receive financial reward for exploring further south than any preceding voyage. The following year, in August 1838, the United States Exploring Expedition (known contemporaneously as the US Ex. Ex.) led by Lieutenant Charles Wilkes, followed in the French wake. This, the first expedition on such a scale sanctioned by the American government, set off with six ships, similar only in their unsuitability for polar exploration. On 30 September 1839, two British ships set sail from Margate bound for the high southern latitudes. The British Antarctic expedition, led by James Clark Ross, sailed with directions from the Royal Society to undertake scientific enquiries, particularly on terrestrial magnetism and meteorology.

Each expedition purported to sail for reasons other than the discovery and colonization of new land. Each used the collection of scientific information as the 'innocent'

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[1] Joseph Hooker Correspondence Project. Archives of the Royal Botanic Gardens, Kew. Antarctic Correspondence. JDH/1/2 f.91-92. From Joseph Hooker to Mrs. Palgrave, 25 April 1842.

face of the undertaking. As Barbara Stafford argues, science was conceived as a 'transcendent interest' above 'naturally commercial, military or colonial exploitation'.[2] Large-scale maritime exploration was expensive, however, and scientific investigation was regularly subordinated to other shipboard requirements. Yet the work conducted during these three expeditions was to prove significant in advancing knowledge on the Southern Oceans.

The central theme of this thesis is how scientific understanding of the marine environment was produced on board expeditionary vessels between 1837 and 1843, through the shipboard practices of collection, measurement and representation. I do not consider the aftermath of voyages of exploration in the construction of scientific knowledge, despite, and as a consequence of recent scholarship on its importance.[3] How the work of each voyage was actually received on the return (as opposed to how their reception was *anticipated*) is vital in understanding how later audiences viewed the work, but does not impact on how work was conducted during the period of the expeditions' time away from home. Scientific knowledge is accepted through processes of production, mobility and reception: this thesis involves itself with production only.

The arguments of the thesis proceed as follows. Each chapter has its own introduction covering the academic literature, conceptual arguments, and contextual material more relevant to the arguments covered in individual chapters. In this way each chapter is intended to be a stand-alone analysis of specific scientific practices conducted on board the expedition vessels, at the same time as offering a wider analysis of mid-nineteenth-century proto-oceanographic practice. This term – proto-oceanography - covers those scientific practices

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[2] Stafford, Barbara M. *Voyage into Substance: Art, Science and the Illustrated Travel Account, 1760-1840* (London: MIT Press, 1984): 32-33.
[3] See: Dritsas, Lawrence. 'From Lake Nyassa to Philadelphia: a Geography of the Zambezi Expedition, 1858-64', *The British Journal for the History of Science* 38 (1) (2005): 35-52.

undertaken primarily at sea and from the ship: measurements of ocean depth, temperature, currents and chemistry; the height of waves; the extent of vision under the water; behaviour of substances at depth; the collection and representation of marine specimens; and coastal topography. This thesis does not analyse those activities primarily conducted from land such as astronomy, meteorology and terrestrial magnetism, but which were, at times, undertaken from the ship. In this way the focus on the practices and protocols of shipboard life, and their connection with the production of scientific knowledge on the marine environment, is maintained.

Whilst the thesis deals with work produced on and from the respective ships, each chapter necessarily uses the textual and pictorial output of the voyages that was produced from material collected on board and worked up on the return home. Knowledge on the ocean gained through the course of the three expeditions considered was transmitted in a variety of ways after the voyages' return: narratives, maps, charts and tables were presented to government departments such as the Admiralty or Foreign Office; papers given to specialist scholarly scientific, missionary and philanthropic societies; books, journals, magazine articles and imaginative literature. This thesis uses these materials – the cartographic representations and the general miscellany of shipboard life – to throw light on the making of scientific knowledge about the sea. The aim here is not to adhere to a self-constructed set of boundaries bookending the beginning and end of the voyages of exploration, but to offer insight into what was important, lasting and influential about the ship-board environment that had both ontological and epistemological significance in the production of scientific facts about the deep sea.

This thesis aims to contribute to an understanding of the place and credibility of the ship as a space of scientific investigation; the differing authoritative positions of the naval, civilian, and scientific men on board; and the embodied practices of shipboard scientific knowledge production that were integral to the successful construction of facts about the deep sea. Maritime history has always been of interest to historians, historians of science, geographers, biologists, oceanographers and others. The combination of exploration, heroic masculinities and bravado, 'high jinks' on the high seas and the prospect of new discovery has been both generally and academically appealing. The focus of this interest has been diverse: war, art, transport, piracy, shipwrecks, slavery, whaling and the ship itself, to name just a few.[4] Scientific endeavour, however, has often taken second place to some of the concerns of the specific period: ethnography has trumped hydrography, terrestrial biology has won out over marine invertebrate taxonomies; mutiny and disaster have had more column inches than disagreements over where to conduct animal dissection on board ship. This is not to say that science at sea, specifically maritime cartography, meteorology and magnetism has not been studied in recent years.[5] Yet scientific investigations of the marine environment –

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[4] For work on the ship see: Sorrenson, R. 'The ship as a scientific instrument in the eighteenth century', *Osiris 2nd series* 11 (1996): 221-236; Hasty, W. and Peters, K. 'The Ship in Geography and the Geographies of the Ship', *Geography Compass* 6/11 (2012):660-676; and Winter, A. '"Compasses All Awry": The Iron Ship and the Ambiguities of Cultural Authority in Victorian Britain', *Victorian Studies* 38 (1994): 69-98 ; for maritime book history and inscriptions see Craciun, A. 'Oceanic Voyages, maritime books, and eccentric inscriptions', *Atlantic Studies* 10 (2013): 170-196; for piracy see Hasty, W. 'Piracy and the production of knowledge in the travels of William Dampier, c.1679 - 1688', *Journal of Historical Geography* 37 (2011): 40-54; for Arctic exploration in the early nineteenth century see Bravo, M. 'Geographies of Exploration and Improvement: William Scoresby and Arctic Whaling, 1782-1822', *Journal of Historical Geography* 32 (2006): 512-538; for slavery see: Lambert, David "'Taken captive by the mystery of the Great River': Towards an Historical Geography of British Geography and Atlantic Slavery', *Journal of Historical Geography* 35(2009): 44-65; for whaling see Burnett, D. Graham. *The Sounding of the Whale: Science and Cetaceans in the Twentieth Century* (Chicago and London: University of Chicago Press, 2012); and for wrecks see Driver, F. and Martins, L. 'Shipwreck and salvage in the tropics: the case of HMS *Thetis'*, 1830–1854. *Journal of Historical Geography* 32 (2006): 539-562.

[5] See for example: Achbari, Azadeh. 'Building Networks for Science: Conflict and Cooperation in Nineteenth-Century Global Marine Studies', *Isis*, 106 (2) (2015): 257-282; Burnett, D. Graham. *Masters of All They Surveyed: Exploration: Geography, and a British El Dorado* (Chicago and London: University of Chicago Press, 2000); Enebakk, Vidar. 'Hansteen's Magnometer and the Origin of the Magnetic Crusade', *British Journal for the History of Science* 47 (4) (2014): 587-608; Jonkers, A. R.T. *Earth's Magnetism in the Age of Sail* (Baltimore: John Hopkins University Press, 2008); Naylor, Simon. 'Log Books and the Law of Storms: Maritime Meteorology and the British Admiralty in the Nineteenth Century', *Isis*, 106 (4) (2015): 771-797; Williamson, Fiona. 'Weathering the Empire: Meteorological Research in the Early British Straits Settlements', *British Journal for the History of Science* 48 (3) (2015): 475-492.

that is the ocean space below the vessel, the surface of the sea and the aerial space above it – seem to have largely escaped (or been denied) detailed attention. This thesis sets out to systematically examine work conducted on and from the ocean – the processes of production and representation rather than dissemination – in the 1830s and 1840s as made on three expeditionary voyages, one each from France, America and Britain.

This work contributes to current understanding of scientific practices at sea by locating it within the historiographical context of oceanic science in the nineteenth century. This is something of a departure from convention for several reasons. The voyages of Captain James Cook and the first voyages around the coast of what is now Australia have received a disproportionate amount of scholarly attention. Jane Samson argues that 'a curtain comes down after Cook, Vancouver and Bligh leave the stage'.[6] Much less attention has been given to voyages of exploration in the mid-nineteenth century. Those studies that have focused on these three expeditions have stressed the interest of the race to claim the Antarctic continent.[7] But important scientific work on the marine environment was performed on these vessels, and is worthy of more in-depth analysis. This thesis is distinctive in its assessment and analysis of work conducted at sea, on the marine environment, at a time where terrestrial investigations were much more widely pursued.[8]

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[6] Samson, Jane. *Imperial Benevolence: Making British Authority in the Pacific Islands*, (Honolulu: University of Hawaii Press, 1998), 2.

[7] See for example: Gurney, Alan. *The Race to the White Continent: Voyages to the Antarctic*, (London: W. W. Norton & CO., 2000); Mawer, Granville Allen., *South by Northwest: The Magnetic Crusade and the Contest for Antarctica* (Edinburgh: Birlinn, 2006).

[8] See for example also Dritsas, Lawrence. 'Expeditionary Science: Conflicts of Method in Mid Nineteenth-Century Geographical Discovery'. In David N. Livingstone and Charles W. J. Withers, (eds), *Geographies of Nineteenth-Century Science* (Chicago and London: Chicago University Press, 2011): 255-277; Hevly, B. 'The Heroic Science of Glacial Motion', *Osiris* (1996): 66-86; Jardine, N., Secord, J. A. and Spary, E. C. (eds), *Cultures of Natural History*, (Cambridge: Cambridge University Press, 1996): Section III; Kennedy, Dane. *The Last Blank Spaces: Exploring Africa and Australia*, (Cambridge and London: Harvard University Press, 2013).

The work conducted by each expedition built upon the tradition of scientific endeavour forged by the Pacific voyages of James Cook in the 1770s, and continued through the work of the French explorers, the Comte de Lapérouse (1785-1788) and Louis-Antoine de Bougainville (1766-1769) in the South Seas, and the British expedition leaders Matthew Flinders (1801-1803), John Ross (1818-1819) and William Parry (1819-1820; 1821-1823 and 1824-1825) in the Southern and Arctic Oceans. These oceanic voyages had, somewhat perversely, overlooked the importance of the marine environment. Their attention focused not on the marine world but on terrestrial exploration, astronomical calculation and imperial aggrandizement. The South Seas expeditions of the 1830s and 1840s helped rectify this disparity by studying the ocean as a space of scientific interest in its own right. As Rozwadowski notes, early ocean science 'blended the promise of tangible, economic benefit with the political potency that derived from mapping and discovering'.[9]

This thesis does not set out to compare and contrast the expeditions from each country. Rather, by the study of three voyages of exploration which sailed at almost identical times, to identical places, a commonality across voyages can be uncovered that sheds light on emergent oceanographic practices in the 1830s and 1840s. This period is often overlooked in historical accounts of nineteenth-century scientific endeavour: less sensational than the spate of Arctic expeditions in the 1820s, and less specialized than the oceanographic work of HMS *Challenger* (1872-1876).[10] These voyages marked an important watershed in the history of maritime exploration: they were the last large-scale exploring expeditions to travel solely

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[9] Rozwadowski, Helen. *Fathoming the Ocean: The Discovery and Exploration of the Deep Sea* (Harvard: Harvard University Press, 2008): 5.

[10] Margaret Deacon dates attention to deeper water as beginning in the 1860s whilst Helen Rozwadowski considers the period after 1850 as the start of deep-sea investigations of real note. Deacon, Margaret. *Scientists and the Sea 1650-1900: A Study of Marine Science* (London and New York: London and New York Academic Press, 191), 72-99; Rozwadowski, *Fathoming the ocean*, ch.4-5. For more on the contribution of the *Challenger* expedition, see Deacon, M., Rice, T. and Summerhayes, C. (eds), *Understanding the Oceans*, (London: Routledge, 2001).

under the power of sail. Travelling using the power of the wind had important considerations for the practices of marine investigation. It hampered the progress of many scientific activities whilst seamen struggled to keep the ship steady. Instruments were regularly lost, 'ran down' or did not function accurately in extremes of climate. Lack of forward movement, however, afforded the scientifically-minded on board the opportunity to undertake experiments, to take soundings or to collect specimens. Studying the sea in the mid-nineteenth century was a difficult and hugely expensive activity and it was only large scale, Government sponsored expeditions that had the costly resources required for detailed scientific investigations of the sea.[11]

For a maritime nation, the ability to know the ocean was a statement of authority. Exploration of the southern ocean sought to advance imperial agendas, pre-empt political rivals, inspire patriotic pride, discover natural resources and promote commercial interests. Michael Reidy has argued that as the politics of imperialism intensified, the Admiralty's need for scientific and technical expertise grew more profound.[12] Better understanding of how the oceans operated could aid navigation, prevent shipwreck and hasten journeys across waters notable for their lack of significant 'landmarks'.[13] In the early nineteenth century scientific understanding of the sea was of a known layer at the surface, with an unknown abyss below. Susan Schlee argues that what was known oceanographically about shallow, coastal waters was extended, without testing, to the deep sea about which almost nothing was known.[14] Among the conjectures perpetrated as 'facts' was a belief that water was more compressible

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[11] For an example of scientific work pursued from a naval voyage see Deacon, Margaret. *Vice-Admiral T. A. B. Spratt and the development of oceanography in the Mediterranean, 1841-1873* (Greenwich: National Maritime Museum, 1978).
[12] Reidy, Michael. *Tides of History: Ocean Science and Her Majesty's Navy* (Chicago and London: Chicago University Press, 2008): 255.
[13] See Deacon, *Scientists and the Sea*, 192.
[14] Schlee, Susan. *The Edge of an Unfamiliar World: A History of Oceanography* (Toronto and Vancouver: Clarke, Irwin & Company Limited, 1972).

than it is, and so the sea was increasingly dense at great depths. Although experiments in the late eighteenth century had shown that the density of water did not change to the extent that its viscosity would be affected, this misapprehension regarding pressure at depth led some to believe that any attempt to lay telegraph cables on the sea floor would result in cables hanging midway in the ocean. More significant and lasting misunderstanding involved the belief that water at the depths of the sea was all 4°C, and that no winds could move water so deep. Because it was believed that there could be no movement in this static water at standard temperature, the view was taken that life could not survive at depth: no movement of water meant no food supply. Information was lacking - but there existed a body of *assumed* knowledge in this period that directly affected the way scientific endeavour was undertaken.

As Dane Kennedy argues, all expeditions share key characteristics. They were supported by institutional sponsors such as governmental agencies, and learned societies; were supplied with instructions, and structured with clear lines of command and defined duties.[15] Each expedition sailed with specific sailing and scientific instructions issued by particular scientific institutions. These expressly demanded the study of the ocean (what was to be studied), but were virtually silent regarding operational procedure (how it would be studied). Recommendations were either very precise – particular specimens of marine invertebrates were asked for – or entirely vague – 'observe' or 'collect all you can'.[16] Although the impact these expeditions had on increasing knowledge on the ocean, that was later to inform the preparation of expeditions such as HMS *Challenger* (one of the first and largest expeditions to sail with science as its *only* remit), was large, the importance of the work that had been conducted and the knowledge that had been produced was largely

[15] Kennedy, *The Last Blank Space*, 28.
[16] See Chapter 3, pp.49-99.

overlooked at the time. Yet, I shall contend, these three expeditions provided an opportunity to test new and unproven instrumentation and to apply continued and improved systems of recording numerical information. They provided opportunities for the collection of time-series of data across wide geographical regions. The expeditions each preserved and transported specimens from the underwater environment to the metropolitan museums and, perhaps, most importantly, set in place a series of practices that were tried, tested and reported upon for the men who would follow them. This thesis is an attempt to recapture the epistemic significance of these practices and protocols by attending to the everyday actions of those on board, and to question the view that interrogation of the marine world only became noteworthy from mid-century.

The wider scope of this thesis is to understand how knowledge both on and of the deep sea was constructed through the space of the expedition vessel itself. Using work in the history of science and in science studies, which addresses the role of 'inscriptions' – the marks and traces of experiment made on paper – this thesis considers how objects and data on the deep seas were 'translated' into scientific facts.[17] Representing objects and measurements from the ocean without being able to offer to distant audiences the ocular proof of directly witnessing the deep sea environment and its contents, was problematic. The deep sea was seen by many as unfathomable, even unknowable. It was accessible only through instrumental and second-hand experimental means. Ensuring that truth claims about what lay beneath the waves was credible was, I contend, a more complex philosophical process than representing life outside the ocean environment.

[17] Latour, Bruno. *Pandora's Hope: An Essay on the Reality of Science Studies* (Harvard: Harvard University Press, 2009): 24-79.

This thesis attempts to understand how the on-board practices and methods of men of science and navy on three voyages of exploration contributed to the understanding of the deep sea in the period 1837-1843. Chapter two looks at the research context in which this thesis sits. I consider work in the history of science, science studies, the sociology of science (particularly the laboratory studies pioneered by Bruno Latour, Steve Woolgar, Michael Lynch and Karin Knorr-Cetina) and show how work in these fields has informed my understanding of how scientific knowledge was produced about the sea, whilst at sea.

Chapter 3 presents a biography of the three expeditions. I attend to the political, scientific and economic imperatives behind each voyage's inception and conduct, situating the expeditions in a network of people and institutions that had something to gain by the prosecution of large-scale southern ocean exploration. This is achieved through critical examination of the orders given to each expedition before sailing that came both from the respective governments and academic institutions. The separation of scientific and sailing instructions highlighted a juxtaposition between work that was undertaken for the furtherance of science and that which addressed the wider implications of exploration in the southern ocean. I also consider the choice of personnel on board: the US. Ex. Ex., for example, was the only expedition to travel with civilian men of science. The variety of instrumentation carried by each country's ships, which would prove decisive in the type and quantity of information collected on the deep sea, is likewise examined.

Chapters four, five and six deal with how scientific knowledge was produced on board ship through the use of a variety of inscriptive practices. Chapter four interrogates the collection of physical specimens from the deep sea, and examines how through the study of this practice details on the expedition vessel as a heterotopic space for scientific enquiry are elucidated. I pay attention to the differing motivations behind collection and the emotional response to the routine taking of animal-life on board ship. This sheds light on the relationship between the ship's officers, crew and men of science. The blurred lines between duty, safety and personal interest – the requirements of naval discipline and the exigencies of scientific conduct that at any moment could be subordinated to the needs of navigation – could make the expedition ship a socially tense space. Also considered here is the significance of the ship as a working arena of oceanographic collection. The ship, I shall show, was neither laboratory nor field site but a hybrid, heterotopic space of scientific investigation.

Chapter five examines the acts of experimenting, measuring and the use of instrumentation from expedition ships. Precision and accuracy were bywords of credible scientific knowledge making in the mid nineteenth century and were achieved through the adherence to set procedural guidelines, specified in the sailing instructions and enforced by those at sea. Particular attention is paid to the use of instrumentation and their associated fallibility on expeditionary voyages. Many narratives of exploration, including those considered here, provide evidence of how instrumental unreliability had an impact upon procedures of experimentation and upon the results of the science itself. Yet work in the history of maritime exploration to date has not always acknowledged that instruments often resisted negotiation rather than accommodated it.

In chapter six I attend to the representation of physical specimens and numerical data on board ship. The mode of reproducing what was seen, either as aesthetic illustration or scientific diagram is explored, as is the importance of the practitioner in deciding what and how the new sights of the southern ocean were presented. Types of presentation are considered here: sketch, map, table, graph and the significance of one mode of representation over another. I pay particular attention here to the epistemological significance of re-visualizing objects and information from below the waves.

In structuring the thesis in this way, there is a risk that questions that speak to all three themes are obscured. I have tried to avoid this. Many instances of shipboard scientific practice could be presented in multiple sections: the collection of information through physical specimen and recorded numbers, the preservation of specimens, and the visualization of the deep sea through instrumental means, to name but a few. Nor is the tripartite structure meant to imply chronology. Whilst many shipboard practices cycled through the processes of collection, measurement and finished with representation, others did not. This format seeks only to present similar practices together to aid our understanding of how marine investigation took place. The final chapter of this thesis explores ideas that cut across themes and bring us back to scientific practice at sea as a more cohesive and continuous mode of knowledge production. Work that was outside the scope of this thesis is considered here also, which may allow other, fresh insights into this under-researched area of scientific investigation of the marine environment in the mid nineteenth century.

## Chapter 2 The Spaces of Scientific Knowledge: Laboratory and Field Site

This chapter considers some of the conceptual work in science studies, the history of science, history, and historical geography that is relevant to the main themes of this thesis: the everyday shipboard, embodied practices undertaken by all men at sea; recognition of the significance of the spatial dimensions to the production of scientific knowledge from the expedition vessel; shipboard hierarchy, the professionalization of men of science and the specialization of the marine sciences; and the importance of credibility of personnel, instrumentation and representation in establishing truth claims about the ocean.

The chapter is divided into three main sections. The first deals with the importance of space and place in constructing scientific knowledge, considering in particular the works of David Livingstone on the 'spatial turn' and Steven Shapin on the role of the experimental laboratory.[1] The identification of the field site, and its separation and contiguousness with the laboratory are highlighted; in particular the role of the expeditionary vessel that served as laboratory, field site, and instrument. This categorization is integral to analysing the role of the ship itself in producing new knowledge on the marine environment.

The second section reviews work on the 'laboratory studies' of the 1980s and 1990s that set out to follow the scientist around in his home environment, and so shed light on the processes that informed the production of scientific 'facts'. Work by Bruno Latour on the role of the 'inscription', the 'transformation' of objects and numbers into two-dimensional representations, and the process of 'circulating reference' are considered.[2] This work is

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[1] See for example: Withers, Charles W. J. 'Place and the 'Spatial Turn in Geography and in History', *Journal for the History of Ideas* 70 (2009): 637-58; Finnegan, Diarmid A. 'The Spatial Turn: Geographical Approaches in the History of Science.' *Journal of the History of Biology* 41 (2) (2008): 369-88.
[2] Latour, Bruno. *Pandora's Hope: An Essay on the Reality of Science Studies* (Harvard: Harvard

central in providing a theoretical framework for this thesis that focuses on operational procedure and the representation of data and specimens at sea.

The third section addresses the issue of credibility: why credibility was so important in this period and how those on board went about achieving it. Considered here are the place of scientific investigation, the instrumentation, social position, personal physical hardship and record of what had been seen. The final section of this chapter describes the materials used in the research of this thesis: the archival resources and primary materials that have supplied the empirical basis for this work.

**Making space for geographies of scientific knowledge**

All knowledge is constructed at specific sites, and a fundamental characteristic of scientific knowledge is its localness and its inseparable link to practice.[3] Shapin has argued that rather than just a factor influencing the production of scientific knowledge, 'space is a necessary condition for there to be such a thing as science'.[4] These 'truth spots' where science is undertaken and claims to scientific knowledge are made are integral to the credibility of the resulting production of knowledge.[5] Powerful colonial critiques and postcolonial counterarguments prompted by Said's *Orientalism* sparked the humanities current engagement with the 'spatial turn'. Michel Foucault sought to show how concerns with knowledge, power and space open up novel questions for geographical thought and practice.[6]

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University Press, 2009): 24-79.
[3] Turbull, David. 'Cartography and Science in Early Modern Europe: Mapping the Construction of Knowledge Spaces', *Imago Mundi* 48 (2002): 6.
[4] Shapin, Steven. *Never Pure: Historical Studies of Science as if it was Produced by People with Bodies, Situated in Time, Space, Culture and Society, and Struggling for Credibility and Authority* (Baltimore: John Hopkins University Press, 2002): 90.
[5] Gieryn, Thomas F. 'Three Truth Spots', *Journal of the History of the Behavioural Sciences* 32(2) (2002): 130.
[6] Philo, Christopher. 'Foucault's geography.' *Environment and Planning D: Society and Space* 10

David Livingstone advises us to take 'with much greater seriousness issues of space, place and geography'.[7]

Scholars such as David Harvey have argued that the leading social theorists in the west prioritised 'time and history over space and geography and, where they treat of the latter at all, tend to view them unproblematically'.[8] For Livingstone this was also true for scholars in the history of science. Livingstone has argued that work on the history of geographical knowledge could make some welcome interventions into debates regarding the production of scientific knowledge by attending to some of the integral geographical concepts – space, site, and location: 'historical understanding of the development of geographical discourse and practice might well be enriched by seeking to locate people, practices, theories and conceptual structures in their spatial contexts, whether material or metaphorical'.[9] Place could be specified and interrogated as a topic in its own right. Ideas, it was claimed, were always situated firmly on solid ground rather than treated as 'free-floating entities'. For Livingstone 'science is not only concerned with ideas and theories, but also with institutions, practices and performances that have material manifestations'.[10] As Golinksi argues, social conventions validated sites as appropriate places for the production of natural knowledge.[11] Spaces of scientific information often determined the degree of credence given to claims of expert knowledge.

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(1992):137-161.

[7] Livingstone, David N. 'Science and religion: foreword to the historical geography of an encounter.' *Journal of Historical Geography* 20(4) (1994): 367.

[8] Harvey, David. *Spaces of Capital: Towards a Critical* Geography (New York and London: Routledge, 2012): 325.

[9] Livingstone, *Putting Science in its Place* (Chicago and London: University of Chicago Press, 2003): 9; 3.

[10] Livingstone, *Putting Science in its Place*, 5-6

[11] Golinksi, Jan. *Making Natural Knowledge: Constructivism and the History of Science* (Chicago and London: University of Chicago Press, 2005 2nd ed.): 80.

The importance of location has also been recognised and addressed by Shapin, in particular the role of space in scientific experimental life. Shapin paid attention to the physical and social settings of experiment: who were the practitioners and observers in a given physical and social space? What were the conditions of access to these places and how were transactions across their thresholds managed?'[12] Questions of admittance were key: 'a matter not just of concrete but of culture'.[13] Shapin referred to the difficulty of public entry to modern scientific laboratories, restricted without (for the most part) laws, rules, or signs. Prohibited entry was common knowledge.[14] Space became, therefore, a matter of access and social position. A public presence would guarantee that experimental knowledge was reliable and authentic, and the privacy of certain scientific practices was widely cited as evidence of their defective character.[15] But whilst certifying the production of new knowledge, intrusions into the experimental workplace could be detrimental to the successful production of experimental knowledge.[16]

Attending to the practitioner, and the relationship with the space they inhabited was key in recognizing the importance of the spatial dimension.[17] Scientific knowledge became recognised by many scholars as being both socially and personally embodied.[18] The interaction between different individuals was contingent on the spaces they occupied: 'people

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[12] Shapin, Steven. 'The House of Experiment in Seventeenth-Century England', *Isis* 79 (1988): 373-374.
[13] Ophir, Adi, and Shapin, Steven. 'The Place of Knowledge: A Methodological Survey', *Science in Context* 4(1) (1991): 9.
[14] Ophir and Shapin, 'The Place of Knowledge', 10.
[15] Shapin, 'The House of Experiment', 374.
[16] Collins, Harry M. 'Public Experiments and Displays of Virtuosity: The Core-Set Revisited', *Social Studies of Science* 18 (1988): 725-48; Gooding, David. 'History in the Laboratory: Can We Tell What Really Went On?' In Frank James (ed), *The Development of the Laboratory: Essays on the Place of Experiment in Industrial* Civilization (London: Macmillan, 1989).
[17] Livingstone, *Putting Geography in its Place*, 3.
[18] See: Shapin, Steven and Lawrence, Christopher (eds), *Science Incarnate: Historical Embodiments of Natural Knowledge* (Chicago and London: Chicago University Press, 1998).

relate differently to themselves and to others in different spaces'.[19] Livingstone has shown how local regional factors were integral to the different readings of scientific ideas, such as Darwin's theory of evolution.[20]

Whilst much early work on the spatiality of scientific knowledge focused on the experimental life of the laboratory, research on the field site soon followed.[21] Direct experimental knowledge of a subject was gained by performing *in* the field. Dorinda Outman has argued the idea of the field is pivotal in its union of spatial metaphor and epistemological assumptions.[22] For Henrika Kuklick and Robert Kohler the rigours of the field inculcated the personal discipline necessary to make field-workers reliable witnesses and reporters, credible to non-participants.[23] The person who could lay claim to direct experimental knowledge of their subject was associated with a degree of authority: their credibility was enhanced as a consequence. Kohler was prepared to acknowledge that the laboratory and field were different cultural terrains but that 'they are contiguous, and there is a steady traffic across the border'.[24] The key was not to blend laboratory and field into one homogeneous space, each to be treated in the same manner, using the same set of conceptual tools, but rather to recognise that there were similarities between the two that could be analysed in a synchronous way: a

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[19] Livingstone, *Putting Geography in its Place*, 4.
[20] Livingstone, 'Science and Religion', 367.
[21] See for example: Cooper, A. 'From the Alps to Egypt (and back again): Dolomieu, scientific Voyaging and the Construction of the Field in Eighteenth-Century Natural History'. In C. Smith and J. Agar (eds), *Making Space for Science,* (Basingstoke: Macmillan, 1998): 39-63; Camerini, Jane. 'Remains of the Day: Early Victorians in the Field'. In B. Lightman. (ed), *Victorian Science in Context* (Chicago: Chicago University Press, 1997): 354-77; *Science in the Field,* H. Kuklick. and R. Kohler, (eds), *Osiris*, 2nd series, 11 (Chicago: University of Chicago, 1996); Outram, Dorinda. 'New Spaces in Natural History'. In N. Jardine, J. A. Secord, and E. C. Spary (eds), *Cultures of Natural History*, (Cambridge: Cambridge University Press, 1996): 259.
[22]Outram, Dorinda. 'New Spaces in Natural History'. In N. Jardine, J. A. Secord, and E. C. Spary, (eds), *Cultures of Natural History*, 259.
[23] Kuklick and Kohler, 'Introduction'. In *Science in the Field,* 6.
[24] Kohler, Robert E. 'Place and Practice in Field Biology', *History of Science* 40 (2002): 189.

focus on the investigator, the minutiae of experimentation, the record of the investigation, the tools of the trade.

Scientific knowledge produced in the field needed to become mobile to be accepted elsewhere. Information travelled from the context of discovery to the context of its production at home: as samples and specimens; as well as personal correspondence, and eventually, through the return of the ships themselves. Latour termed these institutions 'centres of calculation'; venues in which knowledge could accumulate, and in time circulated to other places.[25] In this 'cycle of accumulation', naturalists brought information back from new lands and this knowledge, accumulated at the imperial centre, was reused by future voyagers to extend the boundaries of empire.[26] The products of these accumulations, such as maps, provided the intellectual resources needed to be make imperialism effective. One important field site was the vessel of exploration.

**Reassessing the ship in scientific exploration**

Recent scholarship on the ship as a mobile space of knowledge and social performance has moved it from 'the margins to the centre of geographical research'.[27] In his reappraisal of the role of the ship, Richard Sorrenson argued that they were more than just vehicles or platforms for observers and instruments; they 'shaped the kinds of information observers collected', indeed they were 'primarily *instruments* of geographical discovery'.[28] Key to his understanding is the power of commission: who commissioned a ship´s voyage, and the

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[25] Bruno Latour, *Science in Action: How to Follow Scientists and Engineers Through Society* (Cambridge MA: Harvard University Press, 1987): 232.
[26] Latour, Bruno. *Science in Action*, 215-37.
[27] Hasty, William and Peters, Kimberly. 'The Ship in Geography and the Geographies of the Ship', *Geography Compass* 6 (2012): 660.
[28] Sorrenson, Richard. 'The Ship as a Scientific Instrument in the Eighteenth Century', *Osiris* 11 (1996): 227; (my emphasis).

instruments carried, was integral to establishing the vessel's authority. Ships were more than platforms for experimentation, but could become a scientific space in their own right. The ship was a key factor in the political and natural philosophical work it embodied and represented. [29]

Whilst Sorrenson puts particular emphasis on the maps and charts produced from the body of the ship, and the importance of the trace of the ship upon those manifests, the role of ship as instrument took multiple forms. A common method of measuring ocean currents used by the expedition vessels was to compare the ships calculated position at sea with its estimated position obtained through dead reckoning.[30] Thus the ship itself could be used as the instrument by which the direction and force of the current could be determined. Like any other instrument, keeping the ship in working order ('shipshape') was vital if the information collected with it was seen to be credible. Maintaining the operating efficiency of the ship as it moved across the globe was important: where it was, if it could anchor safely, and where it could find food and water for its crew.

Sorrenson suggests that Cook's ships were not intended to be 'floating laboratories' in Beaglehole's words, and whilst this may have been the case they nonetheless served as such.[31] The ship occupied the unique position of being field site, laboratory and instrument in its own right, as Antony Adler has recently discussed with particular reference to HMS *Challenger*.[32] The multi-purpose nature of shipboard space was common to the exploring

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[29] See: Adler, Antony. 'The Ship as laboratory: Making Space for Field Science at Sea', *Journal of the History of Biology* (2013): 332-362; Laloë, Anne-Flore. 'Where is *Bathybius haeckeli*? The Ship as Scientific Instrument and a Space of Science'. In Don Leggett and Richard Dunn (eds), *Reinventing the Ship: Science, Technology and the Maritime World, 1800-1918* (Farnham: Ashgate, 2012): 115-130.

[30] Sorrenson, 'The Ship as a Scientific Instrument': 227.

[31] Sorrenson, 'The Ship as a Scientific Instrument': 227.

[32] Adler, Anthony. 'The Ship as Laboratory'; Anne-Flore Laloë has also recently addressed the subject of the ship as laboratory, in discussion of its role in determining the true state of *Bathybius*

expeditions, with collecting, dissecting, sketching and preserving carried out by crew and naturalists on deck and below, in communal spaces and in private cabins. The laboratory-like aspects of the ship are thus easy to see. The field-site aspects of the exploring vessel, however, were also apparent. The ocean was experimental ground, in which the information relevant to the burgeoning field of marine science was collected, but the ship itself served as a field site. Robert Kohler has argued that 'field scientists regularly mix and match lab and field method'.[33] When the space served as both such things, this crossing of boundaries between two disciplines was ever more ubiquitous.

The early and mid-nineteenth century sailing ship was an ambiguous space in many ways – a heterotopia to use Foucault's phrase – which, while possessing many of the characteristics of the laboratory also tested many of the criteria necessary to ensure scientific knowledge production would be easily accepted.[34] The spaces on board ship – the captain's cabin, officer's quarters and crew's mess – were certainly more akin to the laboratory than the field. Together they constituted a distinct space in which scientific work was regularly carried out, with instruments to hand and distinct protocols to follow. The spaces above however – the ship's deck, small boats let down onto the ocean for surveying and sounding, and the constant passage of people through the ship – are familiar facets of a field station. Everything on the deck of the ship was ordered yet could become mobile depending on the task in hand, the weather conditions, and the opportunity for doing science. Even record keeping was an expedient task: special shipboard logs existed for taking immediate notes that would later be recorded again below deck. Greg Dening points to the social space being

*haeckelii*, the chemical precipitate taken to be a marine organism. Laloë, Anne-Flore. 'Where is *Bathybius haeckeli*?': 113-130.
[33]. Kohler, Robert E. 'Place and Practice in Field Biology', *History of Science* 40 (2): 189.
[34] Foucault, Michael. 'Des Espaces Autres', *Architecture, Mouvement, Continuité* 5 (1984): 46-49.

cramped by, and requisitioned for, the additional needs of a scientifically minded exploring expedition.[35] The precision instrumentation so vital to the practices of marine investigation was regularly given better space than the most senior of shipboard officers.

This thesis considers the variety of spaces on board the expedition vessel that were co-opted for the use of naturalists, naval officers and crewmen. By maintaining a focus on the ship itself, rather than the spaces of enquiry on land and at home, it is shown how the successful negotiation of space on the vessel was part of a shipboard dynamic integral to acquiring new knowledge on the marine environment. Knowledge constructed at sea was a product of not only the limitations imposed by the strictures of an unpredictable workspace but also a consequence of mobility itself, in the field and at home.

**'Laboratory Life' and beyond**

One of the key questions posed by scholars in the history of science over the past fifty years has involved the deconstruction of scientific knowledge: how does a fact become a fact? What conditions are required for the theories and observations held by the experimenter or investigator to become more than just conjecture, but to be seen as the 'truth'? Much of this early work took its lead from the ideas of Thomas Kuhn. Kuhn's *The Structure of Scientific Revolutions* (1962), partly informed by Wittgenstein's work on forms of life, rejected the seeming objectivity of scientists and the ahistorical nature of science.[36] In Kuhn's theory, there was a state of 'normal science'- that is the everyday working of scientists in agreement to the 'rules' of their profession which was the majority of work that scientists conducted.

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[35] Dening, Greg. *Mr Bligh's Bad Language: Passion, Power and Theatre on the Bounty* (Cambridge: Cambridge University Press, 1992): 80.
[36] Kuhn, Thomas. *The Structure of Scientific Revolutions* (Chicago and London, University of Chicago Press: 1962).

When an old set of theories were disregarded and a new set agreed upon, Kuhn stated that a 'revolution' had taken place. He expressed this in terms of a paradigm shift (a familiar example is Copernicus´s 1543 work on cosmology). Kuhn has largely been seen as the first to express the socialisation of scientific change.[37]

Kuhn did not provide a means for testing his theories: they were event-focused rather than process-based. In the 1970s, Edinburgh-based academics David Bloor and Barry Barnes interpreted Kuhn through what they called the "Strong Programme", that, briefly, stated that the production of scientific knowledge would be considered as four things: causal; impartial with respect to truth and falsity; symmetrical in explanation; and reflexive.[38] The attention to symmetry in the production of scientific facts – the 'symmetry postulate' – was key to the programme. How scientific phenomena were explained were to be considered in the same light, regardless of whether the resultant claim was successful or unsuccessful. The researcher was to maintain a neutral viewpoint in consideration of all claims to scientific knowledge.

The social world was central to the explanation of scientific conduct. This strongly social explanation of the production of knowledge was not met favourably by all researchers in the history of science. Alternative theories and explanations, drawing on the principles Kuhn had set forth, began to emerge in the early 1980s. These theories championed a more integrated social constructivist approach, paying attention not only to the role of human

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[37] For more see: Golinksi, Jan. *Making Natural Knowledge*; Shapin, Steven. 'Placing the View from Nowhere: Historical and Sociological Problems in the Location of Science', *Transactions of the Institute of British Geographers* 23(1) (1998): 5-12.

[38] See for example: Barnes Barry. *Scientific Knowledge and Sociological Theory* (London: Routledge and Kegan Paul, 1974); Barnes, Barry. *T. S. Kuhn and Social Science* (London: Macmillan, 1982); Barnes, Barry and Bloor, David. 'Relativism, Rationalism and the Sociology of Knowledge'. In Martin Hollis and Steven Lukes (eds), *Rationality and Relativism* (Oxford: Basil Blackwell, 1982); Bloor, David. *Knowledge and Social Imagery* (Chicago: University of London Press, 1976).

beings as social actors in the making of scientific knowledge but to the importance of technology and the agency of inanimate objects as well.

A seminal work in this respect was *Laboratory Life: The Construction of Scientific Facts* by French anthropologist and sociologist of science Bruno Latour and sociologist Steven Woolgar.[39] They pioneered the idea that to understand the making of scientific knowledge it was necessary to see how it was made first hand. Latour and Woolgar encouraged the following of scientists around in their 'home' environment, observing social discourse, how they used instruments, and how findings were recorded and communicated to the wider scientific community. They raised the question: when does a statement become a 'fact', free from the circumstances of its production? Using the idea behind the symmetry postulate, they concluded that the epistemological qualities of validity or wrongness could not be separated from sociological notions of decision-making; scientific knowledge was not ´discovered´ under the microscopic gaze of the laboratory but constructed there. In the authors' words, 'we have found it extremely difficult to formulate descriptions of scientific activity which do not yield to the misleading impression that science is about discovery rather than creating and construction'.[40] *Laboratory Life* set out to dispel this idea.

Karen Knorr Cetina, another founding researcher in the laboratory studies period, argued that there were three things laboratory science does *not* need to do that makes it important, indeed indispensable, in the production of scientific knowledge. It does not need to put up with an object as it is, or where it is or when it happens.[41] The idea that it was possible to translate an object or the results of an experiment, or even an idea, from one state to

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[39] Latour, Bruno and Woolgar, Steven. *Laboratory Life: The Construction of Scientific Facts* (Princeton: Princeton University Press, 1986 2nd ed.): 121.
[40] Latour and Woolgar, *Laboratory Life*, 121.
[41] Knorr Cetina, Karin. *Epistemic Cultures: How the Sciences make Knowledge* (Cambridge, MA: Harvard University Press, 2003 2nd ed.): 27.

another – particularly into a more mobile form – resonated with the social studies of science community.

Laboratory science, as championed by Latour, Lynch and Knorr-Cetina among others, was a breakthrough in the way in which scientific knowledge was produced, notable for its pursuit of minute details. This in turn led to the use of the technique to study an array of other topics in the same manner, including topics historical in nature. Geographical scholars such as David Livingstone and Charles Withers, however, warned of the 'the dangers of the 'localist' turn', that is the study of science in local context to the neglect of its wider significance.[42] This thesis considers the local and embodied practices of knowledge production on board ship, but keeps in focus how these processes connect with wider contextual concerns at the time that saw a gradual rise in the specialization of science and the professionalization of scientific practitioners.

It is perhaps surprising, given the prevalence and importance of instrumentation in the production of scientific knowledge, that a focus on instruments and the practices of scientific inquiry came relatively late to social constructivists. Withers writes that 'modernity had tended to accord primacy to science over technology because of its emphasis upon means', but proposes that technology need not be subordinated to science in the traditional way, if the epistemic authority instruments have to confer on the user and the science is considered.[43]

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[42]See: Secord, Jim. 'Knowledge in Transit', *Isis* 95 (2004): 654-672; Livingstone, David and Withers, Charles W. J. (eds), *Geographies of Nineteenth Century Science* (Chicago: University of Chicago Press, 2011): 12-13; Secord, James. *Victorian Sensation: The Extraordinary Publication, Reception and Secret Authorship of* Vestiges of the Natural History of Creation (Chicago and London: Chicago University Press, 2000).

[43] Withers, Charles W. J. 'Science, Scientific Instruments and Questions of Method in Nineteenth-Century British Geography', *Transactions of the Institute of British Geographers 38* (2013): 11.

An idea that sought to bring together science and technology into a coherent network, as well as the agency of the non-human, has become known as Actor-Network Theory (ANT) pioneered by Bruno Latour, John Law, and Michael Callon.[44]Actor-Network Theory is a material-semiotic method, that is, it deals with relationships between material, tangible things and ideas, all in the same social network. ANT has been considered controversial for ascribing agency to all objects – or actors – in a social network, regardless of whether the actors involved are human or non-human. Actors made to act in ANT are termed *actants*. Actors build networks by expressing interests that form connections between participants, ultimately forming a network of interested subjects. Law and Callon expressed the fluid, changeable nature of actors in the network, altering their function and role so as to facilitate the completion of a goal. Proponents of ANT dismissed the symmetry postulate, one of the main tenets of the Strong Programme, and introduced their own concept of "super symmetry", where society, science and technology were co-produced together and by the same processes.[45] Latour later argued that it was not society that should be used to explain nature but that 'one more turn after the social turn' was required, in which society working on nature and nature on society were given equal credence.[46]

Latour and others have repeatedly stressed that ANT is a *method*. As such it has been used by many historians of science to interrogate the causes and results of developments in scientific knowledge and technology. ANT has, however, variously fallen in and out of

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[44] See: Callon, Michael. 'Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St. Brieuc Bay'. In John Law (ed), *Power, Action and Belief: A New Sociology of Knowledge*? (London: Routledge and Kegan Paul, 1986): 196-233; Latour, *Science in Action;* Latour, Bruno. *The Pasteurization of France*, (Cambridge, MA: Harvard University Press, 1988).

[45] Law, John and Callon, Michael. 'On the Construction of Sociotechnical Networks: Content and Context Revisited', *Knowledge and Society* 9 (1989): 57-83.

[46] Latour, Bruno. 'One More Turn after the Social Turn: Easing Science Studies into the Non-Modern World'. In Erna McMullin (ed), *The Social Dimensions of Science* (Notre Dame: University of Notre Dame Press, 1992): 272-94.

favour, being both lauded and heavily criticised by its fans and detractors respectively.[47] Philosophers of science such as Ian Hacking have questioned how much agency we are really able to subscribe to inanimate objects, and Andrew Pickering has argued that intentionality cannot be subscribed to machines, only their users. [48] I agree. Nonetheless, with its framework for incorporating a variety of entities into a network of interactions, ANT has helped shed light on the production of scientific knowledge using networks of actants that other theories tend to marginalize, and, in that sense, has resonance for evaluating science at sea including the ship, instrumentation and on-board personnel.

The importance of technology is a theme expounded upon by many authors, warranting a separate field of study: the social construction of technological systems (SCOTS).[49] One of the authors to take on the topic was Andrew Pickering in the *Mangle of Practice*. His work paid attention to the difficulties involved in the production of new scientific knowledge, a negotiation between humans and machines he termed the 'dance of agency', that dealt with resistances and accommodations, agency and emergence.[50] In this dialectic, problems that emerged temporally during the course of laboratory experimentation were resistances to the ultimate goal of the investigator; when things went according to plan the experimenter was accommodated. Pickering was careful to point out that resistances only counted as such because, in experimentation, the human agent has a particular point of view. He also emphasised the temporal nature of knowledge production: scientist's goals are

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[47] See for example: Collins, Harry and Yearley, Steven. 'Epistemological Chicken'. In Andrew Pickering (ed), *Science as Culture and Practice* (Chicago and London: University of Chicago Press, 1992).
[48] Hacking, Ian. 'The Self-Vindication of the Laboratory Sciences'. In Andrew Pickering (ed), *Science as Culture and Practice,* (Chicago and London: University of Chicago Press, 1992); Pickering, *The Mangle of Practice* (Chicago: University of Chicago Press, 1995).
[49] See Bijker, Wiebe E., Hughes, Thomas P. and Pinch, Trevor. *The Social Construction of Technological Systems* (Cambridge MA: MIT Press, 2012).
[50] Pickering, Andrew. *The Mangle of Practice*, 50.

always emergent. As Ian Hacking has stated, no knowledge held before the beginning of an experiment is immutable.[51] The experiment, not just the laboratory, is the arena in which scientific knowledge is constructed.

Asserting and assuring credibility was vital to the development of expeditionary science in Europe in the 1830s and 1840s. The increasing prevalence of precision instrumentation was key in asserting and ensuring credibility for new conjectures and theories on the natural world. A map, for example, was not trusted on its own, but needed to be ´backed up´ by tables of measurements produced by instrumentation in the field. Numbers and measurement held epistemic authority, and connoted trustworthiness, supplying the surety of 'precise knowing'.[52] Humboldt, one of the strongest contemporary advocates of precision instrumentation, warned that not just *one* instrument should be used to ensure confidence in the results, but wherever possible multiple instruments should be carried to measure the same phenomena.[53] Similarly portable instrumentation was valued over stationary tools, limited in use by their own restricted environment. Unlike travellers, instruments were not expected to be modified by their surroundings; Bourguet *et al.* highlight the nineteenth-century enthusiasm for self-registering instruments as the 'ultimate means of achieving objectivity'. Reidy argues that the self-registering instrument, such as the self-registering tide gauge, became an essential part of fact gathering as early as the eighteenth

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[51] Hacking, 'The Self-Vindication of the Laboratory Sciences', 31.
[52] The use of the term 'scientific instrument' can be problematic – many of these objects were manufactured as mathematical, optical or philosophical instruments, as a result Warner has argued for the use of terms contemporaneous with the instruments themselves. See Warner, Deborah Jean. 'What is a Scientific Instrument, when did it become one, and why?', *The British Journal for the History of Science* 23 (1) (1990): 90.
[53] Dettelbach, Michael. 'Humboldtian Science'. In: N. Jardine, J. A. Secord, and E. C. Spary (eds), *Cultures of Natural History,* (Cambridge: Cambridge University Press, 1996): 287-304; and Dettelbach, Michael. 'The Face of Nature: Precise Measurement, Mapping, and Sensibility in the Work of Alexander von Humboldt', *Studies in History and Philosophy of Science Part C,* 30 (4) (1999): 473-504.

century.[54] The perceived objectivity of such instruments signified a continued move away from reliance on the social standing of the practitioner, and an emphasis upon the mechanical, crafted technology, in establishing epistemic authority.

Trust in instrumentation was not universal in the nineteenth century. The operator of instruments on board ship was not beyond the questioning glare of contemporary, scientifically knowledgeable society. Joseph Banks argued that mechanical tools could never replace experienced observers.[55] Humboldt himself had similar concerns concerning a loss of the aesthetic aspect of encountering the natural world and the vision of exploration as a sublime venture. Simon Schaffer argues that precision measurement involved a gentlemanly culture, but these gentlemanly values could pose serious obstacles to the values of precision, as uniformity of materials and methods could violate the very identity of being a gentleman.[56] Norton Wise points to different countries harbouring differing sensibilities: while in Britain gentlemanly status was still connected with the credibility of scientific experimentation, in Germany it was the exposing of their experiments to scrutiny, detecting errors and thorough analysing that connoted authority. As Wise puts it, it was ‘trust us v trust our procedures’.[57]

Instrumental measurement and the record of that data helped bridge the gap between places far removed. The same experiments could be performed in two separate geographical locations with the same instrumentation and similar results would be expected. Daniel Clayton argues ‘distance is both an enabling and a constraining variable in power/knowledge

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[54] Reidy, Michael. *Tides of History: Ocean Science and Her Majesty’s* Navy (Chicago: University of Chicago Press, 2008): 141-142; Bourguet, Marie Nöelle, Licoppe, Christian and Siburn, H. Otto. ‘Introduction’. In Marie Nöelle Bourguet, Christian Licoppe, and H. Otto Siburn (eds), *Instruments, Travel and Science: Itineries of Precision from the Seventeenth to the Twentieth Century* (London: Routledge, 2002): 7.
[55] Wise, M. Norton. ‘Precision: agent of unity and product of agreement’. In M. Norton Wise (ed), *The Values of Precision* (Princeton: Princeton University Press, 1995): 227.
[56] Schaffer, Simon. ‘Accurate Measurement is an English Science’. In *Values of Precision*, 135-172.
[57] Wise, ‘Precision: Agent of Unity’, 230.

relationships at both an imaginative and material level'.[58] In order to maintain commensurability between these distant places, however, 'instruments have first to be calibrated and made comparable under a common standard'.[59] The comparability of instruments was of the utmost importance if measurements obtained in one place were to transfer to someplace else. By the mid nineteenth century, it was commonplace for ships to devote considerable effort to ensuring their chronometers were well calibrated; stopping at ports, and moving between boats comparing instruments. Calibration forced commensurability. The importance of this precious navigational tool could not be forgotten or overlooked.

An increase in the complexity of technology, including practice and standards, meant that environments that had hitherto been untouched by human or instrumental intervention became accessible for the first time. As Burnett has shown in his review of surveying on the American exploring expedition, hardly any coasts had been surveyed thoroughly, following French cartographer Charles-Francois Beautemps-Beaupre's new approach to the discipline. Interrogation of the deep ocean, like the precise and accurate record and representation of new coastline, was only attempted when the vessels carried the most advanced equipment, using new techniques applied at the 'autre-mer margins of expanding global ambitions'.[60] In depth sounding, simple ropes were replaced by silk lines and commercial twines. Sympiesieometers were designed to test underwater currents rather than relying solely on throwing bottles overboard. Scoleoscopes were carried to extend the distance the human

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[58] Clayton, Daniel. *Islands of Truth: The Imperial Fashioning of Vancouver Island* (Vancouver: UBC Press, 2000), 240.
[59] Bourguet, Licoppe and Siburn, 'Introduction', 9.
[60] Burnett, D. Graham. 'Hydrographic Disciple among the Navigators: Charting an "Empire of Commerce and Science" in the Nineteenth-Century Pacific'. In James R. Akerman (ed), *The Imperial Map* (Chicago and London: The University of Chicago Press, 2009): 219.

observer could see below the surface of the ocean. Precision in manufacturing led to credibility from which came reliance and repetition. From these came reputation.

**Credibility, Experimental Procedure and Inscription**

The importance of trust, authority and credibility has long been part of the concerns of social constructivism. As Gillian Beer succinctly puts it, the question of the personal is the key issue: who sees? What is seen? What are the conditions of observation?[61] Dorinda Outram, in the context of the Enlightenment, stated that voyages and travels in particular raised troubling questions about authority.[62] Can the explorer be trusted? Thomas Gieryn has argued epistemic authority exists only that it is claimed by some and denied to others, and in terms of knowledge brought back from new and foreign lands, confirmation by a scientist was essential for an object of natural history to become classed as scientific knowledge.[63] Achieving credibility was integral to producing scientific facts that were taken up and propagated by the scientific community, and it was achieved in a number of ways.

For Steven Shapin, credibility was directly associated with trust. Discussing the status of the 'gentleman philosopher' in the seventeenth century, Shapin reasons that social standing had a direct impact on the likelihood that a statement of fact would become universally accepted: if the person making the claim was held to be credible, so were the resultant truth claims.[64] Epistemology was indubitably moral. Shapin identifies familiarity as key to accepting such claims: one man was much more likely to believe the statement of a man he

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[61] Beer, Gillian. 'Travelling the other way'. In Jardine, Secord and Spary (eds), *Cultures of Natural History*, 323.
[62] Outram, Dorinda. 'New Spaces in Natural History', 259.
[63] Gieryn, Thomas. *Cultural Boundaries of Science: Credibility on the Line* (Chicago and London: University of Chicago Press, 1999): 14.
[64] Shapin, Steven, *A Social History of Truth: Civility and Science in Seventeenth-Century England* (Chicago: University of Chicago Press, 1994): 27.

knew and trusted. The same principle applies for a well-known and reputable figure, known through association with other participants in a network of interested actors, even if they were not personal acquaintances. The importance of association is key and does not apply just to the individual: funding or approval for an expedition from the Admiralty, for example, came with undeniable credibility, in comparison to a singular traveller.

Although social status would affect judgments on trustworthiness, the traveller's veracity was also dependent upon following scientific protocols and practices. As Mary Louise Pratt argues, Cook's narratives in many ways marked the end of a period of writing that dealt predominantly with a sensationalist discourse of exploration. By the late eighteenth century authors were staking their authority in contrast to this.[65] Objectivity (or at least the appearance of it) and a focus on numbers, measurements, graphs and tables rather than tales of pure adventure were the mark of the credible scientific explorer. Discussing the role of method in geography in the nineteenth century, Withers highlights the importance of the role of instruments, and their ability to infer credibility upon the user. Drawing links between the credibility of 'instruments, inscription and the real world', Withers argues that a written account of a travel expedition was more likely to be credited with truth if both the people *and* the technology were seen to be credible.[66] By the nineteenth century links between 'gentlemanly' status and credibility were being replaced by a reliance on instruments and numbers.

Scholars have highlighted the physical demands of working in the field that also leant credibility to truth claims through physical hardship. Kuklick and Kohler argue that the 'rigours of the field inculcate the personal discipline necessary to make field-workers reliable

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[65] Pratt, Mary Louise. *Imperial Eyes: Travel Writing and Transculturation* (London & New York: Routledge, 2008 2nd ed.): 37.
[66] Withers, 'Science, Scientific Instruments and Questions of Method', 20.

witnesses and reporters'.[67] The act of having been at sea, on an expedition that in most cases lasted for years away from home, and experiencing the deprivations associated with a long voyage to unknown lands conferred on the collector a degree of scientific and authorial credibility.

Achieving credibility through social status, the use of instruments, and the written record was often sufficient to ensure claims to scientific knowledge were upheld. Explorers and travellers faced an additional hurdle, however. How was the voyager to offer proof of something that could not be directly shown or reproduced for those at home? For Bruno Latour, the key to knowledge was how to be familiar with things, people and events which were distant.[68] To communicate the results of maritime investigation, in particular, on return to land could be problematic. Where it was not possible for an experiment performed in one place to be readily repeated elsewhere, what could not be seen must be taken on trust. [69]

Steven Shapin and Simon Schaffer identify three ways in which experimental knowledge can travel: direct witnessing, replication, and virtual witnessing.[70] Eyewitnesses were ideal in establishing facts, and one way of ensuring this was to conduct scientific experimentation in a social space: a public space with restricted access, such as the coffee house or private living quarters. As Shapin and Schaffer wryly point out, 'arguably, this is an adequate characterization of the scientific laboratory of the late twentieth century'.[71] Accessing the experiment through instrumental means or via representation would obviate the necessity of seeing the experiment first hand. For an experiment to be repeatable,

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[67] Kuklick and Kohler, 'Introduction', 6.
[68] Latour, *Science in Action*, 220.
[69] See Shapin, 'Placing the View from Nowhere', 1998
[70] Shapin, Steven and Schaffer, Simon. *Leviathan and the Air Pump: Hobbes, Boyle, and the Experimental Life.* (Princeton: Princeton University Press¸1985).
[71] Shapin and Schaffer, *Leviathan and the Air Pump*, 336.

however, the recording and adherence to strict procedures was required. Instrumental measurement was a form of warrant about standardization and exactness.[72]

Replication was desirable but potentially problematic as it was often extremely difficult to get experimental technology working elsewhere without direct contact with the original experimenters. Harry Collins refers to this need to socialise directly with the original experimenter in order for the skill of experimentation to be conveyed as ‘tacit knowledge’.[73] Collins argues the replication of results also frequently requires the transfer of the entire subculture surrounding the original production.[74] Critically this was achieved by images (in the form of engravings) and diagrams, what Shapin and Schaffer call ‘mimetic devices’.[75]

Bruno Latour termed this translation of an object into a two-dimensional mark on paper as an ‘inscription’.[76] Once the inscription had been committed to paper in its new form it achieved permanency even as it continued to move around, regardless of context; he termed this the ‘immutable mobile’. Latour regarded the processes of production and manipulations of inscriptions as the central scientific activity taking place in the laboratory. Belief in the author’s word was replaced by trust in the inscription of figures.

The concept of the all-powerful inscription was an idea that resonated with scholars in the history of science and beyond. In *Pandora’s Hope*, Latour combined several ideas about inscriptions and the idea of the ‘immutable mobile’ into what he terms ‘circulating

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[72] Keighren, Innes M., Withers, Charles W. J. and Bell, Bill. *Travels into Print: Exploration, Writing and Publishing with John Murray 1773-1859* (Chicago and London: University of Chicago Press, 2015): 13.
[73] Collins, Harry. ‘The TEA Set: Tacit Knowledge and Scientific Networks’, *Science Studies.* 4 (1974): 165-86.
[74] Collins, Harry. *Changing Order: Replication and Induction in Scientific Practice* (Beverly Hills and London: Sage Publications, 1985).
[75] Shapin and Schaffer, *Leviathan and the Air Pump*, 62.
[76] Latour, Bruno. *Pandora’s Hope: An Essay on the Reality of Science Studies* (Harvard: Harvard University Press, 2009): 24-27.

reference'.[77] Through a chain of transformations from field site to paper there is a loss of 'locality, particularity, materiality, multiplicity, and continuity' and a gain in 'compatibility, standardization, text, calculation, circulation, and relative universality'.[78] The transformation from a three-dimensional object into a two-dimensional representation increases the availability of the product for further use: it is now easily transported and compared with other inscriptions. For Latour, the process of transforming an object into a transcription increases the durability of the object in question, and, ultimately, its stability. In one example, Latour described a researcher standing in the Amazon rainforest looking not at the site around him, but at a graph produced back at the laboratory. Latour argued that the diagram does not have to – should not – resemble anything that led to its production. It is not realistic: indeed, it is more than a copy; it 'takes the place of the original situation'.[79] Along this chain of transformation a series of references are made that are obscured in the final representation. For a successful claim to knowledge to exist, however, it must be possible to trace ones path back through the references and arrive at the field site or laboratory experiment.

Ian Hacking suggested that inscriptions themselves could in fact be treated as actants in the actor-network that Latour was proposing. In his work on Portuguese maritime expansion in the fifteenth and sixteenth centuries, John Law put ANT theory into practice by examining the translation of images seen through an adilade or latitudes taken with a quadrant into marks on a chart. For Law, these instruments were powerless without human involvement. The image seen through an alidade pointed at the sky, he claimed, has little significance in relation to navigation. Rather, it was the *transformation* of these sightings into

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[77] Latour, *Pandora's Hope*, 24-79.
[78] Latour, *Pandora's Hope*, 70.
[79] Latour, *Pandora's Hope*, 67.

– eventually – latitude that was important.[80] The transformed object was more powerful than the original.

**Shipboard practice: The pursuit of credibility through accurate measurement, experiment, and representation**

Precision instrumentation and precise and accurate measurement were vital tools of epistemic authority for the nineteenth century scientific-explorer. The polymath Alexander Von Humboldt (1769-1859) typified this programme of instrumental exactitude, represented by ventures such as the magnetic crusade that gave James Clark Ross's Antarctic exploring expedition its raison d'etre. The emphasis of this intellectual programme was on the need for ever more precise observation in the field using the latest advances in portable instrumentation and a concern with the spatial relations between geology, biology and, meteorology and their role in determining the geography of plants and animals.[81] The model of Humboldtian fieldwork inspired others; Joseph Dalton Hooker ranked Humboldt as one of the 'Gods'.[82] Susan Faye Cannon, who originally termed the phrase 'Humboldtian Science', and its associated programme of numerical and instrumental endeavour, has emphasized the importance of the accumulation of instruments and sources of error in measurement. These were, she argues, new conceptual tools for the study of scientific endeavour.[83] Authors such as Janet Brown have recognised the importance of the Humboldtian model in understanding how and why a shift to the importance of measurement, numbers and graphical representation

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[80] Law, John. 'On the Social Explanation of Technical Change: The Case of the Portuguese Maritime Expansion', *Technology and Culture* 28 (1987): 227-252.
[81] For a detailed discussion of this see: Driver, Felix. *Geography Militant: Cultures of Exploration and Empire* (Oxford, Blackwell Publishing, 2001).
[82] Quoted in Arnold, David. *The Tropics and the Travelling Gaze: India, Landscape, and Science 1800-1856,* (Seattle: University of Washington Press, 2006): 190-91.
[83] Cannon, Susan Faye. *Science in Culture: The Early Victorian Period* (New York: Dawson, 1978).

occurred in the early part of the nineteenth century.[84] As authors such as Michael Dettelbach have argued, however, the Humboldt that Cannon described was a translated figure, and in attributing the instigation of such practices to him, complex concerns were prematurely 'black-boxed'.[85] Other authors, such as Mary Louise Pratt, have questioned the erasure of the human in the scientific travel writing exemplified by Humboldt.[86] More recently authors such as Michael Reidy and Helen Rozwadowski have pointed to the importance of the Humboldtian model for work on the sea, although until recently it has largely been used in the examination of terrestrial based scientific enterprise. Humboldt, however, began his own career in studying the oceans. [87]

By the 1830s and 1840s, instrumentation had achieved a new importance in the production of credible scientific knowledge at sea: precise record of measurement obtained using precision instrumentation lent epistemic authority to truth claims. The type of instrument, who made it, and where it had been used previously were newly pertinent considerations in writing up scientific data. Without the appropriately sanctioned device no measurement could be held trustworthy.[88] (The role of instrumentation and the associated themes of calibration, replication, standardization, accuracy and precision are discussed further in chapter five).

As Richard Dunn argues, notions of tolerance and accuracy were always contingent: for instruments to agree 'tolerably' with one another, and for their operators to agree

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[84] Brown, Janet. 'Biogeography and Empire' in *Cultures of Natural History*, 305-321.
[85] Dettelbach, Michael. 'Humboldtian Science' in *Cultures of Natural History*, 287.
[86] Pratt, *Imperial Eyes*, 118.
[87] Reidy, Michael and Rozwadowski, Helen. 'The Spaces in Between: Science, Ocean, Empire', *Isis* 105 (2014): 341.
[88] See for example: Poovey, Mary. *A History of the Modern Fact: Problems of Knowledge in the Sciences of Wealth and Society* (Chicago: University of Chicago Press. 1998); Porter, Theodore M. *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life* (Princeton: Princeton University Press, 1996).

likewise, was, often, all that could be hoped for.[89] An instrument's reliability was of paramount importance in the successful, and to be hoped, continuous taking of measurements. It was also one of the most difficult things to achieve at sea. Instruments rarely work as intended. Operators varied in their use of them. The ship-board environment could be challenging, not only in terms of weather and cramped storage, but also in the time spent away from land and from expert instrument makers and repairers. As Simon Schaffer has commented, it was 'the importance of normal repair work, its tacit and improvised quality, the difficulty of reliance on and autonomy from the instrument maker, the mutability of maintained devices' that determined the successful working of a complex instrument'.[90]

After observing, measuring and experimenting, the next step in the series of transformations undertaken on board ship was the act of presenting what had been seen for examination by viewers elsewhere. Representation secured trust. Images provided confirmation of the authentic presence of the observer in the field, affirming credibility as a faithful witness.[91] Illustrations reinforced the printed word and visual images became more than representations but acquired scientific value in their own right. The tangible proxies of observation were transported from the field to 'centres of calculation' and in so doing aided the process of virtual witnessing. Epistemic authority was founded on the extent of the observations collected in the field and their distribution across space – and then bolstered by the representation of the observations.[92]

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[89] Dunn, Richard. 'North by Northwest? Experimental Instruments and Instruments of Experiment'. In Fraser Macdonald and Charles W. J. Withers (eds), *Geography, Technology and Instruments of Exploration* (Farnham: Ashgate, 2015): 61.
[90] Schaffer, Simon. 'Easily Cracked: Scientific Instruments in States of Disrepair', *Isis* 102 (4) (2011): 714-15.
[91] Keighren, Withers and Bell, *Travels into Print*, ch.1.
[92] Naylor, Simon. 'Log Books and the Law of Storms: Maritime Meteorology and the British Admiralty in the Nineteenth Century', *Isis* 106 (2016): 782-3.

Visualising, re-presenting, or re-imaging what was seen during the course of an expedition was essential to the successful construction of scientific knowledge aboard ship, and later to its publication and dissemination on return. In a pioneering work from the 1950s, Bernard Smith considered the work of men of science and those artists aboard voyages to the South Pacific in the eighteenth and early nineteenth centuries, and showed how artists' drawings both extended and supplemented scientific records.[93] More recently, Geoff Quilley has illustrated how art and the visualization of the maritime world contributed to Britain's expansion and retention of empire.[94]

Pratt was one of the first critical authors to argue that in representing and naming new land, it was also claimed through the process. Daniel Clayton, in his telling of George Vancouver's expedition along the North West Pacific coastline, echoes the work of Latour and the social constructivists on inscriptions and mobile images, arguing that geographic features were rendered mobile through processes of cartographic inscription and the practices of naming, classification, tabulation and illustration.[95] In considering the representation made on board the expedition vessels, different forms of inscription present themselves for interrogation, as part of how scientific knowledge on the marine environment was made on board ship and elsewhere.

Images of the landscape were not always objective visualisations, but personal reactions to the scenery, a combination of the picturesque, the scenic and the topographical.[96] Meanwhile, artists and artistically trained men of science produced images of dissection and

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[93] Smith, Bernard. *European Vision and the South Pacific*, (New Haven and London: Yale University Press, 1985 2nd ed).
[94] Quilley, Geoff. *Empire to Nation: Art, History and the Visualization of Maritime Britain 1768-1829* (New Haven & London: Yale University Press, 2011).
[95] Clayton, *Islands of Truth*, 183.
[96] Klonk, Charlotte. *Science and the Perception of Nature: British Landscape Art in the Late Eighteenth and Early Nineteenth Centuries* (New Haven, CT: Yale University Press, 1996): 151.

specimens that followed a tradition, common in botany, of displaying what had been seen outwith the context of its finding.[97] As John Berger argues, to look at an object or a person is to construct the relationship that exists between things, people and ourselves. For Berger, 'seeing comes before words' and 'what you saw depended on your position in time and space'.[98] These matters of visualisation and representation related to the construction of knowledge on the sea in the 1830s and 1840s are discussed in Chapter Six.

**Professionalization of the ship savant**

The credibility of the individual in establishing truth claims was vital on the expedition sailing ship. By the late eighteenth century, it was not only the social standing of the individual but also the adherence to certain practices and protocols around authority and trust that garnered credibility for the explorer and experimenter alike. Discovery in the age of James Cook, John Ross and Edward Parry had become more of a specialised set of scientific practices that required specialist training. But being at sea threw up considerations above and beyond merely following guidelines. While discovery through sail may have begun to feel familiar territory, investigation of the marine environment has slipped firmly under the radar. As Rozwadowski has argued, the very act of going to sea defined practitioners of early ocean science more than the sharing of specialized knowledge.[99]

Randolph Cock argues that the beginning of the professionalism of men of science on board expedition vessels came with civilian naturalists and astronomers aboard Arctic expeditions during the 1820s, where the importance of scientific investigation began to be

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[97] Hartley, Beryl. 'The Living Academics of Nature: Scientific Experiment in Learning and Communicating the New Skills of Early Nineteenth-Century Landscape Painting', *Studies in the History and Philosophy of Science* 27(2) (1996): 150.
[98] Berger, John. *Ways of Seeing* (London: Penguin Classics, 2008): 7; 18.
[99] Rozwadowski, *Fathoming the Ocean*, 177.

recognised and allowances for scientific experimentation and investigation granted.[100]As Jim Endersby argues, 'British men of science still saw themselves as disinterested gentlemen not scientific tradesmen, much less as servants of centralized government, as were their French colleagues'.[101] This was a feeling echoed at the time: Charles Babbage (1791-1871), the British polymath, claimed that 'Britain was falling behind France because French savants, unlike their British counterparts, received direct government funding'. [102]

The categories of amateur and professional were still being negotiated, as Endersby refers to in his discussion of the botanist and British expedition naturalist, Joseph Hooker. Neither category had precedence and nor did one automatically defer to the other. There was, however, an association between being paid for working and low social standing. Having a naval commission was one of the best ways to circumvent some of this stigma, as such a position came with a salary. Hooker was paid £114 a year for his place aboard the *Erebus*, as assistant surgeon (The entire expedition cost nearly £110, 000). Endersby argues that for Hooker, and others like him, the term 'professional' had negative connotations. Terms used at the time would have been 'professed' (suggesting a vocational quality) or 'philosophical' (although this term is not directly interchangeable). Importantly, the professionalization of the sciences at this time was not a goal many men-of-science were working towards.[103]

For Margaret Deacon the value and quantity of scientific work accomplished during expeditions was still largely determined by the degree to which the work was valued by the captain and the officers. This is to highlight the importance of rank and hierarchy on board

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[100] Cock, Randolph.'Scientific Servicemen in the Royal Navy and the Professionalism of Science, 1816-55'. In David M. Knight and Matthew D. Eddy (eds), *Science and Beliefs: From Natural Philosophy to Natural Science, 1700-1900* (Aldershot: Ashgate, 2005): 95-111.
[101] Endersby, Jim. *Imperial Nature: Joseph Hooker and the Practices of Victorian Science* (Chicago and London: Chicago University Press, 2008): 2.
[102] Endersby, *Imperial Nature*, 38-39.
[103] Endersby, *Imperial Nature*, 25.

ship.[104] Nor was pulling rank between captain and men of science (usually officers themselves) the only point of tension. Christopher Lloyd has shown that the hierarchy on board ship took into account not only the commissioned officers but also other crew members.[105] For Greg Dening, space was inseparable from the social authority of its occupants.[106] The relationship of the captain to his crew could be skewed by personal interest, and there were usually rigid and hierarchical arrangements on board. The naval ship represented a contradiction between those whose power rested with their ability as seamen and those who were granted power due to a king's commission.[107] The negotiation of these categories is a central theme of this thesis.

**Investigating marine science in the mid-nineteenth century through the travel narratives, journals, log books, letters and images of the South Seas expeditions 1837-1843.**

The work of Latour, Law, Knorr-Cetina, Shapin and Schaffer and others offers a framework for interrogating the South Seas' expedition texts and the representations of the deep sea which these voyages produced in the form of samples, specimens, charts, maps, drawings and graphs. As Felix Driver argues, it is important to consider forms of texts beside just published narratives in order to situate those narratives historically.[108] Marie-Nöelle Bourguet argues, 'many studies on travel literature are based on published accounts' continuing 'the distinction between a printed narrative and notes taken in haste tends to get blurred, or is hardly

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[104] Deacon, Margaret. *Scientists and the Sea*, 192.
[105] Lloyd, Christopher. *The British Seaman: 1200-1860. A Social Survey* (London: Paladin, 1970): 212.
[106] Dening, Greg. *Mr Bligh's Bad Language: Passion, Power and Theatre on the Bounty* (Cambridge: Cambridge University Press, 1992): 19.
[107] Dening, *Mr. Bligh's Bad Language*, 80.
[108] Driver, Felix. *Geography Militant: Cultures of Exploration and Empire* (Oxford, Blackwell Publishing, 2001): 8.

addressed as such', although she also concedes that 'in practice, the time elapsed between the instant of the observation and the moment of its transcription on paper eludes reconstruction'.[109]

This work focuses on interrogation of the published travel narratives by the captains and officers of the expeditions; the ship board journals of captains, officers and crew where they exist; private correspondence from and to the ship during the course of the expedition; official correspondence between captain and officers and public figures in the countries' respective government and navies; and related miscellaneous documents relating to the voyaging of the three expeditions (see bibliography for a full list). Particular attention is paid to the work of the naturalists on board the expeditions: Joseph Dalton Hooker and Robert McCormick on the British expedition and Titan Ramsey Peale on the American voyage. Hooker in particular left a trove of private correspondence and journal entries that are enlightening in this context. Whilst an attempt was made to access as much of the material relating to the scientific investigations of the expeditions, and the sailing of the voyages more generally, as possible, this was not always achievable and it must be acknowledged that some interesting sources were not accessible: materials that existed only in institutions in the United States and Australia, among other countries, were not examined for this thesis.[110] Some sources proved difficult to locate, with little evidence to suggest they were still in existence, for example, the instructions to the French expedition issued by the Sociéte de Geographié. In other cases the material was similarly inaccessible: as Duyker notes, 'all of

[109] Bourguet, Marie-Nöelle. 'A Portable World: The Notebooks of European Travellers (Eighteenth to Nineteenth Centuries)', *Intellectual History Review* 20 (3) (2010): 379; 384.
[110] There are three journals from American officers and civilians on board the US Ex. Ex. that fall into this category: that of Charles Pickering at the Massachusetts Historical Society. Philadelphia Academy of Natural Sciences, that of Joseph Couthouy at the Boston Museum of Science and the journal of crewman Henry Eld, held at the Beinecke rare book and manuscript library.

d'Urville's surviving original manuscripts present great challenges because of their exceedingly difficult legibility.'[111]

*Recording at sea*

Recording what had been seen and performed on the expedition vessel took place in a variety of ways. Written records came in the form of the log book entry, journal and correspondence with those at home. Information from the field was also presented visually as sketches, diagrams, maps, graphs and tables. On the voyages' return, this information was 'translated' into different types of representation; the expedition's narrative, its book manuscript and 'official' published account, including illustrations and maps. Whatever had taken place during exploration it was these tangible records and images that were the public face of the expeditions and would be the lasting memorial to its achievements and failures.

In evaluating the variety of ways information on the sea was recorded, it is important to distinguish *what* exactly we are looking at. The term journal or narrative is not always a good indication of what the item was. Many of the journals handed in by the officers and scientific contingent at the end of the expeditions were really no more than a collection of observations, with little description and no personal information; a log book rather than a diary. Clayton cautions that scholars should not make distinctions between the logs of daily events and more generalizing 'manners-and-customs', descriptions of lands and peoples that followed them, arguing that they are not two distinct modes of knowing enshrined in these different forms of description, but a 'set of provisional, situated knowledges'.[112] Similarly, Martins and Driver argue that, 'rather than simply assuming a sharp distinction between, say,

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[111] Duyker, Edward. *Dumont d'Urville: Explorer & Polymath* (Otago: Otago University Press, 2014): 21.
[112] Clayton, *Islands of Truth*, 36.

formal logbooks kept by sea-captains and shipboard diaries kept by civilians, we should rather think of a continuum of literacy and graphic forms in which the model of the logbook had an influence far beyond its normal function'.[113]

The log book was one of the key devices for recording observations at sea. According to Basil Hall (writing originally in the 1830s), three copies of the log-book were made, one of which was sent to the Admiralty, another to the Navy Board, and the third to the Admiral of the station. The original logbook was eventually deposited at the Admiralty for the purpose of future reference.'[114] The log book page layout followed a set structure and was familiar to those on board.

Paul Carter argues that the journal aimed to capture the *process* of traveling and was thus revised and polished; authors could amend their field notes, and so could construct new meanings and chronology.[115] The journal at sea was written linearly as a 'biography' of the voyage but, 'one need only plot the routes of the explorers and navigators to realize that their courses were anything but uniformly progressive. Return journey were woven into the outward journey for interest and favoured stops on the outward leg replaced by better ones on the way back'.[116] Rather than being a record of everything that happened on board, the choice of events recounted was important. Frederic Regard goes further to suggest that, 'all reports – log entries, journals, retrospective narratives, fictional re-elaborations – were *narratives*.

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[113] Martins, Luciana and Driver, Felix. 'John Septimus Roe and the art of Navigation, *c.*1815-30'. In, Tim Barringer, Geoff Quilley, and Douglas Fordham (eds) *Art and the British Empire* (Manchester: Manchester University Press, 2007): 56-57.
[114] Hall, Basil. *The log Book of a Midshipman,* (London: Blackie and Son, 1894): 177.
[115] Carter, Paul. *The Road to Botany Bay: An Essay in Spatial History* (London: Faber and Faber, 1987): 75; Keighren, Withers and Bell, *Travels into Print,* 2.
[116] Carter, *The Road to Botany Bay*, 75.

Exploration account, as well as ethnographic descriptions or anthropological studies were, and still are, *literary artefacts*. [117]

The authority of an explorer was established practically, on the expeditions' return, through the writing of a travel narrative, either first or second hand. Many crew members kept a personal account of what occurred when they were at sea. Flinders, perfecting the art of writing whilst imprisoned in Mauritius, set the precedent for the explorer to write his own narrative.[118] Charles Erskine of the American flagship, *Vincennes*, recorded his experiences as a narrative whose daily entries offered readers vicarious participation in the voyage.[119] As Helen Rozwadowski points out, 'writing at sea satisfied personal as well as professional needs. First-time sailors kept journals to record the novelty of their experience for themselves and their families and friends. Old salts wrote to occupy their time'.[120] Some used previous explorers accounts to help make sense of their experiences at sea; the libraries on each ship were extensive (see Chapter 3, pp. 49-99).

For the scientifically minded, a continuous record of investigation and experimentation on board was vital; Linnaeus cautioned his pupils that there was to be 'no day without writing'.[121] Those on board the expeditions studied here appeared cognisant that a full account of daily life on board ship was required. Wilkes demanded his officers display scientific curiosity toward every new thing they encountered and issued an order at sea soon after the expedition's sailing regarding the keeping of a daily journal which he considered

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[117] Regard, Frederic. 'Introduction: Articulating Empire's Unstable Zones'. In Fredric Regard (ed),. *British Narratives of Exploration: Case studies of the Self and Other*, (London and New York: Routledge, 2009): 10.
[118] Cook's narrative underwent heavy editing by publisher John Hawkesworth. See: Nugent, Maria. *Captain Cook was Here* (Cambridge: Cambridge University Press, 2009): 31; 44-45.
[119] Rozwadowski, Helen. *Fathoming the Ocean: The Discovery and Exploration of the Deep Sea* (Cambridge MA: Harvard University Press, 2005): 23.
[120] Rozwadowski, *Fathoming the Ocean*, 19.
[121] Bourguet, *A Portable World*, 380.

‘paramount to all others’. As he further notes ‘the duties devolving upon all the officers of the Expedition are altogether of a public nature’ that could only be carried out ‘by keeping full and complete memoranda of all observations, made at the time, and entered in the journals’. The order continued, ‘The kind of journal required is not a mere copy of the log-board, but it is a diary, in which will be noted all that relates to public information, being a record of all objects of interest, however small, which may take place during the cruise, in the scientific or any other department: and the views of the officer ought to be briefly expressed concerning things that may come under his notice’.[122]

The log-book, journal and diary are the familiar partners to recording and representation on the expedition vessel. Adriana Craciun has recently advised us to ‘look beyond legibility and beyond the codex printed book in order to better understand the cultures of maritime exploration’: John Ross in the Arctic inscribing the name of his boat onto a piece of ice, for example, or his acceptance and reliance on Inuit cartographic knowledge, help illuminate cultures of maritime exploration.[123] Ian Hacking has urged us to consider the full range of images that the term ‘representation’ encompasses, stating that ‘representations are external and public, be they the simplest sketch on a wall, or, when I sketch the word ‘representation’, the most sophisticated theory about electromagnetic, strong, weak, or gravitational forces’.[124]

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[122] Wilkes, Charles. *Narrative of the United States Exploring Expedition during the Years 1838, 1839, 1840, 1841, 1842 ... 5 vols. and Atlas* (Philadelphia: Lea and Blanchard, 1845), I: 38. The original Wilkes papers, held at the Smithsonian Institute (SIA RU007 186) have been substantially examined and incorporated into the primary published material. Due to this being the case, I have used the primary published material here.
[123] Craciun, Adriana. ‘Ocean Voyages, Maritime Books and Eccentric Inscriptions’, *Atlantic Studies* 10 (2) (2013): 173.
[124] Hacking, *Representing and Intervening*, 133.

Pratt argues that the travel narrative was an essential intermediate between the scientific elite and the general reading public, arguing that the form legitimatised scientific authority.[125] The travel narrative written by the expeditions' captain was important in producing and disseminating scientific knowledge gained through the hardships of lengthy sea voyages to the less mobile reader at home. It was undoubtedly a format that was designed to appeal to a wide audience, however, and often the majority of the scientific information was withheld from the narrative. The return of the expeditions, and the dissemination of knowledge from that point, is not the focus of this thesis, but the narratives and post-expedition materials are used to illuminate this research: whilst the expedition narrative was predominately constructed after the ships returned home, it is also one of the best sources we have for knowing what occurred on board ship during voyages. It is important to acknowledge, nonetheless, that it is a document produced with hindsight and with political and commercial imperatives.[126] The post-positivist view of records embraces the record as a socially constructed and maintained entity. That each form of inscription – published narrative or ship board log book – is important in analysing the construction of knowledge on the deep sea in the mid-nineteenth century is fundamental to this study.

The example of the laboratory science studies that focuses on the everyday practices of the scientist during experimentation and investigation suggests a tentative framework for the analysis of scientific investigation on board the nineteenth-century sailing ship. Tentative, in that there are some stark and unavoidable differences. We cannot follow the men of science around in situ: we cannot see science-in-action in real time but we can chart science in reconstruction. The idea of following the scientist at work allows us to reject historical

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[125] Pratt, *Imperial Eyes*, 29.
[126] See Keighren, Withers and Bell, *Travels into Print*.

notions that lead us to consider scientific work in the light of conclusions we already know. The application of the symmetry postulate that dictates all forms of knowledge should be understood in the same manner, regardless of whether the resultant claims to truth were accepted or not, has particular resonance at a time when any knowledge on the underwater world was new and open to discussion. Focus on *practice*, rather than results, is one way this can be achieved. Understanding that scientific knowledge should be interpreted in relation to the contexts of its discovery and of its verification ensures that new knowledge and the spaces in which it is made should be studied with reference to the world beyond the spaces themselves: the institutions that funded expeditions, imperial and political imperatives, and commercial and economic concerns.

The inscription is integral to any study that uses the ideas of the laboratory studies' authors, the theories of ANT and of social constructivism more generally. As Shapin comments, 'what we cannot see we must take on trust'.[127] Not only were those at home expected to believe what had been seen in new, foreign lands, by the ship crew and officers but they were also being asked to believe in something the ship personnel had often not seen themselves. Extreme depths were often not measured but inferred by the absence of reaching bottom with the lead line; creatures brought from the depths were seen only as specimens in a habitat removed from their own in the ocean depths; marine invertebrates brought up from foreign depths were drawn through the use of microscopes. Their representation was as important to the original discoverer as it was the reading public at home.

The following four chapters consider how knowledge on the underwater environment gained credence from being conducted during the South Seas exploring expeditions between

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[127] Shapin, *Never Pure*, 60.

1837 and 1843, using a framework suggested by science studies scholars: the identification and importance of personal and instrumental credibility; the use of precision instrumentation and the collection of numerical data; the translation of objects and data from the marine world into marks and traces on paper; the use (and abuse) of space and the emergence of the ship as field site and laboratory space; and the everyday, embodied practices of scientific investigation that shaped and produced maritime knowledge.

# Chapter 3 Motivating, financing and organising three expeditions to the Southern Oceans in the 1830s

## Introduction

This chapter offers a background to the three expeditions studied, assessing their motivations in voyaging to the South Seas, the links between earlier South Seas expeditions and those of the 1830s and 1840s and the role of formal governmental instructions and institutional scientific recommendations in the programme of scientific investigation undertaken at sea. In its focus on the impetus to the voyages, this underpins the following three empirical chapters.

The first section outlines the history of maritime exploration into the southern oceans at the end of the eighteenth century and the beginning of the 1800s, paying particular attention to the scientific work that was carried out on these voyages. Each country had a different history of experience and achievement in the Pacific that, I contend, heavily influenced the preparations for the exploring expeditions here considered.

The second section reviews the origins of the expeditions here studied, situating them in relation to the larger story of political and commercial interests in the Pacific in the first half of the nineteenth century. The section looks more closely at the institutions and the main *dramatis personae* involved in the expeditions. This section also looks at the ships themselves. The types and quantity of instrumentation taken by each country is considered in order to assess their roles in scientific practice at sea and the collection of instruments by the captains of each country.

In part three attention is paid to the sailing instructions issued to each expedition after the respective governments involved had given the expeditions the go-ahead, and how these instructions complemented and stood at variance with the recommendations given to each expedition by their countries' scientific institutions. This juxtaposition between scientific and political imperatives was, I suggest, a constant source of tension throughout the voyages, one that directly affected the conduct of marine experimentation and investigation.

### Maritime exploration and science at sea prior to 1837

European interest in the South Seas became more pronounced from the 1760s and was predominantly focused on astronomical and cartographic investigation. Captain James Cook's first voyage to the South Pacific in 1768 had been sponsored by the Royal Society to observe the Transit of Venus from Tahiti. The expedition was unusual in that it carried a large complement of civilian scientists, including the botanist Joseph Banks who had covered the cost of his scientific party himself, so keen was he to partake in the voyage. The success of the expedition ensured a second voyage, four years later, in 1772, again captained by Cook, and a third in 1776, ostensibly to search for a North-West Passage connecting the Pacific and Atlantic Oceans.[1]

The French were rivals to Britain over maritime exploration and discovery. Since the expedition of Louis de Bougainville in 1766-1769, two French expeditions had sailed to the South Pacific. In 1771 Maride de Fresne, discovered the Marion and Crozet Islands, touching Tasmania and anchoring in New Zealand (where Fresne was killed by Maoris). The voyage

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[1] For more on the voyages of Cook, including controversy in the telling of his story, see for example: MacKay, D. 'A Presiding Genius of Exploration: Banks, Cook and Empire, 1767-1805'. In R. Fisher and H. Johnston (eds), *Captain James Cook and his Times* (Vancouver: University of Washington Press, 1979): 21-39; McLynn, Frank. *Captain Cook: Master of the Seas* (Yale: Yale University Press, 2011); Obyesekere, Gananath. *The Apotheosis of Captain Cook: European Mythmaking in the Pacific* (Princeton: Princeton University Press, 1992); Sahlins, Marshall. *How "Natives" Think About Captain Cook, for Example* (Chicago and London: University of Chicago Press, 1995); Salmond, Anne. *The Trial of the Cannibal Dog: Captain Cook in the South Seas* (London: Penguin, 2004); Williams, Glyn. *The Death of Captain Cook: A Hero Made and Unmade* (London: Profile Books, 2008).

of Jean-Francois de Galaup, Comte de La Pérouse, in 1785, took place five years after Cook's third journey to the Pacific, and with the strong support of King Louis XVI (see Appendix I for more detail). Lapérouse's orders directed him to concentrate on the unknown areas of the north and west Pacific that had been overlooked during the voyages of Cook. Scientific exploration was a part of national rivalry and the expedition was notable for the range and depth of scientific research and the detailed surveys that were conducted. The Lapérouse expedition carried fifteen civilian scientists: artists, astronomers, civil engineers, surveyors, botanists, an ornithologist and a clockmaker. Lapérouse received his scientific orders from the Académie des Sciences. These ran to 200 pages and made provision for astronomy, physics, chemistry, mineralogy, astronomy, botany and zoology. After three years at sea, the expedition left Botany Bay on 10 March 1788, and was never seen again. The loss was keenly felt by France, and many expeditions into the region over the following decades were charged with searching for information on the disappearance.[2]

The Pacific was of commercial interest in the late eighteenth century for commercial and geopolitical reasons.[3] Before Cook landed on the Australian continent, the British suffered from a lack of bases to repair their ships in the South Seas, especially their whaling boats and trade vessels. British attention had been diverted from the South Seas in 1775 by the American War of Independence, which stopped the transport of approximately 1,000 British convicts a year, mostly to Virginia and Maryland to work on the plantations. Botany Bay was seen as a good replacement for these colonies and acted as a staging post and base against French threats in the Indian Ocean, and Dutch interests in the East Indies.

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[2] Piouffre, Gérald. *Lapérouse, le voyage sans retour: À la recherché de l'expedition perdue* (Paris: La Librairie Vuibert, 2016).

[3] Gascoigne, John. 'From Science to Religion: Justifying French Pacific Voyaging and Expansion in the Period of the Restoration and the July Monarchy', *The Journal of Pacific History* 50 (2) (2015): 116.

The turn of the century saw Britain and France in competition over the Pacific, specifically in connection with charting, with each claiming the southern coastline of the new Australian continent, then known as New Holland. French captain Nicolas Baudin sailed in 1800 in an expedition organised largely due to British advancement in the region. The expedition was more elaborate than that of his British contemporary Matthew Flinders. These expeditions, notable for their Australian charting work, were the last to sail before the commencement of the Napoleonic wars in 1803. Scientifically-orientated expeditions by Britain and France were not to resume again until the cessation of war in 1815.[4] As authors such as Margaret Deacon and John Gascoigne have argued, this marked a peak of expansion in the marine sciences in Europe that continued until *c*.1830.[5] Between 1817 and 1840, France sponsored eleven voyages of exploration into the Pacific, Britain five, Russia ten and the United States three.[6]

It was not just government-sponsored expeditions that showed interest in the deep sea, although the resources and personnel available to these large-scale expeditions meant the opportunities for investigations of the ocean environment were more apparent, and there was less obvious competition. Individuals such as William Scoresby, the Arctic sealer who charted vast lengths of Greenland coastland and supplied many natural history specimens to the scientific elite in England, among other achievements, and James Weddell who measured surface temperatures almost daily in 1824 until both his thermometers broke.[7] There were

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[4] Russia sent multiple expeditions into the southern ocean at this time by Krustenstern, Kotsebue and Bellingshausen. See Appendix I for details.
[5] Deacon, Margaret. *Scientists and the Sea 1650-1900: A Study of Marine Science*, (London and New York: London and New York Academic Press, 1971): 192; Gascoigne, John. 'From Science to Religion', 116.
[6] Gascoigne, From Science to Religion, 116.
[7] Bravo, Michael. 'Geographies of Exploration and Improvement: William Scoresby and Arctic Whaling, 1782-1822', *Journal of Historical Geography,* 32 (2006): 512–38*;* Weddell, James. *A Voyage towards the South Pole, Performed in the Years 1822-24* (London: Longman, Rees, Orme, Brown, and Green, 1827): 55.

difficulties, however, in organising any programme of sustained and systematic marine research in the absence of government support.

Whilst specialist work on the physics of the sea existed in the first few decades of the nineteenth century, work on marine biology was absent. As Deacon argues, no one worked in the new oceanography in the way Charles Lyell did for geology.[8] For Deacon, this gap in scientific development was due to the problem of communication between specialists and seamen that was exacerbated by the wide range of researchers involved, who did not yet share a common objective.[9] Theories claimed the ocean below 60 fathoms was a standard 4.4°C but offered no means of testing it.[10] This theory had already been disproven by Alexander von Humboldt and American surveyor Matthew Fontaine Maury among others, but was still being investigated on voyages into the 1830s. John Ross had found marine life at great depths on his 1818 voyage into the Arctic but this knowledge had been either discounted or forgotten by the 1830s: many persons believed that animal life could not survive below 300 fathoms.[11] It was known that pressure affected temperature readings at depth, but in the Royal Society Report issued to the British Antarctic expedition in 1839 there was no mention of the need to protect thermometers in order to gain accurate results.[12] Communication (or its lack) among academic communities was an important part of the recognition of science in the eighteenth century.[13] This continued to hold true as the nineteenth century progressed.

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[8] Deacon, *Scientists and the Sea*, 276
[9] Dean, *Scientists and the Sea*, 276
[10] Deacon, *Scientists and the Sea*, 278
[11] For more see: Millar, Sarah Louise. 'Science at sea: Soundings and Instrumental Knowledge in British Polar Expedition Narratives, *c*.1818–1848', *Journal of Historical Geography* 42 (2013): 77-87.
[12] *Report of the President and Council of the Royal Society on the Instructions to be prepared for the Scientific Expedition to the Antarctic Regions* (London, 1839).
[13] McClellan, J. E. 'Science is part of "Public Knowledge", the Product and Responsibility of a

As Helen Rozwadowski has highlighted, the nineteenth century saw a general increase in effort by scientists to comprehend and control large spaces of various types: meteorology focused on the earth's atmosphere; terrestrial magnetism concentrated on the magnetic properties of the earth; exploration of the Arctic sought to comprehend the vast ice fields of the northern polar regions and mountaineering gave glimpses into the state of life at the world's highest points.[14] Investigations and interrogation of ocean space was concurrent with these new large-scale projects. As well as interest in the ocean itself, the economies of maritime countries rested on being able to navigate the oceans regardless of the weather. Britain defined itself predominantly as an island with a need to master the sea, and the US maintained a strong maritime orientation even during decades of vigorous westward land expansion.

By the mid-nineteenth century, the importance of expertise relating to the ocean was beginning to be more fully understood. When the Napoleonic Wars ended in 1815, prospects of new trade stimulated northern exploration. In searching for a North West Passage into the Pacific Ocean, it was realised that knowledge of the oceans could provide assistance. Strong currents of saline water would flow through open channels whereas landlocked bays would contain colder, fresher water, derived from melting ice. Increased knowledge relating to terrestrial magnetism was of use to the field sciences as well as of value to mariners trying to navigate by compass. New knowledge on tides promoted trade and overseas expansion by providing mariners and navies with accurate information about shores and maritime nations

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Community of Workers, Not the Lone Investigator or Prophet'. In J. E. McClellan (ed), *Science reorganized: Scientific Society in the Eighteenth Century* (New York: Columbia University Press, 1985): xviii.

[14] Rozwadowski, Helen. *Fathoming the Ocean: The Discovery and Exploration of the Deep Sea*, (Cambridge, MA and London: Harvard University Press, 2005): 214.

and their colonial possessions.[15] Advances in hydrography led to safer navigation. Studying the sea threw light on declining fisheries, especially whaling. Whilst there was no active or well-defined programme of oceanographic science in the 1830s and 1840s there was a growing recognition that work on the underwater environment could itself be of value and service, especially to those navigating in poorly-charted seas.

Participation in scientific exploration demonstrated military prowess and commercial power and was spurred on by nationalistic imperatives. France, Britain, and America each had long histories of maritime exploration, although naturally America less extensively than her counterparts. The circumstances that led to the approval of those exploring expeditions in the Pacific are interrogated in the following section.

## France, America and Britain begin their campaigns: support, funding and institutional guidance *c*.1837

### *France*

France had a long history of maritime voyaging prior to the mid eighteenth century. Defeat in the Atlantic in the Seven Years' War in 1763, however, left the country in need of exploring new arenas to exert influence. After the Peace of Paris in 1763, the French turned to the Pacific for new lands and markets.[16] The Pacific exploring expedition of Louis de Bougainville (1766-1769) was not state sponsored; that of Joseph de Kerguelan-Tremarec

[15] Reidy, Michael. *Tides of History: Ocean Science and Her Majesty's Navy*, (Chicago and London: Chicago University Press, 2008).
[16] Gascoigne, John. 'Navigating the Pacific from Bougainville to Dumont d'Urville: French Approaches to Determining Longitude, 1766-1840'. In Richard Dunn and Rebekah Higgitt (eds), *Navigational Enterprises in Europe and its Empires, 1730-1850* (London: Palgrave Macmillan, 2015): 180.

(1771-1772) was the first in this respect. By the 1800s, however, France was the pre-eminent scientific nation in Enlightenment Europe, with the Parisian Musée National d'Histoire Naturelle and the Académie des Sciences eclipsing their British and German rivals. For Gascoigne, the justification for Pacific expansionism before the Napoleonic Wars came from 'a continuation of the nexus between scientific exploration and a French presence in the pacific, which had been well established in the voyages from Louis de Bougainville to Nicholas Baudin.' [17]

Neither France nor Britain sponsored expeditions until the end of the Napoleonic Wars in 1815. A defeated France was at a low ebb, but science was an area where that country enjoyed a history of 'international pre-eminence'.[18] Scientific achievement provided a foundation for rebuilding national glory after 1815. As France was so rebuilt, however, interest began to turn away from scientific achievement to the renewal of French prestige through imperialism. Additionally, the cessation of war left many French naval men out of work. A major impetus for the voyages of exploration was the career aspirations of scientifically inclined half-pay French naval officers: 'Science could provide one way of resuscitating the glory of France, and the Pacific provided a theatre in which it had already displayed its scientific and maritime eminence'.[19] New exploration was also expected to provide a base from which to challenge the increasing British presence in the Pacific.

The main thrust of Pacific voyaging for France began in 1817, when the *Uranie* sailed under Louise de Freycinet. The expedition was notable amongst other scientific achievements, for recording series of measurements rather than merely single point observations. Surface temperatures were recorded every two hours and fifty-five samples of

[17] Gascoigne, 'From Science to Religion', 112.
[18] Gascoigne, 'From Science to Religion', 117.
[19] Gascoigne, 'From Science to Religion', 117.

sea water sent home for analysis. Hyacinthe de Bougainville similarly invested in recording surface temperatures every six hours on the *Thetis* and every four hours on the *Esperance* (1824-26).[20] On the *Astrolabe* in 1826, the first Pacific expedition with d'Urville as captain, the Académie des Sciences asked specifically for measurement of deep sea temperatures.

The impetus to explore with science as the driving force would not last. As Gascoigne argues, 'the scientific character of French Pacific voyaging, however, began to abate. Faivre sees this as becoming more marked after about 1836. Dunmore dates the shift from the period after Dumont d'Urville's first *Astrolabe* voyage of 1826-29. Similarly, Blais sees the transition occurring from around the middle of the 1820s'.[21] By the 1830s, Britain had a territorial advantage in the Pacific Ocean although Samson has seen this as a 'piecemeal response to circumstances rather than a formal policy of colonial expansion'.[22] The French, on the other hand, had been slow to claim land in the Pacific and were keen to make amends.

Conflicts between scientific and naval personnel, together with political tensions were a feature of French voyages of the pre-1815 revolutionary period.[23] Initially naturalist-voyagers on exploring expeditions were civilians and professional naturalists, but difficulties on the Baudin expedition between officers and civilian experts helped cement the idea that naval officers could cover the work of the civilians, despite the Académie declaring it to be a 'sad example' of scientific prowess.[24] The medical corps in particular were expected to take on the duties as shipboard naturalists. Conseils de santé in the ports encouraged young surgeons in the training of natural history and a constant supply of natural history specimens

[20] Deacon, *Scientists and the Sea*, 231
[21] Gascoigne, 'From Science to Religion', 116.
[22] Samson, Jane. *Imperial Benevolence: Making British Authority in the Pacific Islands* (Honolulu: University of Hawaii Press, 1998): 10.
[23] Gascoigne, 'Navigating the Pacific', 189.
[24] Gascoigne, 'Navigating the Pacific', 191.

were sent back to the Ecoles de Medicine Navale, particularly in Brest.[25] The removal of all civilians on board voyages of exploration was also a means of the state exerting control over the output of the voyages.

Naturalists on board the *Uranie, Coquille* (1822-25) and *Astrolabe*, were chosen from among the officers of the Service de Sante-Jacques Leonard: of 35,000 students at the Ecoles de medicine navale between 1814 and 1835, 2,300 later served in the navy. The shipboard naturalists were top of their cohorts, but there was still a distinction between naval and "true" naturalists. In 1825 the zoologist Etienne-Geoffrey Saint Hillarie grumbled that the 'decision to rely wholly on naval naturalists [was] paramount to sending no naturalist at all'.[26] Ollivier argues that there were two flaws in using trained medical men in the navy: inadequate training, which was not necessarily compensated for by personal aptitude; and the need to have a surgeon on duty at all times'.[27] This was the protocol on French expeditionary vessels. Britain also demanded that every ship should be manned by a qualified physician at all times. This complication, however, led to a conflict of interest over the surgeon-naturalist role.

By 1837, French exploring expeditions were manned entirely by naval personnel, with a less elaborate scientific remit than had been previously demanded, and a mixed history of successful exploration in the Pacific Ocean. The main impetus for the French Pacific expedition of 1837 came from Jules Dumont d'Urville. D'Urville was a seasoned Pacific explorer, having captained the four-year long expedition of 1826-29 and, earlier, having spent three years in the Pacific as second-in command to Louis Duperry. By the late 1830s Dumont d'Urville was eager to lead another exploring expedition into the Pacific. His reasons, as he

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[25] Ollivier, Isabel. 'Pierre-Adolphe Lesson, Surgeon-Naturalist: A Misfit in a Successful System'. In Ray MacLeod and Phillip F. Rehbock (eds), *Nature in its Greatest Extent: Western Science in the Pacific* (Honolulu: University of Hawaii Press, 1988): 46.
[26] Ollivier, 'Pierre-Adolphe Lesson, Surgeon-Naturalist', 49.
[27] Ollivier, 'Pierre-Adolphe Lesson, Surgeon-Naturalist', 57.

recorded them, were personal. D'Urville felt 'haunted by the example of Cook', who had made three Pacific voyages of discovery, and he felt a similar feat would leave a more promising legacy to his son.[28] He was also keen to create comparative series of measurements, and felt a prolonged stay away from the Pacific would create an unhelpful gap. He wrote to the Minister of the Navy, Vice-Admiral Claude Charles Marie du Campe de Rosamel, expressing his wish to lead a last large-scale exploring expedition to the pacific. Rosamel was favourable, but thought it expensive. He referred the request to M. Tupinier, director of ship movements. D'Urville knew Tupinier would look favourably on his request. D'Urville wrote, 'I received a communication in which I was told that the King himself, to whom my plan has been submitted, had welcomed it, but having learned that an American whaling ship had got very near the South Pole, he desired that a French expedition be sent in the same direction'.[29] Although d'Urville had his doubts about the information the King had received (believing it came from either the journal of James Weddell or Benjamin Morrell, both of whom he classed as simple seal hunters), he understood the accomplishment to France and himself if he were to reach the South Pole ahead of America and Britain.[30] As such, d'Urville accepted the new terms of the expedition, choosing Hector Jacquinot, his previous second in command, to accompany him on the second ship needed for the journey. The expedition also included the hydrographer, Clément Vincendon, and, at d'Urville's personal request, the cranioscopist, Pierre Dumoutier, a prominent figure in the emerging area of phrenology. Alexander von Humboldt and the Russian navigator Adam Johanne

[28] Rosenman, Helen. *An Account in 2 Volumes of Two Voyages to the South Seas* (Melbourne: Melbourne University Press, 1987): 323.
[29] Rosenman, Helen. *Two Voyages to the South Seas*, (Melbourne: Melbourne University Press, 1992): 115.
[30] James Weddell (1787-1834) was a British seal hunter who had reached the furthest yet southern latitude in 1823 into a region of the Southern Ocean later known as the Weddell Sea. Benjamin Morrell (1795-1839) was an American sealer and trader who spent many years in the Southern Ocean.

Krusenstern sent congratulations to d'Urville on the impending mission, recognizing the potential importance such a voyage could bestow on the European scientific community, particularly if overseas observing stations were set up in scientifically strategic positions such as Tasmania and Madeira.

The fitting-out of the French boats proceeded apace once instructions for sailing (reviewed below) had been given, in order that the ships would reach the southern hemisphere at the most favourable time of year. Even so, the expedition still faced opposition in France, and d'Urville was disappointed in the lack of interest shown by the Académie des Sciences, and in particular, the hostility of François Arago, director of the Paris Observatory to the project, whom he believed personally disliked him. Arago – physicist, astronomer and mathematician – had a reputation for scrutinising government expenditure and a 'repugnance for voyages of simple curiosity'.[31] Arago was disturbed by the hasty approval of the d'Urville expedition and its projected departure before its scientific instruments had been properly tested. Admiral Rosamel, formerly a Pacific explorer himself, defended the expedition and its raison d'etre: it would better survey the straits of Magellan, thus preventing further loss of life and property such as had befallen Lapérouse, and it would further France's commercial profile by searching for favourable whaling stations. Arago was eventually appeased and the ships allowed to depart.

The French expedition was made up of two corvettes, a type of ship closely related to the sloop-of-war used by the Americans: *Astrolabe* and *Zélée*. *Astrolabe* had been a horse barge and had been converted for exploratory use for the Pacific expedition led by Duperry in 1822. It was renamed *Astrolabe* in honour of the ship of the same name captained by

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[31] Duyker, Edward. *Dumont d'Urville: Explorer & Polymath* (Otago: Otago University Press, 2014): 325.

Lapérouse, and had been used before on the Pacific expedition of 1826-29. As such, it was well-tested in Pacific conditions, but had not been exposed to the pack ice of the Antarctic seas before the 1837 expedition. The *Zélée* was a three masted corvette of 380 tonnes, built in 1811. It carried seventy-nine crew members. On the *Astrolabe,* seven officer's cabins were accessed off the great cabin at the stern. Those for the surgeon and pharmacist opened onto the area designated to prepare natural history specimens and for conducting experiments, thus confirming their dual role as medic and naturalist. The library and armoury were aft of the captain's cabin and illuminated by stern windows, so highlighting the importance of the rooms: their contents were to be visible occupying a prominent position on the expedition vessel.[32] The *Zélée* left Toulon on 14 August 1837, and the *Astrolabe* followed one week later.

*The United States of America*

The end of the 'War of 1812' in America brought a rejuvenation of trade with the Far East that kick-started a regular presence for America in the Pacific. In 1829, US *Vincennes* was ordered to visit various Pacific and Far East ports and became the first ship to circumnavigate the globe for America. The depletion of the seal populations of the Falkland and Juan Fernandez islands prompted search for new, lucrative possibilities in the southern ocean. Seal beaches were found between 1819 and 1820 in the New South Shetland Group, and in 1820 the American sealer Nat Palmer coasted along the Antarctic Peninsula.[33] In the 1820s another American sealer, Benjamin Morrell, explored areas of the New South Shetlands, publishing

[32] Duyker, *Dumont d'Urville,* 340.
[33] Ponko Jr, Vincent. *Ships, Seas, and Scientists* (Annapolis: United States Naval Institute, 1974): 5.

'*A Narrative of Four Voyages'* in 1832. Morrell claimed he had seen an ice-free southern polar sea.[34]

Whilst America sought to establish itself on the international stage as a country capable of mounting an exploring expedition, it was nevertheless entirely dependent at this time – regarding the instrumentation, maps, charts, and journals to be carried – on the stock of knowledge available only in Europe.[35] Many in America viewed meteorology as a subject where the country could finally advance beyond her European counterparts. Increasing operations in distant areas required accurate charts and navigational instruments and ability to use them. As a result, the Navy established a Depot of Charts and Instruments in 1832 which was followed by a naval observatory in 1842.[36]

The origins of the United States Exploring Expedition into the southern oceans began years before its eventual sailing. In 1818, the American army officer, John Cleves Symmes Junior, started to publicise his theory that the earth was hollow, and that its 'inner core' could be reached by sailing through from the poles. This became known as the 'Holes in the Poles Theory'.[37] Gradually Symme's theory gained support, and in particular an enthusiastic young supporter, Jeremiah Reynolds, the newspaper editor – whom Edgar Allen Poe was to call the 'prime mover' of the lobby – became interested.[38] The pair took their theory around the mid-western states, gaining support, before disagreements over whether an expedition to the North or South Pole should be encouraged split the partnership. At this stage Reynolds dropped the

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[34] Morrell, Benjamin. '*A Narrative of Four Voyages'* (New York: J and J Harper, 1832).
[35] Mawer, Granville Allen, *South by Northwest: The Magnetic Crusade and the Contest for Antarctica*, (Edinburgh: Birlinn, 2006): 34.
[36] See: Dick, Steven J. 'Centralizing Navigational Technology in America: The U. S. Navy's Depot of Charts and Instruments, 1830-1842', *Technology and Culture* 33 (3) (1992): 467-509.
[37] For more see: Gurney, Alan. *The Race to the White Continent: Voyages to the Antarctic* (London: W. W. Norton & CO., 2000); Mawer, Granville Allen. *South by Northwest: The Magnetic Crusade and the Contest for Antarctica* (Edinburgh: Birlinn, 2006).
[38] Mawer, *South by Northwest*, 36-37.

more fanciful parts of Symme's theory. The lecture-circuit advocacy of American maritime enterprise brought him to the attention of the secretary of the US Navy, Samuel Southard.[39] Southard commissioned Reynolds on an overland mission to Connecticut and Massachusetts to speak with sea captains about the Southern Ocean (Pacific and Antarctic). Reynolds spoke before Congress, solicited memorials from scientific organizations and commercial bodies and generated much newspaper publicity. The idea of an expedition was encouraged by President John Quincey Adams, and also supported by New England merchants whom Reynolds had lobbied. The then secretary of the US Navy at the time, Mahlon Dickerson, was strongly against an expedition, but also adamant that if it did go ahead, the officers, and not civilians, were to perform the science. He wanted the expedition to be kept small in size, advising imitation of the French expedition that set sail in 1837.

There was more behind the interest in despatching ships south than fanciful ideas about sailing to the centre of the earth. To the Americans, a thorough exploration of the unchartered areas of the Pacific Ocean made good commercial sense. For America, imperial expansion and whaling went hand in hand. The American whaling fleet at this time was vast: in 1835 there were 400 whaling ships operating out of the eastern American seaboard. This 'represented an advanced maritime guard for US imperial goals in the Pacific'.[40] The American congressional committee commented in 1836 that 'in the seas which it was proposed to explore, the whale fishery alone gave employment to more than one-tenth of all

[39] Burnett, D. Graham. 'Hydrographic Discipline among the Navigators: Charting an "Empire of Commerce and Science" in the Nineteenth-Century Pacific'. In James R. Akerman (ed), *The Imperial Map* (Chicago and London: University of Chicago Press, 2009): 194.
[40] Igler, David. *The Great Ocean: Pacific Worlds from Captain Cook to the Gold Rush*. (New York: Oxford University Press, 2013): 103.

our tonnage, moved by twelve thousand men, and requiring capital then estimated at twelve millions of dollars'.[41]

By the second half of the eighteenth century, the Greenland whale industry could not meet the demand for whale oil. The hunt for whales shifted by geography and species. In the early 1800s it changed according to the market value, the technological innovations in capture and processing and the remaining populations. Sperm whales, which ranged farthest from land in the least well-charted waters, were now the favoured catch. This encouraged both American and British whalers to try the southern latitudes in search of new whale colonies to target: indeed the First Fleet to Botany Bay had many whalers in its number. The pelts of sea otters on the North West American coast as well as those of fur seals fetched huge sums.[42] The prospect of sandalwood and beche de mer in addition made the Pacific a risky but profitable destination for the Americans. The resultant oil and blubber obtained from the whales provided America's burgeoning industrial factories with the fuel they needed for illumination and the lubricants for new machinery.

In May 1828, the House of Representatives passed a resolution calling on the Navy Department to send a small vessel to the Pacific Ocean and South Seas. A sloop of war, the *Peacock*, was secured for the purpose. Naval officers with scientific interest were interviewed for the position of captain of the expedition, but there were very few of them: Charles Wilkes was one. Wilkes wanted to be in command of the escort ship and thus second in command of the expedition but was sent away as assistant astronomer to buy instruments instead. Jeremiah

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[41] Haskell, Daniel. *The United States Exploring Expedition, 1838-1842 and its publications 1844-1874: A Biography* (New York: New York Public Library, 1942): 1. See also: see Burnett, D. Graham. *The Sounding of the Whale: Science and Cetaceans in the Twentieth Century* (Chicago and London: University of Chicago Press, 2012)
[42] Gibson, James R. *Otter Skins, Boston Ships, and China Goods: The Maritime Fur Trade of the Northwest Coast, 1785-1841* (Montreal and Kingston: McGill-Queen's University Press, 2000).

Reynolds was appointed historiographer and Master Commandant Thomas ap Catesby Jones eventually appointed captain. Wilkes was slow in collecting the instruments, and wanted only navy men to be trained in how to use them. Then, the whole expedition was cancelled by the chairman of the committee on Naval Affairs Robert Y. Haynes.[43]

On 3 April 1836, Reynolds addressed the House of Representatives, calling again for an expedition to the Pacific and South Seas, arguing that America had been living too long in the wake of the British and French.[44] America was still using having to use other nation's maps in voyages departing from the Eastern seaboard, a situation Burnett has dubbed 'hydrographic nationalism'.[45] The 'holes at the poles' theory may have been the original catalyst for gaining support for a large-scale exploring expedition into the polar regions, but other factors eventually proved decisive. Exploration and discovery, and claiming new land and seaways were high priorities for the Americans who did not have centuries of maritime exploration and expansion as did the French and British. These empirical designs also served to 'forward the interests of science'; the production of new scientific knowledge was made an important consideration.[46] Charting the seas, especially the Northwest Pacific coastline of the United States, was also prioritised. The American expedition was to devote a substantial part of its time ensuring they laid claim to this area by charting the region for the first time.

Reynolds's expedition proposal gained approval on May 4 1836. The civilian men of science were to be paid $2500 a year with rations; the artists were allotted $2000. The funding was set at $300,000 (the final bill would be over three times this much).[47] In a state

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[43] Mawer, *South by Northwest*, 32-43; Gurney, *The Race to the White Continent*, ch.6.
[44] Gurney, *The Race to the White Continent*, 103.
[45] Burnett, 'Hydrographic Discipline', 196.
[46] Poesch, Jessie. *Titian Ramsey Peale 1799-1855 and his Journals of the Wilkes Expedition* (Philadelphia: The American Philosophical Society, 1961): 63.
[47] Bryan, G. S. 'The Purpose, Equipment and Personnel of the Wilkes Expedition', *Proceedings of the American Philosophical* Society 82 (5) (1940): 552.

of confusion, Jones resigned his commission in November 1837. A suitable naval man of science to lead the expedition could not, however, be found. There was considerable controversy over the eventual appointment of Wilkes as expedition head. In the end he was the only man willing to take on the task of commanding what had become an increasingly shambolic operation. Wilkes included in his official narrative a letter from Naval Secretary Mahlon Dickerson who justified the appointment of Wilkes taking charge of the entire expedition despite his relatively low ranking, due to the need for the expedition 'to be entirely divested of all military character'; this was undoubtedly only part of the reason for his appointment.[48] Reynold's backers in Congress were marginalized during protracted preparations for the expedition and so, despite being the man who had done perhaps the most to garner enthusiasm for such an expedition, he did not join the voyage.

Wilkes was adamant that officers were to undertake the scientific work, and only nine civilian scientists accompanied the vessels, reduced from an original twenty-five: the ethnographer and linguist Horatio Hale; artists Joseph Drayton and Alfred Agate; naturalists Charles Pickering and Titian Ramsey Peale; botanists William Rich and William Brackenridge, conchologist Joseph Pitty Couthouy, and the mineralogist James Dwight Dana.

The ships assigned to the American expedition were six in number: The *Vincennes* was the flagship, a 127 foot sloop-of-war of 780 tonnes, capable of carrying 190 men. The next largest was the *Peacock*, the ship launched for the aborted 1828 expedition. It was also a sloop-of-war and weighed 650 tonnes. The *Porpoise*, Wilkes's old gun-brig of 230 tonnes from the Georges Bank survey, was 88 foot and carried 65 men. The expeditions' store ship was the *Relief*, a 109ft store ship of 75 men led by Comby. The expedition took two New

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[48] Wilkes, *Narrative of the United States Exploring Expedition*, I: 352.

York pilot boats of 110 tonnes and 96 tonnes, the *Sea Gull* and the *Flying Fish* respectively. The *Sea Gull* was a 73 foot schooner-rigged pilot boat and the *Flying Fish*, a 70 foot pilot boat of the same type.[49]

The *Vincennes* had an extra deck added, and was fitted with additional living quarters, drafting space and a preparatory room for scientists and their collections, facilitated by the reduction of their heavy armour allowance. A poop cabin and a forecastle were added to the *Porpoise* at Wilkes' personal request. Wilkes wrote in his narrative that the carpenter of the Washington Navy Yard built, under orders of the Commissioners of the Navy, 'a very convenient Portable Pendulum-house and Observatory'.[50] The masts and sails were reduced in size on all vessels, an adaptation which left some of the vessels, such as the store-ship *Relief*, slow and ill-adapted for the voyage. Wilkes accused the Board of Navy Commissioners of trying to sabotage the mission by approving inferior workmanship on the vessels: 'I was well aware, from my own observations and the reports made to me, that we were anything but well equipped for such a cruise'.[51] When the boats reached Rio de Janiero, their first major port of call, extensive repairs would be needed on all the American ships.

The US Ex. Ex. sailed from Hampton Docks on 19 August 1838. The *Seagull* was lost in bad weather with all hands in the first year of the expedition. The *Peacock* was lost on entry to the Columbia River in 1841; the crew survived. None of the American scientific contingent was taken on the first voyage from Australia to the Antarctic regions, Wilkes considering it an unnecessary addition, and they were left at Sydney until the return.

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[49] Viola, Herman J. and Margolis, Carolyn (eds), *Magnificent Voyagers: The U. S, Exploring Expedition, 1838-1842* (Washington D C: Smithsonian Institute Press, 1985): 149-62.
[50] Wilkes, *Narrative of the United States Exploring Expedition*, I: xvi.
[51] Wilkes, *Narrative of the United States Exploring Expedition*, I: xxii.

*Britain*

War with France had ended the 'Age of Discovery' as exemplified by Cook but the end of the wars in 1815 saw a revival of scientific expeditions, with the British concentrating on the North West Passage and the French on circumnavigation. By this stage Britain had a Pacific presence from Canton to the colonies of New South Wales, and from Van Diemen's Land to the North West coast of America. With the end of the War, the British Royal Navy became an expensive burden on the state's finances. In 1815 there were 90 ships and 130,000 officers and men. Two years later there were only 13 ships and 20,000 men in the navy. Placed on half pay, the men became available for expeditions on behalf of the Admiralty.[52] In 1817 interest in the North West Passage had been re-kindled, following reports from whaling Captain William Scoresby that the Greenland ice sheet had receded to a much greater extent than he had ever before witnessed. This prompted John Barrow, second secretary to the Admiralty, to initiate a twenty-five year program of expeditions into the Arctic to search for a North-West passage: a route through the ice from the Atlantic to the Pacific Ocean that would cut thousands of miles off the journey from Europe to the East.[53] In May 1818, John Ross embarked on a mission to investigate this possibility. Further voyages followed by William Parry (1819-1820; 1821-1823 and 1824-1825), accompanied by George Lyons and John Franklin amongst others: all pursued the commercial and economic goal of more rapid passage to the Pacific Ocean, but each was also noteworthy for its programme of scientific study that emphasized the importance of precision instrumentation and careful observation.

Although primarily concerned with the Arctic, Britain, like France, also sent vessels into the southern hemisphere. In 1831 Lieutenant Robert Fitzroy was charged with a mission

[52] Mitchell, Sally. *Daily Life in Victorian England* (Westport & London: Greenwood Press, 1996): 281.
[53] Fleming, Fergus. *Barrow's Boys* (London: Granta, 1998), 1-13.

to complete an earlier study of the coasts of Patagonia and Tierra del Fuego that had taken place under Phillip Parker King in 1826-30. With him on the *Beagle* was the naturalist Charles Darwin.

The polar expeditions centred their enquiries on terrestrial magnetism: James Clark Ross was the first to locate the position of the northern magnetic pole. Terrestrial magnetism was becoming increasingly important and studied at the beginning of the nineteenth century. Alexander von Humboldt had set up a chain of magnetic observations in Germany and the Russian Empire in 1827; this was extended by Gauss in 1834 all over Europe so simultaneous observations could be made. There was, however, still a need to perfect the charts for variation, dip and magnetic intensity.[54]

One leading figure in the terrestrial magnetism 'crusade' was Edward Sabine. Sabine was a veteran of Arctic exploration, having journeyed on Polar expeditions with John Ross (in 1818) and with Parry (in 1819-20 and 1821-23). Sabine, a member of the Royal Society, was appointed Scientific Advisor to the Admiralty in 1828. He developed a project to investigate geomagnetism on a world-wide scale that would require comparable data from observatories across the world and an expedition to the Antarctic. This project was first raised with the British Association for the Advancement of Science (BAAS) in 1835. The BAAS meetings brought together people from a wide range of backgrounds involved in all the sciences, and had already expressed an interest in geomagnetism, commissioning S. Hunter Christie to produce a report on the matter in 1831. Sabine, Lloyd and their associates - the 'magnetic lobby'- began their campaign in the early 1830s, motivated in part by the view that their European counterparts, such as Humboldt, Gauss and Arago, were taking the lead in

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[54] For more see, Withers, Charles W. J. *Geography and Science in Britain, 1831-1939: A Study of the British Association for the Advancement of Science* (Manchester: Manchester University Press, 2010).

geomagnetism.[55] Britain and France were particularly keen rivals, and the Paris Observatory, under the supervision of the Bureau des Longitudes, had been the leading centre of magnetic research at the turn of the nineteenth century. The project was global in scale because long distances were needed between points of observation in order to reveal the geographical variation of the earth's geomagnetic field. It had been hoped that through investigation of the declination of magnetic north that an alternative method of establishing longitude at sea would be obtained, but, for Cawood, the main proponents were aware by the early 1800s that this would prove difficult: its continual inclusion was the surest way to ensure government and Admiralty backing for an Antarctic exploring expedition.[56]

At the 1835 BAAS meeting, the recommendations from 1831 were enlarged to include a recommendation to the Government that an Antarctic expedition be given the go ahead, along with the establishment of observatories. Nothing was achieved at this time concerning this worldwide endeavour, but a magnetic survey of the British Isles was undertaken by Humphrey Lloyd, Edward Sabine and James Clark Ross. A Magnetic Committee was then set up consisting of Sabine, Airy, Christie, Lubbock and Whewell: in 1838, John Herschel joined the movement. Herschel had just returned from five years of astronomical work in the Cape Colony, and considered British science to be in decline. Further resolutions were passed and Herschel wrote to the Prime Minister, Lord Melbourne, stating that the British Association viewed with interest the system of simultaneous magnetic observations carried out in Germany and parts of Europe, and that these should be repeated in British domains. The importance of Canada, Ceylon, St. Helena, Van Diemen's Land and Mauritius or the Cape of Good Hope was stressed. Measurements such as horizontal dip,

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[55] Cawood, John. 'The Magnetic Crusade: Science and Politics in Early Victorian Britain', *Isis* 70 (4) (1979): 497.
[56] Cawood, 'The Magnetic Crusade', 502.

direction and intensity were to be taken and recorded, and the magnetic direction and intensity in the southern hemisphere in particular was to be measured, between the meridians of Cape Horn and Australia. For this, a naval expedition was recommended. Lord Minto, First Lord of the Admiralty advised Herschel that the Royal Society carried more weight than the BAAS and the matter was raised at the Royal Society as a result soon after.[57] Herschel presented a report requesting action similar to that proposed by the BAAS. The Royal Society's council resolved to approve the report. After more lobbying, the Antarctic expedition, to be led by James Clark Ross, was finally approved.

James Clark Ross was a seasoned voyager and the obvious choice for captain. Ross received his commission for the *Erebus* on 8 April 1839, commenting in his narrative that the directions allowed him to 'proceed with the equipment of the expedition upon the most liberal scale'; the expedition ended up costing over £100,000.[58] The naturalist and assistant-surgeon was Joseph Dalton Hooker. Robert McCormick, veteran of the *Beagle* voyage, was chief surgeon. All roles were filled by naval personnel.

The British expedition vessels were both bomb vessels, that is, specialized vessels ordinarily used for mortar bombardment. *HMS Erebus* was a 373 tonne, 3 masted *Hecla*-class bomb ship built in 1826. It carried two mortars, one 13 inch and one 10 inch. It was of a strong build and capacious hold, able to carry 64 people.[59]

HMS *Terror* was built by Robert Davey of Topsham to the *Vesuvius*-class design in 1813. The ship weighted 340 tonnes. Originally she would have carried two mortars, together

[57] Cawood, 'The Magnetic Crusade', 510.
[58] Ross, James Clark. *A Voyage of Discovery and Research in the Southern and Antarctic Regions during the Years 1839-1843* (London: John Murray, 1847): I: xviii; Cawood, 'The Magnetic Crusade', 517.
[59] Colledge, J. J. *Ships of The Royal Navy: A Complete Record of all Fighting Ships of the Royal Navy from the 15th Century to the Present* (Oxford: Casemate, 2010).

with two six-pounder long guns and eight twenty-four pounder cannons. The design called for strong construction to take the recoil of forces generated by discharge of the mortars; this made them highly suitable for work in the ice packs of the Polar Regions, and *Terror* had been proven by George Back on his attempt on Repulse Bay in 1836-37.[60] The upper deck was pierced with thirty Preston's patent illuminators, a relatively small thick lens set in a metal frame in the timber of the deck, to allow light from the upper deck to penetrate to the lower deck.[61] The British ships left England on October 5 1839.

### Knowledge and know-how on board ship: reference works, library and instruction guides

Every attention was paid to the material taken on board ship to aid with navigation, scientific investigation and the encounter with new territories. The ship's library contained previous expedition narratives, scientific works, maps and chart. As Harold Otness argues, a common-place feature of sailing ships in the nineteenth century was 'working reference collections of books on navigation, repair, and maintenance' as well as 'the proper political and religious literature'.[62]A comprehensive library aboard ship reflected concerns to establish authority through the display of previous knowledge. As scholars have noted, credibility for knowledge claims was aided by the 'adoption of certain style of address and studied reference to numerous other works by naturalists and travellers who had witnessed the same thing'.[63]

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[60] For more on this see: Lyon, George Francis. *A Brief Narrative of an Unsuccessful Attempt to Reach Repulse Bay* (London: John Murray, 1825).
[61] http://www.hakluyt.com/PDF/Campbell_Part3_Appendices.pdf: 174-175 (accessed 25 Novemebr 2016).
[62] Otness, Harold M. 'Passenger Ships' Libraries', *Journal of Library History* 14 (4) (1979): 486.
[63] Keighren, Innes M., Withers, Charles W. J. and Bell, Bill (eds). *Travels into Print: Exploration, Writing and Publishing with John Murray 1773-1859* (Chicago and London: University of Chicago Press, 2015): 13.

The authors of the American scientific recommendations advised that the American expedition should 'be provided with books of reference, which they will require in order to be constantly aware of the labours of their predecessors in the same field'.[64] The *Vincennes* was modified to include a library of 4000 books. In his first letter home, Midshipman William Reynolds described having on board all the books of the French and English expeditions of the seas they were to visit.[65] There was also one French and five English sets of official hydrographic charts on board and the British mapmaker Aaron Arrowsmith's chart of the Pacific Ocean, first published in 1798, but which had undergone many editions before 1838.[66] The library *implied* familiarity and understanding of previous southern ocean exploration, but also served as a reminder of large gaps in knowledge of the region.

Most of the scientific works taken on the British expedition were botanical, reflecting the concerns of Hooker and Ross, but a few were zoological or geological. Cook and Weddell's narratives were on board. Ross refers to the log books of others throughout his narrative, particularly the log book of the *Eliza Scott* by John Balleny (Balleny had discovered islands and land south of Australia).[67] The importance of Balleny's findings had been identified before the British expedition set sail. In a letter to Ross, the British Admiralty

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[64] Conklin, Edwin G. 'Connection of the American Philosophical Society with Our First National Exploring Expedition', *Proceedings of the American Philosophical Society* 82 (5) (1940): 531.
[65] These included: Lord Anson's *Voyage round the world* in HMS Centurion 1740; Bougainville's *Voyage round the worlds* (Georg Forster's translation) 1769; Freycinet's Narrative Voyage (*Autour du monde fait par ordre du Roi sur les corvettes de S. M. l'Uranie et la Physicienne, pendant les années 1817, 1818, 1819 et 1820,* in thirteen quarto volumes and four volumes of plates and maps); Duperry's hydrographic work on the Freycinet voyage; Dumont d'Urville's 1830 *Astrolabe* narrative and atlas (*Voyage de la corvette "l'Astrolabe," 1826–1829*), Cook's Narratives of his three voyages, Berings Straits &c (1828); F. W. Beechey's 1832 Narrative and Three Important Maps, (*Narrative of a Voyage to the Pacific and Bering's Strait*), and Vancouver's *Voyage Of Discovery To The North Pacific Ocean, And Round The World In The Years 1791–95*.
[66] Hoffman Cleaver, Anne and. Stann, E.J (eds), *Voyage to the Southern Ocean – Letters of Lieutenant William Reynolds of the United States Exploring Expedition 1838-1842* (Annapolis: Naval Institute Press, 1988): 147.
[67] Ross, *A Voyage of Discovery and Research*, I: 274.

Hydrographer of the Navy, Francis Beaufort, wrote 'Captain Balleny arrived here today with his chart and his logbook – and I have employed Walker these two hours in laying down his track for you. W. Croker has been so kind as to promise to copy a sketch of the Balleny Isles for you and will dispatch it by dawn'.[68] Two days later he wrote to Ross again, 'I have been so good as to send you the Eliza Scott's journal for the several days she was near them [the Balleny Islands]. And also where he dips in on the other patch of (supposed) land'.[69] Beaufort makes it clear that this knowledge, gained through the whaler John Balleny, could not be entirely relied upon, despite its possible worth.

Many of the scientific works were brought on board by individuals as personal property rather than being supplied by the government: Hooker wrote to his father that 'the library of Natural History that you fitted me out with is to me worth any money. Blainville's *Adinologie* and Edwarde's *Crustacae* are particularly useful'.[70]

Hooker reflected often on the dearth of material he required for identification of new specimens. Writing to his father he stated that, 'As far as I could I imitated Banes's style of drawing dissections, but as the only sketches (on board) of that artist are two in Parry's Voyage, I have not much to copy from and I do not expect that they will please you much'.[71] On another occasion he complained, 'it was very foolish in me to have brought so few books on *Cryptogomic* Plants, having nothing but Louden's *Encyclopedia* and the miserable Sprengel to help me'.[72] Referral to renowned scholars expressed familiarity with past works,

[68] The National Archives, Kew (TNA), BJ2/3, 15-16. Francis Beaufort to James Clark Ross, September 21 1839.
[69] TNA, BJ2/3, 21. Francis Beaufort to James Clark Ross, September 23 1839.
[70] Huxley, Leonard. *Life and letters of Sir Joseph Dalton Hooker: Based on Materials Collected and Arranged by Lady Hooker* (London: John Murray Publishing, 1918): 57.
[71] Joseph Hooker Correspondence Project. Archives of the Royal Botanic Gardens, Kew. Antarctic Correspondence. JDH/1/2 f.66-67. Joseph Hooker to William Hooker, 6 July 1841.
[72] Huxley, *Life and Letters of Sir Joseph Dalton Hooker,* 131.

ensured a further element of credibility for knowledge claims. The chance to refute an important author was also beneficial to establishing truth claims: McCormick, for example, recorded, ‘the great naturalist Cuvier had been under the erroneous impression that the albatross laid more than one egg’.[73] Wilkes took umbrage at the veracity of the maps they had been supplied with: ‘The published charts of these islands were found so inaccurate, as to be a cause of danger rather than safety’.[74]

The naturalists required specific reference works on board if they were to fulfil their job as well as complete their shipboard duties. Books were prized possessions for those who could read them; every care was taken to maintain their condition in the often ill-suited damp cabins under deck. Again writing to his father, Hooker pleaded,

> I must pray you not to forget the Encyclopedia of Geography & if you could spare me any of the following books you would confer a great boon on me, Linnaeus’ *Amoenitates*, Nees *Phil[osophia] Botan[ica]* (for the German); Forster’s *Flora*, Lamarck, Latreille & the vol[ume]s of Griffith’s Curia containing *Crustacea* & *Annelides*, these are books you do not use, &, I assure you, if you are willing to spare these I will take the greatest care of them. My books are still as good as new, having covered them & our berth being very clean also if you would purchase for me the continuation of Endlicher after the tenth number, & of the Annals after the July 1839 number -- *Grant’s Outlines of Comparative Anatomy* after the 4th No & *Jones’ Animal Kingdom* after 5th No. Any other books especially on Botany or Ornithology would be duly prized.[75]

Hooker was specific and knowledgeable about the books he wanted, and was fortunate enough to be able to ask his father for those he had not taken with him at the outset of the voyage. Being part of a strong network of other collectors and respected gentlemen of science was integral to completing work at sea.

[73] McCormick, Robert. *Voyages of Discovery in the Arctic and Antarctic seas, and Round the World* (London: S. Low, Marston, Searle, and Rivington, 1884): 136.
[74] Wilkes, *Narrative of the United States Exploring Expedition*, V: 65.
[75] JDH/1/2 f.26-27. Joseph Hooker to William Hooker, 17 March 1840.

The 1830s marked the beginning of a new stage in the circulation of material aimed at assisting the traveller to make observations and undertake successful experimentation, both on land and in maritime exploration. This desire to 'Regulat[e] the traveller' through printed instruction guides was motivated by a desire to improve the intellectual and social standing of geography, and was an expression of the emerging status of science and authorial training.[76] Instruction guides aimed at helping the traveller understand their new geography in a regulated way had been circulated since the late seventeenth century by men of science such as Robert Boyle and John Woodward. Following a strict set of instructions on what to observe and how was vital in construction of credibility.[77]

In France in 1818, the Museé Royal d'histoire Naturelle issued a booklet of detailed practical instructions on the compilation and preservation of natural history collections, at the Navy's request, aimed specifically at marine voyages and colonial staff.[78] In Britain in 1836, William Nugent Glascock wrote, *The Naval Service Officers' Manual for Every Grade in His Majesty's Ships*, which gave instructions to crewmen of all levels on various activities they would be required to undertake on board ship.[79] In 1841 Julian Jackson's *What to Observe or The Traveller's Rembrancer for the Uninitiated Traveller* was published.[80] Jackson's book aimed to instil a culture of regulation and procedure about what to look out for and how best to record observations. I have not been able to ascertain if this book made its way to the Ross expedition, which did not return from their voyage until 1843. Its publishing at this time, concurrent with the sailing, reflects concerns at the time of the Ross expedition over the

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[76] See Keighren, Withers and Bell, *Travels into Print*, ch.2.
[77] See: Withers, Charles W. J. *Placing the Enlightenment: Thinking Geographically about the Age of Reason* (Chicago and London: University of Chicago Press, 2005): 93-94.
[78] Ollivier, 'Pierre-Adolphe Lesson, Surgeon-Naturalist', 46.
[79] Glascock, W. N. *The Naval Service Officers' Manual for Every Grade in His Majesty's Ships* (London: Saunders and Otley, 1836).
[80] Jackson, Julian. '*What to Observe or The Traveller's Rembrancer for the Uninitiated Traveller*' (London: James Madden, 1841).

proper observation and record of what had been seen by a variety of travellers, not just captains of exploring expeditions.[81] The expeditions considered here sailed before the travel guide became prevalent, however, such as Jackson's *What to Observe,* and later John Herschel's *Manual of Scientific Inquiry,* published in 1849. What was included in the scientific recommendations and sailing instructions, and knowledge gained from reference books on board, was the main resource which most of those on board had regarding what they were to see and do.

### Outfitting the exploring expeditions[82]

By far the most complete history of the procurement of scientific instruments for an expedition is given for the American voyage, possibly a consequence of the lengths the Americans had to go to in order to obtain them. America did not have its own skilled precision instrument makers. The instruments required could only be obtained from Europe, and it was Wilkes who had been sent to purchase the collection long before he was given command of the expedition. He had travelled to Europe in 1828 to buy instruments for the first, abandoned, exploring expedition. In 1833, Wilkes had been appointed head of the newly-formed Depot of Charts and Instruments. In July 1836 he was ordered to Europe to buy scientific instruments and charts for the proposed exploring expedition, causing him to visit London, Paris, and Munich.

In London, Wilkes met with the most renowned and influential of England's scientific world: Francis Bailey, vice president of the Royal Society (for pendulums), Professor Peter

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[81] For more on the importance of method at this time see: Withers, Charles W. J. 'Science, Scientific Instruments and Questions of Method in Nineteenth-Century British Geography', *Transactions of the Institute of British Geographers* 38 (2013): 167-179.

[82] For a full list of the instruments taken see Appendix III.

Barlow and James Clark Ross (magnetic instruments) and Captain Francis Beaufort (for charts).[83] It was not just the scientific elite that attracted Wilkes; much of this time was spent in negotiation with the instrument makers themselves. Wilkes had become acquainted with the London chronometer firm, Parkinson & Frodsham when he was superintendent of the Depot of Charts and Instruments, and from them he purchased many of the forty chronometers taken on the expedition. In his autobiography Wilkes stated that he did not just purchase, but superintended the making of some of the instruments for the expedition.[84] In addition to Parkinson and Frodsham, Wilkes attempted to meet with several instrument makers: in England, Messrs Troughton and Simms, Donald, Jones of Charing Cross, Molyneux, Dents, Charles Frodsham and Lloyd; Gambey and Chevalier in Paris and Messrs Ertel, Meyr and Fraunhofer in Munich.[85]

Wilkes's instructions stated that if he were unable to procure the instruments directly he was to submit on his return a list of those he wished to obtain. Securing the intricate precision instrumentation required proved difficult. Despite his connections Wilkes was unable to procure a Fox's dipping circle before sailing in 1838. Wilkes reported to the Secretary of the Navy that 'in all my inquiries I have not found any of the instruments we required in the hands of the Makers finished, and they are all so fully employed that most of them have refused positively to undertake any thing whatever in the time required'.[86] Wilkes believed he expedited the process when he made the makers aware of the great objects of the

[83] Mawer, *South by Northwest*, 38.
[84] Wilkes, Charles. *Autobiography of Rear Admiral Charles Wilkes U.S Navy 1798-1877*, (Washington: Department of the Navy, 1978): 328.
[85] Wilkes, Charles. *Hydrography* (Philadelphia: Lea and Blanchard, 1845): 2.
[86] Borthwick, *Outfitting the United States Exploring Expedition*, 164-165.

expedition, writing, '[I] came forward, and desired that their orders might be postponed or laid aside until the instruments required for the Expedition should be completed'.[87]

Wilkes´s purchase of instruments cost almost $20,000. On return to New York he found that the instruments had been 'broken open and their contents examined by those entirely unacquainted with them'.[88] In the midst of this he received orders to take the brig *Porpoise* to perform a survey of Georges Banks; the exploring expedition was again in disarray.[89] When the expedition finally set sail with Wilkes in charge, the instruments were brought from storage in New York and part of them, including the chronometers, were landed at the Naval Asylum, where a portable transit had been set up to rate them. Wilkes wrote 'there were a great many duties to perform previous to our day of Sailing, among them the testing of our Instruments and the obtaining Results from our Pendulums, besides Dip & inte[si]ty observations and the Rating of our Chronometer, twenty-four in number'.[90]

When Wilkes noted that 'every expense that could be lavished on this [scientific] equipment was incurred', he was referring to those instruments which related to the investigation of the physical rather than the natural sciences, of which he appears to have paid only passing interest. No microscopes were purchased for the expedition.[91] James Rehn, a secretary of the Academy of Natural Sciences of Philadelphia later commented that 'unofficial information brought to the Academy's attention in recent years advises us that Dr. Paul B. Goddard, an active member of the Academy and a well-known physician and photographic pioneer of Philadelphia, helped the Corps meet this deficiency by loaning his

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[87] Borthwick, *Outfitting the United States Exploring Expedition*, 165.
[88] Wilkes, *Narrative of the United States Exploring Expedition*, I:324
[89] For more on the George's Bank survey see: Nathaniel Philbrick, *Sea of Glory: America's Voyage of Discovery, The U.S. Exploring Expedition, 1838-1842* (London: Penguin, 2004): 35-39.
[90] Wilkes, *Autobiography*, 352.
[91] Borthwick, *Outfitting the United States Exploring Expedition*, 172.

personal microscope to aid the field work of these investigators'.[92] Each officer had to bring his own sextant and watch. Anticipating the breakage of such fragile apparatus, a component instrument maker was attached to the expedition for repairs. Duplicate instruments for those thought likely to break were also brought along.[93]

Wilkes was the only captain to give a full list of the instruments he took on board the expedition vessels. I have been unable to locate any such complete surviving list for the British and French expeditions. The American list, printed in the hydrography volume of Wilkes's official narrative, is reproduced in full in Appendix III, with a description of the purpose and operation of each instrument. Those that relate specifically to the study of the marine environment were as follows: two Massey's patent logs, six Surveying chains, two Sympiesometeres by Adie, nine Standard thermometers, by Simms, Jones and Dolland, sixteen Six's self-registering thermometers, with copper cylinders for deep-sea sounding, and two Scopeloscopes.

There are many points of interest in this list. Wilkes was fastidious in recording not only the type and number of each instrument but also its maker. This was important: a recognized instrument maker was vital for trust to be established in the instrument and in its measurements. The best manufacturers added not only credibility but enhanced the status of the voyage, not least given the substantial cost of such instruments. Wilkes procured instruments from manufacturers in Britain, France and Germany. If Wilkes felt that the need to procure instruments from their rivals in Europe was at odds with the nationalist imperatives of the American expedition, he made no mention of it. With no suitable

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[92] Rehn, James. 'Connection of the Academy of Natural Sciences of Philadelphia with Our First National Exploring Expedition', *Proceedings of the American Philosophical Society* 82(5) (1940): 548.
[93] For more on the fallibility of instruments see: Schaffer, Simon. 'Easily Cracked: Scientific Instruments in States of Disrepair', *Isis* 102(4) (2011):706-717.

manufacturers at home, there was no question but that such instruments would have to come from abroad.

Instruments relating directly to the natural sciences are striking by their absence. This is not entirely surprising considering Wilkes's personal disregard for this branch of the sciences. What is more telling is what equipment *was* carried on board ship but not recorded in the list of scientific instruments: the dredge, tow nets and lead weights for sounding, the nets that brought much needed fresh fish on board ship, and the sounding lead that was a vital piece of navigational kit. This technology was seen as part of the ship's standard equipment rather than specific pieces of scientific instrumentation.

The record of instruments for the French expedition was low-key by comparison with America. D'Urville commented on the 'short time we had to put in order the various instruments of the expedition', although he noted that he was supplied with everything he asked for in advance of the ships sailing from France. [94] This included a week-long trip to London for the books, charts and instruments he was unable to obtain in France. There he was received by Francis Beaufort, and John Washington, the secretary of the Royal Society. D'Urville commented that, 'beneath their politesse, their offers of service, it was easy to sense the regret they felt in seeing someone other than an Englishman attempting this career that they considered their nation's exclusive domain'.[95] D'Urville asked their opinion of James Weddell, whose stories of seeing land in the southern Polar Regions he had heard. The British were unimpressed when d'Urville referred to him as a 'simple seal hunter' - they considered (or at least claimed to believe) their compatriot a 'true gentleman'.[96] D'Urville

[94] Dumont d'Urville, Jules. *Voyage au Pole Sud et dans l'Oceanie sur les Corvettes l'Astrolabe et la Zélée*, 1837-40, 10 volumes (Paris: Gide, 1841), I: 2.
[95] Rosenman, *Two Voyages to the South Seas*, 118.
[96] Rosenman, *Two Voyages to the South Seas*, 324.

brought a map of the circumpolar region back from London, but not much in the way of instrumentation, nor does he refer to it in his record of the proceedings for sailing of the expedition.

The British Association, original supporters of an Antarctic expedition, supplied the instruments for the magnetic observations on the British voyage. Hooker complained that the government were loath to make large grants of money available to the natural history department, and that they were expected to make it up from their own pockets. He wrote 'anything that they won't supply my surgeon [McCormick] will make up from his own pocket'.[97] Luckily for naturalist and assistant-surgeon Hooker, his family was relatively affluent. His grandfather sent him a traveling thermometer and his father a chronometer for the voyage.[98] Ross does not record the procurement of instruments in the same way Wilkes and d'Urville did.[99] That the attention was firmly placed on the instruments relating to magnetism and meteorology is understandable as these, unlike the French and American voyages, were the primary reasons for the expedition.

**Institutional instructions for sailing: controlling the expeditions through science**

There were two types of instructions relating to the sailing of the expeditions submitted to the captain of each voyage before their departure: sailing instructions and scientific recommendations. These recommendations came in a variety of guises. The sailing instructions came from the Government: the Minister for Marine in France, the secretary to the Board of Naval Commissioners in America, and the Lord High Admiral in Britain. These

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[97] Huxley, *Life and Letters of Joseph Dalton Hooker*, 45.
[98] Huxley, *Life and Letters of Joseph Dalton Hooker*, 46.
[99] The Scott Polar Research Institute (SPRI) in Cambridge, the main archive of polar works in the UK, does not hold a list of the instruments taken on the voyage, nor does the TNA.

official orders were reprinted in the travel narratives of all the captains, and served as lists of undertakings that the voyages were to attempt to complete at all costs. There was little negotiation: once the instructions had been committed to paper, they served as a clear mandate as to how the expeditions should proceed.

As scholars have noted, formal instructions 'presumed formal purpose and with particular ends in view for the exploration'.[100] There were specific instructions for personnel, such as the handing-over of all materials relating to the voyages on their return, and instructions that prohibited certain activities such as forming personal collections. Instruction was a form of control by the state over its authorised agents and that which they may discover. Breaking with official instruction was a disciplinary matter at a time when punishments on board ship were still harsh: courts-martial on expeditions' return were not unheard of. Members of the social system on the expeditionary vessel had reason to follow the sailing instructions closely.

The scientific instructions were desiderata of what might be achieved during the expedition, a list of recommendations rather than strict instructions that pointed those on board in the direction of gaps in scientific work that the voyages might fill. This is not to imply that there were no connections between the two: the sailing instructions did include scientific points, and in making it into the official orders, they attained an importance that the desiderata from the scientific instructions did not. Despite coming from scientific institutions, these scientific instructions, demanded by the governments of each country, were an additional form of state control over what procedures were to be conducted at sea. As Hélène

[100] Keighren, Withers and Bell, *Travels into Print*, 35.

Blais argues, in a situation of colonial conquest, the state's interests took precedence over scientific advice.[101]

Despite the level of details regarding what the expeditions were to do, and why, there is little detail over how it should be undertaken (what there is is considered in more detail in the three chapters following). The instructions for each expedition considered here demanded standard shipboard and expeditionary procedures but gave little operative information. Detailed instrumental observation was crucial but those on board ship were directed only towards its accomplishment, not guided in its practical implementation.

*France*

In France the majority of recommendations regarding scientific investigation to expeditions in the nineteenth century were supplied by the Museé National d'Histoire Naturelle and the Académie des Sciences. Bruno Latour coined the term 'centre of calculation' to describe the site where knowledge accumulates as resources circulate from and to it from other places.[102] At this time the Museé National d'Histoire Naturelle in Paris served this purpose in France. In the early and mid-nineteenth century it was a centre for the study of all branches of the natural sciences.

An attempt to standardize, organise and rationalize the scientific instructions given to travellers was evidenced in attempts to write policy statements upon travel rather than respond to repeated requests of individual travellers and departmental mission organizers. Instructions were generally kept short. Those for the 1828 *Morea* expedition epitomised this.

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[101] Blais, Hélène. Le rôle de l'Académie des sciences dans les voyages d'exploration au XIXe siècle, *La revue pour l'histoire du CNRS* [En ligne], 10 | 2004, mis en ligne le 04 septembre 2007, consulté le 20 septembre 2016. URL : http://histoire-cnrs.revues.org/587 (accessed 12 September 2016).
[102] Latour, *Science in Action*, 215-217.

The director of the Museé National d'Histoire Naturelle wrote that the instructions would be very simple: 'Collect everything, keep everything, and especially accurately register the names of countries'.[103] As Gascoigne argues, this attention was reflected in the pamphlet produced by the museum in 1818 at the request of the navy: *Instructions pour les voyageurs*.[104]

The Académie des Sciences played an active role in the organization of explorations, acting as an intermediary between expedition personnel, the state and an organising office. The state appealed to the Académie to organise, verify and endorse the scientific aspects of overseas exploratory travel in the nineteenth century. The Académie´s role was thus more supportive than initiatory, and was unique in France in bringing together scientists from all scientific fields. It was also the only body at this time not to be a specialized society. This came at a time when a number of specialized scientific bodies were bring formed: the Paris Geographical Society (La Société de Geographié de Paris), founded in 1821, also sought to promote exploration. Travellers submitted a plan to the Académie in hope of obtaining scientific instructions.

In 1835 the Académie was asked to supply instructions for the *Bonite*, a Pacific voyage of exploration captained by Auguste-Nicolas Vaillant. These instructions were then reused for the next circumnavigation by France and every few years following as they were judged by the Académie to be a model of its kind.[105] In the British Royal Society Report, instructions relating to the temperature of air referred to the 'elaborate instructions for the voyage of the *Bonite*', written by M. Arago. The Académie instructions supplied to the d'Urville expedition before sailing were a more concise version of the *Bonite* instructions

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[103] Blais, Le rôle de l'Académie.
[104] Gascoigne, 'From Science to Religion', 115.
[105] Blais, Le rôle de l'Académie.

from the year before; I have here referred to the full set of recommendations for the *Bonite* expedition in discussing the scientific agenda for *Astrolabe* and *Zélée*.

The sailing instructions for the French expedition were issued to Dumont d'Urville on 26 August 1837, by the Minister for the Navy, Vice-Admiral Rosamel. They began with a direction to call at the Cape Verde islands for re-provisioning, before heading south to the Polar Regions, 'where you will extend your explorations towards the pole as far as the polar ice will permit'.[106] They were then to proceed to the Straits of Magellan, calling in to survey Chiloe Island and then on to Valparaiso for repairs and re-provisioning. Upon leaving Chile the expedition was to follow the 23°S parallel to Fiji, and from there to Banks Island, Vanikoro (to seek information on Lapérouse) and the Solomon Islands, before heading to the Torres Strait and Amboyna. The *Astrolabe* would then carry on to Australia and New Zealand, and the *Zélée* would return to France with the collections, reports and any sick sailors. The *Astrolabe* was to search for the Chatham Islands to confirm their existence or otherwise, specifically in the interests of French whaling, suggesting that commercial goals were as of as much importance to the French as the Americans and British. They would then travel north, charting islands as they came across them, before finishing the expedition by calling in at Borneo and Sumatra, and sailing home via the Cape of Good Hope. The minister concluded his instructions with the following assessment of the importance of commerce for the voyage:

> His Majesty has in mind not only the advancement of hydrography and natural history; his royal solicitude for the interests of French trade and the development of our shipping has caused him to take a much broader perspective of the scope of your mission and the likely advantages to accrue from it. You will call at a great number of places which should be closely examined from the point of view of the resources they may be able to offer our whaling ships. You are to collect all the information appropriate to guide them in making their expeditions more productive. You will put

[106] Rosenman, *Two Voyages to the South Seas*, 110.

> in to ports where our trade is already established and where the passage of a French warship can have a salutary influence, into others where perhaps our manufactured goods could find markets that have been so far ignored, and on which you will be able to provide valuable information on your return.
>
> You will also probably have the opportunity at several points on your voyage to provide protection which is the finest prerogative of the ships of the King's Navy, and which is always to the advantage of our merchantmen when they meet.
>
> I am particularly drawing your attention to this part of your mission, There is nothing I can tell you about the routine duties which flow from your position as commander of an expedition: you know them and how to fulfil them, as on your previous voyage, with all the firmness demanded by service discipline and, at the same time, with all the tact that this type of mission require.[107]

Furthering geographical knowledge to provide information for whaling ships was a vital requirement of the French expedition, as it was for the American expedition. Unlike the American ships, those of France were allowed, encouraged even, to make use of the military and martial nature of their expedition to expedite both their objectives and those of other French vessels in the region. Rosamel's finishing statement, expressing his absolute trust in d'Urville to make the necessary decision regarding the running of the vessel, was somewhat in contrast to the previous litany of orders and recommendations throughout the remainder of the sailing instructions, but it does highlight that division in authority – between captain on board the expedition vessel and the remainder of the personnel - that dictated which investigations were pursued on the voyage.

Regarding the scientific recommendations, d'Urville was unhappy with the response from the Museé National d'Histoire Naturelle, stating he had 'accumulated riches for the museum for twenty years'.[108] Dumont d'Urville believed he was ´blackened´ in the eyes of the astronomer Francois Arago, but hoped he would get something from the natural history

[107] Rosenman, *Two Voyages to the South Seas*, 199.
[108] Dumont d'Urville, *Voyage au Pole Sud* Vol.I: LXXIV-LXXV.

department. They showed little enthusiasm, however, and he complained they were like the instructions he would expect for someone they did not know, despite being formed of members of the Académie des Sciences, with whom d'Urville was well acquainted.[109]

Following this response, d'Urville wrote to the Académie des Sciences Morales et Politiques (Academy of Moral and Political Science) and the Paris Société de Geographié and received what he believed were much more relevant and worthwhile recommendations.[110] The instructions from the Académie des Sciences Morales et Politiques address ethnographical concerns. The Académie records stated that d'Urville had 'begged the Académie to give him specific instructions to direct its investigations on the races of men'.[111]. How far these personal recommendations to d'Urville could influence the work undertaken on the two corvettes is debatable. D'Urville as captain had much of the power on board ship, had been given supreme charge in the state instructions by Rosamel and could subtly and directly dictate the type of work that was undertaken. But to routinely spend time and resources on scientific investigations not demanded by the state could result in other necessary work being overlooked. This conflict between personal and professional imperatives was a source of tension on board all the expedition vessels studied here.

*The United States of America*

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[109] These instructions from the Académie des Sciences are held at the Chateau du Vincennes archives, Vincennes, Paris: $BB^4$ 1009, on microfilm. They are very difficult to decipher, due to the age and handwriting, but they summarise the instructions issued to the *Bonite*, a year earlier in 1836. D'Urville was probably upset that no new instructions were drawn up specifically for his voyage.

[110] Dumont d'Urville, *Voyage au Pole Sud* Vol.I: LXXIV-LXXV.

[111] Mémoires de l'Académie des Sciences Morales et Politiques de l'institut de France, Tome 3, Académie des Sciences Morales et Politiques (Paris, 1841), xxxviii. I have been unable to locate the instructions given by the Société de Geographié, and they are not mentioned explicitly in any of the narratives

While Wilkes claimed to having written the sailing instructions for the American expedition himself, it was Secretary to the Board of Navy Commissioners, James Kirke Paulding, who issued them.[112] The instructions were of considerable length, but at the outset Paulding outlined what he saw to be the main purpose of the expedition: 'The Congress of the United States, having in view the important interests of our commerce embarked in the whale-fisheries, and other adventures in the great southern ocean, by an act of the 18th of May, 1836, authorized an expedition to be fitted out for the purpose of exploring and surveying that sea, as well to determine the existence of all doubtful islands and shoals'.[113] They were also to pay attention to *vigias* (obstructions in the water) that were marked on charts, the position of which were thought doubtful. This practice was to be carried out around Japan as well, to ascertain if there was a safe route through the Sea of Sooloo which would shorten the passage of American vessels to and from China.

The commercial benefits for American were emphasized throughout. At Rio Negro, Argentina, the expedition was to survey its resources and the facilities for trade and then proceed to Tierra del Fuego, calculated to be of interest to the scientific corps. The *Porpoise* was to be taken south and the other vessels to remain surveying the ports, harbours and bays of the southern coast of South America. The expedition would then sail to the Pacific Islands, and to the Navigator's Group, where they were again to establish whether shoals and islands marked on the existing charts were accurate. On reaching Fiji, the expedition was to examine the islands for a safe harbour for U.S. whaling vessels and to establish the importance of increasing America's presence in the Pacific for financial and commercial reasons. After completing surveying around the Pacific Islands, the expedition was to cross the Pacific, stop

[112] Gurney, *Race to the White Continent*, 135.
[113] Wilkes, *Narrative of the United States Exploring Expedition*, I: xxv.

at the Hawaiian Islands, and end at the north-west coast of America.[114] Here the vessels were to survey and examine the territory of the United States on the seaboard of the Columbia River, then proceed up the coast of California, surveying as they went.

The American instructions focus on commerce and safe navigation for commercial vessels did not entirely obscure scientific imperatives: '[you are] to extend the empire of commerce and science; to diminish the hazards of the ocean, and point out to future navigators a course by which they may avoid dangers and find safety', continuing 'you will take all occasions not incompatible with the great purpose of your undertaking, to extend the bounds of science, and promote the acquisition of knowledge'.[115] Scientific investigation was not to interrupt the primary business of the vessels, however. In the introduction to his published narrative, Wilkes stated that this expedition was the only voyage by the U.S 'fitted out by national munificence for scientific objects'.[116] All observations relating to astronomy, terrestrial magnetism and meteorology were to be taken by officers of the navy: Wilkes believed this was necessary to bring the officers into 'more intimate connection with the scientific duties'.[117] There was a reduction in the size of the corps of civilians than had originally been suggested, although Wilkes claimed 'as many of these [civilians] were taken as could be accommodated'.[118]

No special directions were given in the general sailing instructions relating to the conduct of scientific researches and experiments. Paulding's instructions directed the attention of those conducting scientific investigation to the *Atlas of the Pacific Ocean* by the

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[114]The North West Coast of America consisted of what is today British Columbia, Washington, Oregon and Idaho, and was jointly occupied by the British and the US under the treaties of 1818 and 1827.
[115] Wilkes, *Narrative of the United States Exploring Expedition*, I: xxix.
[116] Wilkes, *Narrative of the United States Exploring Expedition*, I: xiii.
[117] Wilkes, *Narrative of the United States Exploring Expedition*, I: xiii.
[118] Wilkes, *Narrative of the United States Exploring Expedition*, I: xiv.

Russian Vice-Admiral Krusenstern.[119] The following direct instructions were given to Wilkes:

> As guides to yourself and to the scientific corps, the Department would, however, direct your particular attention to the learned and comprehensive Reports of a committee of the American Philosophical Society of Philadelphia, the Report of a Committee of the East India Marine Society, of Salem, Massachusetts; and to a communication from the Naval Lyceum of New York, which accompany, and are to be regarded as forming a part of these instructions, so far as they may accord with the primary objects of the Expedition, and its present organization. You will, therefore, allow the gentlemen of the scientific corps the free perusal of these valuable documents, and permit them to copy such portions as they may think proper.[120]

The recommendations from the American Philosophical Society were lengthy. The Society was asked to supply details of who to include in the scientific corps, and what work they should perform. The list was drawn up by seven men appointed to a committee at that time to answer just this question, two of which were later to be included on the expedition itself - Titian R. Peale and Charles Pickering. They gave recommendations for zoology and botany, respectively.  These ran to 'thirty closely written pages', covering eight different fields of scientific observation and research.[121] The instructions that covered the investigations relating to measurement of the marine environment were drawn up by Dr. Robert M. Patterson, a member of the society since 1809, and fell under the heading of astronomy and physics, the latter being rather a catch-all term for any scientific interrogation that concerned the use of precision instrumentation and the record of precise measurement.[122] The report also included a recommendation for the scientific personnel (totalling over twenty

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[119] Krustenstern, Adam Johann. *Atlas de l'Océan Pacifique* (St. Petersburg: Departement de l'instruction publique, 1838).
[120] Wilkes, *Narrative of the United States Exploring Expedition*, I: xxx.
[121] Conklin, Connection of the American Philosophical Society, 520.
[122] Rupke, Nicolaas. 'Humboldtian Distribution Maps: The Spatial Ordering od Scientific Knowledge'. In Tøre Frangsmyr (ed), *The Structure of Knowledge: Classifications of Science and Learning Since te Renaissance* (Berkely and Los Angeleos: University of California, Office of History and Technology, 2001): 93-116.

people), a request that time allowing, the scientific contingent were to be allowed to visit Europe in order to procure instruments and books, and that on the expedition's return the Commanding officer 'should require all journals, charts, collections, and drawings made by Officers, Members of the Scientific Corps, or others, to be given up into his hands, for the Navy Department'.[123] Wilkes was not altogether impressed, stating that different societies had submitted 'very diffuse and lengthy reports with recommendations entirely at variance with the objects to be attained'.[124] Wilkes was not only mindful of the primary reasons the expedition had been funded, but was also generally disparaging of all but the sciences he was personally interested in. The specific scientific recommendations, as they relate to investigations concerning the sea, are given in the following three chapters where they become most relevant.

*Britain*

Scientific recommendations to British expeditions in the eighteenth and early nineteenth century were commonly supplied by the Royal Society.[125] Banks´s control over the Royal Society meant that it was unsympathetic to growing claims for disciplinary specialization in Britain: Banks considered science to be 'a unified continent'.[126] Following Banks´s death, the later 1820s saw the beginning of a period of intense specialization in scientific societies in Britain. In 1830 The Royal Geographical Society was founded in London, and, in 1831, the British Association for the Advancement of Science (BAAS) began.[127] This body has been

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[123] Conklin, Connection of the American Philosophical Society, 539.
[124] Wilkes, *Narrative of the United States Exploring Expedition*, I: 323.
[125] For more on the Royal Society after Bank's death see: Miller, D. P. 'Between hostile camps: Sir Humphrey Davy's Presidency of the Royal Society of London, 1820-1827', *British Journal for the History of Science*,16 (1983): 1-47.
[126] Gascoigne, 'Joseph Banks', 168.
[127] For more on the founding of the RGS see: Driver, *Geography Militant*, ch.2; for more on the BAAS in this period see: Withers, Charles W. J. *Geography and science in Britain, 1831–1939: A*

shown to be influential in securing governmental backing for the Antarctic expedition of 1837. Where, before, Bank's house in Soho Square operated as a private 'centre of calculation' from the late eighteenth century, by the 1830s institutions such as the British Admiralty, the BAAS, and Kew Gardens, founded in 1840 and directed by William Hooker, performed this role, receiving material from expeditions and individual collectors around the world, processing it and enabling its dissemination.[128]

James Clark Ross received his commission to captain the British Antarctica expedition from the Admiralty on 8 April 1839 and stated that he was allowed to 'proceed with equipment of the expedition upon the most liberal scale'.[129] The final sailing instructions focused more directly on the scientific goals of the expedition than did those of France or America. This was particularly the case for geo-magnetism, the instructions stating firmly that practical navigation may be improved by an extensive series of magnetic observations. The instructions were issued by Samuel John Brooke Pechell, Lord of the Admiralty. The ships were to stop first at Madeira to take readings of the chronometers, then to sail to St. Helena. Here, an observatory was to be erected, and a similar enterprise was to be carried out at the Cape of Good Hope. Invariable pendulums and the apparatus necessary for determining the figure of the earth were used at several points on the voyage: Kerguelen Island was especially well suited. Should operations be completed before the end of February 1840, the ships were to proceed south, to where indications of land had been noticed. If not, they were to go straight to Van Diemen's Land via the islands of St. Peters and Amsterdam. At Van

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*study of the British Association for the Advancement of Science* (Manchester: Manchester University Press, 2010).

[128] MacKay, David. 'Agents of Empire: the Banksian Collectors and the Evaluation of New Lands'. In D. P. Miller and P. H. Reill (eds), *Visions of Empire: Voyages, Botany and Representations of Nature* (Cambridge: Cambridge University Press, 1996): 38-57; Miller, D. P. 'Joseph Banks, Empire and "Centres of Calculation" in Late Hanoverian London'. In Miller and Reill, *Visions of Empire*, 21-37.

[129] Ross, *A Voyage of Discovery and Research*, I: xxviii.

Diemen’s Land, they were to communicate with Sir John Franklin who was to have prepared magnetic instructions for the observatory there. The ships were then to sail to Sydney, with the remaining winter months to be spent in New Zealand and the surrounding islands. The following summer, the expedition was to determine the position of the southern magnetic pole and reach it if at all possible. If any great extent of land was found they were to ‘lay down the prominent parts of its coast line’.[130] They were also to correct the positions of Graham Land and Enderby Land and ‘other places which have been seen only at a distance’.[131] To do this the hydrographer was instructed to share his parts of the instructions usually given to surveying vessels with the ship´s crew. The expedition was to be concerned with the scientific success of the voyage ‘which will engross the attention of the scientific men of all Europe’. A frequent change of the observations made by the two ships was to be made in order that if any scientific discovery was made by one, it should be communicated rapidly to the other. Ross was advised to communicate frequently with his sister ship, keeping them together whenever possible. It was specified that the ships were not to partake in any hostile act if Britain was to enter into war: ‘the expedition under your command being fitted and for the sole purpose of scientific discoveries’.[132]

On return, Ross was ordered to lay a full account of the proceedings to the Board of Admiralty, who also required that the logs and journals, charts, drawings and observations from officers and other crew that had been made on the voyage be passed over: ‘You will also receive our future directions for the disposal of all such specimens of the animal, vegetable, and mineral kingdoms’.[133]

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[130] Ross, *A Voyage of Discovery and Research,* I: xxvi.
[131] Ross, *A Voyage of Discovery and Research*, I: xxv.
[132] Ross, *A Voyage of Discovery and Research,* I: xxvii.
[133] Ross, *A Voyage of Discovery and Research*, I: xxviii.

Alongside the Admiralty instructions, a Report to the Council of the Royal Society concerning the scientific mandate of the expedition ran to nearly 100 pages. Only the terrestrial magnetism section was included in the official narrative, a fact which highlights the importance of advancing knowledge concerning this branch of science. As well as the magnetic observations, Ross´s work to be done, stated in brief, was as follows: circumnavigation of the Antarctic Pole; determination of length of the invariable pendulum in high South latitudes; observations of the tides; keeping of meteorological register; temperature of the sea at the surface and at depth, as well as temperature of the soil; Soundings and specimens to be taken; Aurora; brightness of southern stars; horizontal refraction, celestial and terrestrial eclipses.[134] The content and direction of these scientific recommendations can be seen throughout the following three chapters: those that relate to investigations of the sea are reproduced in Appendix IV.

## Conclusions

The eighteenth-century tradition of exploration provided a compelling model for those sailing to the Pacific in the mid-nineteenth century. In their programmes of scientific investigation and experimentation meshed with discovery and colonization they offered to the world the example of the beau idéal exploratory expedition. The significance of scientific achievement as an 'innocent' face of exploration was stressed and repeated on subsequent voyages, but, in truth, these expeditions sailed with mixed scientific, economic, commercial and imperialist imperatives.

[134] *Report of the President and Council of the Royal Society on the Instructions to be prepared for the Scientific Expedition to the Antarctic Regions* (London, 1839).

Each of the three expeditions into the South Seas in the late 1830s and early 1840s hoped to secure national success for their country. For Britain it was the imperial prestige of the magnetic crusade. For France it was extending a tradition of maritime glory through exploration. It was the ambition of America to be a player on the world stage. Scientific accomplishment was one way to secure these several objectives. Scientific voyages were considered transcendent, unencumbered by martial ends in view. Knowledge gained through expeditions throughout the preceding century was made use of in all three expeditions. What the American expedition lacked in 'personal' experience was, in part, made up for by reference to the works of those who had been there before. The American expedition was unique in its emphasis on recording publicly the ships' libraries, the instruments they carried and the tacit knowledge gained before sailing. But each of these three nations made use of previous knowledge on the southern oceans to further its cause. In a letter to William Palgrave, Hooker wrote that, 'our sealers are the men who have most contributed to elucidate the geography of the ocean & lands of the Antarctic Circle'.[135] Ross frequently referred to information gleaned from the log book of the *Eliza Scott*, thus showing the importance of up-to-date information on one of the least reconnoitred areas of the globe. With so little substantiated knowledge on the southern oceans and Antarctic continent, any information was considered and investigated. Where d'Urville had openly scoffed at information brought back by the British sealer Weddell, Ross embraced it. Credibility for Weddell, a sealer with little personal authority, would be gained by the ability of those who vouched for his accuracy by following in his carefully-recorded footsteps. Observations and geographical claims needed to be repeatable and confirmed, as did measurement and experiment. This requirement for confirmation by another credible witness is later discussed.

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[135] JDH/1/2 f.207 Joseph Hooker to William Palgrave, 28 April 1843.

The difficulties experienced by the French captain d'Entrecasteaux in 1791 with his civilian savants meant that this was the last of the French expeditions to sail with anyone but naval men on board. By the time Baudin sailed in 1801, the surgeons and their assistants were doing the natural history. Britain had similarly dispensed with its civilian contingent after animosity between men of science and naval personnel. Officers in the navy were expected to be trained in areas such as trigonometry and navigation which meant they were capable of performing the tasks of surveying. The attention to precision and accuracy required made them suitable operatives for undertaking other experimental work, work that was directed at the currents and the temperature of the ocean. Surgeons and their assistants had a background in the biological and anatomical sciences and were deemed capable of performing the role as shipboard naturalists and botanists. Circumventing the need for civilians on board removed the threat to the ship´s social order. Tension with officers, with whom the civilian savants were effectively equal, had been particularly pronounced in some later eighteenth-century voyages. The hierarchal natural order of the ship was ´restored´ by the absence of civilians, although tensions still existed over demands on the naturalists' time, living conditions and collections. But, in effect, the removal of civilians lengthened the arm of the state, increasing the captain´s power to dictate what jobs were to be prioritized, and regulating the officers under his command.

America did not follow the same model as Britain and France in crewing its expedition. The United States had experienced success with land-based explorations that included civilians and they did not have the experience of the other nations that had proven difficulties related to social hierarchy. The following chapters show how these complexities over social order on board ship directly affected the work of all three expeditions, and highlights how decisions regarding personnel made even before the expeditions set sail were integral to the practical accomplishment of duties on board, and to the representation of the observations and investigations pursued.

In the design of the ships, France and Britain drew upon their previous expedition experience. Britain chose a ship tested in the Arctic Seas. Both Britain and France kept the number of vessels to an effective minimum, knowing how difficult keeping ships together could be. The French corvettes which had been tested in the southern ocean previously, were suitable for Pacific exploration but were largely unsuitable for venturing into Antarctic waters. The Americans chose six ill-adapted vessels and they made alterations to the decks that made the boats difficult to handle. No testing was undertaken to confirm their suitability or otherwise for oceanic exploration.

While the British and American instructions specifically forbade the ships of the expedition to be involved in hostile activities, and even stripped the ships of their cannons (the American instructions stated that the expedition was 'not for conquest, but for discovery'), the French allowed such involvement should it be necessary; perhaps seeing hostile action as the most effective way of securing a French presence in the South Pacific and in recognition of Britain's much larger and extensive naval presence there.[136]

All countries realised how important the instrumentation taken on aboard would be to any resultant truth claims about the scientific investigation undertaken. Wilkes was the most particular in his record of the devices his expedition carried. Unable to source the majority of the required precision instrumentation in America, Wilkes's visit to Europe and his meetings with instrument makers and prominent scientific individuals such as Herschel was vital to Wilkes´s claim that the American expedition carried with it the capability for precise and

[136] Wilkes, *A Narrative of the United States Exploring Expedition*, I: xxviii.

accurate measurement, and that their claims to new scientific knowledge on the southern oceans would be as valid as those of France or Britain. Many of the instruments used to study the marine environment, however, were not included in Wilkes's list of shipboard instrumentation. Dredges, seine nets and sounding leads were the general paraphernalia of the working seagoing vessel; they did not demand a space next to the precision engineered chronometer.

There was a tension between the two sets of instructions, sailing and scientific, each country issued to its expedition. The sailing instructions demanded the strict adherence of all on board to the main goals of the expeditions. For France and America these were predominantly the following of a route across the oceans, surveying and charting as they went. Attention to commercial details – whale and seal colonies, safe and bountiful harbours – was of high importance. British concerns centred upon specific and lengthy experiments on, and investigation of, terrestrial magnetism. Large sections of the scientific report were included in the Admiralty´s sailing instructions. Britain's goals were scientific in nature, (as they publicly claimed), but there still existed tensions between one set of scientific practices (relating to magnetism) and others as they related to the natural sciences. What actually occurred on the ship once it had sailed was often the personal preference of the respective captains rather than a direct response to the scientific recommendations or instructions by naval superiors. All three captains had strong scientific leanings, but their individual interests – Wilkes on hydrography, Ross on magnetism and d'Urville on botany – meant that more time was devoted to these activities than some of the other subjects.

There were close ties between political authority and the scientific institutions, especially the Académie in France and, in Britain, the Royal Society. Although often cited as 'recommendations', the scientific desiderata were politically allied to the needs of the state and the criteria to be addressed had economic and political motivation. This being the case, it is perhaps surprising that the instructions include so little reference to the study of large marine mammals. The sailing instructions were clear that the discovery of new whale colonies was a task for the expeditions but the actual study of the animals themselves was given little importance.  All recommendations refer to the need to fill particular lacunae in institutional collections at home as a need in investigation. Despite the turn in the 1830s to precision measurement and numerical record as a necessity to claim epistemological authority for oceanic truth claims, collection of tangible objects was seen still as an important way to establish trust in knowledge gained at a distance. Governmental-issued sailing instructions, such as those for France and America, finished with a direct statement to the captain that there was no need to instruct them on how to perform the necessary scientific tasks on board. This statement of faith served to confer a high level of authority – both in the ship's social structure and in reference to truth claims – on the captain, and in doing so rested much of the potential glory, and failure, on their shoulders alone.

Secrecy as to where the vessels had been and what they had encountered was to be maintained throughout the expeditions. The American instructions explicitly stated that no persons were to furnish others with copies of charts and other materials made during the expedition. This instruction was upheld: the French expedition found it difficult to gain any information on the progress of the Americans whilst themselves in the Pacific. On arriving in Hobart before their journey south, for example, Dumont d'Urville was understandably keen to hear news of the American expedition, but there was no news either in print or by word of mouth. The sharing of information during the three expeditions, and the impact the order to surrender all materials from the voyage on each expedition's return had on the scientific practices undertaken  on board ship, are discussed in chapter six. What follows here is study of the collecting practices.

# Chapter 4 Sampling the South Seas: collecting specimens from the depths

## Introduction

This chapter focuses on the collection of scientific specimens in order to better understand how activities more commonly associated with naturalists on land were undertaken on board ship. This, in turn, is to provide a window into the previously unobserved spaces below sea level that fuelled interests in the ocean as a space of scientific study. Consideration of collecting as a set of practices, driven by established scientific concerns and, in part, guided by techniques performed on the spot by trained men and untrained sailors, can allow us to understand how marine-orientated science began to emerge.

The chapter addresses a number of themes. The first is the importance of the scientific recommendations issued to the French, British and American expeditions by each country's leading scientific institution. These instructions set the tone of the expedition investigations during the course of the expedition. The recommendations reflected differing concerns amongst the three countries over what was expected of their respective expeditions and allows us to access the importance of collecting from the marine environment amongst an extensive and varied ship assemblage.

For Alastair Sponsel, science is 'a set of activities or practices, as well as a body of knowledge.[1] The following section considers the quotidian practices of observation and collection, and addresses the motivations behind collecting. Observation provided the first

[1] Sponsel, Alistair. 'Geology, Zoology and the Problems of Theorizing during the U. S. Exploring Expedition'. In Katherine Anderson and Helen Rozwadowski (eds), *Soundings and Crossings: Place and Practice in the Oceans, 1800-1980* (Sagamore Beach, MA: Science History Publications, 2017 In press).

stage of evidence regarding what had been seen - a note in a journal or letter to describe a new species or phenomenon of natural history - and was of particular importance in situations where specimens could not be obtained. Collecting was often opportunistic rather than the following of a systematic approach, as will be examined. The importance of bird collection, not strictly marine species, but integrally connected to the marine environment and regularly taken from the ship is illustrative of this claim. In most instances, collecting required the death of the specimen. Killing was ubiquitous on board. A dead specimen was required if the creature was to be drawn or preserved, but it was also a leisurely pastime undertaken in long periods of ennui. Death could also provide food: specimens could be the next meal. I discuss here how these processes were central to shipboard life, and how witnessing and participating in the taking of lives of the creatures studied were dealt with by those on board. Matters relating to the preservation of specimens, are discussed in Chapter Six in relation to representation.

The technologies involved in collection are also analysed. Specimens from the deep sea were routinely taken on board via dredges, sounding leads and fishing nets: bird life and marine mammals were shot or caught on hook and line. The sailing instructions were silent regarding operational procedure for collection: this section interrogates the practises and instruments involved, stressing how this was a form of tacit knowledge learnt on board and perfected through practice.

The final section of the chapter considers the relationships on board the expedition vessel between crew, officers, captain and, where applicable, the civilian men of science, in relation to the scientific investigations carried out on board. This section links with preceding sections and with the following two chapters in highlighting the importance of the hierarchical social structure on the ship to the completion of tasks of collection.

**Natural history in the 1830s and the role of collection**

The collection of specimens was a popular and prevalent activity on maritime voyages throughout the eighteenth and nineteenth centuries. Live or preserved specimens provided the most credible way to bring home what was seen abroad. Many scholars have highlighted the importance of the collector to nineteenth-century science. Janet Browne places great emphasis on collecting native flora and fauna in the natural sciences. Bernard Smith has stressed the importance of collecting alongside measuring, drawing and painting on voyages of exploration.[2] The act of collection from foreign lands offered an insight into what existed beyond Europe, and reinforced the imperial and geopolitical nature of maritime endeavour. Collecting, recording, and classifying species new to the European scientific fraternity stamped the authority and ownership of maritime explorers on 'new' space.[3] Richard Drayton had stressed the importance of science in regard to furthering imperialism. Scientific endeavour guided the exploitation of exotic environments and made conquest seem both necessary and reasonable. For Drayton, the botanical gardens of Europe – the Jardin des Plantes in France and Kew Gardens in England – acted as instruments of government. Scientific curiosity and collection legitimated colonial conquest.[4]

In recent academic scholarship an emphasis on the end products of scientific investigation – the transformed object, be it sketch, trace, stuffed object or tabulated data –

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[2] Browne, Janet. "Biogeography and Empire". In N. Jardine, J. A. Secord and E. C. Spary (eds), *Cultures of Natural History*, (Cambridge: Cambridge University Press, 1996): 305-321; Smith, Bernard. *European Vision and the South Pacific*, (New Haven and London: Yale University Press, 1985). For more recent work see, Williams, Glyn. *Naturalists at Sea: From Dampier to Darwin* (New Haven and London: Yale University Press, 2013).
[3] For more on how naming places on a map conferred a sense of ownership over the charted land.see Clayton, Daniel. *Islands of Truth: The Imperial Fashioning of Vancouver Island* (Vancouver: UBC Press, 2000).
[4] Drayton, Richard. *Nature's Government: Science, Imperial Britain, and the 'Improvement' of the World* (Yale: Yale University Press, 2000): 129-135; 248-255.

has meant that the practices involved in obtaining the objects in question have often been overlooked. Whilst it is true to say that measurements of depth, water current or temperature were also a type of collection – numbers rather than physical objects – the two were commonly seen as separate, with different intellectual motivations behind their acquisition. Drawing on the work of Susan Faye Cannon, Michael Dettelbach argues that Alexander von Humboldt was transformational in his science because he focused on the act of measurement rather than the act of collection.[5] Yet, collecting specimens, as opposed to making measurements, was still a popular activity with crew members and civilian naturalists for a variety of reasons: it provided specimens for later study; it occupied time (was even a form of leisure activity); it provided nourishment. It was, at heart, about empirical enquiry with no clear end in view: how could one know what one would gather?

Randolph Cock argues that the beginning of the professionalization of science at sea occurred through civilian naturalists and astronomers on polar expeditions in the 1820s, where 'open-air and ship-board laboratories promoted the training of the midshipmen, junior officers and seamen'.[6] The 1830s did mark the tentative emergence of marine zoology as a discipline. It was grounded in the more traditional techniques of natural history. The majority of the innovation occurred in Edinburgh, which had been the focus of British natural-history training since the late eighteenth century. The anatomist Robert Grant (1793-1874) and others developed a new style of marine zoological enquiry in which naturalists 'adapted the tools and skills of fishermen in order to gather specimens farther from shore and in deeper water'.[7]

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[5] Dettelbach, Michael. 'Global Physics and Aesthetic Empire: Humboldt's Physical Portrait of the Tropics'. In D. P.Miller. and P. H. Reill (eds), *Visions of Empire: Voyages, Botany, and Representations of Nature* (Cambridge: Cambridge Uni. Press, 1996): 260.
[6] Cock, Randolph. 'Scientific Servicemen in the Royal Navy and the Professionalism of science, 1816-55'. In *Science and Beliefs: From Natural Philosophy to Natural Science, 1700-1900,* David M. Knight and Matthew D. Eddy (eds), (Aldershot: Ashgate, 2005): 95-111.
[7] Sponsel, Alistair. 'An Amphibious Being: How Maritime Surveying Reshaped Darwin's Approach to Natural History', *Isis* 107(2) (2016): 260.

In France, the importance of the study of invertebrates had been ‘elevated to a new level’ by the work of Lamarck and others at the Paris Musée National d’Histoire Naturelle.[8] Charles Darwin, a pupil of the anatomist Robert Knox (1793-1862) spent time studying the oceanic creatures on his *Beagle* voyage, thus raising the profile of such specimens in his network of friends and colleagues.[9] Edward Forbes, who also trained in Edinburgh after Darwin, was particularly enthusiastic about the potential of the dredge to investigate marine animals, describing it as an ‘instrument as valuable to a naturalist as a thermometer to a natural philosopher’.[10]

Yet, despite this growing interest in Britain and France in the study of marine natural history, there was little readily accessible or standardised knowledge on the subject. Tacit knowledge was vital to the processes undertaken from the deck of the ship. As Jim Endersby argues, the *Erebus* was a network of non-expert collectors, who learnt thorough repetition.[11] Considering the example of Darwin aboard the *Beagle*, Sponsel argues that ‘specific techniques of observing and collecting could themselves help to generate a particular theoretical orientation’: such practical experiences were ‘a more proximate source of Darwin’s “Humboldtian” interest in distribution and diversity than Alexander von Humboldt’s writings themselves’.[12] These views of experience and tacit know-how – and their influence on the work of collection on the exploration vessel – are the focus of this chapter.

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[8] Deacon, Margaret. *Scientists and the Sea 1650-1900: A Study of Marine Science* (London and New York: London and New York Academic Press, 1971): 296.
[9] Sponsel, ‘An Amphibious Being’, 280.
[10] Rozwadowski, Helen. *Fathoming the Ocean: The Discovery and Exploration of the Deep Sea*, (Cambridge, MA and London: Harvard University Press, 2005): 101.
[11] Endersby, Jim. *Imperial Nature: Joseph Hooker and the Practices of Victorian Science* (Chicago and London: Chicago University Press, 2008): 43.
[12] Sponsel, ‘An Amphibious Being’, 254.

**Scientific instructions relevant to collecting**

One may begin the study of the act of collection on board ship by asking what, exactly, was to be acquired and why and how it was to be collected. The instructions issued by the sponsoring governments and scientific institutions are crucial here – a point not widely acknowledged in work to date.

The scientific instructions for the American expedition came from the American Philosophical Society. Naturalists Titian Ramsay Peale and Charles Pickering were members of the society and contributed greatly to the recommendations: they also sailed on the voyage themselves. Two other scientific members of the expedition were correspondents of the Academy: Joseph Couthouy, a conchologist, and James D. Dana, a mineralogist. The section for the American Report that dealt most heavily with collection was that entitled 'Zoology'.[13] The section was split between terrestrial and marine based activities.

The first recommendation was for the study of marine mammals: 'The Zoologists should be instructed to collect information of the baits, localities, times of gestation, food &c. of all the large mammiferous animals, such as Seals and Cetacea, that inhabit the southern oceans, and which constitute the great source of commerce in those seas'.[14] Whaling was of great commercial importance to the Americans in the 1830s and the recommendations ask specifically for observational studies to be made of their environment, although little specific instruction is given regarding the collection and processing of physical specimens at this juncture. Advice was also given regarding another of the commercially and nutritionally important species: fish. They read: 'In observing the Fish, it will be important that the

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[13] Conklin, Edwin G. 'Connection of the American Philosophical Society with Our First National Exploring Expedition', *Proceedings of the American Philosophical Society* 82 (5) (1940): 520.
[14] Conklin, 'Connection of the American Philosophical Society', 530.

zoologists should particularly remark, when, where and how they are taken, and whether they will be likely to be worthy of consideration in a commercial point of view, like the Cod, Mackarel [sic], Herring &c.'

The instructions continued with advice to: 'observe the various Turtles, and Molluscae with the same views [as the marine mammals]; the Pearl fisheries; to dredge the deep as well as shallow water for the numerous inhabitants of the ocean, and to ascertain as nearly as possible, the different depths at which these animals exist.' Dredging of deep water was a relatively untested technique in the 1830s. The instructions offered no advice on how to proceed with the practice, only that it should be conducted. The details were left to those on the voyage.

Whilst observations of habitat and life-history traits were important, they were not sufficient proof of sighting, or enough evidence for the classifiers at home to work with. The recommendations finished with a call to *collect* and *preserve*:

> To accomplish all the above views, it will be requisite for the persons employed to collect and prepare specimens, as far as practicable, of all the animals noticed, both as vouchers to the accuracy of the observations made, and to correct errors which might be committed in the hurry of a varied occupation: - it will be imperatively necessary that the Zoologists be liberally provided with appropriate Nets, Dredges, Boxes, Casks, Spirits, and all the various instruments and materials used for procuring and preserving specimens. They should also be provided with Books of reference, which they will require in order to be constantly aware of the labours of the predecessors in the same field.[15]

Whilst again the operational details are few, information on instruments and equipment for storage are briefly supplied and the importance of reference material is alluded to although not specifically named here. The instructions also stipulated that assistants should be qualified to collect, draw and prepare specimens for preservation. The credibility of the

[15] Conklin, 'Connection of the American Philosophical Society', 530-31.

scientific knowledge brought home from far-away seas rested upon ocular proof that what had been purported to exist actually did so. No sketch or diagram, no matter how well made and by whom, was quite as good at cementing truth claims as the thing itself.

In addition to the scientific recommendations, the sailing instructions to Wilkes made brief mention to the acts of collecting from the marine environment. Wilkes was ordered that:

> all phosphorescent lights, fishes, and all substances adhering to weeds, must not fail to claim attention, and specimens of them obtained. Fish caught must be preserved till opened in the presence of an officer, and their stomachs carefully examined, and of any thing is found, it must be taken care of. Things and animals that might in ordinary cases be deemed troublesome and useless, are not to be lost sight of, but are to be picked up for examination.[16]

The elevation of the examination of fish from the scientific recommendations alone to the government-sanctioned instructions for sailing indicates the importance that was attached to furthering knowledge on species that might be of scientific interest, a vital food source for those on aboard, and a possible basis for commercial or colonial development. The method of examination – being 'opened in the presence of an officer' – shows that this was a practice undertaken by crew rather than solely scientific staff. Crew were expected to perform the examination, but not trusted to do so accurately on their own. Important scientific work on the sea was witnessed, and its credibility vouched for, by reliable authorities. This was an official instruction.

The British expedition's scientific recommendations relating to collection are reproduced in Appendix IV. For the collection of rock and mineral specimens the officers were, as for the Americans, referred to extant publications rather than given explicit instructions. They were advised to avoid 'rarities', forming a collection instead that better

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[16] Wilkes, Charles. *Narrative of the United States Exploring Expedition during the Years 1838, 1839, 1840, 1841, 1842 … 5 vols. and Atlas* (5 vols, Philadelphia: Lea and Blanchard, 1845), I: 363-364.

represented the landscape they were travelling through.[17] The botanical section made no reference to marine flora.

The section of the Royal Society Report that dealt with the collection of zoological specimens contained the most information relevant to the marine environment, as had the American report. The first group dealt with was Crustacea and Mollusca. The investigator was advised to consider the development stages of specimens, examining them under a microscope. One species of Mollusca, *Spirula* (a species of deep-water squid-like cephalopod), was singled out for special attention. If possible, the movement of the species in water was to be observed, by bringing it on board and placing it in a vessel of sea water.[18] In this context there was an understanding that the details of the specimens collected were as important as the lived natural history, not just the lifeless bodies. More than this, the laboratory-like features of the ship were made apparent in bringing the sea on board the vessel and examining a part of it, and its contents, in a way so often denied to those on board from the deck alone. For fish, the 'mode and speed of swimming, living colour, temperature, and any other peculiarity, should be noticed before placing the specimen in spirit'.[19] Apart from the identification of a few species of particular interest (such as the Port Jackson Shark and the Southern *Chimaera*) and the need to preserve 'all external parasites', there is no more detailed information.[20]

The Instructions end with short paragraphs on reptiles, birds and mammalia, the latter relating exclusively to marine mammals: the sperm whale, elephant seal, and southern seal.

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[17] These publications included the concluding pages of 'Mr. Darwin's *Journal of his Voyage in the Beagle;* M. Cordier's *Geological Instructions for the voyage round the world of l'Astroble and La Zélée* and the instructions for the voyage of the *Bonite*.

[18] *Report of the President and Council of the Royal Society on the Instructions to be Prepared for the Scientific Expedition to the Antarctic Regions* (London, 1839): 38.

[19] *Report of the Royal Society*, 38.

[20] *Report of the Royal Society*, 39.

Despite the commercial aspects of these expeditions being apparent in the sailing instructions, and the importance of new fishing grounds emphasised, details regarding the collection and study of the creatures were few. That they were recorded when seen, that abundances were detailed, and species listed, was the only information required.

The French instructions relating to zoology were drafted by M. de Blainville (the French zoologist and anatomist) for the expedition of the *Bonite* in 1836. These instructions were comprehensive, and, as we have seen, the Académie deemed them useful enough to be re-issued, unchanged, a year later (see Chapter 3, pp.49-99). These recommendations began with a recognition that zoology was not to be the main, or even an important, facet of the voyage: '[the voyage] will unfortunately be that of relatively few, short breaks, [thus] the Académie will merely draw the attention of the commander and of the staff, to a few particular animals, inviting them, if they cannot obtain them themselves, at least to kindly report them to the friends of science they may encounter.[21] Collection was at once side-lined and subjugated to more important tasks.

Recommendations regarding sea mammals and fish were omitted entirely or offered only as vague statements regarding species, with little information regarding procedure. Experiments were called for on 'the nature of the gases contained in the swim bladder of fish, caught at depths and at fixed and varied latitudes, as well as investigating the phosphorescence seen in a large number of marine animals of different classes, even if it is a little known phenomenon'. More attention was given to the shellfish, and three species in particular: 'namely, *Spirula*, we have never seen this animal after the first encounter; *nautilus*, on which Mr. Owen gave interesting details some years ago, but has only been

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[21] Vaillant, M. *Voyage Autour du Monde Execute Pendant les Annèes 1836 et 1837 sur la Corvette La Bonite Commandée par M. Vaillant*. (Paris: Arthus Bertrand, 1845): 421.

found that one or two times, and finally the Argonaut, in the shell'.[22] Information regarding their whereabouts was given: 'these three animals, mainly found in the Indian Ocean, will probably not be observed in the open sea, and likely found in times of perfect calm, and perhaps most usually at nightfall'. The recommendations continued with the Académie noting that the officers did not 'neglect to observe and collect the microscopic shells of which the animals come to the surface of the sea in calm weather and nightfall; which can be done fairly easily with gauze nets or black crepe, dragged to the back of the ship and removed and checked frequently'. The authors believed that shellfish were under-represented in the French collections at home, as were the flexible polypiers, zoophytes and sea pens, deemed to be 'almost in the same situation, as they have been rather neglected since the expedition of Captain Baudin. It is likely that we will find many new things, and their collection should be tried for in all favourable circumstances.[23] These recommendations point to a specific and clear motivation to improve collections at home. Collection was not to be random but systematic: particular specimens were to be obtained and sent home. Details were given regarding their location and a means of their collection given.

The Académie concluded its recommendations with a hint towards experiment, inviting the voyages to do research 'whenever the opportunity arises on the temperature of mammals, birds, reptiles and fish, taking proper precautions so that the practices are exactly comparable´.[24] Experiment is rarely referred to in the zoological instructions for any of the expeditions considered here. The importance of standardization was seldom remarked upon. What was to be collected was clear enough. So too was the why. The how was almost entirely overlooked. As Burnett argues, it is the interpretative space left by what the

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[22] Vaillant, *Voyage autour du monde* , 421.
[23] Vaillant, *Voyage autour du monde* , 425
[24] Vaillant, *Voyage autour du monde*, 426.

instructions did *not* say that we should consider.[25] It is possible to propose two main reasons for this: first, the collection of specimens was of a relatively low priority. This is evidenced by the standing of zoology in general. In the reports published by the British Association for the Advancement of Science (BAAS) between 1835 and 1844, all the subjects relating to natural history were ranked lower than geology, geography, chemistry, mineralogy, mathematics and the physical sciences in terms of work published on each.[26] Collection and processing of zoological samples was time-consuming, and as the French authors pointed out at the beginning of their recommendations, the ships would have little time for it in the wider scheme of shipboard activity. Second, having scientifically trained personnel on board meant that much of the daily decision making regarding collecting was left to the personal interests of those involved. Collecting was never a coordinated whole-crew endeavour. That collection was subordinate to other procedures was made clear to the naturalists on board as the following sections show.

**Observation and collection: furthering knowledge of marine life in the southern oceans**

Observation did not need to yield a physical specimen: it was a form of knowledge with an epistemological significance different from the act of physical collection. Unverifiable through prior specimen or comparable measurement, its claim to significance rested in the observer and the recorder.

The processes of observing started early on all three voyages. Ross recorded that they took 'daily, almost hourly, observations of various kinds, from which so large a measure of

[25] Burnett, D. Graham. 'Hydrographic Disciple among the Navigators: Charting an "Empire of Commerce and Science" in the Nineteenth-Century Pacific. In James R. Akerman, *The Imperial Map*, (Chicago and London: University of Chicago Press, 2009): 188.
[26] Endersby, *Imperial Nature*, 37.

useful and important results were expected'.[27] D'Urville was less systematic about his early observations, but was clearly impressed by the marine and bird life that surrounded the ship, recording that 'with the good weather all species of sea creature reappeared around us. Albatross, petrels, damiers, played at the surface of the water, whilst countless bands of mackerel and bonito shook the water for a while', continuing 'we saw also some peaceful whales, revealing their presence to us by solitary jets of water accompanied by a dull and monotonous noise'.[28] The sight of familiar animals was reassuring; its absence was also keenly felt and noteworthy: d'Urville recorded later in the unfamiliar Antarctic environment: 'the most profound silence reigns amongst the frozen plains, and life is no longer represented by a few petrels, fluttering quietly, or whales whose dull and gloomy breath comes only to break this distressing monotony'.[29] D'Urville also made reference to the appearance of the valuable marine mammals species: 'we could easily see their blunt snouts, their acute, straight, dorsal fins, eighty to one hundred centimetres long, and the four yellow spots that stand out on the uniformly grey colour of their bodies'.[30]

Observation was not just confined to officers: Sergeant Cunningham of HMS *Terror* made repeated references to the number of fish around the ship in his journal.[31] Robert McCormick, surgeon on the *Erebus,* made detailed observations of bird life, including their interaction with marine species: 'the whales very numerous again to-day and I witnessed this evening a singular habit I had never before noticed. A flock of about 100 cape petrel

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[27] Ross, James Clark. *A Voyage of Discovery and Research in the Southern and Antarctic Regions during the Years 1839-1843* (London: John Murray, 1847), I:4.
[28] Dumont d'Urville, Jules. *Voyage au Pole Sud et dans l'Oceanie sur les Corvettes l'Astrolabe et la Zélée,* 1837-40, 10 volumes (Paris: Gide,1841), I: 47.
[29] D'Urville, *Voyage au Pole Sud,* II: 50.
[30] D'Urville, *Voyage au Pole Sud,* II: 130.
[31] Cunningham, W. 'The Journal of Sergeant William K. Cunningham, R. M. of HMS Terror'. In R. Campbell (ed), 'The Voyage of HMS Erebus and HMS Terror to the southern and Antarctic Regions', *Journal of the Hakluyt Society* (2009): 38-153.

following the whales'.[32] Hooker, assistant-surgeon on the *Erebus,* was fascinated by the variety of life that existed in the marine environment:

> [T]he extent of this branch of natural history is quite astonishing, the number of species of little winged & footed floating shells provided with wings, sails, bladders or swimmers appear marvellous. The causes of the luminousness*[sic]* of the sea I refer entirely to animals (living). I never yet saw the water flash without finding sufficient cause without electricity, phosphoric water, dead animal matter, or anything further than living animals (generally *Entomostracous Crustacea* if anybody asks you), the little shrimps are particularly numerous especially two species of them, thousands of one kind being caught in one night. Besides these the Pyrosoma, some Sertularias & other animals all help to illumine the sea.[33]

Observations of marine and bird activity served the interests of natural history and navigation both. Birds around the ship were often a sign that land was close; seals and penguins even stronger indicators. Peale described the sight of 'a Noddy (*Sterna Stolida*) near us but no other indications of proximity to land'.[34] This sort of keen observation was especially important in the Southern Ocean due to the constant proximity of icebergs. Entering these colder waters, Ross remarked that the sea had 'assumed its oceanic light blue colour, from which we inferred that the *ferruginous curinaculae*, which give a dirty brownish tint to the waters of the southern ocean, prefer the temperature which obtains in the vicinity of the pack'.[35] D'Urville was also made cognisant of the approaching ice pack from environmental indicators: 'The wind turned towards the north, the horizon became misty, the icebergs closed up, and the number of petrels of all species, especially the white petrel, was so great, that everything seemed to suggest we would soon meet land or the banquise [the

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[32] McCormick, Robert. *Voyages of Discovery in the Arctic and Antarctic seas, and Round the World* (London: S. Low, Marston, Searle, and Rivington, 1884): 341-2.
[33] Joseph Hooker Correspondence Project. Archives of the Royal Botanic Gardens, Kew. Antarctic Correspondence. JDH/1/2 f.26-27. Joseph Hooker to William Hooker, 17 March 1840.
[34] Poesch, Jessie. *Titan Ramsey Peale 1799-1855 and his Journals of the Wilkes expedition* (Philadelphia: The American Philosophical Society): 129.
[35] Ross, *A Voyage of Discovery and Research,* II: 214.

French term for the Antarctic ice barrier]'.[36] The absence of life was also relevant and anticipated entry into the open ocean. On leaving the Pacific for Antarctic waters, d'Urville recalled that 'all around the ships, many hooks offered misleading bait for the flocks of sea-birds which fought with countless groups of flying fish, leaping at the surface of the water. Then, as we entered the open sea, the birds disappeared, the sea swelled four or five metres higher, but we became alone, the fish no longer came to ride the frothy waves; we left the warm water of the tropics and its inhabitants'.[37] Close attention to constants and change in the ocean and its inhabitants was indelibly linked to navigation for the officers and crew at sea, signalling the approach or disappearance of land and physical obstructions. More than this it provided an emotional connection to the often stark marine landscape for those away from home for long periods of time.

Collecting specimens signalled a desire to stake a claim not only upon new territory, but also upon the space beneath the ship. Collected items served as proof that what was claimed to exist did exist and had been seen. Collecting and classifying the marine inhabitants conferred a sense of ownership upon the content of those spaces. Whilst furthering political goals may have been one reason for procuring specimens (as implicit in the sailing instructions and scientific recommendations), the reasons behind acts of collection varied between personnel, ship and location.

Collection was a quotidian practice that added new examples to species already known, and expanded established collections. Captains were often unhappy that their naturalists spent large amounts of time on land. Restrictions upon time spent offshore in many nineteenth-century voyages of exploration increased the once unpopular activity of

[36] D'Urville, *Voyage au Pole Sud*, II: 242.
[37] D'Urville, *Voyage au Pole Sud*, VIII: 73.

collecting specimens from the sea rather than the more familiar artefacts from land. In 1841, Hooker observed that ‘we are comparatively seldom off the sea, and then in the most unpropitious seasons for travelling or collecting. This is my main reason for devoting my time to the Crustacea, Etc., a study to which I am not attached and have no intention sticking to’.[38] Hooker wrote frequently to his father throughout the course of the expedition detailing his work on crustacea and other marine invertebrates: his opinion of his subject matter varied according to his mood, but the most pervasive feeling expressed to his father was one of ‘making-do’.[39] Given the nature of the expedition, one might have expected Hooker to have been better prepared for spending lengthy periods at sea but this was not so. Darwin had been able to spend three-fifths of his time away on land, with his interest predominantly on the geology.[40] Hooker turned to the inhabitants of the marine environment when it became obvious he would have little opportunity to collect on land: marine zoology was a necessity before it became an interest.

Objects were routinely collected based on their strange and curious appearance rather than from any prior notion of what should be brought on deck. McCormick recorded in his journal that the ‘sea [was] very luminous’, attributing it to ‘clusters of minute animalcule – caught some in a bucket’.[41] On reaching the cold Antarctic waters, d’Urville recorded that: ‘it is needless to add that curiosity alone for some, and the interest in science for others inspired

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[38] Huxley, Leonard. *Life and letters of Sir Joseph Dalton Hooker: Based on Materials Collected and Arranged by Lady Hooker* (London: John Murray Publishing, 1918): 113.
[39] See Chapter 6, pp.204-69 for more examples of Hooker’s interaction with the crustacea.
[40] Williams, Glyn. *Naturalists at Sea: From Dampier to Darwin* (New Haven & London: Yale University Press, 2013): 233-234.
[41] Wellcome, MSS.3366, Book 2. The Wellcome Institute also holds MS 3369: a meterological register from the *Erebus*. This was not the focus of this thesis and material from this source is not included here, although the emphasis on enumeration and shipboard safety relevant to investigations of the marine environment were likewise important considerations in the collection of meterological data. See for example: Naylor, Simon. ‘Log Books and the Law of Storms: Maritime Meteorology and the British Admiralty in the Nineteenth Century’, *Isis* 106 (2016): 797.

all members of the crew without exception'.[42] For the French, there was a clear distinction between curiosity and scientific interest. Before the clear definition of any programme of marine science, any reason for paying closer attention to what lay on and beneath the waves drove the emergence of this new branch of the natural sciences. Collecting out of curiosity, just like more formulaic collection in answer to specific scientific recommendations resulted in the discovery of new species and affirmation of those known.

The shooting of birds from the ship, as on land, was an important source of specimens, a welcome source of food for the crew, and for some a pleasurable pastime. Midshipman Reynolds of the *USS Vincennes*, stated 'I shot a beautiful bird of the Heron kind – of white and delicate plumage, the only one of the kind that has been obtained. He makes a fine specimen for the Naturalists and had not his species been already supplied with a name, I should have had him termed the *Rinaldius*'.[43] The means of collecting birds differed across the expeditions, and was additionally dependent on the species involved, but many were attracted by the bait hooks meant for fish. The American expedition caught several albatross with small hooks and the British expedition took gigantic albatross and cape pigeons with fishing lines, as well as by baited hooks slung over the side of the ship and soaked in salt water. D'Urville recorded 'we took several sea-birds on a line, such as damiers, puffins, and some sooty albatross'.[44] On board the *Vincennes*, a crew member recorded, 'I noticed that the Mother Carys Chickens that hovered around the vessel were much larger than those we generally meet with near our coast, although in every respect apparently the same – some of them were entangled in twine and retained as specimens by Mr. Peale who was as ever on the

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[42] D'Urville, *Voyage au Pole* Sud, II: 68.
[43] Cleaver, Anne Hoffman and Stann, E.J. (eds) *Voyage to the Southern Ocean – Letters of Lieutenant William Reynolds of the United States Exploring Expedition 1838-1842* (Annapolis: Naval Institute Press, 1988): 83.
[44] D'Urville, *Voyage au Pole Sud*, II: 127.

*que vive* to add to his collections'.[45] On leaving the Torres Strait, d'Urville commented that there was 'not a day that our fishermen do not harpoon some porpoises and some sharks are not taken on the swivel hook'.[46] This was not just the production of knowledge by observation and experiment but science by slaughter.

The method most widely used though was shooting. Improvements in firearms at the beginning of the nineteenth century were particularly useful to bird collectors. Instruction manuals for shooting birds at this time were 'virtually silent as to technique'– assuming the average gentleman bird enthusiast would be a proficient shot already.[47] Bird shooting was seen as legitimate recreation. Time was given for gun practice. D'Urville recorded that 'the crew then practised shooting their muskets at a white object hanging from the foreyard, five shots per man'.[48] Shooting well was an important aid to establishing social position: recent scholarship has argued that military men of rank who undertook ornithological activities would make better officers.[49]

McCormick, the British surgeon, was more interested in collecting birds than all other ship board activities: he recorded numerous and varied examples of collecting of birds from the deck of the expedition vessel: 'being anxious to secure an early specimen of this rare and beautiful bird [white petrel] for the collection, I seated myself in the gallery, on the port-side of the quarter-deck, with my old double-barrelled gun in my hand'.[50] When his own weapon was not available he readily borrowed from others, 'I shot several small birds for the

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[45] Poesch, *Titan Ramsey Peale*, 70.
[46] Rosenman, *An Account in 2 Volume*, 383.
[47] Larsen Hollerbach, Anne. 'Of Sangfroid and Sphinx Moths: Cruelty, Public Relations, and the Growth of Entomology in England, 1800-1840', *Osiris* (2nd Ser.) 11 (1996): 206.
[48] D'Urville, *Voyage au Pole Sud*, III: 124.
[49] Greer, Kirsten. 'Placing colonial ornithology: imperial ambiguities in Upper Canada, 1791-1841', *Scientia Canadensis* 31 (1-2) (2008): 112.
[50] McCormick, *Voyages of Discovery*, 145.

collection with foreman's gun'.[51]The small boats for the ship were also readily put to use in the collection of shot specimens, 'I shot a young herring gull from the stern of the ship, it fell at some distance, and a shore-boat pulling astern of us picked it up, and brought it alongside to me.'[52] McCormick's long-held interest in the collection of birds inspired an eclectic use of the ship's resources.

The unexplored Antarctic environment supplied many new species of bird for McCormick: birds were central to his work on *Erebus*. On getting into trouble on the way back from a collection trip on a small boat he recalled, 'to lighten her and increase her buoyancy, my worthy colleague ventured, though reluctantly, to propose that my boxes of specimens should be thrown overboard as a sacrifice to the storm. But this was expecting too much from me after all the toil and risk I had undergone in collecting them' [53]

Hooker was also interested in the white petrel, unique to the Antarctic: not for his own collection but to send home. In a letter to his aunt Palgrave he wrote:

> I have not, however, forgotten my cousins, but have a white Petrel for them, actually shot within the 78th degree of S[outhern] Latitude: they are most beautiful creatures & our constant companions when in, or near, the Pack Ice, flying over, or round, our Ships, or hovering on the crests of the waves, & picking up the marine animals, with extraordinary agility. They do not take the baited hook, like other Petrels; but must be shot when flying to windward, whence they fall on board. Hence it is very difficult to procure good specimens, & they are so very fat & full of oil, that the skinning of them proves a troublesome job.[54]

Hooker, by contrast, was not so taken by the variety of species in Antarctic *waters*. In a letter to his cousin William Palgrave he wrote: 'The whole Antarctic Ocean is very barren of anything interesting, except the curious Birds called Penguins & some of the marine

[51] Wellcome, MSS.3367, Book 6
[52] Welcome, MSS.3366, Book 1
[53] McCormick, *Voyages of Discovery*, 83.
[54] JDH/1/2 f.89-90. Joseph Hooker to Elizabeth Hooker, 25 April 1842.

animals. You would enjoy yourself far better fishing for Pike & Eels in Irstead Broad, than in any employment whatever down to the Southward.'[55]

Most forms of collection were opportunistic rather than systematic. Hooker referred to harpooning seaweeds as the ship sailed past interesting-looking floating masses and Peale reported the spearing of dolphins in the same way, as well as optimistic shooting at whales.[56] Butterflies, bats, moths and birds when landed on board were captured and killed; insects swimming near the ship were collected. McCormick recorded a prime case of opportunistic collecting when a small cuttlefish fell on board the ship, 'a number of sepia fell on board, between 20 and 30 were picked up. I picked up one of the animals on the starboard side alive. It pulsated strongly in my hand and in putting it into a flask of sea water, it emitted its ink-bag of dark fluid. It soon died.'[57]This moment of collection provided not only the initial act of collecting but also the opportunity to witness the animal's behaviours.[58]

One fortuitous instance of collection came late in the British expedition, when a small ice-fish, *Pagatodes*, typical of species found in the high southern latitudes but then unknown to science, was brought on board ship (Figure 1). John Richardson, the naturalist and arctic veteran, described its collection and classification in the zoological volume accompanying the voyage, enlarging on Ross's own account from his published narrative:

> when the ships were in the high latitudes of 77° 10'S., and long. 178 ½°, a fish was thrown up by the spray in a gale of wind, against the bows of the Terror, and frozen there, It was carefully removed, for the purpose of preservation, and a rough sketch was made of it by the surgeon, John Robertson, Esq., but before it could be put in spirits a cat carried it away from his cabin, and ate it.....we have introduced a copy of

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[55] JDH/1/2 f.207. Joseph Hooker to William Palgrave, 28 April 1843.
[56] JDH/1/2 f.26-27 Joseph Hooker to William Hooker, 17 March 1840; Poesch, *Titan Ramsey Peale,* 143.
[57] Wellcome, MSS.3366, Book 3
[58] McCormick, *Voyages of Discovery*, 35.

> the design, merely to preserve a memorial of what appears to be a novel form, discovered under such peculiar circumstances.' [59]

This example highlights the extreme conditions the ship was operating under in Antarctic waters. Despite these conditions, the specimen was noticed by a member of the expedition, and collected, sketched, and laid out for preservation so that both a two-dimensional 'inscription' of the specimen was supplied along with the animal itself. That the specimen was stolen by one of the 'intervening' forces on board – the ship's cat – highlights the many obstacles collectors faced.

[59] Richardson, John and Gray, John. *The Zoology of the Voyage of the H.M.S Erebus and Terror, under the Command of Cpt Sir James Clark Ross, during the years 1839 to 1843* (London: E. W. Jansen, 1844): 15.

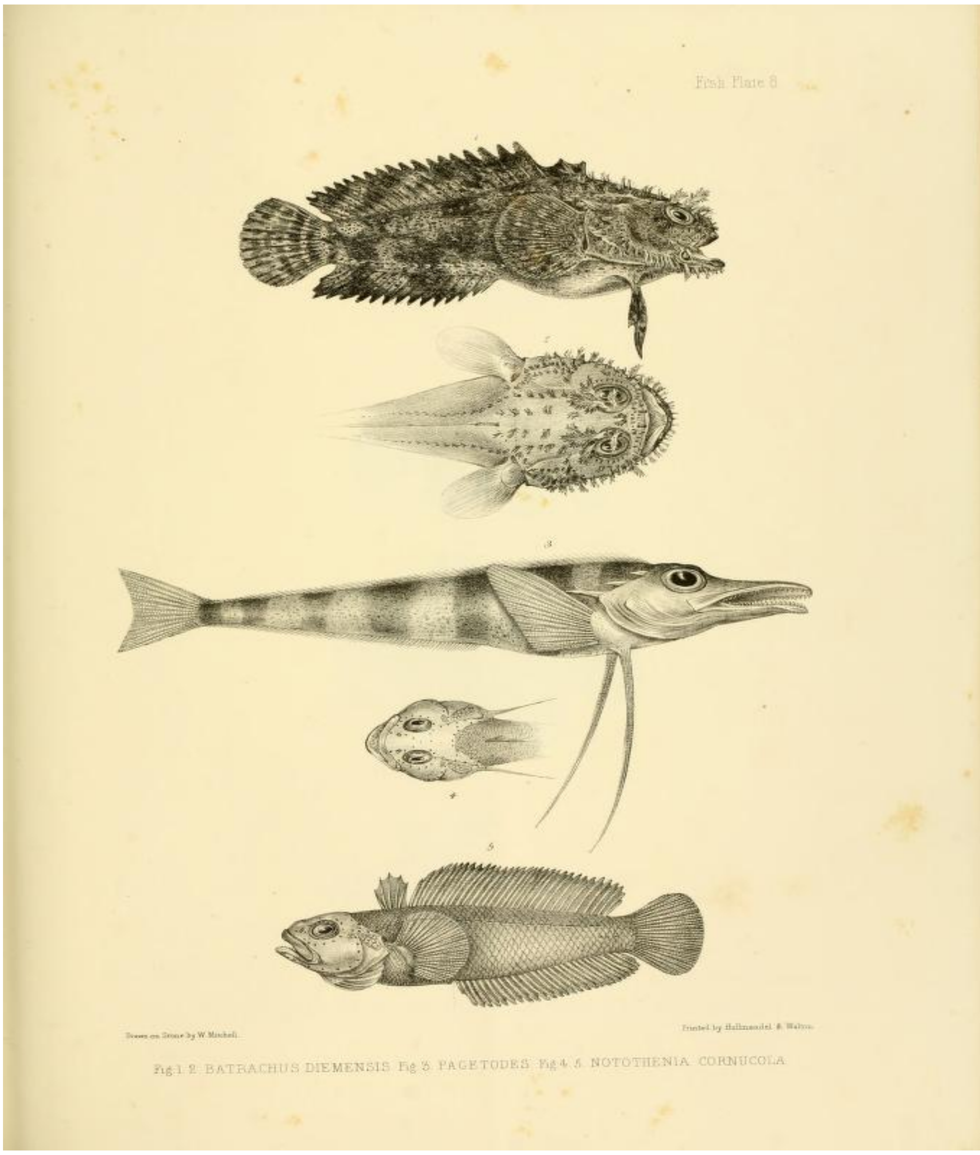


Figure 1: *Pagatodes*: the ice-fish brought on deck in a storm and frozen there, only to be later eaten by the ship's cat. (From John Richardson and John Gray, *The Zoology of the Voyage of the H.M.S Erebus and Terror, under the Command of Cpt Sir James Clark Ross, during the years 1839 to 1843* [London: E. W. Jansen, 1844], 15, courtesy of the RGS-IBG, London).

For all three expeditions, the scientific recommendations were virtually silent regarding the operational procedures involved in catching and preserving specimens. In his travel narrative McCormick understood that practical details were vital to the would-be collector. Recalling occasions where birds he had shot missed the ship's deck he wrote: 'This afternoon I shot two pintados from the deek[*sic*], from near the fore-rigging, both to windward. The first bird fell when the ship was on the starboard-tack, striking the gunwale just abaft the main-rigging, and bounding overboard. The second biid[sic] was flying before me, when on the port-tack, hovering over the fore-topsail yard, falling to leeward on the forecastle, and was picked up by one of the crew, and brought to me'. He continued: 'I have been minute in what may appear trifling details under the impression that it may prove of service to others, who may hereafter be placed under similar circumstances as myself, with a desire to secure rare or new species of birds with no boat which they could be picked up'.[60] McCormick was also expressing here in print a long-held frustration over the lack of opportunity he was afforded to collect specimens, the result of orders from Ross.

Wilkes was keen to point out that specimens would prove important for collections at home. This being so, collecting sought to give some prior consideration to species type, and where it could, directly meet aims demanded by the instructions for sailing, procuring examples of creatures hitherto unseen. Many new species of fish were taken off Bellingshausen Island, which Wilkes believed would be most sought after by the Department of Natural History in Philadelphia. Wilkes recorded many unsuccessful attempts to secure a petrel here, one finally being shot by Peale with boats lowered for its retrieval. Both Ross and Wilkes described the pursuit of particular bird species in order to obtain specimens for an extant collection with Ross recording: 'numbers of the young pintado [cape petrel] were flying about, and one shot by Mr McCormick fell on board, it was the first specimen of the kind we obtained'.[61]

Attempts at collection were often unsuccessful. Attempting to secure a chinois, d'Urville was forced to admit that although they were very common on the shore, 'having been mistaken for the white petrel, it had been completely neglected and everyone was

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[60] McCormick, *Voyages of Discovery*, 158.
[61] Ross, *A Voyage of Discovery and Research*, I: 200.

involved with the penguins. It resulted that the *Astrolabe* remained deprived of these good individuals of each species, because in all the rest of the campaign, no other favourable occasion returned for their collection'.[62] Once the opportunity had passed, there was no certainty it would come again; collectors had to be vigilant. Often specimens were observed but were just out of reach. Dumont d'Urville expressed the loss: 'finally I saw two species of jellyfish, quite strange, and I shipped the boat to collect them, but could not retrieve them'.[63] A basic understanding of foreign animal physiology led to the loss of many penguins, lost when their feet were tied together, and the crew, not realising that the animals would still be able to drag themselves to the water, left them unattended. In other cases, the continual failure to capture a desired specimen forced the collector to reconsider tactics. Peale recorded in his journal they, 'had an unusual number of *Procellaria* [a southern long-tailed seabird] round us. I tried catching them with a fishing line but did not succeed until we prepared a light thread line without a hook, with that we caught four in a short time'.[64]

### Death on the expedition vessel

Flightless penguins, a bird that spent much of its time in the waters surrounding the ship, were of particular interest to all three expeditions. The novelty of the different species, their size and visual allure made penguins one of the most desirable specimens to collect. All the expeditions' narratives and private journals contain multiple descriptions of their physical traits, life history, and, most commonly, their death (Figure 2).

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[62] D'Urville, *Voyage au Pole Sud*, II: 133.
[63] D'Urville, *Voyage au Pole Sud*, II: 153.
[64] Poesch, *Titan Ramsey Peale*, 132.


Figure 2: 'Catching the Great Penguins' by Joseph Hooker (From James Clark Ross- *A Voyage of Discovery and Research* Volume II [London: John Murray, 1847]).

Charles Erskine, crewman aboard the American expedition, recalled that the capturing of the birds had left the sailor's 'bodies and limbs covered with bruises'.[65] Wilkes wrote of the amusement the birds' capture afforded the crew, 'it was an amazing sight to see them [the crew] associated in pairs, thus employed, and the eagerness with which the sailors attacked them with oars and boat-hooks'.[66] Whilst usually taken from land, where the penguins were slower and ungainly, this involved the deployment of small boats in an often dangerous swell. McCormick described how on an ice floe he had 'knocked down an old penguin with my geological hammer, and put it in my knapsack, with a few specimens of the rock,' so providing information on the size of the creature and the multi-purposeness of one of his instruments.[67] On a different date he recounted, 'a number of penguins were assembled on the

[65] Erskine, Charles. *Twenty years before the mast* (Washington D.C: Smithsonian Institute Press, 1890): 116.
[66] Wilkes, *Narrative of the United States Exploring Expedition*, I: 143.
[67] Wellcome, MSS.3367, Book 7.

beach', continuing, 'I shot 5 of them by discharging my double barrelled gun and caught another and brought it on board alive; it became savage when captured.'[68]

Ross described the difficulty in killing three specimens of large penguin that were eventually brought on board and eaten, but they proved unpopular: the flesh was dark, rank, and fishy in flavour. Ross wrote: 'it was a very difficult matter to kill them, and a most cruel operation, until we resorted to hydrochloric acid of which a tablespoonful effectually accomplished the purpose in less than a minute'.[69]

It was not just the Antarctic's penguins that attracted those expedition members blood-lust. The abundant seals were also a target. McCormick recorded the details of a chase in his journal:

> The *Terror's* people attacked a large seal on the beach. The animal on being wounded escaped them. I took the water and a boat shored off in chase of and despatched him, hauling him up on the south side of the harbour. I landed in another boat as soon as I heard of the chase, and was just in time to witness his last struggles. Had him hauled above high water mark in the boat, and skinned, leaving the skeleton and it, to be cleaned by the numerous birds. [70]

Not all of those on aboard the expeditions witnessed the act of killing so dispassionately. Midshipman Reynolds of the American expedition wrote in a letter home that, 'one of the boats brought on board a mammoth penguin', continuing 'he was cruelly put to death that his skin might be preserved for the satisfaction of those who are content to see the curious things of the world second hand'.[71] Reynolds obviously identified with the animal – his use of the pronoun 'he' rather than 'it' speaks to an emotional connection to the creature. Describing the death of a dolphin on board the *Peacock*, Titian Ramsay Peale had

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[68] Wellcome, MSS.3367, Book 5
[69] Ross, *A Voyage of Discovery and Research*, II: 158.
[70] Wellcome, MSS.3367, Book 5
[71] Cleaver, *Voyage to the Southern Ocean*, 51.

time to reflect: 'I hastened to witness its colours whilst dying. I found them to be truly beautiful as they have been described'. But he continued 'that 'the sight however, was painful from a kind of sympathy with the beautiful sufferer. I could but feel that the gratification of my curiosity was at the expense of its life'.[72] Peale's expressed reluctance over taking the life of his captured specimen highlights the fact recounted so often in the surviving material from this time: that in order to learn more about life in the oceans, that life was necessarily extinguished. Here can be seen an emergence of sensitivity to the natural world, very often overlooked in the desire to capture marine life for food or display. In the collection of specimens for science there was, at times, real sympathy for the life taken.

Dumont d'Urville made sure to record the pleasure the penguins had for the crew whilst alive: 'They entertained us above all by the admirable quickness of their movements. As much as their gait on land is ridiculous, once in water, they develop flexibility and agility. It is especially swimming in mid water that they surpass other birds'. He added further:

> Nothing was as pleasing as to see, following a stroke underwater, [penguins] arise suddenly shaking their heads, and then consider us blackly and let out their bizarre cry. Our crew imitated it, and it is said, that the brave penguin liked to continue the conversation until the moment when envy made it make a new dive and continue the game. This poor animal, so lacking in defence ashore, is nearly unattainable in the water. It is very difficult to shoot and the most heavy shot slips on its thick fur'.[73]

These comments on the bird's behaviour, physicality and vocalization were a record of living animals, and a remembrance of some of the facets that made the creatures, when alive, so new and exciting for those unfamiliar with their habitat and natural history.

McCormick similarly expressed his reluctance and sorrow at the killing of animals he so prized. On the British expedition's third attempt on the South Pole he recorded:

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[72] Poesch, *Titan Ramsey Peale*, 70
[73] D'Urville, *Voyage au Pole Sud*, II:73

> I am sorry to record here, as I do reluctantly and with remorse, that I was the cause of an instance of devotion and affection in the animal creation, which, however interesting to the naturalist as a study of animals' life was most painful to witness. I happened to fire at a white petrel as it flew past me, when it fell on a treacherous part of the floe. I lost it, but its mate, flying in the company with it at the time, instantly alighted near the wounded bird.[74]

On another occasion he referred to the penguins:

> [F]or notwithstanding that my duties as ornithologist compel me to tales the lives of these most beautiful and interesting creatures of all the works of their great creator, I never do so without a sharp sting of pain and qualm of conscience, so fond am I of all the feathered race. But as we have to sacrifice their lives for our food, we cannot do otherwise that to meet the claims of science in the same spirit'.[75]

McCormick makes clear that birds were often taken to provide fresh meat for those on board, and in describing scientific imperatives in the same vein attempts to raise it to ship board necessity rather than mere idle curiosity, pre-empting the likely distaste many of the reading public would have felt for such numerous descriptions of death during the expedition. The taking of life on the expedition vessel – for food or study – was ubiquitous and as quotidian as any of the more technical practices performed on board ship.

There was an intricate and embodied relationship between the crew and the animals they encountered. Specimens could also be foodstuffs, prepared for the table rather than study. The British zoological volumes contain numerous references to fish that were described in the main part by their qualities of taste and texture. The phrase 'good eating' was used commonly, and species were described as being 'prized' as a food. Information of this type was collected frequently from those encountered on land: 'Mr. Mapriere informs me that this wrasse and the following one form a coarse food, disagreeable to some palates, but not his'.[76] The importance of fish as a source of nutrition often outweighed its importance as a

[74] McCormick, *Voyages of Discovery*, 256.
[75] McCormick, *Voyages of Discovery*, 170.
[76] Richardson and Gray, *The Zoology of the Voyage of the H.M.S Erebus and Terror*, 128.

scientific specimen. There is evidence that in the hustle and bustle of the ship's deck specimens new to science were whisked away before they were fully examined. Richardson writes of the species *Labrus Inscriptus* that 'after a sketch of Lesson's specimen was taken, the fish was eaten, so no comparative examination of the species has yet been made'.[77]

Those on board frequently referred to the importance of eating what they had caught. Sergeant Cunningham recorded in his journal that they had, 'dined off one of the Penguins and very fine it was – it was cooked in a Sea Pie, had no taste whatever of fish as some of them I have eat'.[78] Later he wrote that they had 'dissected Mr Jack Shark and I may say every man on aboard had a Splendid Blow out of his carcass; his flesh was white as milk and not the least rank'.[79] The catch was of such significance to those on board that the shark became an honorary member of the crew – 'Jack Tar' being a common term to refer to seamen at this time. McCormick showed that it was not just the crew who were surviving from the fruits of their fishing activities, recording that he had 'some dolphin for breakfast caught yesterday and again at dinner, at Captain Ross's table'.[80] He also recorded that he had 'cormorant soup for supper', and on the day after Christmas day (which occasioned a special meal of beef) recorded, 'three dolphins caught today, had some for dinner.'[81] On another occasion McCormick recorded in his diary that he had seen '3 bonito hauled up to the deck caught with the hook and line. Saw several white tern and some porpoises. Had some of the Bonito

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[77] Richardson and Gray, *The Zoology of the Voyage of the H.M.S Erebus and Terror*, 135. Lesson was a naturalist aboard the *Coquille*, one of the ships in Dumont d'Urville's second Pacific expedition in 1829.
[78] Cunningham, *The Journal of Sergeant William K. Cunningham*, 73.
[79] Cunningham, *The Journal of Sergeant William K. Cunningham*, 47.
[80] McCormick, *Voyages of Discovery*, 26.
[81] Wellcome, MSS.3366, Book 2

for dinner.'[82] Other meals sounded less appealing, such as the frequent servings of 'bird-soup supper'.[83]

Dumont d'Urville recorded that at one stage 'a dozen superb breams were surrounding the corvette. One of our sailors, a skilled harpooner, soon brought back on board two of these fish, about three feet long. This dish was very well received at our table, and it's most unfortunate that these good fortunes arrive so rarely.[84]As well as fish and dolphin, other marine meats were tested for their suitability as foodstuffs. Tasting a new species of turtle Wilkes described the flesh as 'coarse, and was drier than that of the green turtle'.[85] The French crew 'feasted on the flesh of seals, although it is dark, oily and leathery', but seemed not to be put off at the chance of consuming some fresh meat.[86] Later, catching more seal, the third in command of the French expedition, Louis-François-Gaston-Marie-Auguste Roquemaurel, recorded that 'some of these animals were stunned or slaughtered. Only one was dragged aboard', continuing, '[t]he other seals remained on site. The skin was removed, the head and the liver were good to eat. The rest was the prey of giant petrels or the other seals who did not have any scruples about devouring their companions'.[87] Eating what was collected from around the ship was vital to the wellbeing of those on board, and also supplied information on the environment that may prove vital to the establishment of new colonies overseas. These meals, to use Livingstone's phrase were experiments in 'gustatory

[82] Wellcome, MSS.3366, Book 3
[83] Welcome, MSS.3367, Book 5
[84] D'Urville, *Voyage au Pole Sud*, I:47
[85] Wilkes, *Narrative of the United States Exploring Expedition*, II: 64.
[86] D'Urville, *Voyage au Pole Sud*, II: 110.
[87] D'Urville, *Voyage au Pole Sud*, II: 262.

geography'.[88] Such meals provided 'geographical knowledge though sensory and social experience', and as such were important facets of at-sea life.[89]

**Technologies of collection: sounding, dredging and casting the net**

Use of the dredge for scientific purposes was first recorded by the Italian Luigi Ferdinando Marsigli (1658-1730).[90] Dredges were derived from those used by oyster fishermen, but with a reduced mesh size to catch the smallest of bottom dwelling creatures. Before the 1840s, however, the dredge tended to be based on whatever style of dredge the local fishermen were using. The dredge was a very heavy piece of equipment, difficult to lift, and required a thick rope to drag it across the sea bed. On his Arctic expedition in 1829-1833 John Ross had been able to dredge only to a limit of 70 fathoms (itself a deep water dredge at the time) due to the man power required to turn the capstan hauling in the line.[91] The first to use the dredge in deeper water was by the Danish naturalist Otto Frederic Müllar (1730-1784) who designed a modified version of the oyster dredge known as the naturalist's dredge, which was used on board the expeditions here studied (see also Appendix III).[92]

Specimens from the sea bed were collected in one of two ways: by the dredge or the sounding lead. The benefit of the sounding device was its size. It was smaller and lighter than the heavy, cumbersome dredge and could be wielded more easily, more rapidly and sent

[88] Livingstone, David. *Putting Science in its Place: Geographies of Scientific Knowledge* (Chicago and London: University of Chicago Press, 2003): 57.
[89] Baigent, Elizabeth. 'Sir Arthur de Capell Brooke (1791-1858)'. In Hayden Lorimer and Charlie W. J. Withers (eds), *Geographers: Bibliographical Studies, vol 32*. (London and NY: Bloomsbury, 2013): 156.
[90] Rehbock, Philip F. 'The Early Dredgers: "Naturalizing" in British Seas, 1830-1850', *Journal of the History of Biology* 12(2) (1979): 295.
[91] For more on the dredge at this time see: McConnell, Anita. *Historical Instruments in Oceanography* (London: Her Majesty's Stationery Office, 1981).
[92] Rehbock, 'The Early Dredgers', 296

deeper. The lead, as Sponsel argues, 'captured samples in a fashion that went against the grain of ordinary natural history practice. Using the sounding lead meant gathering whatever was to be found in a particular location on the seafloor, rather than setting out to collect organisms belonging to a particular group.'[93]These specimens came on board with additional information about their spatial location and the depth from which they were collected. The British expedition used John Ross's 'deep sea clamm' as their main sounding device (see Appendix III for full details). This device acted in much the same way as the sounding lead: coated in tallow, it collected specimens from the seabed and brought them to the surface, while measuring the distance to the sea floor.

Use of the sounding device brought up an entirely random selection of marine specimens. Ross described the lead bringing up black stones at one stage, which to Ross, confirmed the volcanic origin of the sea bed. Living corals were also brought up from over 1000 feet below sea level. Ross recognised several of the species from his Arctic voyages and noted how 'the extreme pressure at the greatest depth does not appear to affect these creatures'.[94] The deep sea clamm brought up mud, sand and small stones as well as fragments of starfish and coral.[95]

The practices of retrieving and examining part of the sea floor, though time consuming, were undertaken on a regular basis by the British. Hooker wrote to his father that '[s]ince leaving St Helena, my time has been employed exactly as before [,] the net is constantly over board'.[96] To N. B. Ward, he wrote: 'I have been unable, with the constant use of the towing net, in all practicable weather, & a minute examination of the dredge, to

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[93] Sponsel, 'An Amphibious Being', 255.
[94] Ross, *A Voyage of Discovery and Research*, I: 202.
[95] Ross, *A Voyage of Discovery and Research*, I: 204.
[96] JDH/1/2 f.26-27. Joseph Hooker to William Hooker, 17 March 1840.

discover more than one seaplant [sic] within the Antarctic circle and it belongs to the very dubious Genus Diatoma'.[97] To his sister Hooker wrote: 'All yesterday I was employed dredging for shells & sailing about the harbor*[sic]* with a fine breeze & altogether I picked up a good many things after a hard day's work; though there were but very few shells & only one scarce shell alive, a fine specimen of the rare Voluta magellanica, the first I have seen & which, of course, goes to the Government Collection'.[98]

For Hooker, the reason for the frequent investigation of the marine environment stemmed from Ross's interest in life in the deep sea that allowed time from other ship board tasks to be devoted to plumbing the depths. Hooker wrote to this father:

> No other vessel or collection can ever enjoy the opportunities of constant sounding & dredging & the use of the Towing net that we do, nor is it probable that any future collector will have a Captain so devoted to the cause of Marine Zoology & so constantly on the alert to snatch the most trifling opportunities of adding to the collection, & lastly it is my only means of improving the expedition much to my own advantage (as far as fame goes) or to the public for whom I am bound to use my best endeavours.[99]

Ross set out with prior conceptions about what he was likely to find, and the belief, instigated by Edward Forbes, that animal life could not exist in water deeper than 300 fathoms, was a spur to his persistent interest in deep-sea sounding and dredging. Ross commented that 'contrary to the general belief of naturalists, I have no doubt that from however great a depth we may be enabled to bring up mud and stones of the bed of the ocean, we shall find them teeming with life'. Material was collected from new depths of over 400 fathoms were reached.[100]

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[97] JDH/1/2 f.107-110. Joseph Hooker to N. B. Ward, 13 June 1842.
[98] JDH/1/2 f.117-119. Joseph Hooker to Maria Hooker, 4 September 1842.
[99] JDH/1/2 f.99-100. Joseph Hooker to William Hooker, 28 April 1842.
[100] Ross, *A Voyage of Discovery and Research*, I: 208.

Wilkes also used the dredge as a means of collection. He instructed his crews to dredge in all harbours and asked that they dredge when possible in deep water, stating that the results would be 'more rare and valuable for doing so'.[101] Wilkes reported that, 'the dredge continued to be used, and with success, and many interesting objects were obtained: among them terebratulas, chitins, corallines, sponges, many small and large crustaceans, animals and large volutes'.[102] The pleasure of the undertaking, however, was not always contingent on the perceived success. D'Urville recorded, 'I enjoyed a dredge with my baleniere [type of dredge]. I never brought up huge bundles of *balmites*; one *fasciolaire* and two or three *terebratules* are the only fruits of my efforts'.[103] The absence of life was often as telling as its presence and of particular interest in shallow water close to land, where the ships were likely to harbour, and levels of fishing and collecting likely to increase.

Fish were collected in a variety of towing nets. The American expedition used a seine net, adding what they believed to be new species in botany, conchology, zoophytes, and fossils as a result. On occasion, the everyday important activities of the ship occurred in direct opposition to the act of collection. Peale referred to the ship travelling too fast to catch fish.[104] Catching fish was not a task of simply throwing a net over the side when the ship was moving, or dangling a rod from the side of a small boat when at standstill. Fishing could be physically demanding and potentially dangerous. The zoological volume of the British expedition noted that when catching the species *Plectropoma Dentex* with a hook, 'if the fishermen be not on his guard it is apt to use its remarkably strong canine teeth very effectively, and to bite him severely'.[105] In their later volume on ichthyology, Richardson and

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[101] Wilkes, *Narrative of the United States Exploring Expedition*, IV:524
[102] Wilkes, *Narrative of the United States Exploring Expedition*, I: 112.
[103] D'Urville, *Voyage au Pole Sud*, I: 110-111.
[104] Poesch, *Titan Ramsey Peale*, 129.
[105] Richardson and Gray, *The Zoology of the Voyage of the H.M.S Erebus and Terror*, 117.

Gray recognised the work of the British expedition: 'Sir James Ross's success in the discovery of novel and interesting forms of fish, may be attributed to the constant employment of a towing net, and to his use of a dredge whenever possible. The stomachs of seals and sea-birds were explored with success by him and Dr. Hooker'.[106]

Neither officers nor man of science could accomplish the variety of collecting tasks undertaken from the expedition vessel without assistance: Hooker, for example, did not have the authority to demand the deployment of any instrument, but Ross was sympathetic to the interests of his scientifically-minded subordinates. Hooker, in a letter to his sister wrote: 'with 6 men, knocking about the harbor*[sic]* like a channel oyster-boat, blowing hard with snow-squalls & of course wet through, fishing up all sorts of submarine animals, sailing from point to harbor*[sic]*, with always a foul wind. Capt[ain] Ross always gives me a good boat, which is a great comfort. And I suppose I shall get some credit for what is collected.'[107] Similarly Ross could have concentrated his efforts more firmly on the mandate of the sailing instructions than on investigation of deep sea zoology. His personal interest in the deep sea made him look elsewhere. Whilst Hooker may have grumbled over receiving only 'some credit' for what was collected, the fact he could expect to receive any recognition testifies to his elevated position on board: the '6 men' manning the small boat he worked from are left anonymous to us.

In all three expeditions, the sheer scale of work involved in processes of collection is apparent. The workload of the expedition vessels meant that the naturalists' prior expectations about what might be completed had to be re-evaluated. Hooker remarked in a letter to his father that 'it is too much for a man to *collect* well and to *note* well'.[108] In a letter

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[106] Richardson and Gray, *The Zoology of the Voyage of the H.M.S Erebus and Terror,* 45.
[107] JDH/1/2 f.120. Joseph Hooker to Elizabeth Hooker, 6 September 1842.
[108] Huxley, *Life and letters of Sir Joseph Dalton Hooker,* 64.

written seventy years later to William Spiers Bruce of the *Scotia* Antarctic expedition, Hooker recalled 'it does not, I think, appear in the Narrative of the Voyage that I was the sole worker of the tow net, bringing the captures daily to Ross, and helping him with the preservation, as well as drawing a great number of them'.[109] Hooker's counterpart on the American expedition, Titian Ramsay Peale recorded remarkably similar sentiments in a letter home, suggesting that their arduous workload was a real strain: 'I had at Madeira, and one at the Cape Verde [a bird], they were overwhelming because I had to do everything myself: shoot, write, draw and explain to the uninitiated'. Worse still was the threat of removing his assistant, Williams, who had been an aide to the process. Peale lamented 'I can be little more than the shuffler of skins'.[110] It appears the naturalists had been promised more help from the ship's crew before the expedition than they were actually given: 'Captain Wilkes' assertion that I would find sailors ready and able to do anything and that I should have their services whenever required, arose merely from the wish to remove impediments to the sailing'.[111] Scientific tasks were not considered by the crew to be part of their job description: they were additional chores on top of a physically demanding workload. It was often personal interest in the investigation, rather than obligation via direct instruction, that contributed to collaborative scientific collection. The scale and scope of the investigations undertaken were dependent upon the personnel available. As Sponsel points out, however, much of the work of the crew is lost when experiment and investigation was recorded, be it in the shipboard diary or eventually the travel narrative or scientific volumes. This process of 'funneling' meant that little of the actions of the assistants to investigation were ever recorded.[112] What is clear is

[109] Huxley, *Life and letters of Sir Joseph Dalton Hooker*, 47.
[110] Poesch, *Titan Ramsey Peale*, 70
[111] Poesch, *Titan Ramsey Peale*, 72.
[112] Sponsel, Alistair. 'An Amphibious Being: How Maritime Surveying Reshaped Darwin's Approach to Natural History', *Isis* 107(2) (2016): 260.

that there was a conflict between time given to scientific investigation and the running of the ship.

**Relationships on the expedition vessel and the role of private collection**

Private collecting for personal purposes was expressly forbidden in each of the sailing instructions issued. All material collected was to be handed over to a superior officer and sent home, or delivered to the appropriate institution on the expedition's return. At the beginning of the American expedition, Wilkes stipulated that the crew were not to keep collections of their own, and ordered that 'the officers and crew of this ship will deliver to Doctor Pickering and Mr. Drayton, all the shells they may have collected or obtained, who will select from the same a sufficient number of each to complete one hundred, of the finest specimens, if possible, and furnish lists of the same with names of the persons who furnished them'.[113] Richard Eyde suggests on the American expedition's return Wilkes asked publicly that the government distribute duplicate specimens among his officers, especially of shells, if they were not needed.[114] Whether this was belated recognition of the importance of the collection for those on board is unclear. That only the officers were scheduled to receive returned objects, and the public nature of the request, suggests this may have been merely another tool of authoritative assertion.

Despite Wilkes forbidding private collection and similar orders in the sailing instructions, these rules were routinely flouted. Reynolds, in his first letter home wrote that, 'I intend to let nothing that is curious slip by me this cruise without procuring it if possible'.[115]

[113] Wilkes, *Narrative of the United States Exploring Expedition*, III:433.
[114] Eyde, Richard H. 'William Rich of the Great U. S. Exploring Expedition and how his shortcoming helped botany become a calling', *Huntia* 6 (2) (1986): 196.
[115] Cleaver, *Voyage to the Southern Ocean*, 11.

Collecting specimens was an important activity for the crew members, and they were unhappy with Wilkes's order to hand everything over. The naturalists suspected that Wilkes did not want the scientific achievements of the expedition to overshadow the naval accomplishments.[116] The crew blamed the civilian scientists for this imposition. Lieutenant Henry Eld of the American ship, *Peacock*, wrote to his father thus, 'You speak of curiosities. I certainly will make collections as circumstances will permit. Am fond of it and as much a mind to do so as you are to have me. But if I am to judge from such expectations heretofore we shall be obliged to give up all curiosities to government when we return, as well as all Journals and information in any way collected'.[117] Reynolds, it seems, hoped to continue his collecting, presumably keeping the store secret from the captain. In one letter he wrote how 'everything curious is sacred to the Scientifics themselves. But I have some stones from the Southern Continent'.[118] He was, however, patently aware of the restrictions on his own collecting, adding in frustration, 'I have not collected many curiosities; the Government is so selfish as to require *all specimens* for the [Public] stock' and continuing, 'In the English Expedition when two specimens of each article were procured the officers were at liberty to collect for themselves'.[119]

Reynolds believed that British personnel were given more freedom to collect privately. In some instances this was the case. British expedition Lieutenant Davis recorded in a letter that he had kept two stuffed examples of the Antarctic bird, *Procellaria*.[120]

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[116] Viola, Herman J. and Margolis, Carolyn (eds), *Magnificent Voyagers: The U. S, Exploring Expedition, 1838-1842* (Washington D.C.: Smithsonian Institute Press, 1985): 14.
[117] Poesch, *Titan Ramsey Peale*, 69.
[118] Cleaver, *Voyage to the Southern Ocean*, 200.
[119] Cleaver, *Voyage to the Southern Ocean*, 228.
[120] Davis, J. E. *A Letter from the Antarctic* (London: William Clowes & Sons, 1901): 11.

McCormick recalled preserving a penguin ‘in a case of pickle, to present to my own college, for a skeleton for the Hunterian museum’.[121] In a letter to his father, Hooker remarked that:

> Lt Matson, of HMS. "Waterwitch", kindly takes charge of a box which will go home along with this. It contains Birds-Skins, a greater part of which belong to Lieut[enant] Oakeley of this ship; but, as he always collects for me, I promised to take charge of his own, by sending them all to you. The sooner (you know) these things get home the better, from out of a Gov[ernmen]t Ship, when there is bad stowage for private specimens.[122]

There was no censorship of letters from the British ships so Hooker felt comfortable in passing details to his father of a fellow ship officer who had made his own, private collection during the voyage. Hooker emphasises the poor storage conditions of the ship. It was not just that the *Erebus* and *Terror* had poor storage facilities for delicate and important specimens – although all expedition vessels at his time were susceptible to the damaging marine environment. Private collections could be sequestered if deemed important, and removing them from the ship as quickly as possible was the surest way to keep them safe from confiscation.

Whilst the likes of Hooker and McCormick did form their own private collections on board the British expeditionary vessels, it was not the free and open collecting society that Reynolds envisaged. Hooker was given special privileges regarding collection, reflecting his good relationship with Ross, his personal standing as a botanist and the standing of his father, William Hooker, who, by the end of the voyage, would be appointed Director of the newly-formed Kew Gardens. In a letter to his father Hooker articulated some of these benefits, regarding some of his botanical specimens:

> Capt[ain] Ross has ordered me to make & send you a set separately, whether the Admiralty send you the others or no, which I have done to a certain extent with the Hermite Isl[an]d plants.  There is no fear but they will all come right in the end, but he

[121] McCormick, *Voyages of Discovery*, 252.
[122] JDH/1/2 f.219-220. Joseph Hooker to William Hooker, 18 May 1842.

> is very jealous of most of the collections & I am the only one he never interferes with. No one whatever is allowed to send other objects of Nat[ural]. Hist[ory] home to their friends, lest they should be made public before our return; I never ask his leave for it would be a sad thing to put him to the pain of a refusal. [123]

Hooker was aware of his privileges and did not wish to endanger the strong personal bond he had with Ross that accounted for it, despite grievances expressed later in the voyage about the danger of keeping new knowledge on the natural world secret until the voyage returned (chapter 6, pages 204-69). Collection was a still a troublesome issue, even for Hooker, and he had reason to try and hide his private collections at times too, if it was seen to interfere with collection for the Admiralty. In a letter to his father he wrote:

> I shall further send home to you from time to time the specimens of my own that I may have collected leaving it to Capt[ain] Ross to do what he thinks best with the Admiralty Coll[ection]. By this means I shall I hope avoid any demand being made upon me for specimens I may have collected & which the Admiralty set may not have, from the Admiralty collector refusing to take them from me when I collect them. This was the case the other day when I collected some crabs from a floating log. Mr McCormick took some spec[imen]s for himself but said I do not care to take any for the Admiralty. Now as I have made notes on the spec[imen]s in my journal which may be curious they may apply to me for specimens which were refused when I offered them. The Admiralty coll[ection] of plants I make up myself but the animals etc. which I collect I take to McCormick for him to choose from before I keep any for myself.[124]

Although Hooker, as naval employee, was supposed to prioritise the Admiralty collection, he clearly did so only when the specimens were not of particular interest to him. Additionally he used his subordinate position as naturalist and surgeon to McCormick and to Ross, who, as captain, had ultimate authority, as a way of distancing himself from any responsibility for the matter. As a skilled and trained naturalist, however, Hooker could not but make a record of his own personal specimens. The result was a record which supplied proof in his own writing that he had disobeyed direct instructions regarding private

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[123] JDH/1/2 f.169-175. Joseph Hooker to William Hooker, 7 March 1843.
[124] JDH/1/2 f.9. Joseph Hooker to William Hooker, 20 October 1840.

collections. On board and at sea, the authority displayed in the sailing instructions and captains orders might be circumvented. On return to port, expedition vessels became a type of 'holding cell': anything that had not already been sent home was handed over to the waiting authorities.

D'Urville, drawing on knowledge gained through two previous Pacific voyages, recognised the 'lure' that forming a collection of new creatures was to those on board. Early in the expedition he recorded:

> A superb albatross, completely white like a swan, with the sole exception of the wing-tips, swam for a long time behind us, looking to profit from what was thrown into the sea. Some shots were fired at him, without reaching him. I took this event to signify that I was not allowing the launch of a boat into the water, where it [the bird] would be picked up as an object destined to go to the museum collection. The mania for special collections is already developing to such a point that I had to take measures to prevent the disorder to which they might lead'.[125]

The subsequent 'measures' are not referred to in detail but d'Urville does record later that collecting on such a scale had ceased and held himself up as an example of restraint.[126] Collecting not only occupied the time of a crew with many other shipboard tasks, but endangered the integrity of the collections that were sent to institutions at home.

Private collection was discouraged or forbidden partly because it took specimens away from the trove that would form the state collection on the expeditions' return. There existed therefore a conflict between private and governmental collection, but also between rival private collections. Hooker wrote to his father that 'the captain [Ross] has a noble collection of Birds in casks, - a most noble one. I do not let him know that I skin any at all'.[127] This was a seemingly trivial but important example of insubordination. Ross was

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[125] D'Urville, *Voyage au Pole Sud*, II: 138.
[126] D'Urville, *Voyage au Pole Sud*, II: 138.
[127] Huxley, *Life and Letters of Sir Joseph Dalton Hooker*, 142.

captain of the expedition. Hooker's concealment of the true nature of collected material from him was an act of defiance in several ways. What can be seen here though, despite the differing approach of the captains, is that while collecting could bring relief from boredom, it was also potentially divisive and against regulations. Both Wilkes and d'Urville used the curtailment of collecting as a disciplinary act on board ship.

The relationship between captain, officers and crew on the one hand and the 'Scientific's' on the other was not easy. It had to be constantly negotiated. The conflict over access to equipment, labour, time and space in which to pursue scientific tasks led from the outset to tensions between crew and the scientific corps. An awareness of the difficult situation they were in and the possibility for strained relations with the officers and crew was vital if the civilian scientific staff and naval naturalist were to have the resources they required in order to pursue their work, which was often in direct opposition to the tasks undertaken to facilitate the smooth running of the ship. Helen Rozwadowski argues that 'scientists who failed to understand and negotiate the social and political dynamics on board compromised their scientific work'.[128] How much time any man was given for a particular task was often dependent on how vital that task was deemed by the Captain to the wider goals of the expedition. How this played out, however, was strongly conditioned by the contingent social and material realities of individual vessels and their changing itineraries.

For Wilkes, it was necessary to bring officers into closer association with the required scientific duties, with a reduction of the tasks placed under the corps of civilians, although he did claim that 'as many of these were taken as could be accommodated'.[129] The initial reception of the men of science by the crew was mixed. Some crew members welcomed their

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[128] Rozwadowski, *Fathoming the Ocean*, 193.
[129] Wilkes, *Narrative of the United States Exploring Expedition*, I: xiv.

presence on board. Reynolds' first opinions of the civilian men of science were good and their reputations preceded them: 'Titian Ramsay Peale, the great Naturalist is with us', continuing 'The other Scientifics are said to possess talents and much zeal in their respective pursuits. We, the ignoramuses, will no doubt take great interest in learning the origin, nature and history of many things'.[130] It is hard to tell from this distance if Reynolds is being self-deprecating or making a barbed judgement about his status on board. At the beginning of the American narrative, Wilkes expressed his own delight at the relations between crew and savants: 'free communications were had. It was amusing to see all entering into the naval occupation of dissecting the fish taken, and to hear scientific names banded about between Jack and his shipmates'.[131] At times, then, collecting brought factions of the ships' social structure together.

Reynolds' admiration did not diminish when they were first at sea. Commenting on 'the Scientific's' attempts to catch marine life, he recounted how,

> The Scientifics have had one chance since we sailed. On a calm day many fish were around us, and we caught them in numbers. Instead of consigning them instantly to the cooks, the Scientifics went at them with the utmost eagerness and relish, dissecting them, found out many mysterious things in the stomach etc., talked over many hard names, and then took drawings of the whole and the parts; all they did was Greek to us, but somewhat interesting.[132]

Reynolds showed genuine interest at such moments. The novelty of the scientific practice to a crew member unused to sailing with civilian men of science is clear. He later wrote how 'The Scientifics have made another haul and it is most curious to see the patient manner in which they toil, toil, seemingly for trifles'.[133] Where Reynolds was enthusiastic,

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[130] Cleaver, *Voyage to the Southern Ocean*, 3.
[131] Wilkes, *Narrative of the United States Exploring Expedition*, I: 4.
[132] Cleaver, *Voyage to the Southern Ocean*, 6.
[133] Cleaver, *Voyage to the Southern Ocean*, 11.

other crew members were less so, naming them 'clam diggers' and 'bug catchers'.[134] Wilkes appeared to address possible criticism of his treatment regarding the scientific contingent: 'to the scientific gentlemen I have only to say, that they are, and always will be considered as one of us'.[135] Wilkes admitted that 'the Scientifics' were not given the chance to do all that they had wanted but argued that they had 'messed with the ward-room officers, and received all the privileges, respect, and attention due to that rank'.[136] For their part, the civilian scientists on numerous occasions claimed that they were not being properly treated by the captain and crew. Their reasons for these views centred on the additional work which the crew believed the civilians had caused. Reynolds described Wilkes ordering every officer on deck to help the scientific gentleman to perform their business, an additional chore to their normal duties. [137]

Relationships were often at their most tense aboard the American vessels, where civilian 'Scientifics' and naval officers were frequently involved in similar enterprises. In a letter from James Dana, the American geologist to the botanist, Asa Gray, who, at the last moment had pulled out of Wilkes's expedition, Dana passed on ship-board gossip: 'It was common opinion among the naval officers when we started that if 6 months' notice had been given to some of the officers in the navy, they might have prepared themselves on any of the departments of science. They would have needed no citizen Scientifics. They would acknowledge, however, that it took at last six *years* to make a good navigator!'[138] This type of comment may have added to a feeling in the scientific contingent that they were neither wanted nor appreciated on board the expedition vessels, and the elevation of the physical

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[134] Viola, *Magnificent Voyagers*, 14.
[135] Wilkes, *Narrative of the United States Exploring Expedition*, I: x.
[136] Wilkes, *Narrative of the United States Exploring Expedition*, I: xix.
[137] Cleaver, *Voyage to the Southern Ocean*, 6.
[138] Eyde, 'William Rich', 189.

sciences echoes Wilkes's own feelings concerning the worth of the various scientific disciplines. Peale was upset by the treatment of scientific staff by the naval officers, writing home that 'the first Lt issued his orders to the boats, running thus, "2d cutter, Lt Emmons will take 10 water bags, 2 buckets, 1 shovel & Messrs Hale & Peale". One comment at Sandalwood Bay was worse – "bring off the yams and Scientifics"'.[139] The naval officers' implication that the men of science were comparable to the material goods, mere objects to be transported, was not received favourably.

There is much less discussion of the tensions between naval men and those interested in the pursuit of scientific goals in the French and British expeditions. The French and British expeditions took no civilian scientific staff. Their surgeon naturalists were doctors and naval men first and foremost. This is not to say that shipboard naturalists, even when it was not their primary role, did not feel the precariousness of their position. If Hooker was not already cognisant of the hierarchical structure aboard ship before he joined the expedition, he had been made well aware of the limitation it would oppose on his ability to collect and operate successfully by his mentor, Mr. Children, almost as soon as it was intimated he would be joining the voyage. He recorded in a letter to his father that his supervisor had declared that 'I must not go if I am not to be the only naturalist, or at least the head Naturalist, for that it is utterly impossible that we should agree, each having an equal claim on going ashore, and he the better right'.[140] Hooker had been given a glowing reference by the naturalist John Richardson before the expedition took place, however, that would have counted in his favour. In a letter to James Clark Ross, Richardson wrote:

> You will rarely meet with any one better qualified as a collector of natural history objects generally, or one of a better disposition or more [unclear] in every way than my young friend – he is enthusiastic in his attachments to natural history, and as the

[139] Poesch, *Titan Ramsey Peale*, 83.
[140] Huxley, *Life and letters of Sir Joseph Dalton Hooker*, 42.

> man has studied medicine and is desirous of entering the navy solely for the purpose of obtaining opportunities for the cultivation of natural sciences, you may depend on his exacting himself to the utmost in collecting should you take him with you.
>
> Anxious that he should have the full credit of his collections by their being transmitted to England, entries in his name, whether they consist of biotical or zoological specimens. I understand from him that you have appointed the surgeon to act as zoologist but this does not appear to me to militate in any way against you complying with Mr Hooker's desire.[141]

Hooker was worried that his subordinate status on the ship would mean he would not be at liberty to pursue his interests. As assistant surgeon, he was one of those officers expected to be on board ship at all times, unless another medical officer was also on board. In an at-sea directive Ross had stated that, 'it is my direction that in future, the surgeon and assistant surgeon of the *Terror*, be not both absent from the ships at the same time'. An identical directive was issued to the *Erebus*.[142] As McCormick recounted: 'I do not hesitate to say that many interesting observations, in natural history and geography and the collateral sciences, in a newly discovered land may have been lost to the world, thought this ill-timed order'.[143]

McCormick, proved to be a satisfactory superior for Hooker because their personal interests rarely overlapped. The botanical collections of Hooker and McCormick were supposed to be merged once collected. But early on in the expedition Hooker wrote that 'McCormick has collected nothing but geological specimens, and pays no attention to the sea animals brought up in the towing nets, and they are therefore brought to me at once'.[144] Hooker and McCormick occupied different 'spaces' on board and were able to coexist

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[141] TNA, BJ2/3, 8-9. John Richardson to James Clark Ross, 11 May 1839. Other TNA materials not included in the thesis are BJ2/3: letters to James Clark Ross, BJ2/8: letters from John Murray to Ross, and BJ2/12: miscellaneous items relating to the expedition of the *Erebus* and *Terror*. These were examined, but did not include information relevant to this thesis.
[142] Scott Polar Research Institute (SPRI): MS 1556: 185 and 186. 1840. James Clark Ross at-sea directive given to the crews of the *Erebus* and *Terror*. SPRI also holds MS 547/1-6: HMS Terror logbooks. These did not contain material relevant to this thesis and are not included here.
[143] McCormick, *Voyages of discovery*, 162.
[144] Huxley, *Life and Letters of Sir Joseph Dalton Hooker*, 68.

amicably because of this. Hooker, however, remained aware of the position he filled as assistant surgeon to another, higher ranked naval man, and even at the very end of the journey wrote to his father that 'whenever there is the slightest difficulty [between Hooker and McCormick] I always give up'. On another occasion he wrote to this father:

> Whenever the seine was shot I attended on the return of the boat, to pick out the fish that were wanted, a very few I kept myself for [John] Richardson [of the British Museum] should he not get them, but my duties of course precluded the possibility of my making any notes or a large private collection. Capt[ain] Ross often feels himself jammed between me & McCormick, when the latter wants to keep a nice thing for his Government collection, & I of course want to put it with ours, for he makes no general collection of anything but rocks & Birds & as I take the drudgery of collecting all other branches of Nat[ural]. Hist[ory]. with the Capt[ain]'s assistance.[145]

All on board were subordinate to the captains' judgement, and Ross had to make decisions that were not always to his own personal benefit: his own private bird collection was subject to securing the correct specimens for the government, a task McCormick appeared to have taken as his own responsibility, probably because it gave him undisputed access to all the bird specimens. At this point the decision was largely his own, regarding whether they would form the Admiralty collection, or his private one.

The split between crew and civilians and naturalists and naval men was not the only factors that led to tensions on board. Christopher Lloyd has shown that the crew shared an elaborate hierarchy quite apart from the commissioned men and civilian officers.[146] McCormick complained:

> seeing two large penguin, apparently a new species, on a piece of ice ahead, I was very naturally desirous of securing them for the government collections, and asked for a boat to go and capture them; but unluckily for me, Cpt Ross being on board the *Terror* at the time, our automatic first-lieutenant, whose prestige, if he has any at all,

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[145] Huxley, *Life and Letters of Sir Joseph Dalton Hooker*, 70.
[146] Lloyd, Christopher. *The British Seaman: 1200-1860 A Social Survey* (London: Paladin, 1970): 212.

> is more for holy-stoning decks in the morning watch than in the paths of science, did not deem them worth the trouble of lowering a boat for.[147]

The acquisition of specimens was facilitated or denied by the officer in charge rather than simply through the desire or capacity of the shipboard naturalist. On one occasion, McCormick recorded how 'my cabin having become filled to overflowing with the government collection of specimens of natural history, I got the second master, in charge of the hold, to relieve me of a case by stowing it away there. But our matter-of-fact first lieutenant, to whom everything connected with science is a bore and an enigma, to prove his zeal for such pursuits, ordered it up again, as having no abiding place there'.[148] Davis, on board the *Terror,* commented on reaching New Zealand that the ship had become 'very uncomfortable, owing to the captain being very much out of temper and the gun-room officers quarrelling amongst themselves. They all succumb to the first lieutenant in a disgraceful way'.[149] Long periods of time confined to the expedition vessel made the multipurpose-space a challenging environment to negotiate and tested relationships to the full. This facet of shipboard knowledge production is explored next.

**Conflict over ship-board space and negotiating the Southern Ocean**

Space was at a premium on board ship and its use for scientific purposes could be controversial. Hooker wrote to his father that Ross had given him 'a cabinet for my plants in his cabinet, one of the tables under the stern window is mine wholly; also a drawer for my microscope, a locker for my papers, etc.'[150] The sick bay was originally given over to the naturalists on the British voyage to help ease the congestion in their cabins. Titian Ramsay

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[147] McCormick, *Voyages of Discovery*, 265.
[148] McCormick, *Voyages of Discovery*, 25.
[149] Davis, *A Letter from the Antarctic*, 9.
[150] JDH/1/2 f.15-23. Joseph Hooker to William Hooker, 3 February 1840.

Peale described his accommodation on board the *Peacock*: ‘The little stateroom in which I live is just about as large as your mother’s bedstead which is packed with clothes, furs, guns, books and boxes without number’, continuing ‘I eat with the lieutenants and Surgeons in the Ward room’.[151] Hooker intimated in a letter to his father that he was at least allowed to use Ross’s cabin to store his collections after a time, writing that ‘until the captain had reduced his cabin into order I had no place to put my collections, and they used to get sadly kicked about the lower deck’.[152]

Reports upon the poor storage conditions of the lower decks were common. In his journal, Peale recorded ‘it is true state rooms on the gun deck have been constructed for our accommodation, [but] they are wet and dark, - where neither drawings nor preparations of specimens can be made. The captain’s Cabin is the only place on board where such apparatus could be carried on and there only at the sacrifice of his private convenience: the *Relief* is the only vessel in the squadron at all fitted for the service’.[153] The *Relief* was, however, a poor ship in terms of seaworthiness.

Once on board, there was conflict regarding what was to be done with the collected artefacts. Wilkes so much disliked the smell of dissected creatures below deck he forbade the practice. If the deck of an expedition vessel proved an awkward space for collecting, sketching and preserving specimens, below deck was even more unsatisfactory. Peale recorded that ‘the usual naval etiquette prevents our working on deck and the want of light and space below!’[154] After American Joseph Couthouy continued to bring dying corals on board, Wilkes issued an order stating that ‘no specimens of coral, live shells, or anything else

[151] Poesch, *Titan Ramsey Peale*, 67.
[152] Huxley, *Life and Letters of Sir Joseph Dalton Hooker*, 71.
[153] Poesch, *Titan Ramsey Peale*, 126
[154] Poesch, *Titan Ramsey Peale*, 126.

that may produce a bad smell will be taken below the spar deck, or into any of the rooms' of the *Vincennes*.[155] In this important sense, collection was a practice designed to know the world's oceans. But processing their contents was a profoundly local affair; contingent on the particular spaces afforded those on board at any one time. As Sorrenson argues, 'ships were more than just vehicles or platforms for observers and instruments: they shaped the kinds of information that observers collected'.[156]

Extreme weather had an effect on the condition of specimens – and the collectors. D'Urville, who was never in the best of health, suffered greatly from the heat in the southern latitudes, recording that when 'the heat began to fill the interior of the ship', he 'established myself in my usual place in the small room of the poop'.[157] As the ship approached the southern ocean the weather became more changeable, with d'Urville grumbling that 'in the afternoon, rain fell and sleet, that maintained an unpleasant humidity in the interior of the ship'.[158] On reaching the coldest regions he admitted, 'the cold forced me to finally leave my little room in the poop'.[159] Whilst bad weather made living and working conditions unbearable, calm days afforded a light relief all the more valuable for being so rare an occurrence. Peale described in his journal being able to 'draw, paint etc. with our ports open without being endangered from having our rooms filled with sea water'.[160]

The hot and humid conditions of the South Pacific contrasted with the freezing, Antarctic environment. The low temperatures made the most commonplace jobs complex. Writing of his attempts to skin a penguin, McCormick complained it 'occupied me for four

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155 Wilkes, *Narrative of the United States Exploring Expedition*, I: 433.
156 Sorrenson, 'The Ship as a Scientific Instrument', 227.
157 D'Urville, *Voyage au Pole Sud*, I: 35.
158 D'Urville, *Voyage au Pole Sud*, II: 43.
159 D'Urville, *Voyage au Pole Sud*, II: 78.
160 Poesch, *Titan Ramsey Peale*, 149.

hours, from the benumbed condition of the fingers in this cold climate'.[161] Hooker described himself 'lashing' his microscope to the table in order to work in the ship's rolling inner cabins, and wrote happily to his father that 'as I am learning to use my left eye to the microscope, I do not find my eyesight affected even by candlelight'. But the constant requirement to be vigilant, observant and precise took its toll during the voyages.[162] Hooker observed that, 'between examining mosses and the glare of the ice and snowy spicules in the wind, my eyes smarted very much during the time the ships were in the pack'.[163] (See Chapter 6 page 204-69 for more on the bodily discomfort of producing scientific knowledge at sea).

As gentlemen of science, Peale and Hooker anticipated using more of their time on traditional means to collect - combing beaches for new species, and spending nights making illustrations. But the harsh physical demands of working on an expedition ship, and the negotiation of social status in a hierarchy where much of the time everyone was close to their limits, meant that shipboard science was more often hard labour than it was directed and leisurely work, organised along coordinated procedural lines.

**Conclusion**

Assessment of the narrative evidence shows that the type of science performed on board ship was influenced by several factors: the remit of the sailing instructions; the personal interests of the scientific contingent on board; and the specific environmental conditions. The collection of physical specimens was an important and regular activity undertaken by all, but not always willingly. The act of collecting was both scientific practice and enjoyable pastime,

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[161] McCormick, *Voyages of Discovery*, 252.
[162] Huxley, *Life and Letters of Sir Joseph Dalton Hooker*, 60.
[163] Huxley, *Life and Letters of Sir Joseph Dalton Hooker*, 60.

something that could be pursued from deck via shooting, dredging and fishing. It continued below deck through sketching, dissecting, painting, and specimen preparation. In these ways, the ship served at once as instrument, field site, and laboratory.

Nearing the end of the British expedition, on its last excursion into the high southern latitudes, Hooker remarked on collecting a particular microscopic marine creature, *Antarctica infusoria*. He recorded its acquisition step by step and commented that, 'no person seems to have thought of collecting such things before for scientific purposes'.[164] Hooker, who had begun the voyage disdainfully disregarding all faunal offerings from the sea, using them only as a way to occupy his time and hone his drawing technique, grew to appreciate their worth as objects of scientific enquiry in their own right. The testing conditions of the expedition vessel – long periods at sea with no sight of land, little opportunity for terrestrial investigation, extreme variations in weather, and a complex hierarchical structure of which he was an important part – transformed the insignificant and scarcely researched facets of the natural world into objects of intense observation and contemplation. If no one had thought of systematically collecting specimens from the deep sea before it was due largely to a lack of means: few people had the opportunity to journey on an expedition vessel.

The activities and practices of the regular crew member have been only partially revealed by the existing written records. Diaries, journals and letters by crew members of the expeditions in the 1830s and 1840s are much less common than their more illustrious captains, officers and naturalists. In these records the procedural details, like in the instructions for sailing, are obscured. When details are given they often refer to nameless, rank-less, assistants; the recording voice is the only one we hear with clarity today.

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[164] Huxley, *Life and Letters of Sir Joseph Dalton Hooker*, 60.

In understanding the impact of collecting, this chapter has shown the importance of the scientific instructions issued to each expedition before sailing. Collection of marine specimens was given a low priority: it was to be undertaken when the ship was hove to, stationary and in weather unsuitable for the more pressing tasks of the expedition vessel – navigation, and the pursuit of the physical sciences. Scientific instructions pointed the reader to the scientific literature, published books, and papers, rather than giving lengthy personal recommendations. Such works gave the most up-to-date information, and also transferred responsibility from the institutions to the authors of such works. Procedural detail and in depth information regarding instrumentation was lacking in each countries' instructions. The practices of sounding and casting of nets were regular shipboard activities, not specifically scientific ones. Know-how was gained through tacit knowledge with more experienced crew members rather than specialist scientific information. Dredging at depth was untested – the technique was to be performed and perfected at sea: the recommendations offered little advice about the process. Collecting new species - one of the oldest and most prevalent forms of shipboard entertainment – was continually re-tried and tested at sea.

The ship itself also determined the attendant scientific practices of collection that could be performed on and below deck. Any knowledge that could be gathered from its predominantly mobile base was only done so after a series of structural and social hurdles had been overcome: specimens processed and stored in particular spaces, both crew and officers engaged in complex tasks, and precious work-time afforded to intricate scientific activities. Personal collections were forbidden, in the sailing instructions issued by the government and by orders from the captains themselves. Everything was to go to state institutions on the expeditions' return. The individual on the expedition vessel was often unimportant, and their time was not their own. Time spent collecting was sanctioned if the results contributed to the mandate of the voyage. Collection was thus regulated, a form of control, initiated in the sailing instructions and supplemented by the naval captains at sea. But instances of disobedience *were* recorded in private letters, the one form of written record that left the ship and which did not have to be surrendered on the return. The desire to capture a small piece of what had been seen and preserved, not for the system but for the self – a physical memorial to what had been witnessed – was, for some individuals, a strong one.

Space on board ship was at a premium and the individual undertaking a scientific activity was not constrained to the civilian contingent. On a vessel where the captain's cabin was shared with the naturalist, and the spaces on deck used by civilians, officers and crew alike, it is unsurprising that collecting was not limited to any one scientific practitioner or group of such. Collecting drew together individuals from across the ship's hierarchical social structure, but, in doing so, it also created conflict. Wilkes followed in a long tradition of expedition leaders in wanting the officers of the ship to undertake the scientific work, and to limit the number of civilians taken on board. For Wilkes, the ability to adapt to ship life and navigate the hierarchical structure of a naval ship was more important than any prior scientific knowledge. As such, the distinction between savant and crew member was often blurred.

Collection began in the scientific and governmental instructions for sailing each expedition received before they departed their home country, and in the choice of would-be collector chosen to accompany the voyage. It likewise ended, not with the return of the expeditions to home ports, but later, in the successful classification and display of species, and the production of credible knowledge on the specimens collected.

While the afterlife of the collected species is outside the remit of the thesis, it is worth reflecting briefly on what those on board new to be true: no 'truth' became accepted knowledge without proper documentation. In a letter to his sister, Maria, Hooker described the final process of forming the collection on board ship: its adequate naming and labelling so those at home could understand what had occurred at sea. In this case, the boxing-up of shells to be sent home was notable for the faults in the procedure: '[n]one of them are properly cleaned, nor are any labels attached, except to the outside of each box; so that perhaps you will gum a label on each specimen, for the habitat is as important as the shell, & no good conchologist should omit such a duty to his or her collection'.

Many specimens never made it from collection to preservation but ended their chain of transformation on the captain's table or in the crew's mess. Death was an omnipresent and inescapable process on the expedition vessel, frequently overlooked or fleetingly mentioned in the journals and narratives. Its articulation, when it was recorded, has particular resonance for modern scholars - as a window into the activities and the emotional responses of those at sea in the mid nineteenth century. The collection and preservation of specimens at sea were the first steps in a chain of transformation that continued on the voyages' return. That the final stages of classification on board were not always performed to a set standard is not surprising. Collection was a complex, difficult, time-consuming task: as Luciana Martins and Felix Driver argue, 'collections may sometimes overwhelm their makers'.[165]

Collection transformed what had been caught, shot, or landed into an object, a specimen that could be successfully communicated to others elsewhere. This process was also achieved by the representation of marine life through measurement and the use of precision instrumentation – the subject of the following chapter.

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165 Martins, Luciana and Driver, Felix. 'The Struggle for Luxuriance: William Burchell Collects'. In, Felix Driver and Luciana Martins (eds), *Tropical Visions in an Age of Empire*, (Chicago and London: University of Chicago Press, 2005): 74.

# Chapter 5 Measurement: Experimentation, Standardization, and Verification

## Introduction

This chapter examines the scientific study of measurement on board ship during the exploring expeditions of France, America and Britain. There are three main concerns. First, the roles of experiment, and the importance of accuracy and precision in ensuring credibility and authority of the results of experiment, are stressed. Precision instrumentation was becoming important in this period to the establishment of truth claims. Next, the scientific recommendations to each country are interrogated, considering how far measurement of the marine environment was a requisite of state institutions, securing information that would aid expansion and colonisation of new territory, and how far a set of institutional guidelines issued before the sailing of any of the expeditions could determine what would be measured on the changeable, heterotopic space of the expedition vessel.

The following section builds upon the directions gleaned from the scientific instructions, moving on to the actual quotidian practices of metrology on board. This section addresses questions of intent: did the experimenters believe they were doing ‘marine science’ or were they just using the instruments they were given, instrumentally interrogating the environment below the surface of the ocean in order to navigate, ensure safety and fulfil a mandate from those at home, without an idea of the ocean as a subject of study in its own right? To answer this, I examine the various practices of measurement and use of instrumentation on board. Specific consideration is given to the practices involved in measuring and establishing distance beneath the waves. The section concludes by questioning the epistemological claims made on the spaces below the ocean surface without the instrumental means of verifying it.

Quantifying the underwater world altered the relationship between explorer and his surroundings. The ship's officers and crew were well used to interacting on the sea in order to ensure safe passage, but science at sea increasingly required knowing about the sea below them – a world to be revealed through instrumentation. Further, recording increasingly required enumerating. This section addresses precision instrumentation on board and asks if it was as ubiquitous and revolutionary as has been suggested. The compromise between temperamental and untested instrumentation and the operator is discussed. I argue here that securing knowledge about the deep sea whilst on the vessel was as much about negotiating the instrument as it was taking the measurement.

With such a rich diversity of measurement during the exploration voyages to the Pacific and Southern Ocean in the 1830s and 1840s – the vast recording of meteorological information, taking up tens of volumes, the huge compilation of magnetic data, to name a few – it is perhaps surprising that the importance of measurement for the emergence of the new field science of ocean research, has been thus far understudied. This chapter shifts our focus to the practices of measuring the deep sea on board ship, the instruments used, and the personnel involved, in interpreting the significance of measurement and its role in the construction of ocean space.

## Experiment, accuracy, and precision

Instrumental and quantitative investigations of the sea made from ships had been occurring before 1800, and reached a hiatus with the voyages of Cook in the Pacific Ocean in the late eighteenth century. Cook paid meticulous attention to the production of accurate observations and verifiable reports.[1] The late eighteenth-century shift to the use of the marine chronometer

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[1] Kennedy, Dane. *The Last Blank Spaces* (Cambridge & London: Harvard University Press, 2013):

symbolized the shift to mathematical instrumentation at sea. Navigating with precision became a demand on all ships captains and officers. Instrumental measurement was a form of warrant about standardization and exactness.[2] Voyages of exploration reached their apogee in the nineteenth century as the sciences became more specialized, with subjects such as natural philosophy replaced or broken up into a variety of new and specific disciplines and taking on new meaning. One feature of this specialization was the adoption of quantitative data.

Recording and displaying facts as numerical data brought new credibility to scientific endeavour. Alongside this was a requirement to prove that it was accurate and precise. Precision measurement sought to emulate the certainty of Newton's *Principia*. Precision validated science. It reified objectivity. Precision instrumentation, measuring and recording of numerical data assumed a startlingly new significance and importance in the world of the nineteenth-century explorer and man of science.[3] Establishing precision was also about establishing credibility and trust.[4] Precision requires standardization; an agreement between communities. So whilst successive measurements should yield the same values, there also needed to be consistency with the results obtained by others under different conditions. This is important: precision is not the product of individual and carefully constructed instruments, but results from an extended network of people. For Schaffer, precision is expensive and

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[2] Keighren, Innes M., Withers, Charles W. J. and Bell, Bill. *Travels into Print: Exploration, Writing and Publishing with John Murray 1773-1859* (Chicago and London: University of Chicago Press, 2015):14.

[3] The term 'instruments of precision' was first used in the nineteenth century by the French Patent Office, and encompassed horology, instruments of physics and medicine and surgery, telegraphy, weights and measures, as well as mathematical instruments. See Warner, Deborah Jean. 'What is a Scientific Instrument, When did it Become One, and Why?', *The British Journal for the History of Science* 23 (1) (1990): 90. See also: MacDonald, Fraser and Withers, Charles W. J. 'Introduction: Geography, Technology and Instruments of Exploration'. In Fraser Macdonald and Charles W. J. Withers (eds), *Geography, Technology and Instruments of Exploration* (Farnham: Ashgate, 2015): 1-14.

[4] For more on issues of precision see, Wise, M. Norton. *The Values of Precision* (Princeton: Princeton University Press, 1995).

usually associated with large institutions whose interest lies in so-called 'big science'.[5] Their resources have to be large enough to make it worthwhile to undertake such an economically exhausting enterprise. Voyages of exploration in the 1830s and 1840s were the 'big science' of their day, requiring substantial financial investment and personnel, both naval and civilian.

Precision sought to refine a measurement, commonly by repetition of an experiment or investigation. Accuracy marked the degree to which any given measurement adhered to a known standard, but accuracy of an unknown distance or speed was nigh on impossible to judge. As John Gascoigne argues, 'the quest might be for total accuracy', but there was 'an awareness that some elements of approximation was inevitable' (although this did not stop the nineteenth-century traveller writer claiming it).[6] As Charles Withers argues, 'the practical accomplishment of accuracy was always a relative achievement. A consequence of the instruments chosen, of operators' tolerance, and, often, of very local circumstances'. For Withers, 'precision and the units selected for its measurement are not innate. Authority over accuracy lies in the claims made about measurement, not in the units themselves. Nature does not provide the means to its own revelation'.[7] Numbers produced from experimentation with precision instrumentation were meant to encompass objectivity, their ability to travel giving them a robust independence from the local values of the diverse labs and workshops on whose agreement they depended.[8]

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[5] Schaffer, Simon. 'Late Victorian Metrology and its Instrumentation: A Manufactury of Ohms'. In Robert Bud and Susan E. Cozzens (eds), *Invisible Connections: Instruments, Institutions and Science* (Bellingham: Wash, 1992): 23-56.
[6] Gascoigne, John. 'Navigating the Pacific from Bougainville to Dumont d'Urville: French Approaches to Determining Longitude, 1766–1840'. In, Rebekah Higgit, Richard Dunn, and Peter Jones (eds), *Navigational Enterprises in Europe and its Empires, 1730–1850* (London: Palgrave Macmillian, 2015): 181.
[7] Withers, Charles. *Zero Degrees: Geographies of the Prime Meridian* (Harvard and London: Harvard University Press, 2017): 10; 36.
[8] Wise, *The Values of Precision*, 230.

Precision and accuracy were gained through repeated experimentation. As Ian Hacking argues, to experiment is to create, produce, refine and stabilize phenomena; it shows aspects of the world that scientists take to be real and presents evidence of it to the wider public.[9] Experimental science was developing rapidly in the first half of the nineteenth century, providing a new regime of knowledge grounded on empirical trials and instruments, and moving out of the laboratory and into the field, although the 'rigours of travel meant one could not replicate in the field the laboratory procedures necessary to make authoritarian claims in certain forms of science'.[10] For Margaret Deacon, individual observations that were taken at random began to count for less at this time: standard observations from season to season spread evenly across the oceans were desired.[11] The taking of measurements over time, by different countries, demanded commensurability: standard conventions, names and classification. This was hard to achieve: units were not standard even in individual countries, much less across continents.[12]

Whilst the use of precision instrumentation was aligned with matters of authority, trust and credibility, the units of measurement used by each country were matters of social and political authority. As Withers writes, 'across Europe, differences in measurement were everywhere apparent. Shared terms were in common use but there was little agreement over the standards of such measurements'. Metrology 'varied everywhere by geography.[13] The metric system was introduced in France after 1800, and was designed to replace the unstandardized units of measurement that existed across the country.[14] The French metric

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[9] Hacking, Ian. *Representing and Intervening* (Cambridge: Cambridge University Press, 1983): 230.
[10] Keighren, Withers and Bell, *Travels into Print*, 97.
[11] Deacon, Margaret. *Scientists and the Sea 1650-1900: A Study of Marine Science*, (London and New York: London and New York Academic Press, 1971): 236-7.
[12] See Keighren, Withers and Bell, *Travels into Print,* ch.2.
[13] Withers, *Zero Degrees*, 2.
[14] For more on the establishment of the metric system see: Alder, Ken. *The Measure of All Things: The Seven-Year Odyssey and Hidden Error that Transformed the World* (London and New York:

system grew out of work to establish the exact shape of the earth.[15] Post-revolutionary France rejected the new system, however, and, in 1812, Napoleon effectively returned France to the old standards. The metric system was reinstated only in the 1840s and made ubiquitous by the issuing of penalties for the use of the traditional measures. Even so, old French measurements appeared in everyday usage long after this time.[16]

There existed a confusing system of weights and measures in Britain before the middle of the nineteenth century: '[f]ar from there being a uniform and coherent system, local anomalies and customs created considerable disparity, complicating internal trade'.[17] As Hoppit writes, 'in 1817 one author believed that in England about 230 provincial weights and measures were in use and in Scotland over 70. But what proportion of places and transactions used these provincial standards in unknown'. [18] Hoppit argues that the enforcement of common standards in Britain was haphazard, and that they were 'defined in relation to physical criteria which were liable to variation'. Additionally the official standards kept in the Exchequer were inaccurate'.[19] When the Houses of Parliament were destroyed by fire on 16 October 1834, all standard weights and measures were destroyed or damaged beyond repair.[20] John Gascoigne argues, however that the systematization of weights and measures in Great

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Free Press, 2003).

[15] Gascoigne, John. 'Joseph Banks, Mapping and the Geographies of Natural Knowledge'. In Miles Ogborn and Charles W. J. Withers (eds), *Georgian Geographies: Essays on Space, Place and Landscape in the Eighteenth Century* (Manchester: Manchester University Press, 2004): 166.

[16] Duyker, Edward. *Dumont d'Urville: Explorer & Polymath* (Otago: Otago University Press, 2014): 21.

[17] Hoppit, Julian. 'Reforming Britain's Weights and Measures, 1660-1824', *The English Historical Review* 108 (426) (1993): 82.

[18] Hoppit, 'Reforming Britain's Weights and Measures', 86.

[19] Hoppit, 'Reforming Britain's Weights and Measures', 86-7.

[20] Withers, *Zero Degrees*, 15.

Britain began to take place in 1826, reflecting a consolidation of the state and its central authority.[21]

A fathom in Britain and America during the 1830s time was 1.8 metres or 6 feet, although was known to be only 5.5 feet on merchant ships and both 5 feet and 7 feet on fishing vessels.[22] In France, the equivalent of a fathom was the *toise* (although this was not standard nationally). This was set at 1.949 metres in France until 1812, but between 1812 and 1840 this changed to 2 metres as Napoleon I tried to facilitate the use of the metric system into France. After this time it returned to 1.949 meters. It is not clear what version of the fathom or toise was used by the French used on their expedition. In the French narratives, however, Dumont d'Urville also records depth in brasse - equivalent to 1.62 metres. Thus it is likely that when recording measurements the standard unit of measurement which the British and Americans employed was 1.8 metres, and that used by the French was 1.6 metres.[23] As Wise has argued, the universal standards of objective science are historically contingent.[24] A single datum, or country-specific series of data measurements may have the attributes of precision and accuracy, but in comparison with measurements from other countries, a shared and combined series of readings could only lay claim to commensurability when they became standardized, one country or unit with another.

The drive for precision and accuracy has been linked to attempts to extend uniform order and control over larger territories. This claim applies to the oceans equally as terrestrial empires. Norton Wise suggests that this desire to quantify came not from a search for

[21] Gascoigne, 'Joseph Banks', 166.
[22] Fenna, Donald. *Dictionary of Weights, Measures and Units* (Oxford: Oxford University Press, 2002): 89.
[23] If the depth was very shallow, it would more commonly be marked on the chart in feet, a unit more common to the three countries
[24] Wise, *The Values of Precision*, 222-236.

mathematical laws of nature, but from the requirement to regulate society and its activities.[25] Michael Bravo suggests that precision added a 'new, critical, and sometimes polemical, dimension to the language of travel'.[26] The foregrounding of measurement as integral to the success, or otherwise, of scientific endeavour, can be seen in the integration of detail into the accounts of travel and exploration, first into the appendices and subsections of the main volumes, and, later, into the main travel narrative itself.[27] It was common in the nineteenth century for travel narratives to include entire volumes describing instrumental practice.[28] Coincident with this interest in matters mathematical and instrumental came recognition that too much focus on the quantitative and technical, and too little on the sensational, would not sell books.[29] At the beginning of his ten-volume narrative, Dumont d'Urville promised, 'I shall be more sparing of purely technical and nautical terms and descriptions than I was two years ago'.[30] Asserting authority via long descriptions of scientific investigation, the reproduction of logbook tables, and maintaining reader interest in published works, was a difficult task to balance.

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[25] Wise, *The Values of Precision*, 4-5. See also Porter, Theodore. *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life*, (Princeton: Princeton University Press, 1996).
[26] Bravo, Michael. 'Precision and Curiosity in Scientific Travel: James Rennell and the Orientalist Geography of the New Imperial Age (1760-1830)'. In, J. Elsner and J. Rubies (eds), *Voyages & Visions*, (London: Reaktion Books, 1999): 163. See also: Wess, Jane. 'Navigation and Mathematics: A Match Made in the Heavens?' In, Rebekah Higgit, Richard Dunn, and Peter Jones (eds), *Navigational Enterprises in Europe and its Empires*, 201-222.
[27] Pratt, Mary Louise. *Imperial Eyes: Travel Writing and Transculturation* (London & New York: Routledge, 2008 2nd ed.): 25.
[28] Licoppe, Christian. 'The Project for a Map of Languedoc in Eighteenth-Century France at the Contested Intersection Between Astronomy and Geography: The Problem of Coordination Between Philosophers, Instruments and Observations as a Keystone of Modernity'. In Marie Noelle Bourguet, Christian Licoppe, and H. Otto Siburn (eds), *Instruments, Travel and Science: Itineraries of Precision from the Seventeenth to Twentieth Century* (London & New York: Routledge, 2002): 52.
[29] Withers, Charles W. J., and Innes M. Keighren. 'Travels into print: authoring, editing and narratives of travel and exploration, *c*.1815–*c*.1857'. *Transactions of the Institute of British Geographers* 36 (4) (2011): 560–73.
[30] Dumont d'Urville, Jules. *Voyage au Pole Sud et dans l'Oceanie sur les Corvettes l'Astrolabe et la Zélée*, 1837-40, 10 volumes (Paris: Gide,1841): I 315.

**Instructions relating to measurement**

The scientific instructions issued to all three expeditions provided a series of statements as to procedure regarding experimentation (see also Chapter 3, pp.49-99). The instructions relating to measurement of meteorological phenomena and to terrestrial magnetism were extensive, particularly for the British expedition. The recommendations concerning the sub-marine world were shorter but then this was not the main – or even secondary – purpose of the expeditions. The desiderata produced by each country's leading scientific bodies were often phrased as suggestions and possibilities rather than definitive orders. Yet instructions for scientific endeavour shed valuable light on what was expected regarding the systematic interrogation of the ocean, and did so before the expedition´s departure and before the intervention of those 'anti-forces that resist scientists attempts to get results' of the voyage played any part in deciding what would and could be measured.[31] This section considers what marine enquiries were expected (or hoped for) from the expeditions by those at home, and the role these played in influencing the work conducted on board. (For a full reproduction of the instructions relating to measurement of marine variables see Appendix IV).

The American scientific recommendations, which were issued by the American Philosophical Society regarding interrogation of the marine largely appeared in the section 'The Ocean'. This covered: 'currents', 'tides', 'temperature of the sea at great depths', ´salt and air in sea water', and 'sound'. Much of the instruction is vague; the subject is specified, such as 'currents' or 'depth', and instruction given to make observations where possible. In measuring currents the officers and crew were instructed only that 'Careful observations on these are of great interest and importance; they will be made by comparing as frequently as

[31] Pickering, Andrew. *The Mangle of Practice* (Chicago & London: Chicago University Press, 1995): 91.

possible, the change of place of the ship as estimated by Astronomical observation by dead reckoning'. On interrogating depth the expedition was informed: 'It is hoped that opportunities of solving this interesting problem will not be neglected; and we would suggest that copper wire might be more suitable for the purpose than hempen cord.' For Tides the instruction read, 'It is hoped that these will be observed with great care, whenever the opportunity is presented'.[32] There is little more operational detail than this. There is a real sense that making *any* observation would be beneficial. At the beginning of this new field of 'oceanographic' research, observation and measurement afforded those involved great leaps in knowledge. As Ian Hacking has suggested, 'at the beginnings of science, much depended on simply noticing some surprising phenomena'.[33] How little was actually known of the operation of these marine phenomena was highlighted in additional instructions for 'Tides' that stated: 'The tides in the Pacific, it has been asserted, obey the influence of the Sun, rather than the of the Moon. If this be so, it is very desirable to know whether this influence may not be exerted through the medium of the land and sea breezes'.

On occasion the scientific instructions did offer advice regarding the methods of instrumentation to be used. In measuring the salt and air in sea water, the expedition was informed that the French physicist, '[Jean-Baptiste] Biot has described a method of determining the quantity of salt, and the amount and kind of air contained in sea water, which we would recommend to be used, in this expedition, at different depths, extending to the greatest that can be reached'. The temperature of the sea was to be taken by 'sinking a self-registering thermometer, or by draining a sufficiently large quantity of water from the depth, as practiced by Dr. Jno. Davy [English chemist John Davy]'.

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[32] Conklin, Edwin G. 'Connection of the American Philosophical Society with Our First National Exploring Expedition', *Proceedings of the American Philosophical Society* 82 (5) (1940): 523.
[33] Hacking, *Representing and Intervening*, 155.

Of additional interest is the inclusion of 'sound' in this list under the banner of oceanic investigation. The instructions refer to the use of sound above the waves.

> when the air is extremely cold, it is stated that sounds may be heard at a much greater distance than when it is warmer; but no means of exact comparison have yet been used. It is desirable, then, that experiments be made, under these different circumstances, in calm weather, as to the distances at which the same person hear the ringing of the same bell, or the explosions of percussion caps of the same kind fired in the same manner. -It is also of great interest to determine the velocity of sound through air of extreme coldness. [34]

When ships were sailing with partners, or in squadrons, there was an imperative to remain in sight; once lost from view, there was little way of communicating with one another to regroup. The situation became more serious in very foggy weather. The use of sound to remain in contact is common throughout the narratives, but the instruction here relates not to this most fundamental of uses, so important for navigation, but to the scientific aspects of sound and its travel through air. These were instructions written by a scientific institution concerned only with the scientific investigation the expedition could undertake, and not the everyday workings of the ship that were the concerns of the captain and crew.

The British scientific instructions relating to the ocean fell under the heading of 'Physics and Meteorology'. They included: 'Tides', 'Distribution of the Temperature in Sea and Landscape', 'Currents of the Ocean', and 'Depth of the Sea'. Like the recommendations for the American expedition, there is a sense that marine observations had a low priority in comparison to the more functional purposes of the expedition. With regard to tides, the instructions warned 'it is not likely that Capt. Ross's other employments will allow him to pursue observations on that subject with any continuity; nor is it desirable that he should do so, excepting he were able to carry on his observations to a much greater extent than is

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[34] Conklin, 'Connection of the American Philosophical Society', 523.

consistent with the nature of the Expedition'[35] This is recognition that series of measurements were integral to attaining knowledge on the ocean: the singular or randomly-obtained data point was of less value.

The British recommendations were more elaborate than those to the American expedition, regarding what experiments they wanted undertaken on the expedition. The programme of scientific works was detailed and well researched. Temperatures were only expected when they could be made with 'precision'. Little further information relating to *how* investigations should be performed was included. In discussing the distribution of the temperature in the sea the desiderata read:

> These questions can only be resolved by observations of the temperature and saltness of the sea, at various and considerable depths, in different latitudes and under a great variety of local circumstances. The procuring of such observations, and the preservation of specimens of the water, or the determination on the spot of their specific gravities, will afford a useful occupation in calms, and may be recommended as well worthy of attention.[36]

Of equal consideration to the collection of data on the temperature of the sea, was the purpose of entertaining the crew. Calm weather was not always ideal for a sailing expedition dependent on the wind to make good progress. An idle crew, moreover, could easily become a dissatisfied one. In these circumstance, scientific investigations provided occupation, contributing to both the scientific aspirations of the voyage as well as the general good running of the ship.

Attempting to measure the temperature of the deep sea was expected to be complex and unfamiliar: the instructions warned: 'Opportunities for determining the temperature of the ocean at great depths must of course be rare'. Thermometers capable of working – and

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[35] *Report of the President and Council of the Royal Society on the Instructions to be Prepared for the Scientific Expedition to the Antarctic Regions* (London, 1839): 12.
[36] *Report of the Royal Society*, 16.

surviving – so far beneath the waves were both recent and fragile. Measuring the *depth* of the deep sea was a different matter. Sounding technology had provided believable measurements of shallower waters for centuries, and some deep sea soundings had been attempted prior to the late 1830s. The recommendations read:

> Soundings to as great a depth as practicable should be taken whenever opportunity may offer. Great difficulty, however, is well known to exist in the way of procuring any exact result, or indeed any result at all in very deep seas; and various methods (all objectionable) have been proposed and tried. Could any means be provided to keep out the water from a shell, and at the same time ensure its explosion on striking the bottom, the time elapsed, between casting the shell overboard and hearing the explosion, would indicate the depth with great precision; nor need we fear that, if the explosion took place, the sound would not be heard, sound being propagated through water with infinitely greater sharpness and clearness than through air.[37]

Such recommendations were not without precedent. Experiments had been undertaken on Lake Geneva in 1826 where a bell was rung underwater and the sound detected through a listening tube nine miles away. In 1833, Henry Fox Talbot (1800-1877) suggested an exploding shell to propagate sound from floor of the sea to the surface, and, in 1836, the French physicist and surveyor Urbain Dortet de Tessan (1804-1879) suggested the use of echo soundings in surveying the Algerian coast.[38] These attempts at sounding do not appear to have been attempted by Ross at any stage during the expedition; there is no mention of it in private correspondence or narratives. Perhaps the idea of using sound to measure distance underwater, a technique used successfully through air, proved too problematic.

The British instructions for sounding anticipate failure: ‘The maximum depth of the sea is a geological datum of such value, that a few failures incurred in attempts may very well be tolerated when places in competition with the interest of even partial success’.[39] The

[37] *Report of the Royal Society*, 19.
[38] Deacon, *Scientists and the Sea*, 285.
[39] *Report of the Royal Society*, 19.

authors of the report recognized the difficulties involved in measuring the depth of the deep ocean precisely, but considered the importance of such a measurement worth the effort. This was a sentiment repeated in the recommendations for measurement of currents: 'The practice of daily throwing overboard a bottle corked and sealed with the latitude and longitude of the ship at noon ought not to be neglected. A single instance of such a record being found may suffice to afford indications of the utmost value, while the trouble and cost are too trifling to mention.'[40]

The one instance where more detailed information was given regarding operational procedure came with consideration of the depth to which sunlight could penetrate sea water. The expedition was instructed that, 'the actual intensity of these rays at various depths might be very easily ascertained, both for direct sunshine and that of cloudy daylight, by the aid of Mr. Talbot's sensitive paper; which duly guarded from wet by varnish and interposition between glass plates, might be sunk, face upwards in a small frame, while a portion of the same paper, cut from the same sheet, should be similarly exposed on deck, and partially shaded inch by inch, from minute to minute'. The recommendations added that, 'Paper duly prepared for these purposes will be supplied for the use of the expedition'.[41] Paper may have been supplied to the expedition but it obviously did not last too long. On the outward journey to the high southern latitudes McCormick recorded in his journal that he 'commenced arranging specimens to be sent home from St. Helene and made some photogenic paper'.[42] He does not describe the process used in the paper's production and I have found no

[40] For previous work on the ocean current see: Rennel, James. *An Investigation of the Currents of the Atlantic Ocean, and of Those Which Prevail Between the Indian Ocean and the Atlantic* (London: J. G. & F. Rivington, 1832).
[41] *Report of the Royal Society*, 19.
[42] Wellcome MSS. 3366, Book 3.

reference to its use. Either the instructions were not followed, or the experiments were unsuccessful and so the results omitted.

The scientific instructions given to the French expedition, including those relating to measurement, were the same as those given to the *Bonite* in 1836.[43] Unlike the American and British recommendations, these did contain notes on procedure. Experiments to measure the height of waves and to test how far light penetrated the ocean were given in detail, including the instrumentation necessary for their execution. The majority of the recommendations relevant to investigations of the ocean came under the section ‘phenomenes de la mer’ (phenomena of the sea), within the instructions relating to the ‘Physics of the world’. It included parts on ‘currents’, ‘height of waves’, ‘temperature of shoals’ and ‘visibility of shoals’. Recommendations relating to the tides came under the section ‘Navigation and Hydrography’.

Unlike the British and American recommendations, there is no specific section relating to the taking of depth measurements in the French instructions. Sounding and temperature readings at depth feature throughout the instructions in relation to other experiments, however, and were to be conducted when the vessels found themselves in calm weather:

> It is not to be expected that a vessel such as the *Bonite*, dispatched on a mission the express purpose of which is to convey some consular agents to the most distant parts of the globe, will ever suspend its progress to engage in physical experiment. At the same time, as hours, and even entire days, of dead calm may be anticipated by the navigator, particularly when he has to cross the line frequently, we conceive that this expedition will act wisely by providing thermometrographical and sounding apparatus, for the purpose of sinking instruments in safety to the greatest depths of the ocean.[44]

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[43] The recommendations frequently refer to the work of the *Bonite*, for which we may substitute *Astrolabe* and *Zélée* in this instance.
[44] Vaillant, Auguste-Nicolas. *Voyage autour du monde :exécuté pendant les années 1836 et 1837 sur*

The use of calm weather in this way was repeated in the orders respecting the tides. The French Académie de Sciences hoped that the 'study of the tides would lead to many interesting experiences, if we had enough interest in its execution. Therefore the Académie hopes that if possible the officers of the *Bonite*, determine at different times in the voyage, during the main periods of calm, the biggest and the smallest tides of the sea, also the direction, the force and the variation of currents'.[45] Lack of forward movement by the ship, when the strength of wind was low would to be used to study the ocean, just as in the American and British voyages.

Temperature readings of the ocean currents were used to place the ship in relation to the nearest land: 'it is only by the assistance of the means of great numbers of observations, that any hope of finding it again can be entertained. The officers of the *Bonite* would greatly facilitate this research, if, from the meridian of Cadiz to that of the most western of the Canaries, they could determine the temperature of the ocean every half-hour, to the tenth of a degree'.[46] The authors appreciated the need to obtain data sets rather than singular points, and expected a high degree of precision. This allowed greater analysis of the measurements and added credibility to the results.[47]

Each of the sets of recommendations include requests to repeat the investigations made by previous voyages in order to ascertain their accuracy. The British expedition was asked to: 'Re-examine temperature measurements made at Table Bay in 1834 by the Earl of Hardwick.'[48] The French recommendations stated that 'The frequent observations on the

*la corvette la Bonite /commandée par M. Vaillant*. (Paris: Arthus Bertrand, Éditeur, 1840-1866): 404.
[45] Vaillant, *Voyage autour du monde*, 429.
[46] Vaillant, *Voyage autour du monde*, 402.
[47] For more on obtaining data sets at sea see: Withers, Charles W. J. 'Science at Sea: Charting the Gulf Stream in the Late Enlightenment'. *Interdisciplinary Science Reviews* 31 (1) (2006): 58-76.
[48] *Report of the Royal Society*, 19-48.

temperature of the ocean which the officers of the *Bonite* will not fail to make between Cape Horn and the equator, will serve to correct, to extend, or to complete the important results obtained by their predecessors, especially by Captain Duperrey.' Further on the instructions stated:

> [E]very one will perceive how much the art of navigation is interested in verifying the fact announced by Jonathan Williams, and which some recent observations seem to contradict; how eagerly also would meteorologists receive comparative measurements of the temperature of superficial waters in the open sea and above shoals; and, in particular, how acceptable it would be to them to see determined, by means of the thermometrograph.[49]

Temperature changes in the ocean not only signified the approach of land but also areas of shallower water in the open ocean, that were responsible for losses of ships at sea. Jonathan Williams had argued that temperatures of the ocean fell in shoal water.[50] These scientific experiments thus had the benefit of being instructive regarding future navigation. Repeating and updating previous work, especially that of respected navigators, added additional credibility to the results of the expeditions.

Similar requests to confirm or refute previous work was included for the study of wave heights. The instructions to the French expedition read:

> Observers have generally been satisfied with forming an estimate of the height. But, in order to show how erroneous such estimates may be, and the influence which the imagination exercises in such matters, we may state, that navigators equally deserving of confidence, have some of them given sixteen feet as the greatest height of waves, others have stated it to be above a hundred. What science, therefore, now requires, is not rough guesses, but actual measurements, of which it is possible to appreciate the correct numerical value.

[49] Vaillant, *Voyage autour du monde*, 404.
[50] Williams, Jonathan. 'On the Use of the Thermometer in Discovering Banks, Soundings, etc.', *Transactions of the American Philosophical Society*, Extract, (1793): 82-98.

> These measurements, we are aware, are attended with great difficulties, but which, however, are not insurmountable; at all events, the question is of too great interest to permit of any efforts to be spared which may be necessary to solve it. [51]

Not only were experiments to determine wave height to be undertaken (and there is a lengthy description of how best to conduct them), but accuracy and precision were specifically called for. The difficult in obtaining results was recognised but the attempt was deemed worth the cost in time and resources. Whilst it must be stressed these were scientific instructions originally written for the *Bonite* expedition a year earlier, they were still deemed relevant: the questions posed remained unsolved, expectations still unmet. This, the official scientific mandate of the expedition, and from France's most influential scientific institution, the Académie des sciences, could not be ignored by d'Urville.

**Practice at sea: experimenting and measuring on expedition vessels**

Regular measurement of the oceanic environment was expected of each of the expeditions and to serve multiple purposes. In repeating the same experiments regularly throughout the course of the voyages, an understanding of the global nature of each phenomena was gathered, fulfilling the brief Humboldt had set out that global measurement, not local, was desired. It also provided a set of practices that crew and 'Scientifics' alike engaged with, a set of protocols to follow in all but the harshest of weathers.

D'Urville began his account by listing on the first page the result of underwater temperature experiments, highlighting the role of instrumentation as well as personnel: 'each day Messrs Dumoulin and Coupvent made repeated observations of inclination with an excellent instrument from the workshop of Mr. Gambey'[52] Within the first few introductory

[51] Vaillant, *Voyage autour du monde*, 404-405.
[52] D'Urville, *Voyage au Pole Sud*, I:129.

pages of his account Ross wrote ‘daily, almost hourly, observations of various kinds [were taken], from which so large a measure of useful and important results were expected’.[53] Ross also referred to their ‘almost daily experiments on the temperature of the ocean to the depth of six hundred fathoms’.[54] Wilkes commented that ‘It is unnecessary to recount the numbers of experiments that were performed, suffice to say, that they were made both by day and night, and were persevered in until the record of them became an almost daily portion of our journals; and the interest in them was extended from the officers, until they became a subject of inquiry even among the crews’. [55]

Adhering to the sailing instructions was an important consideration, and once done the results were readily reported back home. The *Athenæum* printed numerous letters from Wilkes to the American Admiralty stating the scientific investigations that they had made. The following extract describes the American vessels search for *viagas* (obstructions in the water) that had previously been reported, and also a detailed description of the use of the current-log:

> being near a shoal, laid down on the charts as St. Anne’s shoal, I deemed it fulfilling instructions to delay sufficiently for the purpose of examining the same; and having fully explored the locality in and near the supposed neighbourhood, by spreading the vessels of the squadron to embrace a large circumference of the ocean, nothing of it was discovered. A few hours, however, after leaving this vicinity, we fell in with a large cotton wood tree, 120 feet in length and 15 feet in circumference, which was at first reported as a shoal,; and if the sea had been at all rough, it might, in passing, have been mistaken for one.’
>
> We hove to, and tired the current morning and evening, and always found the same result. The current log used was two kegs, with a distance line of five fathoms between them, the lower one being just loaded sufficiently to sink, the air-tight one under the surface of the water, with the usual log line attached to the centre of the

[53] Ross, *Voyage of Research and Discovery*, I:4.
[54] Ross, *Voyage of Research and Discovery*, I:26.
[55] Wilkes, *Narrative of the United States Exploring Expedition,* V: 458.

> distance line, precluding the possibility of its being a surface current; besides which, the dead reckoning of the ship, and our observations gave the same result. [56]

The same issue of the Athenæum printed a letter from Lieutenant Hudson of the Peacock, describing his own investigations and use of the patent log (a device towed in the water behind the ship to measure its distance travelled and speed):

> [H]aving separated from you on the 16th of October, it was not until the 23rd that I had worked up to the Warley's shoal; and at 8 o'clock that night I was directly on the spot where it was laid down on the chart. We placed good lookouts and kept our patent log going for fifty miles before reaching the location of this shoal as laid down on the chart; also observing our drift at night, in hopes of sweeping over it at early daylight.

These comparatively detailed descriptions of procedure (when compared with the published narratives) reflected an imperative to prove that what had been asked of the expedition, in the instructions for sailing, were being fulfilled, whilst the expedition was at sea. The importance of determining the correct location of suspected obstacles in the water, lethal to the whaling ships that frequented southern waters, was also a topic of considerable interest to the readership at home.

Sailing as part of a larger expedition afforded each ship the opportunity to compare its workings, of ship, men and instruments, with those of its partner. By obtaining agreement between ships an additional level of credibility was brought to the findings. Ross was eager to use the advantage of sailing with two ships in close contact to ensure his instruments were doing their job. Three months out of Van Diemen's Land, in the southern ocean, Ross recorded going on board *Terror* to consult with Crozier regarding the workings of the chronometers and barometers. He stated that the chronometers were 'only 4" [off] off time, equal to a mile of longitude, or in this latitude less than a quarter of a mile of distance; a

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[56] TNA BJ2/4: Athenæum, 21 September 1839. Extract from a letter to the Secretary of the Navy, from Lieut. Wilkes, commanding the United States South Seas Surveying and Exploring Expedition, dated on board the Unites States sloop *Vincennes* of Rio Janeiro, November 27, 1838.

sufficient proof of the excellence of the instruments with which we were furnished: – the agreement of the barometers was perfect'.[57] On another occasion, however, unusual readings with the barometer in moderate weather led Ross to question the proper working of his instrument: '[I] suspected it had met with an accident, therefore made the signal to the *Terror* to compare barometers'.[58] D'Urville also recognised the benefits of which the position of sailing as part of a squadron allowed them for scientific purposes. Yet being aware of the possibilities and being able to act upon them were different things. As d'Urville recorded, 'It is unfortunate that our two corvettes, on leaving France, were not both able to be equipped with similar instruments, because making the observations of the sea presents many difficulties and leaves much uncertainty, and science has much to benefit from a comparison of observations, which would be made aboard the two ships, sailing together'.[59] Whilst carrying different instruments aboard each ship allowed the testing of twice as many variations of a particular given technology, it ruled out the chance to check how well any piece was performing in comparison with another.

The repetition of experiments to build up a series of credible measurements was not the only reason experiments were undertaken regularly. Repetition was a way of checking the instruments worked as expected by comparison with previous results. Repetition could increase the precision of measurement, eliminating systematic errors and forming a standard by which all other measurements could be judged. On removing and replacing the iron on board the *Erebus* for repairs, Ross noted the effect on the compass, 'we were surprised to find that both in amount and direction it had very considerably altered', adding, 'these results

[57] Ross, *Voyage of Discovery and Research*, I: 233.
[58] Ross, *Voyage of Discovery and Research*, II: 215.
[59] d'Urville, *Voyage au Pole Sud*, I:129.

point out in a striking manner the necessity of frequently repeating experiments of this nature'.[60]

All three expeditions had a set of experiments that were performed, or were supposed to be performed, on a regular rota. D'Urville listed, '[experiments on] the wood, the water, d'angles horaires, physics, meteorology, tides, natural history etc.' as the common experiments the French undertook in fine weather.[61] Wilkes described the 'usual experiments' performed as the ´measuring of deep-sea temperature, dips, variation, currents, visibility of a white object in water and dip of the horizon', tellingly 'only mentioning such as generally interesting'.[62] He did not, however, see the taking of depth measurements through sounding line as an experiment, treating it as a form of navigation and safe passage, or as a task to be performed in conjunction with other studies of the ocean, such as temperature and current. Nor does he list any but the physical sciences (performed by officers of the ship), neglecting to mention the work undertaken on dredging, for instance, that brought up animal and geological specimens. The 'usual' experiments each involved precise measurement; it was this that marked them out as being the most important of the scientific investigations.

The scientific instructions to all three expeditions expressed the hope that previous experiments would be repeated and more accurate, precise, and credible results achieved. Additionally the firmly-held belief of those on board was routinely confirmed, or denied, through repetitive experimentation. Dumont d'Urville, writing about his expectations regarding an experiment in the freezing temperatures of the Southern Ocean, recalled:

> A thermometer was attached to the lead, it showed at this depth the water was one degree less than at the surface. M. Dumoulin expected to find an increase in temperature at depth rather than a cooling, the water at the surface being zero degrees.

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[60] Ross, *Voyage of Research and Discovery*, I: 27.
[61] D'Urville, *Voyage au Pole Sud*, I: 96.
[62] Wilkes, *Narrative of the Unites States Exploring Expedition*, I: 309.

> He attributed the result to the close proximity of ice. For my part, I agree readily enough with his opinion, which states that, when the water at the surface of the sea is zero degrees, one must expect an increase in temperature at depth.[63]

Dumoulin carried out his experiment on the temperature of the deep sea with a firm belief in what he expected to see in his measurements. That he was found, on this occasion to be incorrect appears to have been of little significance to d'Urville. Their belief in a rise in temperature at depth still held and they continued to experiment, expecting to confirm their hypothesis given time. Knowledge, as Hacking suggests, emerges temporally, however, and no knowledge established before an experiment is entirely immutable.[64] New experiments in tricky surroundings needed repeating multiple times in order to ensure accuracy and reliability, and eventually even pre-conceived ideas were made to give way to new theories that fitted with the measurements they were taking in the field.

With the repetition of experiments on and from the sea came familiarization and increased skill - and ennui. The scientific recommendations all pointed to work that could be undertaken when weather conditions forced the ships to remain stationary: there are many examples of this. D'Urville pointed to the problems relating to such a long time spent at sea for all those aboard: 'the distractions are scarce for the seamen, and often the idleness and boredom that is subsequently cast, discourage the crew'.[65] D'Urville recorded that 'to pass the time they resumed their thermometograph experiments, and gave the men musketry practice'.[66]

[63] D'Urville, *Voyage au Pole Sud*, I:175.
[64] Hacking, *Representing and Intervening*.
[65] D'Urville, *Voyage au Pole Sud*, II:137.
[66] Rosenman, Helen. *An Account in 2 Volumes of Two Voyages to the South Seas*, (Melbourne: Melbourne University Press, 1987): 352.

As a result the captains were happy to use scientific procedure to both fulfil the scientific mandate of the expedition and occupy an otherwise restless crew. Ross described how ‘experiments in the temperature and specific gravity of the ocean, at various and considerable depths, were also made; and as they gave occupation to the crew, so they served, in some measure, to relieve the tedious and wearisome hours of our imprisonment and inactivity’.[67] Offering a visual stimulus also helped, as D’Urville explained, writing on why he kept this boats close to the land when sailing south from France to Spain, ‘This is the way to make navigation less boring for everyone’.[68] The long and tiresome nature of both underwater investigation and shipboard life more generally was an issue acknowledged by those on board, and as shown in the instructions, by those at home.

Although sounding and experimenting on the deep sea kept the crew from idleness, however, it did not always gain favour with those it was meant to occupy. D’Urville made repeated reference to the time consuming nature of experimentation, and its effects on the crew: ‘To use the calm weather, I ordered a sounding to 1000 fathoms. But this fatigue was spared us; the line found the bottom at 180 fathoms and it was rocks, covered with gravel’, and whilst waiting for experimentation to finish he expressed a general discontent with the length of time associated with the process, ‘each of us, tired of this boring break, wait impatiently until the magnetic observations are finished’. [69] Midshipman Reynolds of the American expedition was more vocal: ‘he [Wilkes] saddled us, too, with another species of persecution by requiring us to “heave to” every day, to try the temperature of the Sea at 100 fathoms. A more ingenious system of torture he could not have invented’.[70] Here the slow

[67] Ross, *Voyage of Research and Discovery*, II: 150.
[68] D’Urville, *Voyage au Pole Sud,* 5.
[69] D’Urville, *Voyage au Pole Sud*, II: 152; 46-47.
[70] Hoffman Cleaver, Anne and Stann, E.J. (eds) *Voyage to the Southern Ocean – Letters of Lieutenant William Reynolds of the United States Exploring Expedition 1838-1842* (Annapolis: Naval Institute

and tedious nature of some of the deep-sea investigations was used, in Reynolds's opinion, to delay the progress of part of the American fleet, so allowing Wilkes's ship to arrive home first and take the glory.

Keeping a safe distance from the shore and other navigational hazards was the captain's primary concern. To do so often required the use of precision instrumentation, not just the sounding line. Ross referred to his 'great reliance' on the barometer to ensure safe passage, as well as the use of the thermometer. Wilkes recorded that 'I am satisfied that the use of thermometers would be beneficial to those navigating around this Cape; for by keeping in water of a temperature above 70°, they would, although exposed to a rougher sea, be carried more rapidly around the cape'.[71] The use of the thermometer was particularly useful and indicative in the Antarctic Seas, where a fall in temperature was often the best indicator of icebergs. D'Urville wrote 'The temperature dropped rapidly and a very cold mist obscured the horizon, despite the purity of the sky, announcing the proximity of ice'.[72] In some instances, however, two different instruments gave very different indications, as d'Urville remarked, 'despite the calm and the often frequently good temperatures, for some days the level of mercury in the barometer held a very low level'.[73] Whilst these methods helped ensure the ship did not run aground, they were not useful in navigating the ship from one point to another: that required use of the chronometer, lunar tables, the compass, charts, maps, and instruments that interacted with the environment above the sea level. Measurement of underwater phenomena, particularly the depth and temperature of the ocean, was used with

Press, 1988): 283.
[71] Wilkes, *Narrative of the United States Exploring Expedition*, V: 420.
[72] D'Urville, *Voyage au Pole Sud*, II: 35.
[73] D'Urville, *Voyage au Pole Sud*, II: 56.

a variety of visual clues, such as changes in the colour of the water and the appearance and of animal life to guard the ship against running aground.

Throughout the texts, there is very little, if anything, that relates either to the instruments used or the practices involved in the measuring of collected specimens: the fish, birds, plants and other forms of marine life that were brought on board through the dredge, net and sounding line. There are no descriptions in the narratives, zoological volumes, letters or journals; no tables of numbers accompanying the physical specimen or sketch. It is hard to tell, therefore, if these practices just did not occur on board ship, or if they were not recorded; it seems fair to assume, however, that if it was prevalent it would appear in print. If the measuring of specimens was not a regularly occurring task on board ship, however, was that so? One reason for its absence could be that this was a practice to be undertaken at home, once the specimen had made it safely back to the various institutions in which such material was processed. The precise measuring of zoological and botanical samples on board would have been awkward, but no more so than the taxidermy and illustrative practices undertaken. Another reason could be that a sample was collected, preserved, and sent home in order that it could be classified. To do this, a species needed to be compared with others of its like, to decide if it were new or already known, or a variant of a form already known. For this, a reference collection was required and there was such room on board ship for such: the best that could be done was to consult the various scientific volumes that the ship's library carried, or those in the possession of the officers and naturalists. It was accepted that classification would be done by others back at home, not in the cabins of the expedition ship.

The 1830s and 1840s marked the heyday of comparative anatomy, in which morphological and developmental characteristics were compared between organisms, defining species or groups. This was later to be used extensively in Darwin's *On the Origin of Species*. Comparison of anatomical features was often done by eye alone; the focus was not on precise measurement. John Richardson and John Gray in their zoological volumes of the British Antarctic expedition stated that, in measuring parts of the fish species *Muraena siderea*, 'in one specimen [it] is about a 50th part of the whole length beyond the middle, while in another it is a 13th part, the tail being comparatively short in the latter. This is an instance of the danger of relying solely on such measurements for the establishment of specific characters in this genus'.[74] In the act of preserving the delicate structures of birds and fish, much damage was caused, making reliable measurement difficult (see Chapter 4, pp.100-153). More than this, men of science concerned with describing species at this time were sceptical about precise measurement. Rather than adding credibility to the ultimate aim (of correct classification of species), it was held to confuse the issue. Measurement was used, but only in combination with other, qualitative measures.

**'Seeing' further: sounding the deep ocean and ensuring safe passage**

The functional depth of the ocean changed throughout the course of the nineteenth century. The sounding line, water sampler, and thermometer, amongst others, allowed instrumental investigation of the submarine environment. These devices allowed the construction of knowledge on the deep sea through their ability to go deep, take measurements, and be retrieved. In the mid-nineteenth century, no one had seen more than a few fathoms below the surface using the naked eye. This seemingly most fundamental of activities – to provide first hand ocular proof of what was beneath them – was also one that seemed not to concern those on board. It was a taken-for-granted invisible space, felt through the prosthetic extension of the line. The few mentions of a device that could extend human vision under water, therefore,

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[74] Richardson, John and Gray, John. *The Zoology of the Voyage of the H.M.S Erebus and Terror, under the Command of Cpt Sir James Clark Ross, during the years 1839 to 1843* (London: E. H. Jansen, 1844): 85.

relate not to a wish to confirm ideas of what existed there, but to provide further means of preventing collision of the ship. Dumont d'Urville recorded his assessment of the efficacy of a new device manufactured by M. Arago – the scopeloscope – an instrument designed to increase the depth to which an observer could see clearly underwater:

> [W]e did experiments on the transparency of the sea water. An earthenware plate remained visible to the naked eye until 19 or 20 fathoms deep; at 2 or 3 fathoms more, we ceased to see it using the scopeloscope. The theory seems to indicate that the tourmaline, which is in the body of the instrument, under the visual angle of 37 degrees, must eliminate all the reflected rays of light, to leave only those that arrive directly at an object under the water. It results that this object, seen under an angle of 37 degrees or close to that, must be more apparent with the aid of the scopeloscope than the naked eye, and we hope that this instrument could be a powerful aid in the seas strewn with coral.[75]

The use of sounding devices in coral laden seas was far from ideal: the instruments were constantly and often irreparably damaged. The ability to discern such underwater hazards without the need to sound would have been a safer and instrumentally time saving affair. It was not long, however, before d'Urville was regretting his previous up-beat attitude to the instrument:

> Many times we tried Arago's scopeloscope, and despite all precautions, we could achieve no good results. A porcelain plate was attached to the end of a line and plunged into the water to a depth of 19.5 fathoms where it ceased to be visible with the naked eye; with the scopeloscope it could not be seen at that distance, and it is very untoward that the results of the experiment did not confirm the theory of this ingenious instrument.[76]

It seems that an instrument so unpredictable in its working had little use as a navigational aid: it is not mentioned again. The lengthy description of the use of the scopeloscope points to another facet of recording measurement: experiments were carried out with an understanding that *how* the investigation was being performed was relevant, not just

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[75] D'Urville, *Voyage au Pole Sud*, I: 3.
[76] D'Urville, *Voyage au Pole Sud*, I: 174.

the result. The sailing instructions had mostly overlooked procedural detail but *record* of deliberate method was important as is evident by the repeated and detailed statements about method throughout the narratives and the personal written journals and correspondence of those on board.

The British and American expeditions made no mention of carrying an instrument to extend the normal range of vision as did the French. Wilkes records that they used an iron pot with the bottom painted white to investigate the depth to which an observer could see with the naked eye.[77] Charles Erskine, a crewman, recalled the object and its use in greater detail: 'our pot, which was a large, old-fashioned, thick-legged, iron one, painted white, when lowered into the water, bottom upwards, was seen at thirty-two fathoms (one hundred and ninety feet) deep'.[78] There is undoubtedly a significant difference in wanting to extend the range to which one could see with the eye alone, and measuring the distance. Both the French and American expeditions seem to have used similar objects to carry out the latter: the earthenware plate and iron pot painted white were commonplace, familiar, and expendable items. Everyone wanted to know where the sea floor lay, but the imperative was to prevent accident to the ship, not to further knowledge about the ocean itself. Nonetheless, it was through these everyday acts of shipboard practice that knowledge about the underwater environment was gained, and spurred investigators to know more.

Accepting that what lay beneath the ship was not easily realised visually, made accurately measuring the depth of the water beneath them an integral and often lifesaving task for those on board. The use of the sounding line indicated how close the ship was to land. It was trusted as an indicator of depth even when other, more readily visual indicators

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[77] Wilkes, *Narrative of the United States Exploring Expedition*, I: 4.
[78] Erskine, Charles. *Twenty Years before the Mast* (Washington: Smithsonian Institute Press, 1985): 250.

could be employed. Around the treacherous waters of the Pacific islands, Wilkes recorded they had thought land nearby, 'but on sounding with one hundred fathoms, no bottom was found'.[79] When thought to be in hazardous waters, the boats on the American expedition sounded every half an hour throughout the night, to ensure they did not travel too close to land, in too shallow water. Sounding on the Oregon coast, Wilkes wrote, 'I afterwards discovered, [they] may serve as a sure indication by which danger may be avoided and safety may be insured by not approaching the coast into soundings of less than seventy fathoms'.[80] Wilkes may have been highlighting this particular region due to the fact his companion boat the *Peacock*, for want of sounding, was wrecked on rocks at the entrance to the Columbia River. This expression of careful precision measurement was also an instruction of best practice to those who were to follow.

Deep-sea soundings were the lengthier compatriot of coastal soundings. Hooker, in a letter to his grandfather, gives a thorough account of the procedure, alongside some of the additional routine procedures undertaken concurrently:

> The Captain sounds every day in the deep sea, with 2,500 fathoms of line & draws up water from different depths of which he takes the temperature & specific gravity, this is hardly ever omitted. The ships in the mean time [sic] are hove to & we communicate our longitude, latitude, magnetic variation & slip to the "Terror" by signals, she exchanging hers to us.
>
> All the ships company stamping along the decks with a thick sounding line to any tune the fiddler strikes up, he has favoured us with Rob Roy very much of late. This sounding in 500 fathoms is hard work as the line requires to be very thick & strong: whale line generally is used & when wetted by immersion requires all the men to haul it up again. Self-registering thermometers, & peculiar bottles for bringing the water up from any depths, Massey's & other logs &c. are attached to it. The water from a great depth when brought up is very cold, & foams exactly like soda water & is much less salt than the surface water.

[79] Wilkes, *Narrative of the United States Exploring Expedition*, II: 291.
[80] Wilkes, *Narrative of the United States Exploring Expedition*, IV: 296.

> We have three or four times tried for bottom with an immense length of line but hardly ever fully succeeded[,] once we did & then gained the bottom with 2477 fathoms!!! The line prepared was 30,000 feet long & of three different kinds, that next to the sinker (of 3 cwt) was just strong enough to hold it, an intervening thicker kind was prepared of what is called spun yarn & the remainder was whale line, a strong small rope. -- Of course very little of the line was rewound again, it breaking on the attempt to haul it up.[81]

Hooker's description highlights the multipurpose nature of the sounding line: not only did it provide the means of ascertaining depth, here by Massey's log (see Appendix III), it also allowed measurements of temperature to be taken and samples of water to be collected upon which experimentation was undertaken on-board. The opportunity was taken to pass information between ships, a specific requirement of the official sailing instructions. Hauling the line at this time, before the introduction of wire for the purpose, was an intensive, strenuous activity: the task was lightened, and regulated, by music.

Soundings were often undertaken from a small boat away from the main ship (Figure 3). Erskine recalled how, 'one afternoon I was ordered into the dinky, a small shell of a boat, with lead line and compass'.[82] Ross believed that these small vessels would drift less far than the main counterpart when the sounding was taking place. The line was counted every time 100 fathoms of it ran out, and a slowdown in the rate was the indication that bottom had been reached. This was known to be fairly reliable in shallower seas, of 2500 fathoms or less, but the accuracy at deeper parts was more difficult to ascertain as the rate at which the line slowed down was hard to determine. The procedure was time consuming. On sounding whilst passing through the Saragossa Sea, Wilkes claimed 'deep soundings in this part of the ocean, would be very interesting, and afford an opportunity of settling the origin of this planet'.[83] Unfortunately, he continued, there was no time to spend on such experiments, so highlighting

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[81] JDH/1/2 f.28. Joseph Hooker to Joseph Hooker (grandfather), 28 March 1840.
[82] Erskine, *Twenty Years before the Mast*, 186.
[83] Wilkes, *Narrative of the United States Exploring Expedition*, I: 27-28.

a juxtaposition between the aspirational aspect of scientific investigation and the need to keep to the ship´s strict schedule.

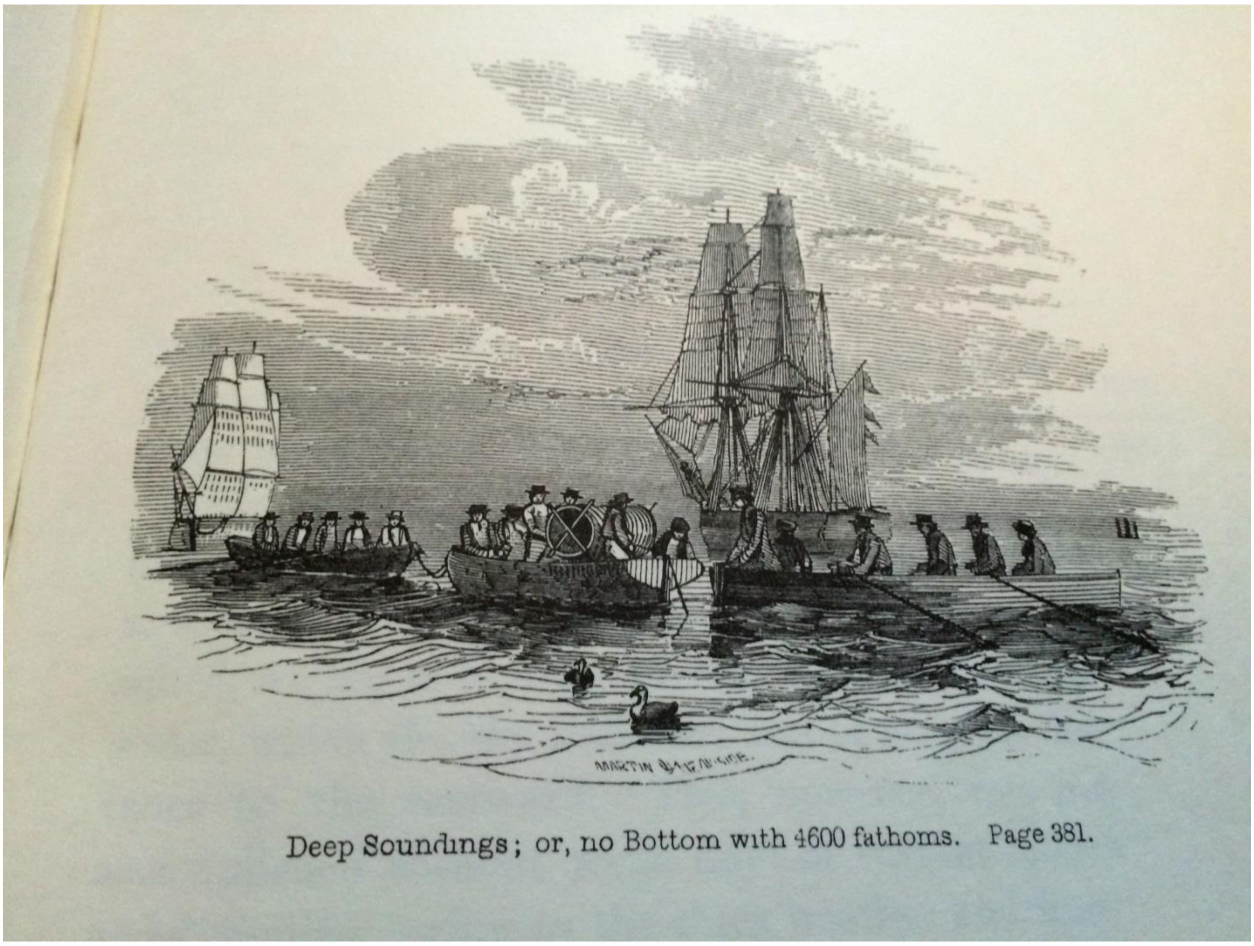


Figure 3: Obtaining deep sea soundings on the British Antarctic Expedition. (From James Clark Ross- *A Voyage of Discovery and Research* Volume II [London: John Murray, 1847], 38).

Ross forwarded ‘an account of an attempt at sounding lat. 68”. 34´S and Lon. 12.” 49.’.W made in the boats of his Majesty, ships Erebus and Terror on the 3rd of March 1843’ to Francis Beaufort that described the process of the deep-sea sounding, and some of the pitfalls:

> It became quite calm. I seized the opportunity of ascertaining the temperature of the ocean at 750, 600, 300 and 150 fathoms, and in the afternoon, the sea having become perfectly smooth, and the calm still prevailing, our boats were lowered down, and the experiment of deep-sounding attempted. I regret that owing to our having always found soundings in less than 2000 fathoms in other parts of the Antarctic sea, I had

> prepared more than 4000 fathoms of line for this occasion. The whole ran off the reel without sticking ground. The experiment was most satisfactory.'

Ross went on to state that 'the weight employed was 340lbs' and that the 'whole [line] was prepared in equal proportions, by the Crew of the Erebus and Terror.' At the same time as the sounding the current was testing and 'found to be setting to the SW as the rate of 0.3 per hour'.[84]

There is little in the French material that relates to deep-sea sounding. That it was an integral part of life at sea if without doubt but was not considered noteworthy in the same way as experimentation on temperature and current. The scientific recommendations omitted it entirely from their instructions. Of all the expedition captains, Ross displayed the keenest interest in obtaining soundings from the deep sea, tailoring his instruments so they were best suited to the job. He had no doubt that his method of obtaining accurate deep sea soundings was a good one,

> I have just obtained another deep sounding, and although we have not yet been able to get down as far as I wished, and still hope to so, I am quite satisfied that if we get into any sea deep enough, we shall have no difficulty in accomplishing it. The weight employed was 540lbs., and we had on the reel something more than 5000 fathoms of line: the first 437 fathoms were a single strand of whale line; the rest was of two strands of three-yarn spun yarn, and the following are the rimes of each of the marks passing off the reel.......Crozier took down the time of each mark passing off the reel, and when the weight struck the bottom, it stopped so suddenly that the boats' crew all cried out, "it is down". We veered away 50 fathoms afterwards, and then hauled in again, but could not get an inch more than the mark at which it first struck. Nothing could be more satisfactory than this sounding, and it is more so from shewing very plainly that we have the means of getting soundings however deep the sea may be, and I trust our next trial will be in deeper water. I have ordered the line to be again completed to 5000 fathoms; but it would be useless to attempt it any more on this side of the Cape.[85]

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[84] SPRI: MS1556, 344. James Clark Ross to Francis Beaufort, 3 March 1843.

[85] Letter from Ross to the Hydrographer of the Admiralty, *Nautical Magazine and Naval Chronicle* (London: Simpkin, Marshall & Company, 1840): 507–8.

If the importance of obtaining a reliable deep sea measurement could be doubted to Ross, the inclusion of Crozier, head of the *Terror*, to mark the time taken for the lead to reach bottom showed that he was taking the process seriously, engaging only the most reliable of men in its operation. Evidence of his inclusion also lent authority to the result; a measurement taken and verified by two captains was more credible than one secured by nameless crew members. The experiment was repeated, the whole lengthy process being performed again just fifty fathoms away and the exact result being once again obtained, lending another degree of credibility. Ross was confident in his instruments and in the process of measurement and did his best to ensure those that notable figures at home would be convinced equally.

Ross was not alone in displaying such interest in the depth of the sea. An unnamed officer wrote home that,

> [p]erhaps the most interesting of our achievements will be the fact of our having gained bottom, at two thousand four hundred and twenty six fathoms, in latitude 27d24'S. Longitude 17d30'W. Both ships being becalmed on the edge of the S.E. trade. A line of 3600 fathoms of spun-yarn being prepared, a weight of 72lbs was attached to it, and two boats were lowered to buoy up the line. The first 100 fathoms took 35 seconds reeling off, - the last nearly 6 minutes; we lifted the lead more than once, but of course the spun yarn broke in the attempt to haul it up.[86]

Of all the achievements of the British Antarctic expedition, to point to this as the main one shows that there was real interest amongst those on board in what was, at this time, a rather abstract measurement. Unlike coastal soundings that gave indication of land, or magnetic measurements that signified the position of the South Pole, the depth of the deep sea was a ´trophy measurement´ rather than a practical one. This officer's detail over the

[86] Reproduced in: 'Southern Magnetic Expedition – Extract of a Letter from an Officer of H.M.S Erebus, 7th February. 1840. In, *Journal of the Franklin Institute: Third Series, Volume I.* (Philadelphia: The Franklin Institute, 1840 ): 70.

method points to an understanding that information of this sort lent epistemological credibility the resultant measurements.

### The fallibility of instrumentation and impediments to experimentation

In order to obtain precise measurements whilst at sea it was necessary to take not just the requisite precision instruments on board, but also to ensure that they were kept in good working order throughout the expedition. Keeping instruments clean, dry, and functional was a serious challenge to the nineteenth-century mariner.[87]Karen Knorr Cetina has argued that whilst lab protocols provide scripts for going about experimentation, in practice they must be negotiated 'with obdurate materials and living things'.[88] The captains may have been given instructions regarding measuring of maritime phenomena; achieving it in everyday conditions was a different matter.

On-board storage of all instrumentation was difficult. Housing them in the captain's cabin offered the best chance of survival. In a letter from d'Urville to the French Minister of the Marine, reproduced in the *Athenæum,* he highlighted the need to keep the most important instruments safe: 'All the compasses in the ship veered in a remarkable manner [on entering the icy barrier], and on board the Astrolabe the reversed compass in my poop-cabin was the only which marked the route with anything like precision'.[89]

Wilkes had reason to regret choosing to store his chronometer in his cabin, recording that due to rough seas; water had 'entered at the cabin windows, and filled the chronometer

[87] For more on damaged instruments see: Schaffer, Simon. 'Easily Cracked: Scientific Instruments in States of Disrepair', *Isis* 102 (4) (2011): 714-15.
[88] Knorr-Cetina, Karen. *Epistemic Cultures: How the Sciences Make Knowledge*, (Harvard: Harvard University Press, 1999): 88.
[89] *Athenæum* (662), July 4 1840, 553.

box with salt water'. The vessel had to return to Sydney in order to collect a new instrument for what Wilkes described as his 'injured time-piece'. [90] Even this precaution of using the captain´s cabin was not always sufficient to ensure no harm occurred to the instruments. The hasty fitting out of the French vessels meant that storage was not given priority, but d'Urville remarked that there has been 'little damage, and the sympiesiometer placed in my room alone suffered'.[91] Microscopes were kept in the naturalist's sleeping quarters, lashed to the table to ensure they did not fall to the deck. The sounding lines, wires, leads and weights remained on deck. Although they were more robust, they nonetheless could fall foul of the busy workspace, becoming tangled, broken or weather beaten. It was the case that the instruments taken on board such long and diverse expeditions as those to the South Seas, were often prototypes, untested in the extreme conditions the expeditions faced, and experiencing problems that those on board were at times unable to fix. These instruments, often the design of one man, were regularly referred to by their maker's names: Six's thermometer and Fox's dipping circle to name two of the most common. D'Urville took particular umbrage with a device for bringing up sea water: 'An instrument invented by Mr. Biot to bring up sea water drawn from great depths, has not been successful', continuing, 'must suspect that there was something defective in this mechanism'.[92] Not long after he continued, 'We did not have a lot of joy with the instrument of Mr. Biot either, with which one can draw water from the sea at various depths. But I believe that if it has not succeeded as was to be expected, it is due to the poor condition of the valves.'[93] Despite the difficulties encountered in its use, it appears that continued use of the instrument did take place, albeit with difficulty. These obstacles were, to use Hacking´s terminology, 'interventions', but not preventions in the process of sub-marine

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[90] Wilkes, *Narrative of the Unites States Exploring Expedition*, II: 370.
[91] D'Urville, *Voyage au Pole Sud*, I: 2.
[92] D'Urville, *Voyage au Pole Sud*, I: 4.
[93] D'Urville, *Voyage au Pole Sud*, I:174.

investigation; despite difficulties of use, repeated trials were undertaken with obdurate instruments. The procedure became about testing the instrumentation as much as obtaining results.

Being seen to have the best instruments for the job at hand was vital to ensuring the credibility of the resulting measurements. In some cases, the expeditions were not equipped with the best instruments from the start. Wilkes was known to have tried to obtain a Fox's dipping circle for measuring magnetic intensity, but was not successful; the loss was lamented during the course of the expedition, when the 'observations for intensity failed for want of a proper instrument, that of Fox'.[94]

On some occasions the right equipment was taken on board but during the course of the voyage became unsatisfactory. The scientific instructions to the Ross expedition made it clear the instruments would be temperamental but manageable:

> The self-registering thermometers are apt to get out of order by the indices becoming entangled, or from the breaking of the column of fluid. When this happens with the spirit thermometer it may be rectified with ease by jerking the index tube down to the junction of the bulb and tube. The whole of the tube will at the same time become wetted with the spirit, and by setting it on end with the bulb downwards the spirit will run together into one continuous column.[95]

Despite this recognition of the potential fallibility of the deep-sea thermometers, there was no comment regarding their protection.

The sounding line, particularly when employed in deep-sea soundings, was prone to failure: it was difficult to bring up the line once the heavy weight had reached bottom without breaking it, losing valuable and scarce line and weight. McCormick made repeated reference to the process in his journal: 'the two captains [Ross and Crozier] went away in their boats to

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[94] *The North American Review* (56) (Boston: David H. Williams, 1843): 268.
[95] *Report of the Royal Society*, 47.

hove the line in and were of the opinion that they had got bottom at 2,400 fathoms, ship hove to, most of the line lost in hauling up the weight carrying it away'.[96] Later, during another deep-sea sounding he recounted, 'got bottom at a depth of 2677 fathoms, with a weight of 540lbs, although to a spun-yarn line of 5000 fathoms. Not being able to raise the weight from such a depth, the line came out, the whole of the portion lost. This is by far the greatest sounding yet obtained, 470 miles from the Cape of Good Hope'[97] Success in measurement was often countered by failure to retain valuable instrumentation, impairing the execution of subsequent investigations. Thus the ship and the surrounding environment presented a space of frequent negotiation. There was no black and white result between success and failure but often a grey area of compromise between environment, instruments, vessel and personnel.

Wilkes described running out a long line but 'on reeling it up, the wire parted, and we lost nine hundred and sixty fathoms of line with our sounding apparatus, including one of our Six's self-registering thermometers. The wire was badly prepared and ill adapted for the purpose'.[98] Wilkes does not elaborate on why, exactly, the wire was so badly suited for its job, but it is clear that instruments and equipment not only suffered through the rigours of their performance, but could be in a substandard state prior to their usage.

That the instruments and equipment they were provided with did not always work as they should, and were not of the quality or accuracy that was desired, seemed to be well understood by those dealing with such objects on a daily basis. In surveying, Wilkes recommended that the other officers 'try your patent log well before using it: a strong line of twenty-five of thirty fathoms will suffice'.[99] In describing the use of the current log, with

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[96] Wellcome, MSS.3366, Book 3.
[97] Wellcome, MSS.3366, Book 3
[98] Wilkes, *Narrative of the United States Exploring Expedition*, I: 38.
[99] Wilkes, *Narrative of the United States Exploring Expedition*, III: 406.

which he was impressed, Wilkes admitted that 'I was, however, aware, as all those who have used this instrument extensively must be, that it is liable to many objections'.[100] Difficulties in obtaining technologies suitable for the demanding marine and shipboard environments were pervasive problems throughout the mid-nineteenth century expeditions.

Sometimes, environmental conditions had an impact upon the working of the instruments. Titian Ramsey Peale recorded that 'the thermometer gives (owing to the hygromatic state of the atmosphere) but a poor indication of the sensible state of the temperature'.[101] Despite having the appropriate hardware, the execution of one of the most fundamental exercises – that of recording the temperature - was made frustratingly complex. Understanding the limitations of the instruments they carried and how to make them work despite the challenging conditions they faced was vital if their users were to produce credible results.

Any instrument destined to measure what lay beneath the ocean waves needed not only to go down but to come back up again. This was the only way to see what had been recorded and due to the expense, accessibility and lengthy manufacturing time associated with many of the instruments, their loss was keenly felt. Peale described trying to record the temperature at 400 fathoms with a 'self-registering thermometer and a brass "marine diver" but the wire used in place of a line which was of copper, broke – the instrument consequently lost'.[102] Wilkes described how, '[the *Porpoise*] attempted to get a deep-sea cast, and had

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[100] Wilkes, *Narrative of the United States Exploring Expedition*, V: 457-8.
[101] Poesch, *Titian Ramsey Peale*, 131.
[102] Poesch, *Titian Ramsey Peale*, 141. The marine diver was a type of water bottle, designed by the English whaling Captain William Scoresby in 1811 that he had felt better adapted to collecting water from the deep sea than the type of water bottles more commonly used. Wilkes does not list the diver in his list of instruments taken on board the expedition, so it was either brought on board by one of the Scientifics themselves, or was not deemed important enough to be included in the official list. Wilkes himself makes no reference to its use in bringing up water samples

nineteen hundred fathoms of line out; in hauling in the line it parted, and nearly seventeen hundred fathoms of it were lost, besides the only self-registering thermometer'.[103] The valuable Six's thermometer and the marine diver were lost as a consequence of the poor performance of the line, not through any failure in its own operation. The French also had problems with the sounding line and thermometer. D'Urville wrote often of their difficulties: 'we profited from the calm weather to make a sounding with the deep sea thermometer; but scarcely had we reached 800 fathoms than the line broke'.[104] Fallibility lay not with the device but in its associated technology – the line.

It was not always in use that equipment was damaged; d'Urville had occasion to bemoan the fact there was no suitable lines to even begin such an event: 'I looked, when the corvettes were idle, to make soundings: unfortunately all the lines were almost out of service'.[105] Depth was not the only enemy of measurement: even at a relatively shallow 200 fathoms, problems with the line resulted in the loss of self-registering instruments. At a time when precision instrumentation was expensive and in short supply, the loss of an item was costly, financially and experimentally. Ross recorded breaking two self-registering thermometers, after which he admitted that fewer measurements were taken. The instrument was pivotal not only in the measurement, but in determining what experiments were undertaken at all.

It was not the case that every time an instrument failed it was lost, although the nature of working in the deep sea meant that this was often the outcome. In some instances, the poor performance of the instrument impeded reliable results. On attempting deep-sea soundings Wilkes wrote that the 'badness of the deep-sea line was a great annoyance to us, for deeper

[103] Wilkes, *Narrative of the Unites States Exploring Expedition*, III: 37.
[104] D'Urville, *Voyage au Pole Sud*, X: 28.
[105] D'Urville, *Voyage au Pole Sud*, II:148.

soundings would probably have obtained bottom'.[106] Human operators could also cause difficulties. An accidental blow to a thermometer, Ross recorded, caused one experiment to fail and, in another, 'the temperature as indicated by the thermometer at that depth, 40.5°, nearly one degree higher than the mean temperature of the ocean, may have been occasioned by a sudden jerk in hauling it up'.[107] Regulating and tolerating the operator in testing conditions was as relevant as that of the instrument.

The fact the expedition ships were at sea for such long periods of time meant that when instruments were damaged or their performance came under question, replacements had to be constructed or modification made on board ship. Ross was unhappy with the performance of the thermometers they were given, and mid-way through the voyage described the use of new instruments, 'that had been made at my request to stand a much greater pressure than those we had been first supplied with, and which could never be safely sent to a greater depth than five hundred fathoms'.[108] Ross was likewise unhappy with the performance of the sounding line, labelling his efforts 'fruitless', when attempting to measure the depth of the ocean whilst passing through the tropics. He attributed this to the type of line used, but additionally noted: 'they served to point out to us that which was most suitable. I accordingly directed one to be made on-board, three thousand six hundred fathoms, or rather more than four miles in length, fitted with swivels to prevent it unlaying [sic] in its descent, and strong enough to support a weight of 76 pounds'. He continued, 'we succeeded in obtaining soundings with two thousand four hundred and twenty-five fathoms of line'.[109] The French also had their problems experimenting at depth, D'Urville bemoaning,

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[106] Wilkes, *Narrative of the United States Exploring Expedition*, II: 329.
[107] Ross, *Voyage of Research and Discovery*, I: 313.
[108] Ross, *Voyage of Research and Discovery*, II: 52.
[109] Ross, *Voyage of Research and Discovery*, II: 26.

> The Zéllée, which I had ordered to send their instrument to 400 fathoms, had their lead line broken when we wanted to retrieve it. Thus, the lead, the thermometer and the cylinder which contained them, were lost with 200 fathoms of line. Mr. Jacquinot sent an officer to give me an account of the accident, and asked me for another thermometer. As to the cylinder, the gunsmith shall make a new one, because I want there to remain at least two for our important experiments.[110]

The ability to adapt to difficult situations by 'tinkering' with the fallible instrumentation – often the only course which expedition crew had to improve upon their unreliable measurements – was an important if not often used strategy.[111] Whilst a captain might have trust in the new instrument he had constructed on board ship, it was likely to be less credible than an older version that had been proven on repeated previous voyages. 'New' technology developed in-situ had to prove its worth if its measurements were to be believed.

Despite experiments on the sea being planned and executed, many were hampered not just by the instrumentation but also by the unpredictability of the southern ocean. Wilkes complained that 'the fog and mist that has now prevailed prevented my observations for ascertaining the rate of current from being as accurate as I desired'.[112] Soon after more inclement weather hampered experimental progress, Wilkes later wrote, 'I regretted this much, as it was my intention to make full experiments on the deep temperature and the velocity of the current in the stream; but the roughness of the sea and the violence of the wind prevented it'.[113] The compass was easily perturbed by the weather too, with Ross commenting that, 'as the breeze freshened and the motion of the ship increased, the compasses became very uncertain in their indications'.[114] The extreme temperatures experienced in the Antarctic seas, could at times, offer an unexpected opportunity for

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[110] D'Urville, *Voyage au Pole Sud*, I: 8-9.
[111] For an explanation of the term 'tinkering' see: Knorr-Cetina, Karin. *The Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science.* (Oxford & New York: Pergamon Press, 1981).
[112] Wilkes, *Narrative of the United States Exploring Expedition*, IV: 421.
[113] Wilkes, *Narrative of the United States Exploring Expedition*, V: 452.
[114] Ross, *Voyage of Research and Discovery*, I: 209.

experimentation, however; d'Urville undertook a most simple of these, 'The sea water was found to be 0 degrees, and I wanted to see if this temperature was enough to melt the ice. Thus, I plunged into a bucket of this water a piece of ice half a kilogram in weight; in about three hours, it was already half melted'.[115] No precision measurement was needed for this experiment to yield interesting results.

Wilkes had a keen interest in ascertaining the velocity of waves, and conducted numerous experiments throughout the expedition to this end, grappling at all times with the state of the sea. Maximum wave height was much disputed in the 1830s with limits differing wildly between observers: how accurate and precise the recorded data was, was a facet of the recorder as much as of the instrument. The French expedition was given specific instructions to shed light on the matter. On the inclusion of data on the possible height of the largest waves, d'Urville commented that he had done so 'simply to establish that the waves of the sea can, in some waters, and under the influence of certain circumstances, attain a size far superior to the alleged limit of 6m'.[116] The exact measurement did not matter, and by all accounts was exceedingly difficult to obtain with any real accuracy, but for d'Urville, being able to disprove the estimates of previous, credible observers and experimenters was sufficient reason to include it in his narrative.

For waves to be high enough to measure required a rough sea, which in turn hindered attempts to measure precisely. When off the coast of Madeira, Wilkes described the process, noting the time the same wave took to pass between the *Vincennes* and the *Porpoise:* 'it was difficult to measure the correct angle subtended by the Porpoise's masts for the distance, on account of the motion of both vessels. Measurement of the height of the waves I found still

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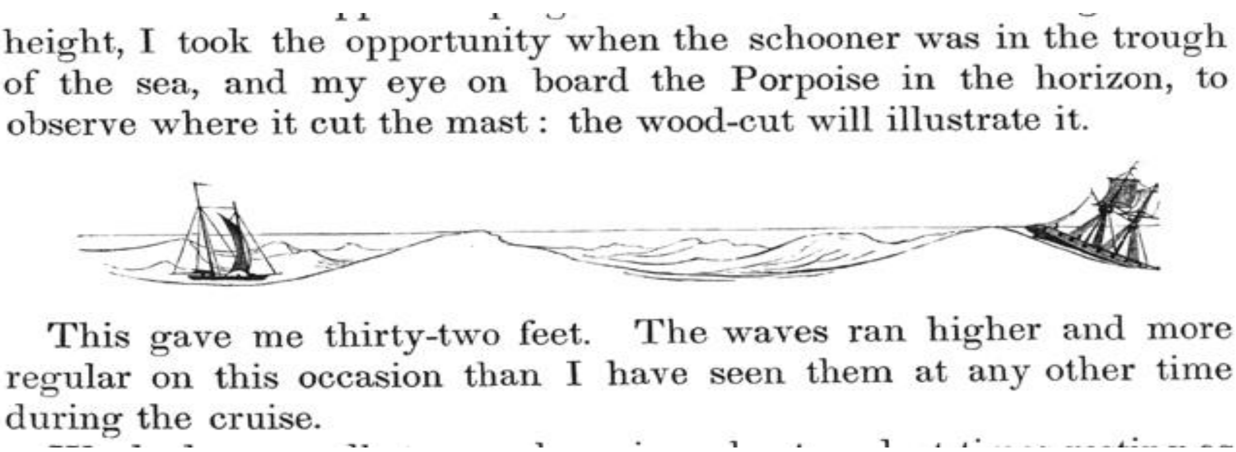
[115] D'Urville, *Voyage au Pole Sud*, II: 53.
[116] D'Urville, *Voyage au Pole Sud*, I: 193. The measurement of six metres was originally conjectured by Boyle, see Deacon, *Scientists and the Sea*, 285.

more difficult'.[117] Another attempt to determine the height of the waves was recorded some short while later, and again trouble was encountered due to unfavourable weather conditions. (Figure 4). Ross likewise reported that no favourable opportunity was found due to the calm seas that produced waves of insufficient size to measure. The French *ensign* M. Gourdin recorded his attempts to make the same observations, detailing the at-times dangerous lengths the officers were expected to go to in the name of science, 'to estimate the size of the waves, I was obliged to climb to 35 feet (about 11.5 metres) above the waterline to put me at the summit of the biggest waves. At this point I saw at a tangent to the horizon', continuing, 'as to the length of the swell, it is very difficult to measure, and I am content to estimate it at around 100 metres.'[118]


height, I took the opportunity when the schooner was in the trough of the sea, and my eye on board the Porpoise in the horizon, to observe where it cut the mast: the wood-cut will illustrate it.

This gave me thirty-two feet. The waves ran higher and more regular on this occasion than I have seen them at any other time during the cruise.

Figure 4: The *Vincennes* and the *Peacock* attempting to measure the maximum height of the waves. (From Charles Wilkes, *Narrative of the United States Exploring Expedition during the Years 1838, 1839, 1840, 1841, 1842 in 5 vols. and Atlas* [Philadelphia: Lea and Blanchard, 1845], 139).

[117] Wilkes, *Narrative of the United States Exploring Expedition*, I: 6.
[118] D'Urville, *Voyage au Pole Sud*, II: 362.

## Conclusion

Experimentation, measurement and the use of precision instrumentation were integral to the scientific programme of the three expeditions. All three countries' scientific instructions insisted on certain measurements of, and experiments on, the ocean: currents, tides, waves, and temperature. The scientific recommendations carried an importance of their own – extending human knowledge about the oceans – aside from the general sailing instructions. They were also connected to the wider aims of mid nineteenth-century exploring expeditions in particular: an intimate knowledge of the oceans, tides, and currents conferred control that allowed countries with overseas colonies such as France and Britain to dominate distant lands. Information about the waves was essential in making decisions about how to rule from them. Knowledge on how to detect shoal water and rocky coastlines helped ensure safer passage for trade ships, passenger vessels, and, importantly for America, whalers and sealers: the frequent travellers of the southern ocean who required new, up-to date charts of little-navigated waters to keep their ships – and personnel – out of danger.

The specification of each country's instructions were broadly similar regarding what was expected from marine investigations. The Americans gave little information regarding operational procedure. The British recommendations ran to nearly 100 pages but had little advice regarding experiments to be conducted *on* the oceans. Their focus was firmly on terrestrial magnetism, which was the reason for the funding of the expedition. French recommendations offered pages of procedural notes for study of the waves and temperature of the deep sea. The instructions were not written specifically for the *Astrolabe* and *Zélée,* however, but had been re-issued for every maritime voyage since the sailing of the *Bonite* in 1836. The French expedition sailed with a similar governmental and personal mandate based on d'Urville's previous voyages, albeit with new instruction to search for the Antarctic continent. The expedition was not expected to break new boundaries regarding the interrogation of the sea, but to continue to build upon those of the previous decades.

Precision instrumentation has become a byword for credible and reliable scientific experimentation, a catch all term that sums up the increasingly quantitative and accurate nature of scientific experimentation in the nineteenth century. In order to produce authoritative results, continuous declarations about precision were required. Much of the instrumentation taken on board the exploring vessels in the 1830s and 1840s was precise, crafted, and intricate. But the devices used on board were not all precision made: the bucket used for establishing the saltiness of sea water and the pot painted white in order to establish the depth the naked eye could see below the waves were everyday shipboard objects. The results they produced did not provide credibility through association with precision instrumentation in the way the self-registering thermometer or Massey's sounder did. Even so, as scholars have argued, the experimenter can make 'any device count as an instrument precisely by using it in a trial and working to establish its reliability'.[119] Precision was a cultural achievement rather than a technological one. Perhaps especially in a science that was not even yet a science – oceanography, marine biology, marine science – the use of the everyday item was as important as the precision instrument. The advance of the sciences of marine investigation required not just precision instrumentation but also practical making-do.

Negotiation of the weather was imperative to the sailing ship. But as well as the risks involved in exploring new and inhospitable oceans, the weather could be a factor in deciding what experimentation could be performed, and when it would take place. When the weather was calm the ship could not move forward at any pace: in the lull, opportunities were taken to

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[119] Gooding, David, Pinch, Trevor and Schaffer, Simon. 'Introduction'. In David Gooding, Trevor Pinch and Simon Schaffer (eds), *The Uses of Experiment: Studies in the Natural Sciences* (Cambridge: Cambridge University Press, 1989): 1-2.

experiment on the temperature and currents of the ocean and the composition of the water. When the winds were strong the deck became more treacherous, but only then could experiments to ascertain the height of waves be conducted. Sounding could not be performed with accuracy, however, and, as a result, the risk of grounding in shoal water became greater.

Experimental procedure on board ship thus required negotiation and compromise with testing weather conditions as well as managing unruly instrumentation and fallible observers. As Withers argues the ‘philosophical and practical pursuit of accuracy and precision’ might ‘at any moment be undone by the circumstances of daily life.’[120]

Repetition lent credibility to the underwater measurements of the exploring expeditions, whilst also producing a series of data that spoke to global concerns rather than regional ones. Hacking has argued that repetitions of an experiment are attempts to do the same thing better and, in so doing, produce a more stable, less ‘noisy’ version of the phenomena under study.[121] By performing the same investigations again and again they became more than just another experiment, but rather a contribution to the formation of standard laws. Even measurements with ill-performing instrumentation were taken repeatedly, testing the instrument rather than necessarily securing credible results. Ross’s deep sea soundings were performed when circumstances permitted, and bottles were still routinely thrown overboard in the hope that one might be found, so indicating current direction.

Ian Hacking has argued that experiments without underlying ideas are not experiments at all, but argues, too, that there need not be a *conjecture* to test in order for an

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[120] Withers, *Zero Degrees*, 17.
[121] Hacking, *Representing and Intervening*, 231.

experiment to make sense.[122] Whilst experiments at sea were often performed with little knowledge of what was being tested (the state of deep sea currents, the rise and fall in temperature of the ocean near shoal water, the speed of sound through air in differing climates, to name but a few), there was always *some* understanding of what was being studied. The marine environment was in many ways unfathomable, completely unknown beyond a few fathoms depth, but the ideas of current, temperature and depth that had been applied to much shallower water were taken as starting points in investigations of the deep sea. The measurement of depth, for example, even in the deepest oceans, was not wholly without prior understanding of what was likely to be achieved. Whilst no one had seen the deep sea with their own eyes, some understanding of it had been inferred by soundings in waters of shallower depths. These soundings had been repeated by multiple investigators, and could be confirmed by eyesight alone, by diving, and by the contact of the ship's hull with the sea bottom. Through repetition, trust in the measurement was obtained, and in turn this conferred trust in the instruments used in making those measurements. It was fair to assume, therefore, that the instruments that were trustworthy and accurate in shallow water should be equally reliable in deeper water, so long as an understanding of the underwater environment was held by those involved. Despite its abstract qualities, its visual and tangible separation from those on board ship, investigators into the deep sea were still convinced of its commensurability with the shallow seas they were familiar with. This reasoning provided the starting point for any investigation into the marine environment during the course of the exploring expeditions.

The fact that the units of measurement used by the different counties were different was not of major concern: what was required was an understanding of whether the water

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[122] Hacking, *Representing and Intervening*, 154.

would be too shallow for the ship to pass safely. What this does highlight, however, are more telling issues about the state of measurement of and about the sea. Firstly, there was no standardization of measurement among countries. Different countries measured the same phenomenon (depth of water) in different ways, using different instruments and recorded it with different units. Whilst it is apparent that the French had an interest in standardizing measurement, this had more to do with France as a country being metrologically diverse than it did with a perceived need to ensure uniformity between France and Britain and America.

The characteristics of a good measurement were precision and accuracy. Was, however, a measurement of depth ever either of these things? The priority end in view in obtaining a sounding in shallow water was to ensure the ship was safe from rocks and shoals. The other significant use of the sounding equipment was for deep sea soundings. Here, the results are recorded as both accurate and precise. As Wise points out, the appreciation of accuracy and precision in the nineteenth century was of a single criterion, not two separate and unrelated ones.[123] A precision instrument was also assumed to be accurate. When Ross recorded a depth of 2546 fathoms he was being precise, and thus accuracy, and the 'true' depth was implied. Deep sea soundings in the mid nineteenth century were exploratory experiments yielding knowledge about the deep sea that was recorded as uncontested truth: they managed this because they were precise.

This chapter has shown that experimentation with and the measurement of marine phenomena occurred frequently aboard expedition vessels in the 1830s and 1840s but did so as a constant negotiation between the aspirations expressed in the scientific recommendations and the testing conditions of the expedition vessel. Precision instrumentation, integral to the

[123] Wise, *The Values of Precision, 3.*

production of credibility, was difficult to maintain in good working order, frequently broke down, or was lost. New prototypes were constructed in the field, where an understanding of the testing conditions was gained through repetition. Some ‘new’ instruments, virtually untried in the field, were successfully employed. Others, all too often, were found wanting and were re-designed in-situ. Epistemological authority was ensured by the persistent recording of measurement with precision, quotidian scientific investigations, an acknowledgement of temperamental instrumentation that spoke to its thorough testing, and frequent reference to the credibility of the human operator. How the results of these negotiations, experiments and observations were recorded was vital to how knowledge on the deep sea would be deployed on the expeditions’ return home.

On the British expedition’s return, John Hershel expressed his disappointment in the results and what was done with them, complaining of too much reliance on compiling data and creating maps.[124] As Paul Carter had argued, however, in what way could explorers truly claim to be the first in the field if they furnished insufficient data to equip subsequent travellers?[125] By emphasising the importance of numbers and measurement, captains and officers aimed to show evidence of both an objective stance and a claim to new knowledge. Sufficient information was required in order for others to repeat the experiments, and test their own results against those already gained. An ability to deploy the information gathered during the course of the expedition was crucial. The following chapter considers the production and movement of knowledge on the marine environment through the representation of information obtained at sea.

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[124] Marsden, Ben and Smith, Crosbie. *Engineering Empires: A Cultural History of Technology in Nineteenth-Century Britian* (New York & London: Palgrave Macmillian, 2005): 24.
[125] Carter, *The Road to Botany Bay*, 104.

# Chapter 6 Representing

## Introduction

This chapter analyses the recording of scientific information on and concerning the sea and the subsequent translation of these numbers and specimens into visual representations. This chapter does not offer a complete account of representation on voyages of exploration during the late 1830s and early 1840s; it addresses a series of particular moments, drawn and written, relating to the voyages here considered, moments that shed light on the practices of reproducing what was seen on the expedition vessel. I consider the evidence for the chain of representation: the importance assigned to the intricate and timely recording of collected data, the immediate processing of specimens drawn from the underwater environment through sketch and preservation; and how this information was translated into a viable and portable format. Processes of writing, recording, sketching, drawing, mapping, and preserving are considered together with the resultant outputs: the graph, table, map, illustration and textual document.

I begin by considering that academic scholarship which, over the last thirty years, has sought to highlight imagery and the rise to prominence of the visual depiction of things seen and numerical information gathered. Alexander von Humboldt was one of the first, and most prominent, exemplars of visual methods – the scientific image, graph and table – to display information in ways that also made reference to the instruments he had used. These forms of representation became integral to establishing credibility for new claims to scientific knowledge. This opening also addresses the crisis of representation in the humanities over the past two decades and the use of the term today, and in this thesis. Conceptual material that relates specifically to the following sections – sketching, mapping and graphical methods – is discussed where it is most pertinent to do so. This format serves to highlight the breadth and diversity of scholarship the term ‘representation’ encompasses.

The second section considers the instructions for sailing and scientific recommendations issued to each expedition before it left home port. This information is, in this respect, notable by its absence: the authors of the reports were concerned that all materials relating to the expeditions were returned to the relevant governmental institution on the expeditions’ return, but gave almost no guidance over how to represent what had been seen at sea. Because this was the so, the main focus of this section is on the ‘trajectory’ of the materials on board ship on the expeditions’ eventual return home.

The third section considers the practice of sketching on the expedition vessel and the production of the topographical and coastal profile that were vital tools for the navigator that depicted the marine environment from the point of view of the ship. Sketches of landscape, and of marine flora and fauna were frequently undertaken, the two often seen as distinct disciplines: the landscape and the ‘portrait’ representation. The 1830s saw a new imperative to make sketches ‘on the spot’, that is from nature, by artists directly involved in the landscape. This was coupled with a requirement to show objectivity, through ‘scientific’ rather than picturesque depiction.

Further sections analyse three other modes of representation: the preservation of collected specimens, the production of maps and charts, and the transformation of numerical information into tables and graphs. Each mode is considered in particular reference to recording information and how these differing modes of representation supplied – and could fail to supply – credibility over knowledge claims about the oceans. The chapter ends with consideration of Adriana Craciun’s ‘eccentric inscriptions’: written and pictorial records that represent what had been seen in less familiar formats than those previously described.[1] In sum, the chapter shows how information collected on the marine environment was represented in several ways in a period when representations were seen to be of little significance to the expedition's goals and when knowledge was expected to be constructed in visual forms, and in other ways, at home, not at sea.

**Scientific depiction in the nineteenth century and the role of 'representation'**

The artistic output of Cook's voyages' in the late eighteenth century has greatly influenced modern art historians to such a degree that Quilley has remarked that, 'the art of Cook's voyages' has largely been treated either as exceptional and effectively unique, or else typifying so fully a genre of travel imagery that the rest requires little or no discussion'.[2] The scope and breadth of art connected to scientific endeavour was from the later eighteenth century significant and changing. The importance of visually recording the new and unfamiliar was widely recognized. John Bonehill comments that there was a 'general cultural conviction current in the late eighteenth century, which saw pictorial forms occupy a privileged position in the communication of knowledge.[3] Art historian Charlotte Klonk has argued that the visual recordings of directly observable phenomena 'produced a convergence between the object of scientific knowledge and the subject-matter of artistic description' in

[1] Craciun, A. 'Oceanic Voyages, Maritime Books, and Eccentric Inscriptions', *Atlantic Studies* 10 (2013): 170-196.
[2] Quilley, Geoff. 'Introduction: Mapping the Art of Travel and Exploration', *Journal of Historical Geography* 43(2014): 3. For exceptions to this statement see Stafford, Barbara M. *Voyage Into Substance: Art, Science, Nature and the Illustrated Travel Account*, (Cambridge, MA: MIT Press, 1984); Charlotte Klonk, *Science and the Perception of Nature: British Landscape Art in the Late Eighteenth and Early Nineteenth Centuries* (New Haven, CT: Yale University Press, 1996); Smith, Bernard. *European Vision and the South Pacific*, (New Haven and London: Yale University Press, 1985).
[3] Bonehill, John. 'New Scenes Drawn by the Pencil of Truth: Joseph Banks' Northern Voyage', *Journal of historical Geography* 43 (2014): 22.

the same period.[4] Not until the beginning of the nineteenth century, however, did the fields of artistic representation and scientific imagery mesh more fully; 'a growing middle class with increased time for leisure was eager for words and pictures recorded by "on the spot" witnesses'.[5] The public began to want and expect imagery that had been taken from nature, from those who had seen it with their own eyes.

An appreciation of the body was of heightened importance in the field, providing a visceral engagement with the environment. As Bonehill argues, 'what is sensed, what is felt, was also central to truth claims'. Further, 'observations and theoretical ideas are joined with a record of personal experiences, or meals eaten and company shared, of seasickness, cold, lice and other hardships'.[6] Making observations required not only the use of instruments, but also a 'discipline of the senses'.[7] Pratt has expressed the importance in travel literature of the author asserting his own physical presence in, and conscious experience of places described. As Martins argues, for the observer who leaves the darkened room of the camera obscura and experiences the world through the direct senses, the locus of truth and power becomes his or her physical body.[8] Observation and sight was a constant preoccupation on board ship. Driver and Martins have urged us to 'restore the eye to the body: to acknowledge the physical labour – the laboriousness – of observation', whilst Jonathan Crary suggests 'that knowledge was conditioned by the physical and anatomical functioning of the body, and perhaps most importantly, of the eyes'.[9] Representation as an embodied practice was nowhere more relevant than on the expedition vessel.

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[4] Klonk, *Science and the Perception of Nature,* 151.
[5] Thomas, Sarah. '"On the spot": Travelling Artists and Abolitionism, 1770-1830', *Atlantic Studies* 8 (2) (2011): 214.
[6] Bonehill, New Scenes Drawn by the Pencil of Truth, 14.
[7] Driver and Martins, 'John Septimus Roe', 159.
[8] Martins, *The Art of Tropical Travel,* 78.
[9] Driver and Martins, 'John Septimus Roe', 158; Crary, J. *Techniques of the Observer: On Vision and*

Whilst the travel narratives and art of Cook's voyages were much admired and copied in the late eighteenth century and early 1800s, it was the polymath and traveller Alexander Von Humboldt who had perhaps the greatest influence on traveller-explorers of the early nineteenth century. Leonard Bell argues that before Humboldt, 'the works of most artists on voyages of exploration were used primarily as scientific illustration, and were usually regarded as secondary to, or, a by-product of science'. The artist's job was to accumulate factual information for the use of the naturalists and in reports on the voyages. In contrast, 'Humboldt envisaged visual images that were not merely instruments of science, but which served scientific ends in themselves'.[10] Humboldt's travels were regarded as a 'model journey of exploration and a supreme geographical achievement', and yet his broadest impact on the public was through his non-specialist rather than scientific writings.[11] As Driver and Martins argue, Humboldt's work 'raises far-reaching questions about the relationship between scene and aesthetics, about the balance between holistic and analytical views of nature, and about the prospect of reconciling sedentary scholarship with observation in the field'.[12]

Humboldt deliberately avoided traditional narrative as a viable mode of representation, concentrating instead on public lectures and illustrated volumes, his visual innovations setting new standards for the use of charts, graphs and tables.[13] As Michael Dettelbach discusses in relation to an engraving of the 'Tropics' in *Essai sur la geographie*

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*Modernity in the Nineteenth Century* (Cambridge MA and London, MIT Press, 1995): 79.
[10] Bell, Not Quite Darwin's artist, 67.
[11] Pratt, Mary Louise. *Imperial Eyes: Travel Writing and Transculturation* (London & New York: Routledge, 2008 2nd ed.): 109. See also, Rupke, Nicolaas. *Alexander von Humboldt: A Metabiography* (Chicago and London: University of Chicago Press, 2008).
[12] Driver, Felix and Martins, Luciana. 'Views and Visions of the Tropical World'. In Felix Driver, and Luciana Martins (eds), *Tropical Visions in an Age of Empire* (Chicago and London: University of Chicago Press, 2005): 21.
[13] Pratt, *Imperial Eyes*, 117.

*des plantes* (1807), it was an 'opposition between vision and measurement', that ensured the effectiveness of the representation. Images on their own were not sufficient to secure the epistemological authority of a scientific statement but were rather 'defined and secured by precise measurement in the side columns'.[14] This combination of text and data, and an appreciation of the importance of showing results as tables and figures rather than translating them into the written word was a new way of presenting information to the nineteenth-century reader. To a reading public more used to a wordy description of scientific findings, the minute precision of the numbers sought to testify to Humboldt's certitude about the accuracy of his data.[15]

In the past fifty years, study of the visual has assumed increasing importance as an object of academic enquiry and has been integral in the development of the History of Science, and Science and Technology Studies (STS). Michael Lynch has argued that visual and graphic methods were crucial for enabling discovery and establishing the properties of natural phenomena. Steven Shapin and Simon Schaffer's attention to the concept of 'virtual witnessing', lays emphasis on diagrams – 'mimetic devices' – as they put it, in promoting understanding. Bruno Latour argues for the power of the *inscription,* the visual representation of data that could tame and transform unruly specimens: reflecting on his own case study he highlights the significance of 'the transformation of rats and chemicals into paper'.[16] David

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[14] Dettelbach, Michael. 'Global Physics and Aesthetic Empire: Humboldt's Physical Portrait of the Tropics'. In Miller & Reill (eds), *Visions of Empire*, 270. See also Godlewska, Anne Marie Claire. 'From Enlightenment Vision to Modern Science? Humboldt's Visual Thinking'. In Charles W.J. Withers and David Livingstone (eds), *Geography and Enlightenment* (Chicago and London: University of Chicago Press, 1999): 236-275.

[15] Bourguet, Marie-Noelle 'A Portable World: The Notebooks of European Travellers (Eighteenth to Nineteenth Centuries)', *Intellectual History Review* 20 (3) (2010): 379. For claims that Humboldt plagirised many of his ideas see: Canizares-Esguerra, J. *Nature, Empire, and Nation: Explorations of the History of Science in the Iberian World* (Stanford: Stanford University Press, 2006): 112-128.

[16] Latour, Bruno. 'Visualisation and Cognition: Drawing Things Together'. In *Representation in Scientific Practice* (Cambridge MA: MIT Press, 1990); Lynch, Michael. *Representations in Scientific Practice* (Cambridge MA: MIT Press, 1990): 22.

Miller has recommended that scholars pay more attention to the 'hard graft' of the organization and the representation of natural history.[17]

The importance of the travelling image is central to Latour's theory of 'circulating reference' – the transformation of a three-dimensional object into a two-dimensional representation which increases its availability for further use. Latour terms this the 'immutable mobile'. It is now easily transported and compared with other inscriptions. For Latour, this process of transforming an object increases its durability and, ultimately, its stability; he argues 'you have to invent objects which have the properties of being mobile, but also *immutable, presentable, readable* and *combinable* with one another'.[18] The diagram is 'a new way of accumulating time and space'.[19] For Latour, 'scientists start seeing something once they stop looking at nature and look exclusively and obsessively at prints and flat inscriptions'; the objects themselves are discarded or often absent from laboratories.[20] Lorraine Daston concurs, reminding us that the idea of a 'perfect representation' – a map scale 1:1 for example – is patently absurd; 'the most faithful renderings are not the ones that could be mistaken for the original.[21]

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[17] Galison, Peter. 'Visual STS'. In Annamaria Carusi, Aud Sissel Hoel, Timothy Webmoor, and Steve Woolgar (eds), *Visualization in the Age of Computerization,* (London: Routledge, 2014): ch.10*;* Lynch, Michael. 'Introduction'. In Coopmans, Catelijne, Vertesi, Janet and Lynch, Michael (eds), *Representation in Scientific Practice Revisited* (Cambridge and London: MIT Press, 2014): vii ; Shapin, Steven and Schaffer, Simon. *Leviathan and the Air Pump: Hobbes, Boyle, and the Experimental Life.* (Princeton: Princeton University Press¸ 1985); Latour, Bruno. *Science in Action* (Cambridge, MA: Harvard University Press, 1987); Miller, David Phillip. 'Introduction'. In *Visions of Empire: Voyages, Botany, and Representations of Nature*, David Philip Miller and Peter Hanns Reill, Peter (Cambridge: Cambridge University Press, 1996): 7. See also: Stafford, *Voyage Into Substance.*

[18] Latour, Bruno. *Pandora's Hope: An Essay on the Reality of Science Studies* (Harvard: Harvard University Press, 2009), 7.

[19] Latour, *Pandora's Hope*, 67 and 10.

[20] Latour, *Pandora's Hope*, 15-16.

[21] Daston, Lorraine. 'Beyond Representation'. In *Representation in Scientific Practice Revisited*, 319.

'Representation' is, however, a contentious term, not least because the idea of the omnipotent visual image has been widely questioned. Whilst recognizing the importance of the visual, Ian Hacking criticises the positivist philosophy of science for its 'single minded obsession with representation and thinking and theory, at the expense of intervention and action and experiment'.[22] At the turn of the twenty-first century Nigel Thrift criticised the focus on representing and instead argued for a shift to 'non-representational theory' in which the lived history of the subject, and embodied experiences are considered.[23] For Lorraine Daston, representation is an intrinsically epistemological notion that assumes *a priori* presentation, lending itself to metaphors of refinement and falsification, and should not be retained.[24] In response to these criticisms there has been a move away from the term 'representation' in STS scholarship to terms such as 'mediation' or 'enactment'. Most pervasive has been 'visualization'.[25] Lynch defends his continued use of the term, arguing that the advantage of 'representation' *is* its temporal association, *re*-presenting, again and again.[26] This idea has links with the idea of chains or cascades of images favoured by Latour or the 'renderings' used by Lynch.[27] Lynch draws on Wittgenstein, in whose *Philosophical Investigations* the concept of representation is 'very elastic' and 'intimately connected with that of "what is seen"'.[28] I use the term here with caution and in acknowledgement of past

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[22] Hacking, Ian. *Representing and Intervening* (Cambridge: Cambridge University Press, 1983): 131.
[23] Lorimer, Hayden. 'Cultural Geography: the Busyness of Being 'More-than-Representational', *Progress in Human Geography* 29 (1) (2005): 83–94; Thrift, Nigel. *Non-representational theory: Space, Politics, Affect* (London: Routledge, 2007)
[24] Daston,'Beyond Representation', 319.
[25] Woolgar, S. and Lezaun, J. 'The Wrong Bin Bag: A Turn to Ontology in Science and Technology Studies?' *Social Studies of Science* 43(3) (2013): 321-340; Burri, Regula and Dumit, Joseph. 'Social Studies of Scientific Imaging and Visualization'. In E. J. Hackett, D. Amsterdamska, M. Lynch and J. Wajcman (eds), *The Handbook of Science and Technology Studies* (Cambridge MA: MIT Press, 2008): 297-317; Wise, V. 'Making Visible', *Isis* 97 (1) (2006): 75-82.
[26] Lynch, Michael. 'Representation in Formation'. In *Representation in Scientific Practice*, 324.
[27] Latour, 'Visualisation and Cognition'; Lynch, Michael. *Representations in Scientific Practice*.
[28] Lynch, *Representation in Formation*, 325; Wittgenstein, Ludwig. *Philosophical Investigations* (Oxford, Blackwell Publishing: 1968): 169.

criticism over its use, but choose it, following Lynch, for its ability to conjure an image of presenting and re-presenting that embraces the mobile qualities of inscriptions as part of a chain, made on voyages of exploration.

**Recommendations over representing and instructions over shipboard inscriptions**

The instructions from both state and scientific institutions issued to the three expeditions were instrumental in dictating what took place on the vessels. What is noticeable about the instructions regarding the representation of scientific information from marine experimentation and observation is how little detail was given. There are no more than a few paragraphs included which refer to how measurement was to be recorded, or what images were to be represented.

In Britain, the Royal Society offered some guidance regarding the collection of meteorological data, demanding ‘the keeping of a regular meteorological register in both ships during the whole voyage, and the paying attention to the phenomena of solar and terrestrial radiation, and generally to all phenomena bearing on the subject of meteorology’.[29] Thus recognition that instruction over recording data was important was not paralleled by statements over its representation. The Royal Society instructions offer only limited directions regarding the preservation of collected specimens: ‘with regard to birds it may be observed, that if spirit be injected down the windpipe, it will pass through almost the whole body by means of the air-cells. In the case of a quadruped preserved in spirit or in the saline solution, it is proper to inject the preserving liquor into the abdominal cavity and intestinal cavity’.[30] There were also guidelines regarding the storage of invertebrates: ‘Care must be

[29] *Report of the President and Council of the Royal Society on the Instructions to be Prepared for the Scientific Expedition to the Antarctic Regions* (London, 1839): 23.
[30] *Report of the Royal Society*, 40.

taken not to crowd too many soft-bodied Invertebrata in the same bottle, and to change the spirit of preserving liquor at least once, if not oftener'.[31]

The French recommendations provided a little information on mammal and fish preservation. The dolphins and whales were to be studied and the Académie instructed, 'besides the drawings, that you bring at least the skull, packed with its skin, as well as the legs cut above the joint.' The Académie recommended 'a particular way of trying to get the skin and skeleton', using spirit of wine as a preservation method where possible. The fish were likewise to be studied, 'taking care to note the colours and features they can offer'. Particular attention was to be paid to freshwater, rather than marine species, although no reasons for this choice were given. The skeletons of the fish were to be dried, and it was deemed 'useful to note the sexes'. Different techniques of preservation were advised depending on whether the specimen was fish, fowl or mammal. The scientific contingents on all three expeditions complained bitterly of the amount of time they were forced to devote to the preservation of specimens, and yet, in the scientific instructions, these issues were only a side-show.[32]

It is hard to know why there was so little instruction regarding the representation of new finds. It perhaps is to be explained by what was to happen with the information collected on their return. The captain was furnished with all the records, both textual and pictorial, that expedition personnel had completed during the course of the voyages. Such instructions were clear as to the control over material, as is evident from the American Philosophical Society:

> we would recommend, as a measure of necessary precaution that, before entering port on the return of the Expedition, the Commanding Officer should require all journals, charts, collections, and drawings made by Officers, Members of the Scientific Corps,

[31] *Report of the Royal Society*, 38.
[32] Vaillant, M. *Voyage autour du monde execute pendant les Annèes 1836 et 1837 sur la corvette La Bonite commandée par M. Vaillant. Tome Premier*. (Paris: Arthus Bertrand, 1845): 421.

> or others, to be given up into his hands, for the Navy Department, to be there retained until after the journal of the Expedition shall be published under the directions of the Government, when such papers and other articles as may justly be considered the private property of individuals should be restored to them.[33]

The significance of these recommendations concerning the record of the expedition's achievements was not lost on the US government when it drew up the official sailing instructions for the voyage. Secretary of the Navy James Paulding gave orders to Wilkes that closely matched those of the Philosophical Society, but, additionally, instructed that Wilkes was to surrender all his private recordings from the four-year expedition: 'when you arrive at New York, you will cause all journals, memorandums, remarks, writings, drawings, sketches and paintings, as well as all specimens of any kind, to be delivered to you; which together with your own journal, you will have carefully boxed up and sealed in the presence of two commissioned officers'.[34] The form and presentation of records made was not prescribed, just as long that they *were* presented to higher authorities. Once they had been surrendered – both on paper and in the form of collected specimens – the countries respective admiralties would be able to decide how the work was to be presented, and who was to turn the material into a formal narrative of proceedings.

Wilkes made sure that his crew were well aware of the public status their private collections would hold. In his narrative, written on the return to America, he stated that he had promised that 'The undersigned [Wilkes himself] will forward the remainder [of the collections] to the Department, with lists, or return them to the collectors, until the return of

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[33] Conklin, Edwin G. 'Connection of the American Philosophical Society with Our First National Exploring Expedition', *Proceedings of the American Philosophical Society* 82 (5) (1940): 537.
[34] Wilkes, Charles. *Autobiography of Rear Admiral Charles Wilkes U.S Navy 1798-1877*, (Washington: Department of the Navy, 1978): 533.

the ship to the United States, as all are prohibited from disposing of them, or sending them home, except to the Department'.[35]

Hooker was also aware of the demands on recording what had been seen, and the expected fate of it, but offered a method at how it could be circumvented:

> I have kept a regular journal whenever there is anything of the slightest importance to set down it is written on sheets of this sized paper on one side only. The Natural History part I copy out into my Admiralty journal which I must keep on board & deliver up on reaching England giving my honor*[sic]* that I have kept no duplicate, this I intend to evade by sending to you as a letter the original journal which contains everything I can think of & more I fear than you will care to read, I reserve the Admiralty journal till my arrival. The blank leaves I leave partly to add anything I think of before sending it, but chiefly with the hope that you would add any observations of your own as you may chance to think of them, so that, on my return if I should have done anything worth publishing, by the references you may make, I may add to the meagre mss [manuscript].[36]

Private correspondence was one of the only methods available to expedition personnel to ensure that an individual's intellectual property was retained.

On the return of the French expedition d'Urville immediately sent his final report to the minister and oversaw the dispatch of the collections to the French Hydrographic Office, Musée de Histoire Naturelle and Naval Museum before returning to home. On writing his narrative, d'Urville added officer's journals as appendices rather than in the main text, stating 'my own journal will provide the only source for the main text'.[37] As Rosenman points out, even with the inclusion of the officer's journals, however, there was little variety of opinion

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[35] Wilkes, Charles. *Narrative of the United States Exploring Expedition during the Years 1838, 1839, 1840, 1841, 1842 … 5 vols. and Atlas* (5 vols, Philadelphia: Lea and Blanchard, 1845): III: 433.
[36] JDH/1/2 f.9. Joseph Hooker to William Hooker, October 20 1839.
[37] Rosenman, Helen. *An Account in 2 Volumes of Two Voyages to the South Seas*, (Melbourne: Melbourne University Press, 1987), 315.

and observations about events and places in the journals; all were conservative.[38] This similarity reflected a common training and background amongst French officers.

It was not only the disposal of information on the return home that was recognized to be significant by the authors of the sailing instructions. There was to be no sharing of data, maps or charts collected during the course of the expedition with other nations encountered during their time at sea. As Maddison argues, ‘this form of censorship [was] also seen in captains of sealing and whaling vessels, seeking to protect their knowledge of potential future grounds’.[39] In a letter to his father. Joseph Hooker wrote, ‘By this conveyance you will receive a picture & map which I made for you. I must request you to be very particular how you show them especially the latter for were it known publicly or taken advantage of I should get into hot water as “All charts drawings writings &c go without reserve to the Admiralty” & Capt[ain] Ross is very jealous; of course you will if you think proper show them to Brown, Boott & Bentham’.[40] In a later letter he urged similarly, ‘Do anything you like with the chart & drawing, except publishing of course. Captain Ross cannot hear of it to give me a wigging till we get home that will be too late for me to care about! -- You are the mainstay of the expedition at home, from Ross’ foolish jealousy of not sending news’.[41] Hooker was flouting the rules in sending charts and sketches home, but even with his caution his own instructions to maintain secrecy were ignored. In a later letter he scolded his parents for their comment: ‘your drawings (you need not tell Captain Ross, unless he would like to know it) are known far and wide’’.[42]

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[38] Rosenman, *An Account of Two Voyages*, 555.
[39] Maddison, Ben. *Class and Colonialism in Antarctic Exploration, 1750-1920* (London: Pickering & Chatto, 2014): 2.
[40] JDH/1/2 f.169-175. Joseph Hooker to William Hooker, 7 March 1843.
[41] JDH/1/2 f.169-175. Joseph Hooker to William Hooker, 7 March 1843.
[42] Huxley, Leonard. *Life and Letters of Sir Joseph Dalton Hooker: Based on Materials Collected and Arranged by Lady Hooker* (London: John Murray Publishing, 1918): 142.

The urge to share information despite strict instructions against the practice was also expressed by the French. At Talcahuano, the French corvettes met the British frigate, *President,* and, as d'Urville later recounted, 'the British were soon au fait with everything that had happened; charts, drawings, observations, everything was shown them'.[43] The British were all praise for their achievements, but an unhappy d'Urville thought the encouragement was only due to the fact they had not been able to beat Weddell's furthest south, leaving the opportunity open for the British. This prohibition on furnishing outsiders with information was, as G. S. Bryan has pointed out, also violated by Wilkes who sent a copy of his Antarctic Chart to Ross before his attempt to find the southern magnetic pole. This was the chart that, later, was to result in so much 'criticism being directed against him', due to Ross's dismissal of its credibility (Figure 5).[44]

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[43] Rosenman, *An Account of Two Voyages*, 352.
[44] Bryan, G. S. 'The Purpose, Equipment and Personnel of the Wilkes Expedition', *Proceedings of the American Philosophical Society* 82 (5) (1940): 558.

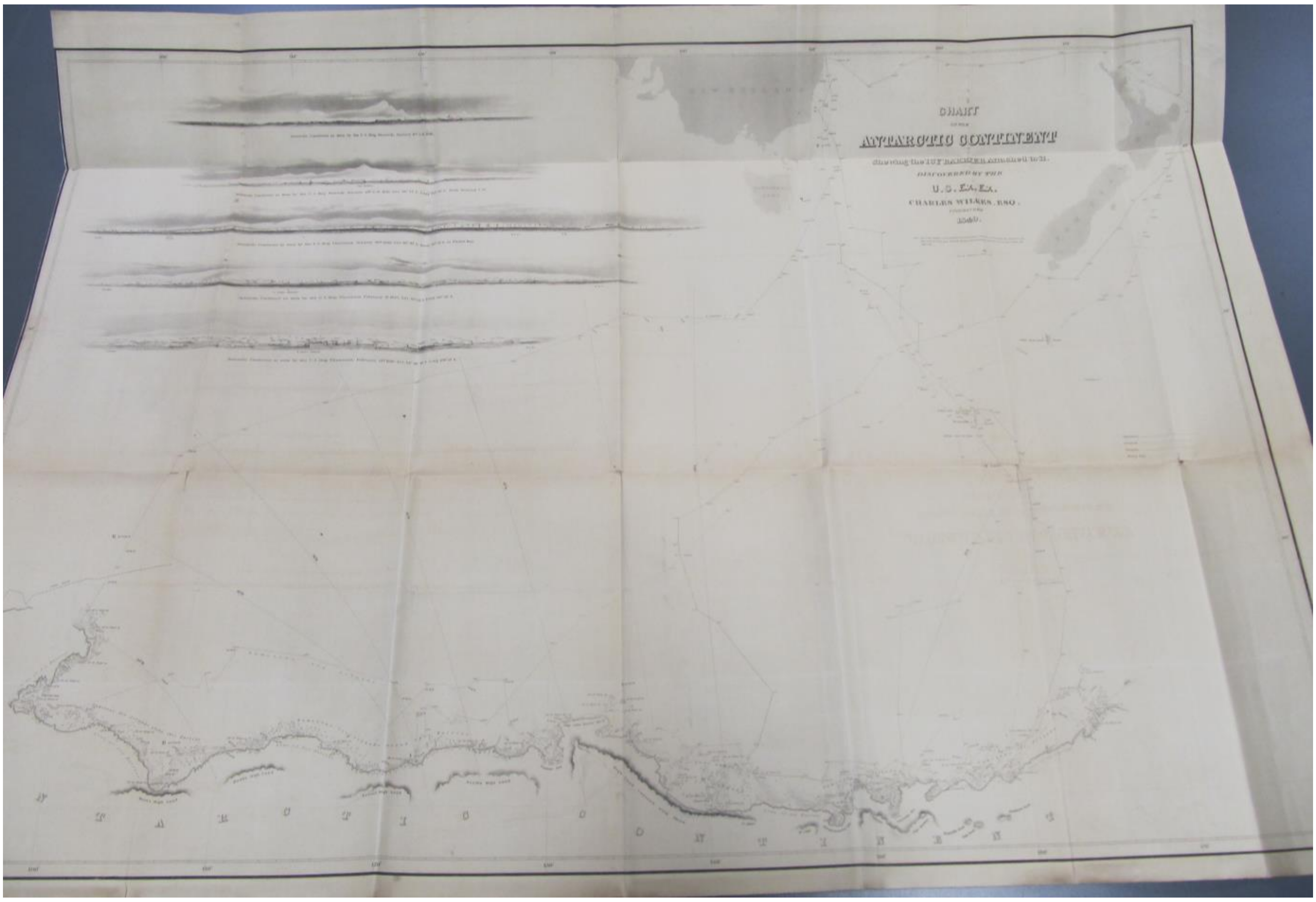


Figure 5: 'Map of the Antarctic continent. Daily tracks of the vessels 'discovered by the expedition'. Winds, currents, temp. Lines of variation and icy barrier'. (From *Atlas of the Narrative of the United States Exploring Expedition* [Philadelphia: Lea and Blanchard, 1844], Courtesy of the RGS-IBG, London).

### Seeing and knowing: coastal and topographical representation and sketching in the field

Observation at sea had epistemological significance for the production of knowledge on the marine environment. Seeing was integral to knowing. Its importance as a skill and form of tacit expertise was understood by those at the time. British astronomer John Herschel (1792-1871) advised that 'seeing is an art which must be learnt'.[45] Charles Goodwin argues that 'the ability to see a meaningful event is not a transparent, psychological process but instead a

[45] Quoted in Dening, Greg. *Readings/Writings* (Melbourne: Melbourne University Publishing, 1998): 8

discursive practice'.[46] Travellers were expected to conduct their observations and writings, in a manner deemed appropriate to the protocols of scientific enquiry in the field. The relationship between travelling, seeing and knowing is highlighted in the practice of sketching in the field. As Martins explains, 'the practice of drawing in the field was not merely a way of illustrating, or of decorating, texts: it was becoming a mode of scientific expression in itself'.[47]

The lasting impression of Cook's expeditions to the South Seas in the decades following their return continued to be felt in the 1830s and 1840s. British officers referred often to Cook in their letters and journals, and in their drawings they 'adopted a formal style unmistakably reminiscent of Cook's artists, notably William Hodges and John Webber, as though this was the only proper means of visually representing the island's topography'.[48] Representing the coastline was a skill performed by the ship's surveyors and artists in combination. Topographic and coastal profiles were vital navigational tools on voyages of exploration, offering ocular proof that a landscape had been witnessed. As Martins and Driver state, reproducing coastlines provided a record of the ship's voyage, enabling others to follow: 'The coastal view was an integral component of maritime charts and log-books, part of a common visual code rendering the maritime world intelligible to navigators'.[49] Representing coastlines was a skilled process: navigational training incorporated

[46] Goodwin, Charles. 'Professional Vision', *American Anthropologist* 96 (3) (1994): 606.
[47] Martins, Luciana. 'The Art of Tropical Travel, 1768-1830'. In Miles Ogborn and Charles W. J. Withers (eds), *Georgian Geographies: Essays on Space and Landscape in the Eighteenth-Century* (Manchester: Manchester University Press, 2004): 79.
[48] Quilley, Geoff. 'By Cruel Foes Oppress'd': British Naval Draughtsmen in Tahiti and the South Pacific in the 1840s, *Journal of Historical Geography* 43 (2014): 79.
[49] Driver and Martins, 'John Septimus Roe', 145

trigonometry, arithmetic, geometry, astronomy and chronometry as well as drawing and calligraphy.[50]

In typical topographical composition, forms of nature were represented accurately and in proportion, based on careful observation and experiment. For Klonk, 'topography stabilises the depicted scene, whether by restricting itself to a limited range of harmonising colours independent of any characteristics that might stem from specific weather or time effects, or by strong compositional structures, which visually assert stability in the face of changing atmospheric conditions'. As the nineteenth century progressed, however, topographical practices changed. As Klonk states, 'the topographical tradition, in which exactitude of delineation was paramount, was merging with the demands of the picturesque for roughness and variety'.[51] An illustration of the effect of light on the sea could help mariners unfamiliar with the changing seascape of the varying latitudes, particularly in areas where charts did not exist. As Smith argues, in the high southern latitudes where the normal pictorial components of classical landscape were not found, Antarctic landscapes encompassed both romantic and scientific facets and so could become a real visual document, revealing information on geology, botany and zoology.[52]

By the late 1830s there were predominantly two distinct types of artist at work: those who favoured a *picturesque* composition and those who documented what they saw in a more *realistic* manner.[53] Part of this latter approach included the gradual emergence of the scientific diagram and a new, analytical approach to representing the beauty of nature, which saw a shift from the image of natural history as romantic to scientific. In the seventeenth and

[50] Martins and Driver, 'John Septimus Roe', 54.
[51] Klonk, *Science and the Perception of Nature*, 71-72.
[52] Smith, *European Vision and the South Pacific*, 59.
[53] See Rudwick, Martin J.S. 'The Emergence of a Visual Language for Geological Science, 1760 - 1840', *History of Science*, 14 (3) (1979): 149-195.

eighteenth centuries, those who had wanted to portray a form could choose either its 'ideal' form, representing a degree of perfection not found in the actual specimen, or a 'characteristic' form, in which the features typical of a class as a whole were located in a selected individual. Lorraine Daston and Peter Galison have argued that the typical form depicted in an image represented the *mean* value for a species, and was distinct from the ideal form. In the nineteenth century a significantly new concept of objectivity was pioneered which linked objective representation with a capacity for discipline and self-restraint on the behalf of the observer. This new, clinical form of representation was seen to express the authority of the artist.[54]

Establishing the credibility of the artist – the one who through images professed to have seen and known the landscape – was further guaranteed from having sketched directly from the field site. 'Sur le motif', or 'on the spot' sketching, was a type of landscape representation based on direct observation in the field that became more common from the late eighteenth century. Exploration artists were central to this development. For Stafford, 'it was the voyaging artist who first turned his studio into a laboratory devoted to the minute examination of palpable externalities out "in the field". He not only positioned himself in front of the world; he entered the world.'[55] 'On the spot' was inscribed by artists onto their sketches to ensure its credibility and also used more generally as a descriptive term to emphasize that the work was created in front of its subject rather than in the artist's studio. For Klonk, the prolonged and scrupulous observation of natural phenomena contributed to a growing practice of sketching on the spot, prioritizing solely what was there to be seen and the artist's experience of it. As Bell argues, such an artist was 'not a passive recording

[54] On the emergence of "objectivity" and its criteria in illustration see Daston, Lorraine and Galison, Peter. *Objectivity* (Cambridge MA: MIT Press, 2010).
[55] Stafford, *Voyage into Substance*, 163.

instrument, but an active agent depicting aspects of the natural as they appeared to him and were experienced by him'.[56]

On the expedition vessel the professional artist was nevertheless a rare occurrence. Naturalists, also usually naval men, were expected to sketch and illustrate as well as artists taken specifically to perform the task. For the naturalists on all three voyages studied here, a requirement to sketch, draw and illustrate was one with which they would have been familiar. As Jim Endersby has argued, there was a uniformity of technique that distinguished the professional naturalist in the nineteenth century that can be seen in the illustrations across the expeditions.[57] This was a distinctive style of botanical drawing that usually included a single specimen, and a few images of plants in their habitats. Walter Hood Fitch, the nineteenth-century botanical artist stressed that, far from simply drawing what one saw, it was vital to acquire some theoretical botanical knowledge before one began drawing. Copying was a major part of the botanical illustrators' training. *Copying* from a drawing ensured *standardization* and the master drawing was often altered to give a perfect copying specimen. In this way the master drawing took the place of the original specimen and became more important than the fragile sample that was the original starting point for the chain of transformations. Similarly, in the description of a new species, a botanical illustration was often made from many separate parts, from many different plants, rather than from one intact plant: a typical specimen. The art of drawing, however, was learned en-route as well as in the classroom. As Secord argues, drawing 'functioned as a learning process only for those already aware of what they should be looking for'.[58] How far we can see these varying modes

[56] Klonk, *Science and the Perception of Nature*, 147; Bell, 'Not Quite Darwin's artist', 63.
[57] Endersby, Jim. *Imperial Nature: Joseph Hooker and the Practices of Victorian Science* (Chicago and London: The University of Chicago Press, 2008): 118.
[58] Secord, Anne. 'Botany on a plate: Pleasure and the Power of Pictures in Promoting Early Nineteenth century scientific knowledge' *Isis* 93 (1) (2002): 39.

of representation to have been a feature of depictions from expedition vessels is the subject of this chapter

For any image to be deemed realistic, its producer had to be acknowledged as being competent. The American and French expeditions both took artists on the expedition ships with them; Alfred Agate and Joseph Drayton for America, and Ernst Auguste Goupil on the French vessel, *Zélée*, respectively. Goupil had studied in the studio of a relative, Jules-Louis-Philippe Coignet, a landscape painter. He exhibited work in Paris in 1836, and met d'Urville in 1837. His appointment was a personal one. When Goupil died at Hobart Town from dysentery, his position was filled by Louis Le Breton, the junior assistant surgeon on the *Astrolabe*, so confirming the expectation that surgeons would be sufficiently trained in visual arts to adequately fill the position. The Americans believed two artists were necessary as there were recognized to be two distinct disciplines of representing: landscape and portrait (which encompassed portraits of the people they encountered) and also images of animal life and other detailed work. Wilkes also had some artistic training, having studied under the same drawing master as Alfred Agate.[59] That the French and Americans devoted so much space to men concerned with the making of images alone shows that, despite receiving very little direction in the scientific and sailing instructions as to the production of visual representations from the voyages, their role was taken seriously.

The British expedition took no person specifically to sketch and draw, relying instead on their crew members. Hooker was called upon to draw many of the coastal profiles as well as the more detailed scientific diagrams of botanical and natural history specimens. McCormick

[59] Wilkes was in fact grounded in many of the naval disciplines: he studied surveying with Ferdinand Hassler, head of the United States Coast Survey, worked in the coast survey himself, and received tuition on astronomical astronomy from Nathaniel Bowditch, one of the founders of modern maritime navigation.

made numerous sketches of the coastline, seen in his journal, that were later used for his own narrative of the expedition, but did not feature in Ross's published narrative, probably due to their deemed lesser artistic merits (Figure 6). On leaving Quail Island (just south of Christchurch, New Zealand) he recounted, 'we got underway with a fine breeze, took a sketch of the coastline of the islands as we passed along it. The land has a remarkable appearance.[60] Joseph Dayman, mate of the *Erebus,* made sketches that were later used for the official narrative until the autumn of 1840 when he was made assistant at the Hobart Observatory, and so missed out on the Antarctic voyages.[61] The more detailed artistic work, particularly the survey charts, was then taken over by John E. Davis, second master on the *Terror*, who was, as Hooker put it, a 'tolerable artist'. [62] Figure 7 shows an example of Davies' work: the watercolour has the impression of an image drawn directly and hastily 'on the spot'. It is not of a comparable quality to some of the work by the professional artists aboard the American and French expeditions, however (shown later). By their reliance on naval men for the artistic duties the British expedition organisers showed trust in the training of their medical men had undergone, and perhaps a more rigorous control over expedition personnel and their productions if all personnel were naval men.

[60] Wellcome, MSS.3366, Book 2

[61] Gurney, Alan. *The Race to the White Continent: Voyages to the Antarctic* (New York: W.W. Norton and Company, 2002): 56

[62] Huxley, *Life and Letters of Sir Joseph Dalton Hooker*, 69.

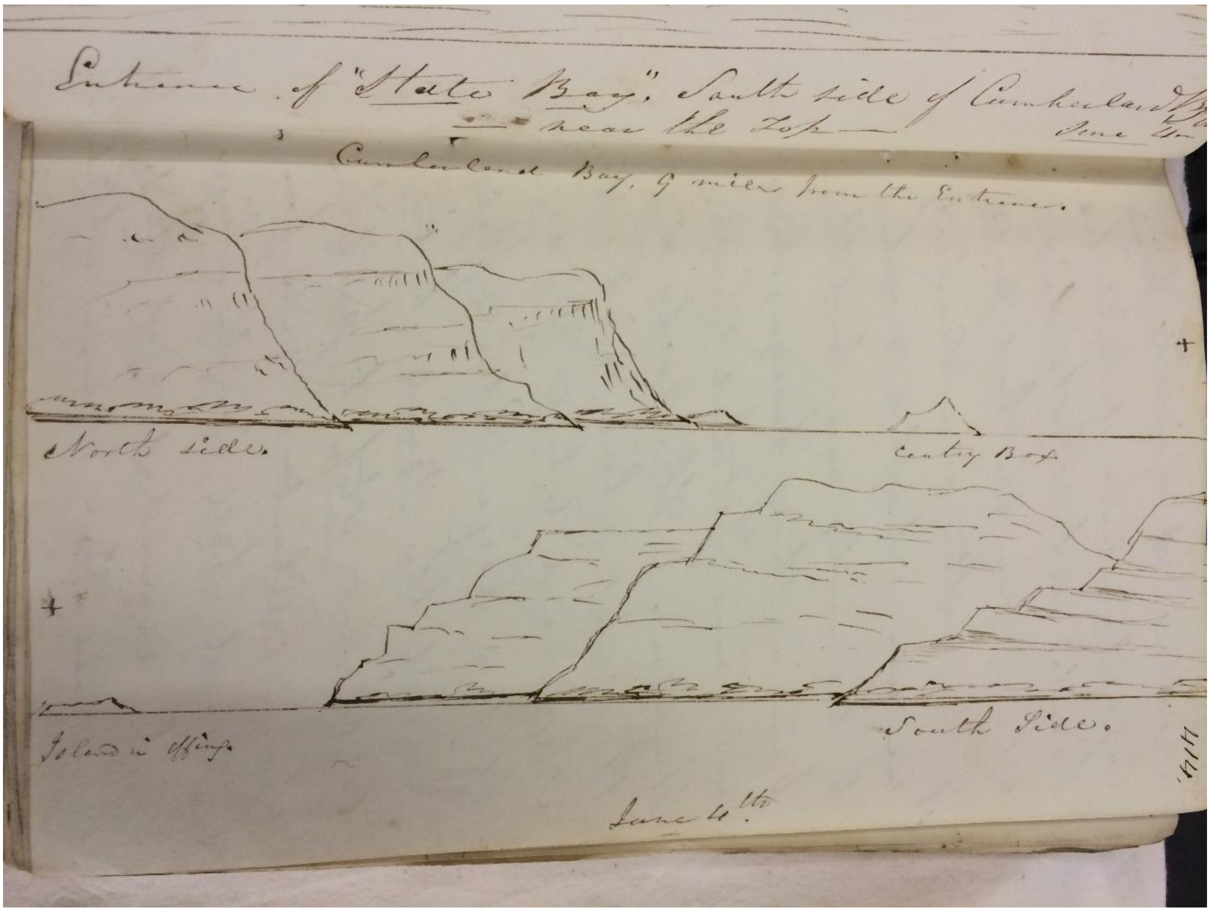


Figure 6. Sketch of the entrance to “State Bay”, south side of Cumberland Bay, Sandwich Islands, 4 June 1840 by Robert McCormick. (From Wellcome, MS 3366, Book 4, 414).

Figure 7: Watercolour: 'Cape Davis. Lat. 70.32.S Long.166.6.E'. (J. E. Davis [c. 1840], Courtesy of the Scott Polar Research Institute. Y: 59/5/4).

The shipboard officers and crew were not the only men who produced images to be included in the published works of the British expedition. In the Zoological volumes written by John Richardson and John Gray, they refer often to images having been produced by prisoners in the southern colonies; when discussing the specimen *Capros australis,* Richardson remarked that he had named it in the *Zoological Transactions* 'from a drawing made by a convict in Tasmania for Dr. Lhotsky' (Figure 8).[63] The authority and credibility achieved by gentleman naturalists and trained botanists from Europe and America, vital

[63] Richardson, John and Gray, John. *The Zoology of the Voyage of the H.M.S Erebus and Terror, under the Command of Cpt Sir James Clark Ross, during the years 1839 to 1843* (London: E. W. Janson, 1844): 137. The paper was published in *Transactions of the Zoological Society of London,* vol. III, (1849): 72.

factors in securing acceptance in truth claims about the new world, was in this instance overlooked, no doubt due to the skill of the convict-artist in supplying new knowledge and the scarcity of reliable information.

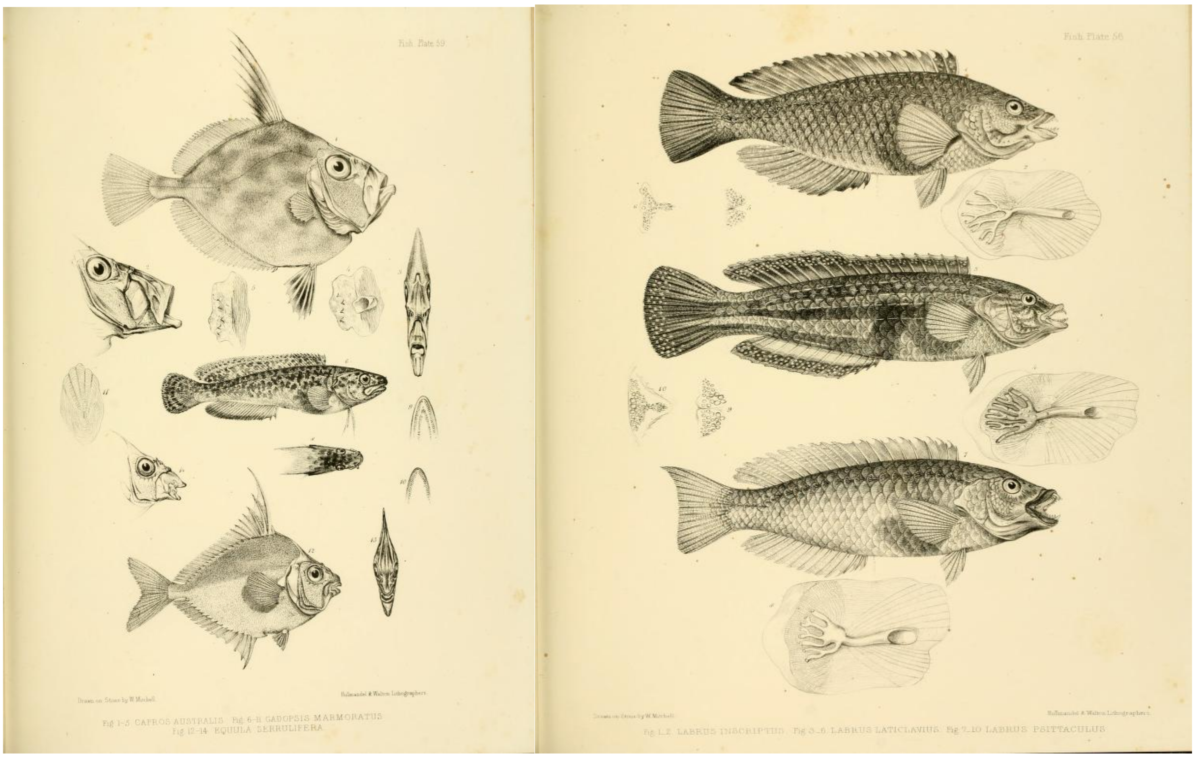

Figure 8: '*Capro Australis'*. From John Richardson and John Gray, *The Zoology of the Voyage of the H.M.S Erebus and Terror, under the Command of Cpt Sir James Clark Ross, during the years 1839 to 1843* [London: E. W. Jansen, 1844], pl.56, courtesy of the RGS-IBG, London).

Whilst there were many similarities between the visual representation of Cook's voyage and those voyages of the 1830s and 1840s, there were also differences. While Hodges on Cook's second expedition had painted over icebergs with a tropical view of New Zealand's South Island in order to depict something more sought after by those at home, the narratives of all three later expeditions contain numerous images of the 'icy barrier'.[64] That

[64] Quilley, Geoff. *Empire to Nation: Art, History and the Visualization of Maritime Britain* (New Haven and London: Yale University Press, 2011): 22.

the act of faithfully representing what had been seen – from the field – was vital in establishing credibility regarding the newly-explored Antarctic ocean is evidenced in the French work 'Debarquement sur une ille des glaces' by LeBreton. The image (Figure 9) shows the artist setting up his artist's stand. The box-like object is the box for paints and the canvas is above, held firm by the indented wood block. He draws whilst those around him perform other vital expeditionary tasks: shooting birds, catching fish, and exploring new terrain.

Figure 9: 'Debarquement sur une ille des glaces' depicting the Astrolabe and Zélée in the Antarctic ice-fields (From *Atlas pittoresque vol 1-2* [Paris: Gide, 1841] by Louis LeBreton [c.1838], courtesy of the RGS-IBG, London)

Figure 10 shows work by McCormick depicting the Antarctic barrier, one of many such images in his narrative. The image is compositionally minimal – the ship offers the only distraction from the ice – but the tabular iceberg form is instantly recognizable. Visual depiction of the Antarctic had become of interest to those at home. On an expedition that was to be overwhelmingly based in the Southern Ocean surrounding the Antarctic continent rather than around the Pacific islands that were to be the mainstay of the French and American expeditions – carrying a trained artist to represent the landscape was not seen to be so necessary.

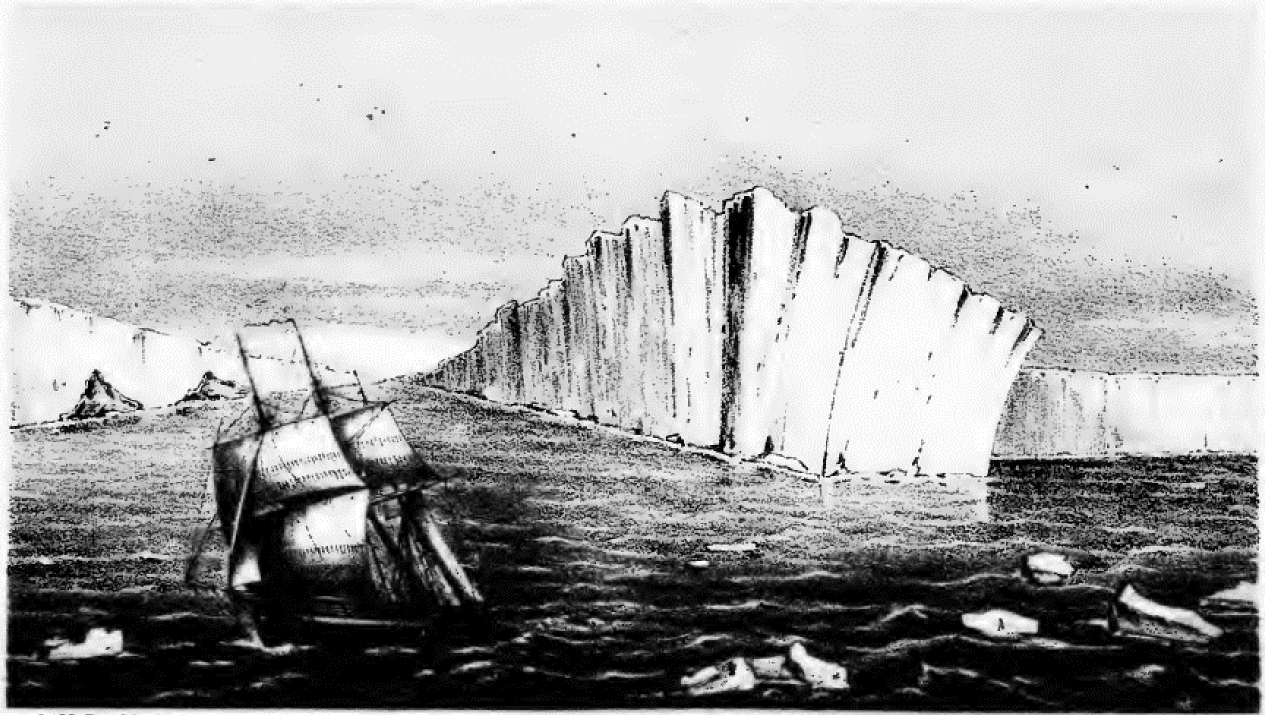


Figure 10: 'The stupendous ice-cliffs forming the extraordinary bight in the great Antarctic Barrier, sketches as the "Erebus" tacked off its entrance' Sketch by Robert McCormick, surgeon on HMS *Erebus* [c. 1840]. (From *Voyages of Discovery in the Arctic and Antarctic seas, and Round the World,* [London: S. Low, Marston, Searle, and Rivington, 1884].

Naturalists' sketches were also used as backgrounds for many of the plates in consequent travel narratives; indeed Smith argues that 'in his landscape and sea work, Hooker sought the same degree of accuracy that he brought to the drawing of minute marine creatures drawn under a microscope'.[65] Hooker did not seem to object too much to this addition in his workload, writing contentedly to his father in June 1841 'at present I am attempting a sketch of the ships off the Barrier and burning Mountain in 78 degrees south'.[66] That he was happy to reveal this information to his father – his staunchest critic – is evidence that he believed it would be seen as, at best, a worthy occupation on board ship, and at worst an unavoidable and obligatory task, unlike many of his natural history related practices.

Coastal views to the travellers of the eighteenth and nineteenth centuries framed their physical approach to the land but also informed their intellectual and emotional approach as well. Representation clearly left lasting impressions. Drawings of coastal profiles, to varying levels of detail and skill, are found in private letters, diaries, sketch-books and log-books of naval officers and midshipmen. In a letter to one of his lieutenants, Wilkes ordered that 'sketches of the islands are required, particularly those as they appear on approaching them from the sea', and stated that 'the officers will be particular in sketching in the shores and tracing the topography'.[67] Hooker's diary has a rare example of a first sketch of coastline made from the deck of the *Erebus*, one showing the key features of a navigational aid: the ship's distance from land, the scale of rock and height of cliffs and any potential inlet (Figure 11). The French atlas has many examples of the coastline illustration: Baie Fortescue (Figure 12), shows a bay in the western portion of the Straits of Magellan, a prime harbour for ships rounding Cape Horn. The difference from Hooker's is evident: the bay is grander in scale, the rolling clouds and light reflected on the ocean present a picturesque representation. Whether the artist (who is not given) executed the preliminary work from one of the small boats seen

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[65] Smith, *European Vision and the South Pacific*, 276.
[66] Huxley, *Life and Letters of Sir Joseph Dalton Hooker*, 61.
[67] Wilkes, *Narrative of the United States Exploring Expedition*, IV: 406; 523

in the image, or whether the view of the two corvettes in harbour is imagined from this angle, is not known.

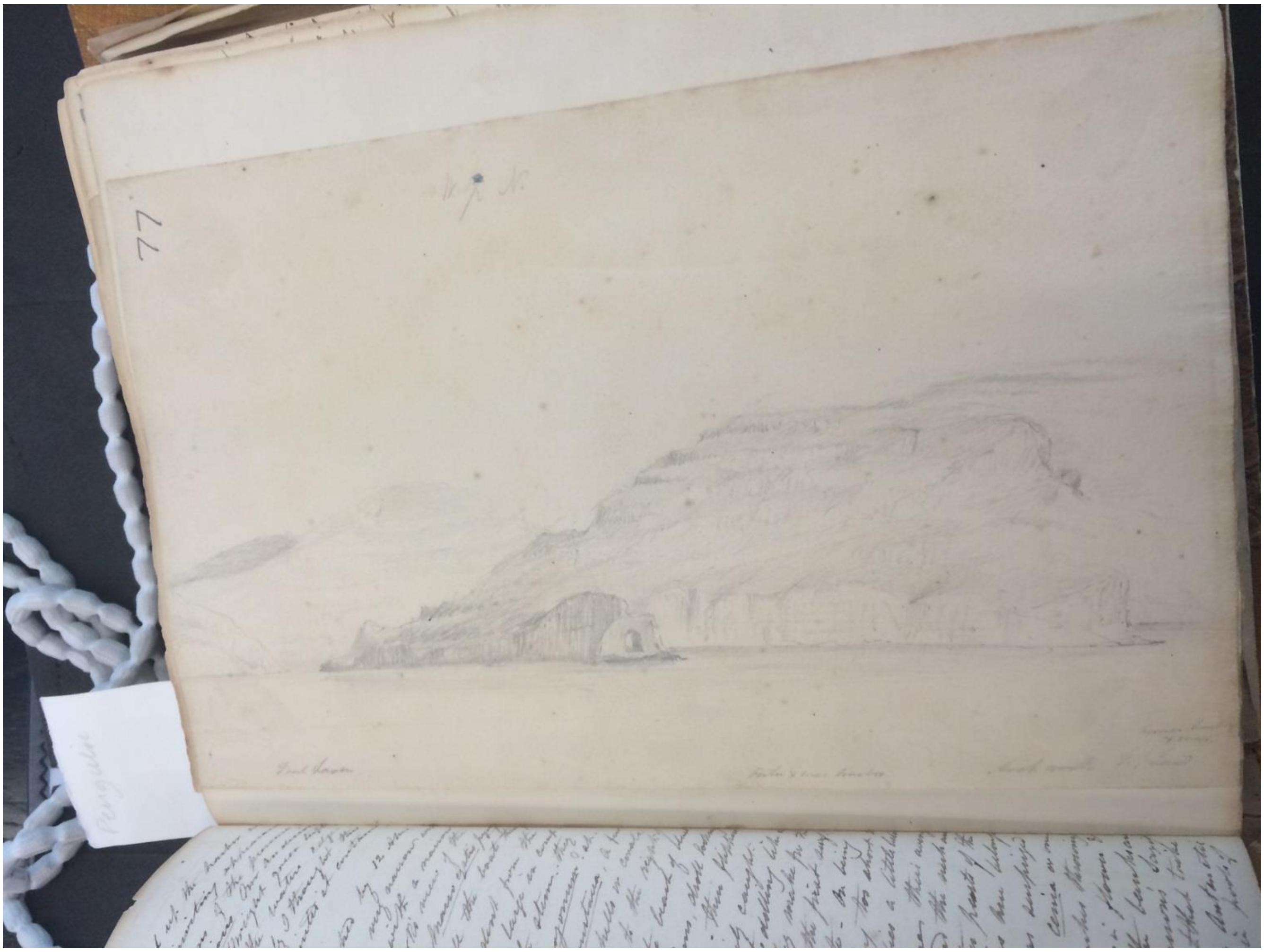

Figure 11: Sketch of Australian coastline *c*.1840 in the diary of Joseph Dalton Hooker. (Courtesy of the Royal Botanic Gardens Kew Archive, JDH/1/1).


Figure 12: The *Astrolabe* and *Zélée* at anchor in Baie Fortescue in the Straits of Magellan. (From *Atlas pittoresque vol 1-2* [Paris: Gide, 1841] by Louis LeBreton [c.1839], courtesy of the RGS-IBG, London).

If representations of coastlines, harbours and obstructions were navigational tools, precise calibrated drawings of specimens were understood as equally vital to on board science. Reproducing something as soon as it was brought up from the depths was paramount, as many plants and animals quickly desiccated on deck, changing appearance. Aboard the *Vincennes*, Midshipman Reynolds wrote how 'the artists copy everything from life'.[68] Time was a serious constraint in the representation of specimens, and the quick sketch as an object was brought on board was often all that could be achieved. As Hooker lamented, 'I often wish that my time admitted of my drawing them, before they were put away; but with such numerous branches of Nat[ural] History to claim my attention, & the Botany of New

[68] Cleaver, Anne Hoffman and Stann, E.J. (eds). *Voyage to the Southern Ocean – Letters of Lieutenant William Reynolds of the United States Exploring Expedition 1838-1842* (Annapolis: Naval Institute Press, 1988): 11.

Zealand to investigate, I have done little more than take notes of the parts of one or two of them'.[69]

Hooker's letters home stress the laboriousness of the task of sketching specimens from the sea, but hint at the gradual improvement of his drawing technique. In a letter to his father near the beginning of the voyage, he wrote, 'McCormick pays no attention to [the sea animals] & they are therefore brought at once to me, almost every day I draw, sometimes all day long, till 2 & 3 in the morning'. He continued, observing that 'I have now drawings of nearly 100 marine crustacea & mollusca, almost all microscopic, some of them are very badly done, but I think that practice is improving me, & as I go on I hope that some will be usefull *[sic]* on my return. Were it not for drawing my sea life would not be half so pleasant to me as it is. In the Cabin, with every comfort around me I can imagine myself at home.[70]

On another occasion Hooker highlighted the importance of the visual image of a new field of study – the marine invertebrates – commenting, 'it is a new field which none but an artist can prosecute at sea'.[71] Sketching and the three-dimensional representation provided a means of preserving the image of what had been seen in a way that preservation of a specimen could not. It could be (although was not always) 'immutable'. This facet of representation was one Hooker was well aware of:

> At sea the Towing-net is always a going, when the weather is fair enough & I draw all the produce, as far as possible. Very curious Fish are sometimes captured: among them a most beautiful little Salmon, with the most resplendent burnished colours of deep blue all over & silver spots, it is not uncommon in the open sea in warm latitudes: also several most extraordinary Ribband fish of which I made drawings, for they shrivel up to mere specks in spirits.[72]

[69] JDH/1/2 f.78-79. Joseph Hooker to Mary Richardson, 8 October 1841.
[70] JDH/1/2 f.15-23. Joseph Hooker to William Hooker, 3 February 1840.
[71] JDH/1/2 f.26-27. Joseph Hooker to William Hooker, 17 March 1840.
[72] JDH/1/2 f.78-79. Joseph Hooker to Mary Richardson, 8 October 1841.

Hooker sketched crustacea to improve his technique and occupy his day. Figure 13 shows images of crustacean ‘worked up’ on the voyage’s return from sketches by Hooker (now lost). They are detailed and precise, although we cannot tell now how much was Hooker’s work. His father, however, was less impressed with this use of his time. Whilst the careful rendering of botanical specimens in pen and paper was a respectable occupation, the same techniques applied to the animals of the marine environment was not. Although Hooker’s contemporaries Charles Darwin and Thomas Henry Huxley had expressed keen interest in the minutiae of the marine world, the majority of the public was less concerned. The specialization of marine science in the mid-nineteenth century faced many obstacles; it was considered not just irrelevant, but detrimental to other work those at sea had to perform.[73]

[73] None of these sketches survive today. Drawings were included in the zoological volumes using Hooker’s sketches but were not by Hooker himself. For more on Darwin at sea see: Brown, Janet. *Charles Darwin. Voyaging. Volume I and II* (Princeton: Princeton University Press, 1996). For more on Huxley at sea see: Goodman, Jordan. *The Rattlesnake: A Voyage of Discovery to the Coral Sea* (London: Faber & Faber, 2005).

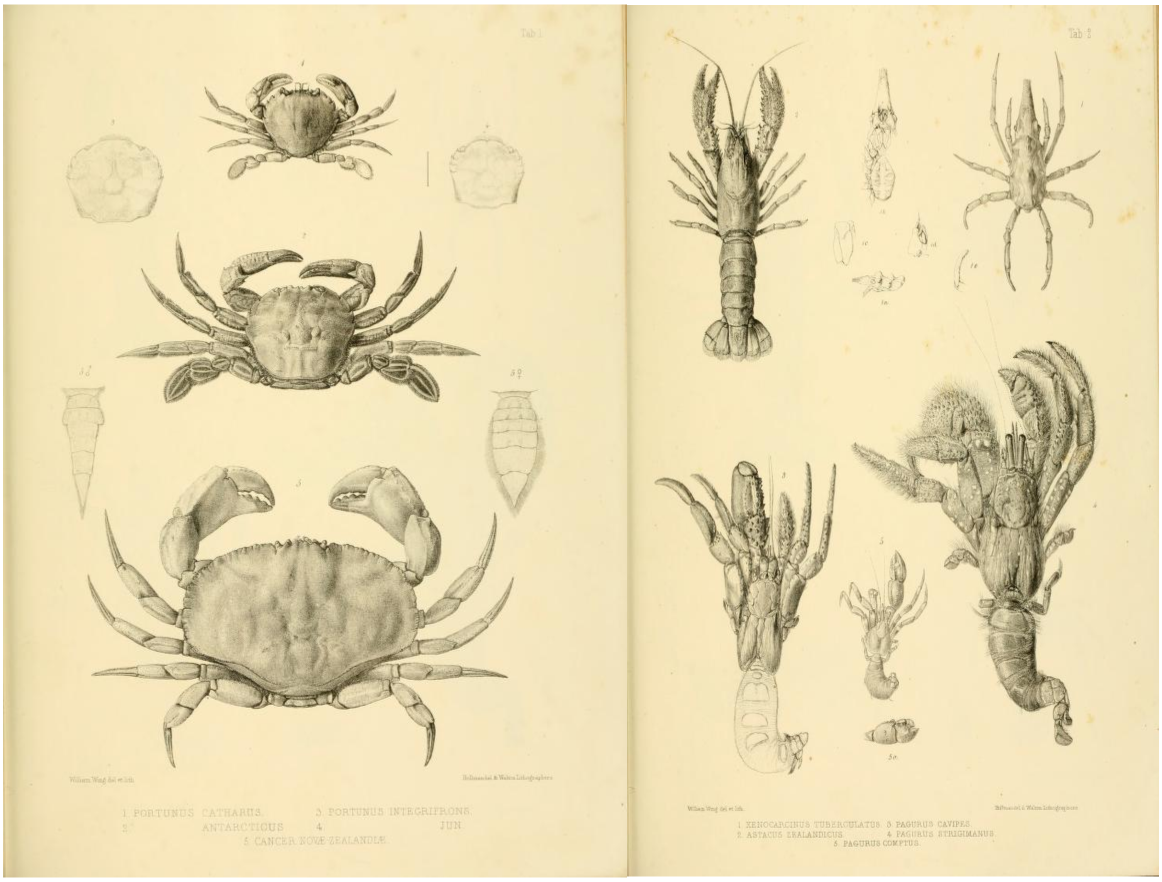


Figure 13: Crustacea, from original sketches by Joseph Dalton Hooker. (From John Richardson and John Gray*, The Zoology of the Voyage of the H.M.S Erebus and Terror, under the Command of Cpt Sir James Clark Ross, during the years 1839 to 1843* [London: E. W. Jansen, 1844], Tab 1 and 2, courtesy of the RGS-IBG, London).

It is clear Hooker read the botanist Robert Brown's work on board. Brown was noted for his use of the microscope in botanical drawing. Hooker was likewise impressed with the style of drawing dissection employed by Francis Bauer, the botanical draftsman employed by Joseph Banks on Cook's first expedition to the South Seas: 'I imitated Bauer's style of drawing dissections'.[74] The impact that a sketch or illustration could make was not lost on Hooker, who had experienced exactly that effect himself in relation to a drawing of sailors killing penguins on Kerguelen's Land printed in Captain Cook's *Voyages*. Hooker recalled

[74] Huxley, *Life and Letters of Sir Joseph Dalton Hooker*, 61.

thinking that he ‘should be the happiest boy alive if ever I would see that wonderful arched rock, and knock penguins on the head’.[75] Hooker got his chance when the ship landed at Kerguelen’s Land in 1841, and not only sat on the rock but made his own sketch of the scene he remembered as a boy. Later he wrote home to his old college friend James Hamilton that ‘such pictures once visualized were ineffaceable’.[76] The arched rock was noteworthy to all three expeditions, each narrative contains an image of it: Figure 14 shows the work by Hooker. The desire to commit what was fleetingly seen to a longer lasting visual image was one held not just by the officers and naturalists but by the crew as well. C. J. Sullivan, blacksmith on the *Erebus* remarked, on seeing the icy barrier of the Southern Ocean that, ‘we had an opportunity to discern the barrier in its Splendid [sic] position. Then I wished I was an artist or a draftsman instead of a blacksmith and armourer’.[77]

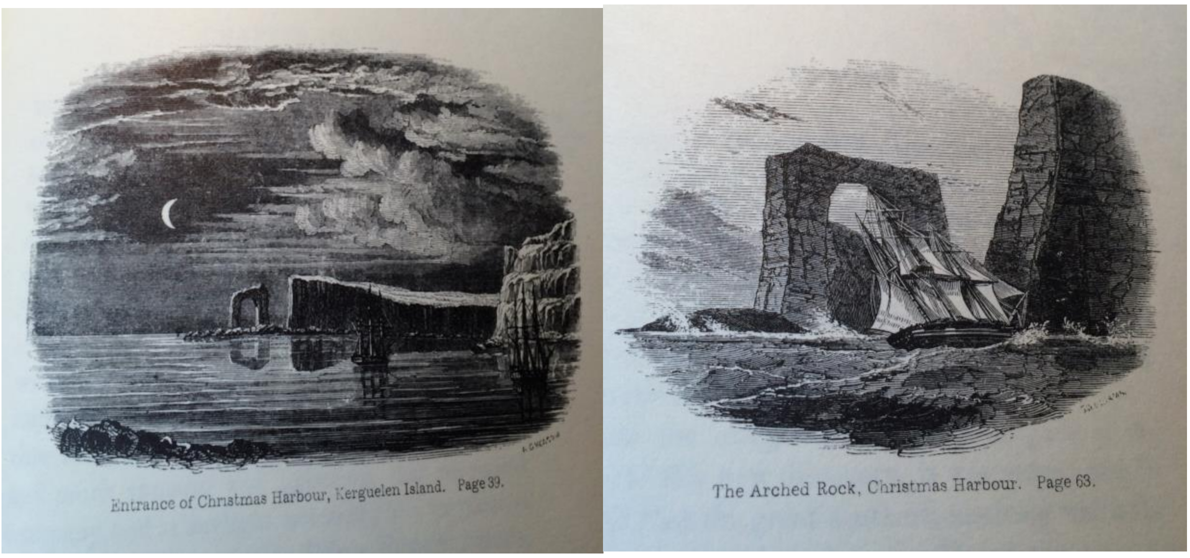


Figure 14: ‘Entrance of Christmas Harbour’ and ’The Arched Rock’ at Christmas harbour, Kerguelen Island, originally sketched by Joseph Dalton Hooker. (From James Clark Ross- *A Voyage of Discovery and Research* [London: John Murray, 1847], I:39; I:63).

[75] Huxley, *Life and Letters of Sir Joseph Dalton Hooker*, 6.
[76] Huxley, *Life and Letters of Sir Joseph Dalton Hooker*, 67.
[77] Savours, Anne. ‘Two Unpublished Accounts of the British Antarctic Expedition 1839-43’, *Polar Record* (10) (1961): 598.

Along with the emphasis on the scientific diagram, the mid nineteenth century saw the introduction of the daguerreotype as a mode of representing what was seen. The process involved the polishing of a sheet of silver-plated copper, its surface made light-sensitive with halogen fumes. It was then exposed in a camera for a length of time that differed depending on the light conditions the picture was taken in. During this time the sitter, or object imaged had to remain perfectly still; the resultant image was a mirror-image of the scene taken. Louis Daguerre introduced the daguerreotype process before any of the expeditions departed, yet the French appear to have made no use of their compatriot’s new technology. This is not surprising. Attempting to carry the necessary technology needed to reproduce Daguerre’s results in Paris in such conditions would have been difficult, especially as it is unlikely that those on board had any familiarity with the technology. There is certainly no mention of its use in any of the narratives. Hooker, however, was aware of its existence when at sea, writing to the wife of John Richardson, that, ‘You amuse me, & instruct me too, by your account of the Daguerreotype’.[78] Drayton and Agate of the American expedition did make considerable use of the camera lucida, an instrument which reflects light through a prism to produce an image on paper, conveying a great deal of geological and botanical information. Goupil on the French expedition also used the camera lucida to make coastal profiles. This can be seen in paintings such as ‘Observatoire de Port Famine’ (Figure 15). As Smith has noted, images produced from the camera lucida are apparent by the faithful description of light and shade and the characteristics forms of vegetation.[79] Use of the instrument in this way achieved the ‘on the spot’, objective image that was required to ensure the image was accepted as a credible representation of what had been seen.

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[78] JDH/1/2 f.78-79. Joseph Hooker to Mary Richardson, 8 October 1841.
[79] Smith, *European Vision*, 335.


Figure 15:'Observatoire de Port Famine' on the north shore of the Strait of Magellan. (From *Atlas pittoresque vol 1-2* [Paris: Gide, 1841] by Louis LeBreton [c.1839], courtesy of the RGS-IBG, London).

The two-dimensional representations of data and specimens made on board did not always stay on board for the duration of the expedition. Objects could be lost or damaged. Transforming a three-dimensional object into its portable equivalent also meant that the resultant transformation was far easier to lose. John Richardson, describing the fish species *Myctophum boop*, commented that 'Dr. Hooker's sketch, No.89, presents a figure of it, drawn from the recent fish, captured on the 19th of January. Unfortunately the notes at the time have been mislaid.'[80] For *Prymnothonus hookeri*, he repeated that, 'the figure introduced is copied from a pencil drawing (no. 217) by Dr. Hooker, and we can give little more information than

[80] Richardson and Gray, *The Zoology of the Voyage of the H.M.S Erebus and Terror*, 39.

the sketch conveys, the notes made at the time by Dr. Hooker having been mislaid'.[81] John Davis, second master of the *Terror,* recorded a more dramatic incident in a letter home: 'about this time the cat gave me a good long job by getting into my drawer in the captain's cabin and tearing some of my charts; she tore six, but fortunately not of much consequence as they were soon repaired'.[82] The fragile and portable paper transformation of the living specimen was often the most easily lost, destroyed and altered, but in this case it faired rather better than the sample on deck, remaining durable and stable in the toughest of environments.

The 'immutable mobile' was also easier to save than its counterpart. When the American ship *Peacock* went down in the Columbia River, all was lost on board except a few precious items. Midshipman Reynolds highlighted the objects of most importance, writing that, 'The captain saved his journals and the surveys, the Master his Chronometer, the Artist a few of his sketches, and all else was left pay to the sea'.[83] Titan Peale wrote 'all our collections (the most valuable of any obtained) all my knick-knacks, clothes – everything but my rifle and the clothes on my back – were – gone'.[84] Lieutenant Emmons of the *Peacock* recorded in his journal, five months after the ship's wreck, that 'having rescued all our survey notes – and other ship's papers together with chronometers and several instruments – the public loss is of no importance'.[85] In this instance the portability of the items meant that they could be rescued: all preserved specimens on board at that time were lost.

Whilst some inscriptions were lost or damaged at sea, others were deliberately sent overboard. Ross regularly threw bottles containing information into the sea. Sailing around

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[81] Richardson and Gray, *The Zoology of the Voyage of the H.M.S Erebus and Terror, 51.*
[82] Davis, J. E. *A Letter from the Antarctic* (London: William Clowes & Sons, 1901): 10.
[83] Viola and Margolis (eds), *Magnificent Voyagers,* 253.
[84] Poesch, Jessie. *Titian Ramsey Peale 1799-1855 and his Journals of the Wilkes Expedition* (Philadelphia: The American Philosophical Society, 1961): 88.
[85] Poesch, *Titian Ramsey Peale,* 88.

the edge of the icy barrier he recorded that ‘both ships [were] made fast to the same piece of ice. Awaiting the opening of the ice to proceed’.[86] In another memo to the Admiralty sent from Antarctic waters Ross recorded that ‘a paper enclosed in a tin case and put into a barrel was thrown from H M Erebus 8 February 1841’. On the paper was written the location of the ships and the following: ‘a barrier of solid ice about 150 feet high, and five leagues distant was in sight from the deck’.[87] If found this information was to be forwarded to the Admiralty in London, with a note of the date, and the latitude and longitude when found. Ross recounted in his narrative later that this ‘may at a future day be met with and help to throw some light on the winds and currents which prevail in these regions’.[88]

Discarding material thus performed an experiment, here on wind and current, by using a two-dimensional transformed image of their physical route. Soon after Ross continued, ‘it was my practice occasionally throughout the voyage to throw over several bottles at the same spot, made to float with different degrees of buoyancy, by loading them with unequal weights of dry sand’.[89] Few of such bottles were ever recovered but those that had been were noted and over time enough instances were recorded to form a ‘Bottle Chart of the Atlantic Ocean’ in 1843 (Figure 16). As the author recorded: ‘The lines drawn (it will be at once seen) must not be taken as the actual tracks of the bottles, as the line of No. 46 will at once show: but, are merely intended to connect the point of departure with that of the arrival of the bottle, the rest being left open to opinion and speculation’.[90]

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[86] Scott Polar Research Institute (SPRI), MS 1556: 280. 18 November 1841.James Clark Ross to the British Admiralty.
[87] SPRI, MS 1556: 192. 1840. James Clark Ross to the British Admiralty.
[88] James Clark Ross, *A Voyage of Discovery and Research in the Southern and Antarctic Regions during the Years 1839-1843* (London: John Murray, 1847): II: 202.
[89] Ross, *A Voyage of Discovery and Research*, II: 235.
[90] Anon, ‘Bottle Papers’, In *Nautical Magazine and Naval Chronicle* (London: Simpkin, Marshall & Company, 1843): 181. The following extract from the *Hobart Courier* in 1851 details what happened to those rare findings of washed-up bottles, ‘Captain Beecher, of the Hydrographic Office, has taken

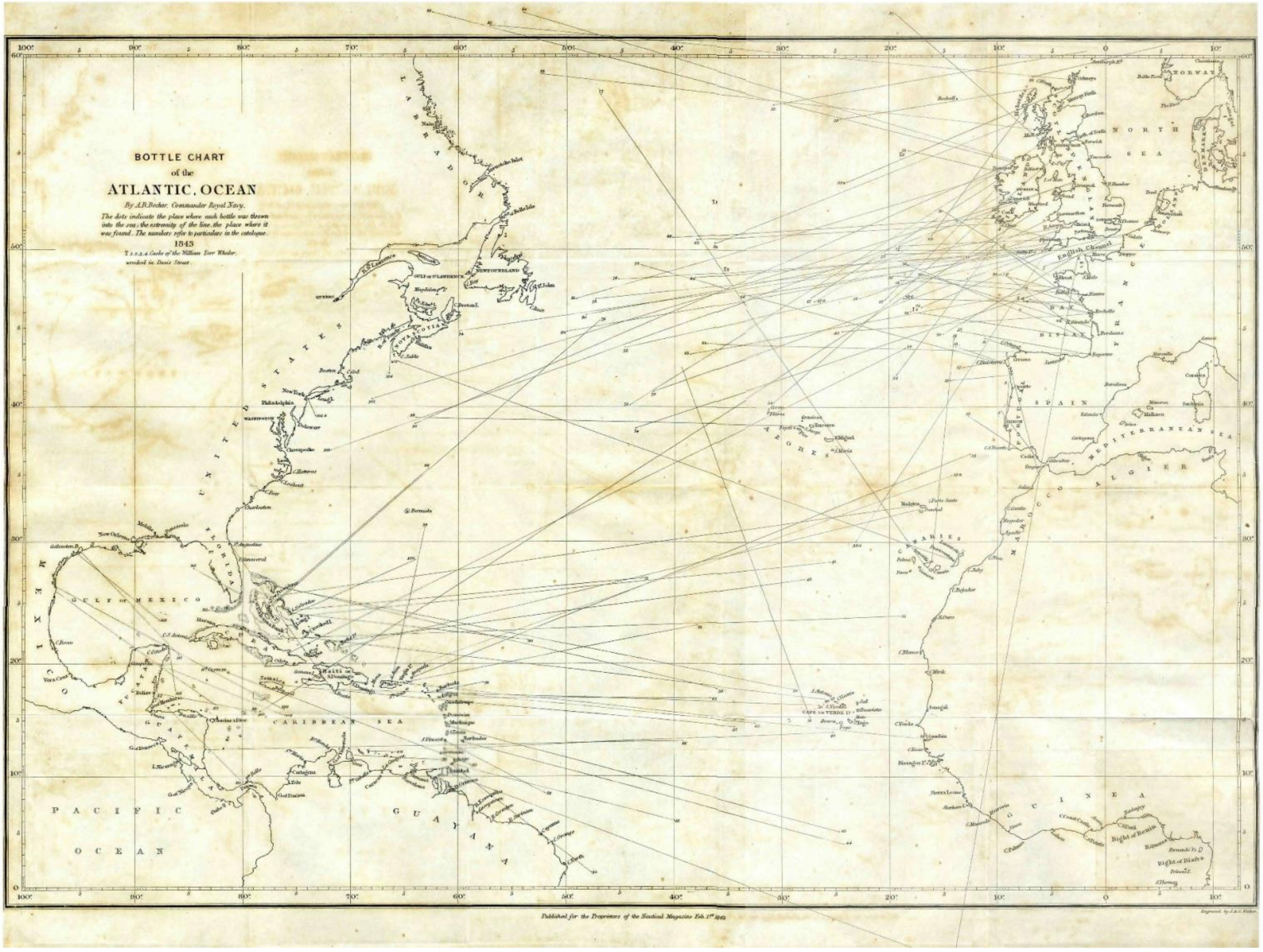


Figure 16:'Bottle Chart of the Atlantic Ocean' by A. B. Becker. (From *The Nautical Magazine and Naval Chronicle* [London: Simpkin, Marshall & Company, 1843], 181.

### The preparation and preservation of collected material

Once a sample had been brought on board ship – either dragged from below the water, retrieved from the surface, or shot from the air, it at once entered a chain of transformations to ensure its permanent record. Through the preservation of a sample, tangible proof of what had been seen and collected was supplied. Jars containing ice fish or cold water crustaceans

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the pains to collect from the columns of the Shipping and Mercantile Gazelle during the last twenty years, and from other channels, all the published records of these bottle-logs, and from them has constructed what he terms a 'Bottle Chart of the Atlantic Ocean. From the tracks laid down of several hundred bottles, a very good indication of the surface-drift, and of the set of the general currents, may be obtained'.[90]

provided material proof of immutable discoveries in ways the sketch alone could not. Preservation was complicated, however. Even when choosing a specimen, some degree of intervention was required to preserve it; the living specimen in its own environment could never be retained perfectly.

The 'craft' aspect of collecting – one that entailed finding and keeping a specimen – did not of itself produce valid scientific specimens. It was necessary to know what to collect, which bits were important and that they were preserved and labelled correctly. The collector had to be trained to produce such specimens. It was understood that life brought on board should be preserved in the way those at home required. On bringing on board a porpoise d'Urville remarked, 'The doctors prepared the skin and the skeleton for the Museum [Naturelle Histoire]'.[91] James Clark Ross brought the first penguin specimen back to England, commenting that, 'some of these were preserved entire in casks of strong pickle, that the physiologist and comparative anatomist might have an opportunity of thoroughly examining the structure of this wonderful creature'.[92]

Specimens were preserved through the processes of drying, pickling in brine and immersing in spirit, but no method could retain the object in its original condition. Each technique came with associated costs in terms of the state of the sample. The pickling liquid used for preservation was very destructive. As a result, hard tissue formed a disproportionate part of most specimens.[93] In addition, specimen's colour and markings were often lost. In the British volume on the zoology of the expedition, John Richardson frequently discussed the damage that marine specimens, particularly fish, had undergone, so giving us insights into

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[91] D'Urville, *Voyage au Pole Sud,* I: 49.
[92] Ross, *A Voyage of Discovery and Research,* II: 159.
[93] See: Larsen, Anne. 'Equipment for the Field'. In Jardine, Secord and Spary (eds) *Cultures of Natural History*, 358-377.

how the specimen would have been preserved at sea. Discussing the fish species *Cheironectes pictus,* Richardson recorded 'from the rigidity of its expanded fins, and the stiffness of its filaments, it was probably plunged, while still alive into strong spirit'.[94] Of the species *Harpagifer bispnins* he wrote that it had been 'much injured by immersion in brine'.[95] Commenting on the poor state of the fish, *Gobius bynoensis*, he wrote 'the original colours cannot be ascertained from the specimens which have been long macerated in spirits'.[96] In the entry for *Myctophum hians*, Richardson remarked, 'I am unable to describe the shining apparatus on the forehead, the jaws having come away while the specimen was in the artist's hand, before I had properly examined them'.[97] In a letter to James Clark Ross on the expedition's return, Richardson credited also the particular circumstances of the voyage for the damage: 'I have had 6 plates done out of the 10 of fish which are to form the largest number. The fish got at Kerguelen land and the Aucklands are mostly new forms and it is to be expected that so many of the species have suffered by the length and severity of the voyage'.[98] Unfortunately the American volumes on ichthyology were never published, despite the renowned Louis Agassiz (1807-1873) spending many years on the tomes which numbered over 1000 pages.[99] The French zoological volumes make no reference to the state the samples were in when they were described and classified.

The task of preservation was labour intensive. Hooker described the process of preserving and sketching one of the rare marine botanical specimens thus: 'the Captain & myself with our sleeves tucked up picking sea weed roots, & depositing the treasures to be

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[94] Richardson, *The Zoology of the Voyage of the H.M.S Erebus and Terror*, 15.
[95] Richardson, *The Zoology of the Voyage of the H.M.S Erebus and Terror,* 19.
[96] Richardson, *The Zoology of the Voyage of the H.M.S Erebus and Terror*, x.
[97] Richardson, *The Zoology of the Voyage of the H.M.S Erebus and Terror,* 41.
[98] TNA, BJ2/1, 6-7. From John Richardson to James Clark Ross; 30 May 1844.
[99] An unpublished manuscript is held at the Smithsonian Institute (no catalogue number currently available).

drawn in salt water, in basins quietly popping the others into spirits. Some of the sea weeds he lays out for himself often sitting at on[e] end of the table laying them out with infinite pains'.[100] McCormick routinely recorded the practice of 'skinning my birds' in his journal.[101] He described being '[e]mployed all day in superintending the preservation of the skeleton of the silver-grey seal' and how he had been 'four hours in skinning and preserving the large penguin I shot the other day'.[102] It was also complex. Hooker wrote to this father that the 'beautiful *Columba spadicaa'* was 'by far the most difficult bird to skin I ever saw from its tender skin, loose feathers & fatness'.[103] McCormick bemoaned the time taken to prepare a specimen after it had been caught: 'I was employed in skinning birds and storing away specimens until two a.m.'.[104] In bad weather the opportunity was often taken to begin the processing of specimens taken from the sea. McCormick recalled how he had 'employed myself in arranging and stowing away my specimens of natural history' at such a time, as well as being 'employed all day packing specimens and writing descriptions of them'.[105] Sergeant Cunningham of the *Terror* recorded instances of time occupied by the preservation of collected specimens, writing how he had been, '[e]mployed making specimen cases most of the day'.[106] Preservation was a good use of time when sailing conditions afforded little other occupation: immobility and calm weather contributed to the advance of marine science.

[100] Huxley, *Life and letters of Sir Joseph Dalton Hooker* , 87.
[101] Wellcome, MSS.3366, Book 2
[102] McCormick, Robert. *Voyages of Discovery in the Arctic and Antarctic Seas, and Round the World* (London: S. Low, Marston, Searle, and Rivington, 1884): 251-252.
[103] JDH/1/2 f.80. Joseph Hooker to William Hooker, 23 November 1841.
[104] McCormick, *Voyages of Discovery*, 21.
[105] McCormick, *Voyages of Discovery*, 101; 107.
[106] Cunningham, *The Journal of Sergeant William K. Cunningham*, 94.

The time and skill required to preserve a specimen not only led to sleepless nights for those involved: specimens could also be lost altogether. On finishing preparing a batch of birds, Peale recorded in his journal:

> [S]everal of my best birds spoiled before I could prepare them, my drawings and notes requiring too much of my time to allow of my accomplishing all in such warm weather. An assistant had been furnished me by Capt. Wilkes for this purpose and he has been rated on the ship's books with extra pay for the service, but on my application for him to be excused from ship duty today to skin my birds, the first Lt. Mr. Walker refused.....consequently I have to submit both the loss of specimens which are numerous, and to the necessity of stuffing skins myself at the sacrifice of more important labours'.[107]

The everyday shipboard practices required to run the ship were frequently given greater importance than the labours of the naturalists. The scientific investigations performed by each expedition was largely dependent on the interests of those in charge at the time. Unlike Ross, who continually expressed his interest in the inhabitants of the deep sea, Wilkes' primary concern was for the physical sciences. Much time was devoted to surveying: zoological investigations could wait.

One of the most popular methods of preservation was simple drying, particularly of small, bony creatures such as fish. Drying meant that the resultant specimen became much more compact, and rid of its soft body parts, was less likely to deteriorate than a specimen preserved in brine. On the return to land the specimen could be partially rehydrated with water. This process, however, was complicated. Irish naturalist William Harvey wrote to Hooker concerning algae for *Flora Antarctica* that 'it is difficult, in things which do not *perfectly* recover their original form on moistening, to determine what allowance to make for *drying*'.[108] Anne Secord has argued that there was some mistrust of illustrations among

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[107] Poesch, *Titan Ramsey Peale*, 161.
[108] Endersby, *Imperial Nature*, 127.

serious botanists who found it difficult to know what allowance to make for things that had been dehydrated. One thing was certain: once a specimen had been re-hydrated it was lost as a sample, and existed only as a pictorial representation of the original.

Re-hydrating a specimen, as well as foreseeing its loss, actually afforded little chance for the illustrator to make a copy: samples soon lost rigidity and disintegrated. Recording the classification of the fish species *Glauosoma hebraicum* Richardson complained, 'being a dried section, much of the original markings must have disappeared'.[109] Richardson remarked of the species, *Notacanthus sexspinins,* that 'it was prepared simply by drying, and on soaking it well in water it resumed its former dimensions, in which state it was drawn by the artist'.[110] Of the species *Pataecus fronto* he was scathing of its preparation, 'we have seen but a single example of this very curious fish, which was dried without any preparation whatever'.[111] Hooker pasted many dried specimens, all botanical, into his journal of the British expedition, along with notes and annotations.[112] These formed a different trove to that preserved in brine and pickle. This was his personal account of things he had seen (Figure 17).[113]

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[109] Richardson, *The Zoology of the Voyage of the H.M.S Erebus and Terror*, 29.
[110] Richardson, *The Zoology of the Voyage of the H.M.S Erebus and Terror*, 54.
[111] Richardson, *The Zoology of the Voyage of the H.M.S Erebus and Terror,* 20-21.
[112] See: Secord, Anne. 'Pressed into Service: Specimens, Space and Seeing in Botanical Practice'. In David Livingstone and Charles W. J. Withers (eds), *Geographies of Nineteenth-Century Science,* (Chicago and London: Chicago University Press, 2011): 283-310.
[113] Huxley broke this mould by spending much of his personal time investigating the minutiae of the marine environment.

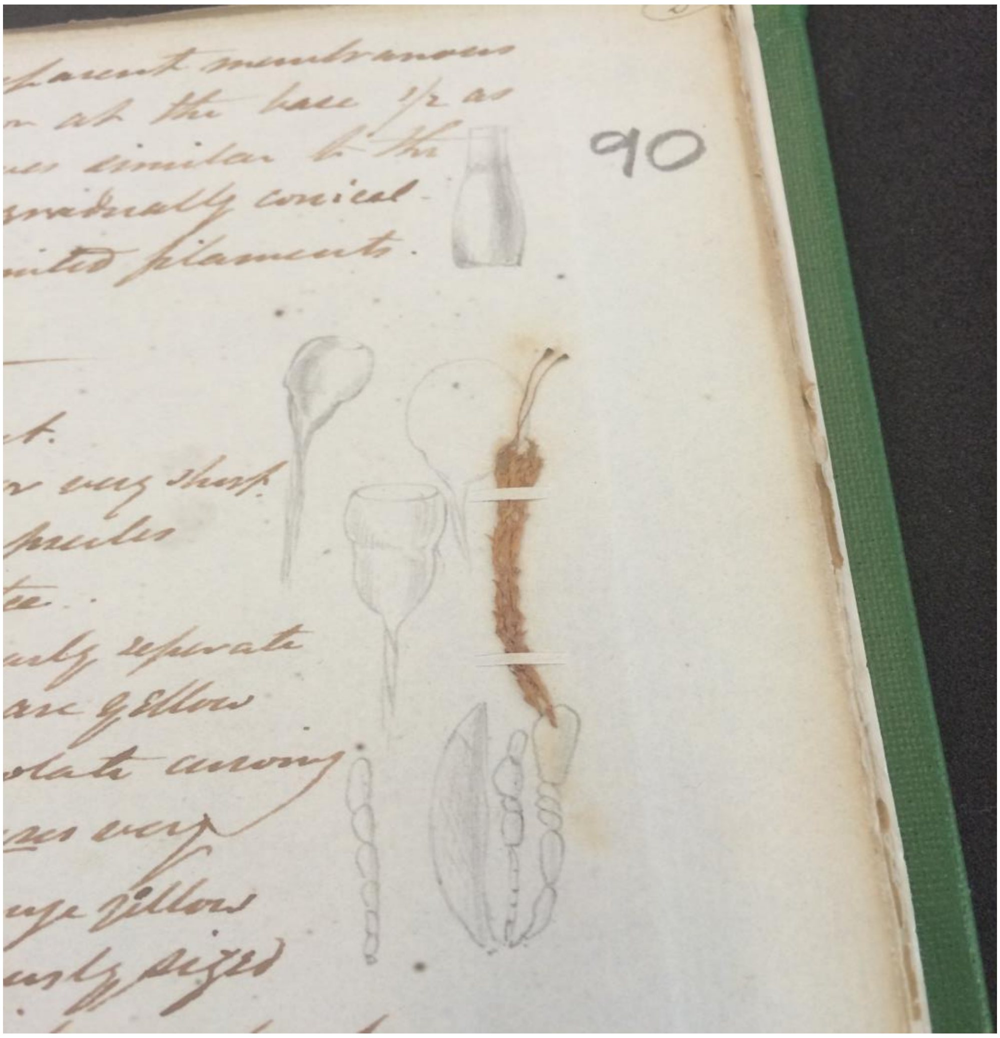


Figure 17: Dried botanical specimens in the diary of Joseph Dalton Hooker, *c.* 1843. (Courtesy of The Royal Botanic Gardens Kew Archive, JDH/1/1).

Despite the often poor condition of preservation, however, it was the duty of the artist to re-present the specimen in ways that could be understood by others. One specimen was not always sufficient to produce a viable representation of what had been seen. In the case of the fish species, *Notothenia cornucola*, Richardson had to do the best he could with what he had been given: ‘These specimens have suffered much injury from deterioration of the spirit in which they were put, and the figure is a combination of the most perfect, one supplying what was wanting in another. It is drawn to the dimensions of the largest specimen’.[114] Just like the

[114] Richardson and Gray, *The Zoology of the Voyage of the H.M.S Erebus and Terror,* 8.

ideal botanical specimen that was a creation of the best pieces from several samples, so Richardson's representation of his fish species was a combination of the best preserved pieces from a number of different individual specimens. On occasion the most viable parts from multiple types of representation were also used to construct a more complete image of a species. Richardson remarked when illustrating a specimen of *Myctophum boop*, that 'in figure 6, the small eminence behind the eye, on the hind head and nape, is added from Dr. Hooker's figure, there being no remains of any glandular matter so far back in the specimens'.[115]

The demands of the instructions – to sketch all that was seen, to preserve what was possible, to change the liquid in the preservation jars during the course of the voyage – appear to have been increasingly difficult to observe as the voyage proceeded. These processes also involved significant alterations to the original specimen: they did not remain (if ever they were) immutable. These processes, along with other deleterious effects on board ship can be referred, to use Hacking's terminology, as 'interventions' in the movement from original object to that which arrived as specimens at the journey's end. Any errors incorporated in sketching would remain, immortalized in pen and paper. What was seen by those at home was a transformation of what had been prepared by those on board; a version of the specimen they had attempted to preserve as they had seen it.

**Mapping and surveying**

The importance attached to the production of maps in the naming and claiming of new land has been well documented.[116] Creating the map lays claim to the country: Cosgrove argues

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[115] Richardson and Gray, *The Zoology of the Voyage of the H.M.S Erebus and Terror*, 39.
[116] See for example: Akerman, James R. *The Imperial Map: Cartography and the Mastery of Empire* (Chicago and London: Chicago University Press, 2009); Cosgrove, Denis. *Mappings* (London:

that to map 'is in one way or another to take a measure of the world', that it is 'to figure the measure in such a way that it may be communicated between people, places or times'.[117] For Pratt the naming, representing and claiming inherent in map production was all one. Pratt sought to offer a corrective view to the likes of John Cawte Beaglehole who claimed that eighteenth-century voyages were 'innocent' scientific voyages, by arguing the production of a map was more than the charting of new space but the claiming of it for one's country.[118] As Geoff Quilley argues, 'cartography in this period was hardly ideologically neutral, but served the ends of the commercial maritime state: while colonisation and navigation could not have taken place without cartography and its refinements, maps and charts were not simply passive tools to implement a preconceived ideology. They were constitutive of it'. To Michael Reidy and Helen Rozwadowski, mapping the oceans' contours, 'outlining its navigable waters, and setting forth its physical laws and features', meant that science and its practitioners defined the ocean. [119] Daniel Clayton has written of the 'geographic features registered mobile through processes of abstraction – cartographic inscription and practices of naming, classification, tabulation and illustration'.[120] The map not only provided a navigational route or a claim to discovery but characterized a region's potential; the marking of a safe harbour, location of good fishing grounds or a supply of fresh water, to name but a few. Richard Sorrenson, in positing the ship as an instrument, highlighted the role of the ship's track on a map in claiming the space. In considering the meteorological record, Naylor has argued,

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Reaktion Books, 1999); Ryan, Simon. *The Cartographic Eye: how Explorer saw Australia* (Cambridge: Cambridge University Press, 1996).

[117] Cosgrove, 'Introduction: Mapping Meaning'. In *Mappings*, 1-2.

[118] Pratt, *Imperial Eyes*, 37.

[119] Cosgrove, Denis. 'Introduction: Mapping Meaning'. In Denis Cosgrove (ed), *Mappings*, 3-4; Pratt, *Imperial Eyes*, 32; Quilley, 'Introduction: Mapping the Art of Travel', 6; Reidy, Michael and Rozwadowski, Helen. 'The Spaces In Between: Science, Ocean and Empire', *Isis* 105 (2) (2014): 340.

[120] Clayton, *Islands of Truth*, 183.

‘these ships left traces on the map, bearing mute and reliable witness to the actions of the atmosphere and ocean in a way that a barometer or an officer of the watch could not necessarily be trusted to do so. The ship produced an archive of the weather in its wake’.[121]

In the mid nineteenth century, the types of maps that were being produced were slowly changing. As Reidy argues, William Whewell’s isotidal map extended science not only geographically over the world’s oceans but also intellectually with the Admiralty’.[122] By the 1850s Matthew Fontaine Maury was using interpolated data to construct maps of the deep sea and meteorological charts, revealing an ‘order that would otherwise have been concealed in tables of numbers, while retaining particular details, notably the positions and tracks of ships’.[123] Whilst Maury made advances in the graphical presentation of sounding data, the use of depth measurements on maps was common on charts prior to mid-century.[124]

The cartographic output from the three voyages has been the most well-studied of areas concerning these expeditions.[125] The maps, charts and images of coastlines were one of the most visually striking representations brought home, offering proof of new lands discovered and charted and supplying improved navigational aids to subsequent sailors. American navigators, including the American whaling fleet, were still using European maps for the majority of their long distance voyages. Burnett writes that ‘a number of surveying

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[121] Sorrenson, Richard. ‘The Ship as a Scientific Instrument in the Eighteenth Century’, *Osiris* 2nd Series (1996): 221-236; Naylor, Simon. ‘Log Books and the Law of Storms: Maritime Meteorology and the British Admiralty in the Nineteenth Century’, *Isis* 106 (2016): 797.

[122] Reidy, Michael. *Tides of History: Ocean Science and Her Majesty’s* Navy (Chicago: University of Chicago Press, 2008): 255.

[123] Naylor, Log Books and the Law of Storms, 783-4.

[124] Millar, Sarah Louise. ‘Science at Sea: Soundings and Instrumental Knowledge in British Polar Expedition Narratives, c. 1818-1848’, *Journal of Historical* Geography 42 (2013): 77-87; Höhler, Sabine. ‘Depth Records and Ocean Volumes: Ocean Profiling by Sounding Technology, 1850-1930’, *History and Technology* 18 (2) (2002): 122. For work on underwater mapping see: Lawrence, David M. *Upheaval from the Abyss: Ocean Floor Mapping and the Earth Science Revolution* (New Brunswick, New Jersey and London: Rutgers University Press, 2002).

[125] Burnett, D. Graham. ‘Hydrograhic Disciple among the Navigators: Charting an “Empire of Commerce and Science” in the Nineteenth-Century Pacific. In *The Imperial Map*, 197.

track charts from nineteenth century whaling voyages, are manuscript annotations on British Admiralty base maps'.[126] It was not only the Americans who found themselves using knowledge gained from other nations. The British hydrographer Francis Beaufort offered to send a copy of the Russian navigator, Fabian Bellinghausen's account of his time in the Antarctic to Ross, 'I will ask D- if it has been translated into French – and if so I will undoubtedly send a copy to V. D. land after you'.[127] Hooker wrote to his father that 'a little Isl[an]d to the NW of us appears to be Hope Isl[an]d of the old charts, rejected or omitted in d'Urville's chart though not far from the Point Francaise', showing the British were happy to use the information and charts of Russia and France, their rivals in the South Pacific.[128]

Maps of coastlines were produced by surveying. Wilkes, a seasoned surveyor from his work on George's Bank in 1837, paid it particular attention. The act of surveying required working from small boats, the use of precision instrumentation and forms of shipboard experimental practice, such as that of sounding. Wilkes wrote in his instructions to his officers, that 'it is expected that soundings will be full, and no part omitted, and that every part of the harbours that are surveyed will be attended to in this respect, as few things give so unsightly an appearance to a survey as an irregularity of soundings'. In recording and representing the data, great care was taken. Wilkes demanded that the results be 'plotted immediately' and kept up daily, in order that a full and accurate view of the work that had been done could be presented. [129]

This link between investigation and its immediate recording was especially important at sea, when weather could change suddenly and interrupt plans to produce more intricate

[126] Burnett, 'Hydrographic Disciple among the Navigators', 197.
[127] The National Archives, Kew (TNA), BJ2/3, 15-16. September 24 1839.
[128] JDH/1/2 f.169-175. Joseph Hooker to William Hooker, 7 March 1843.
[129] Wilkes, *Narrative of the United States Exploring Expedition*, IV: 523.

representations. Wilkes demanded that his surveyors 'make a rough diagram as you proceed, on a large scale' that would be improved upon when the small surveying boats returned to the main ship.[130] In a letter to his team he ordered that 'before quitting Grays Harbour, you will see that all the work of the survey is plotted, and a copy of it is taken on tracing paper, which must be deposited in a separate place, to prevent the loss of both'.[131] Wilkes demanded that, 'anyone who may have the diversion of such duties, should be careful that the rough charts be at once drawn from the note-books, and that these latter should be kept in so clear a manner, and in a formula so well understood, as not to require explanations'.[132] Working from a moving ship in often stormy seas, meant that strict attention to the recording and preservation of work was as important as the mapping of new coastline. Wilkes was well aware of this. In addition, more than the technology could cause valid observations and measurements to be lost. Rapid record taking of all types improved the chances of recording what was seen as faithfully as possible. As Bourquet argues, 'the rationale for travel note-taking derived from the twin dangers of an unruly observation in the field and an unreliable memory'.[133] Diligent book keeping ensured that these allied dangers were circumvented.

Despite the time Wilkes devoted to surveying and the detailed maps that were produced from this and his crew's labours, it was not always enough to convince others of the American's credibility. Wilkes sent James Clark Ross a copy of his Antarctic coastline, ostensibly to aid the British ships in their navigation of the area (see Figure 5). On his own journey through the same region, Ross found the map to be inaccurate. Referencing Wilkes, Ross recorded in his narrative:

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[130] Wilkes, *Narrative of the United States Exploring Expedition*, IV: 403.
[131] Wilkes, *Narrative of the United States Exploring Expedition*, IV: 535.
[132] Wilkes, *Hydrography*, 5.
[133] Bourguet, 'A Portable World', 14.

> I cannot refrain from observing that the practice of "laying down the land, not only where we had actually determined it to exist, but in those places also in which every appearance denoted its existence", is not only entirely new amongst navigators, but seems to me likely to occasion much confusion, and even to raise doubts in many minds whether the existence of some portions of land that undoubtedly were seen might not also be of an equally questionable character with those laid down from appearances only.[134]

Wilkes was upbraided by the experienced Ross over his decision to include as land on his chart of the ocean space in which no land had actually been seen. Navigators were well used to using the visual clues of changing water colour, sightings of animal life and changes in temperature to infer where land should be. This was considered to be good and requisite practice for the navigator and crew men alike - a form of tacit expertise. It was a mark of the experienced and knowledgeable sailor. To take the further step and commit these indications of land to paper, however - to represent these navigational practices as real and tangible earth, rock and ice - was a step too far. As Nigel Leask argues, 'aesthetic and emotional responses to natural phenomena counted as data about these phenomena in contrast to their rigorous, exclusion from contemporary practices of naval and maritime surveying'.[135] But in the commitment to paper of the everyday, embodied scientific and shipboard practices of the navigator, Wilkes' credibility as a trusted surveyor in the eyes of Ross, was lost. Whilst the Americans continued to use some of Wilkes's charts until the Second World War, Britain was, at least in print, content to ignore them altogether. In preparing his own general South Polar Chart, Ross included only discoveries by himself, d'Urville and the sealer Balleny.[136]

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[134] Ross, *A Voyage of Discovery and Research,* I: 298.
[135] Leask, Nigel. *Curiosity and the Aesthetics of Travel Writing, 1770-1840* (Oxford. Oxford University Press, 2002): 248-9.
[136] Gurney, *The Race to the White Continent*, 185.

**Tables and Graphs: transforming of numbers into images**

The inclusion of tables in the narratives and scientific volumes was a recent feature in the nineteenth century. Christian Licoppe has stressed the need to recognize two epistemologies in considering the output of scientific travel: the first founded on the circulation of first person accounts that were penned by eye-witnesses, and the second built upon ‘comparable instruments and the circulation of tables that were outputs of them’.[137] The mid nineteenth century travel narrative attempted to combine both of these in one format, with varying degrees of success. Commenting on the inclusion of meteorological tables, Bourguet has argued that ‘the quantified data listed in the weather table were meant to suppress subjectivity and conceal any manifestation of personal feelings in order to contribute to the making of a meteorological science’.[138] Ross included meteorological and magnetic tables in his narratives, mostly at the end of the volumes but at points throughout the main chapters as well, following the framework of the early nineteenth century Polar explorers (at the insistence of publisher John Murray).[139] In attempting to integrate tables of submarine measurements into the flow of his prose, however, he appears to have found it more difficult to let the tabulated data speak for itself. On sailing southeast from the Cape of Good Hope, Ross remarked upon the existence of a stream of cold water around the Cape, related to the distance from the land, consistent with a northerly current running along the western coast of Africa. When nearing the Namibian coast the temperature of the water fell, and so occasioned

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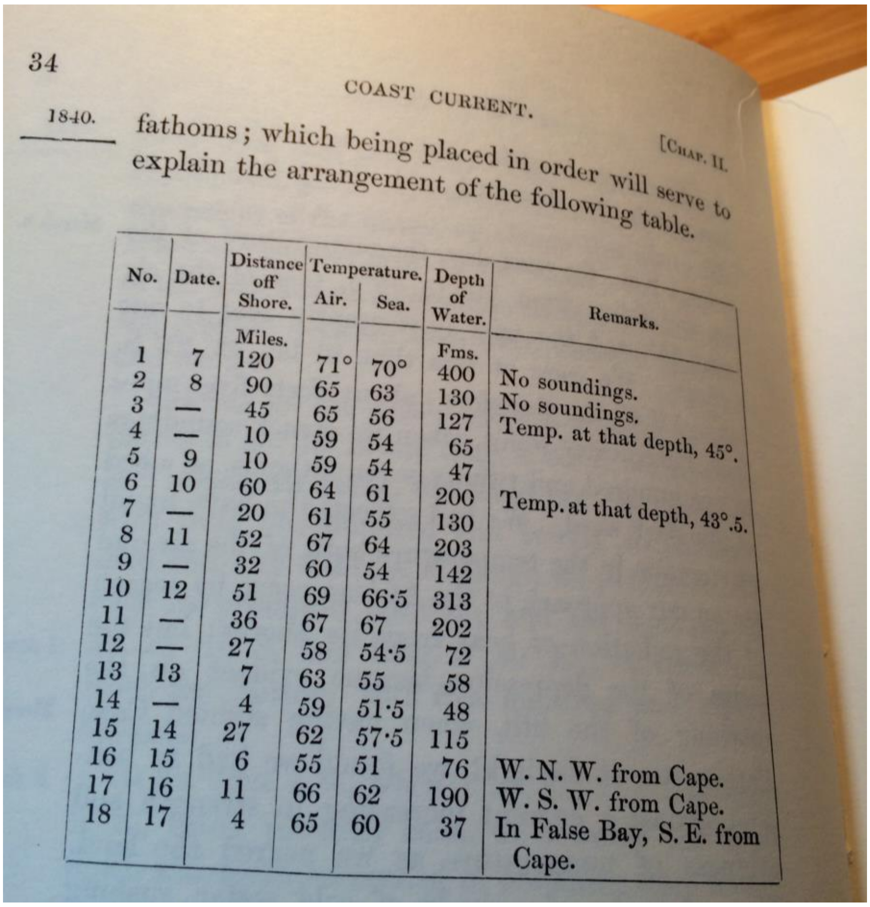
[137] Licoppe, Christian. ‘The Project for a Map of Languedoc in Eighteenth-Century France at the Contested Intersection Between Astronomy and Geography: The Problem of Coordination Between Philosophers, Instruments and Observations as a Keystone of Modernity’. In Marie Nöelle Bourguet, Christian Licoppe, and H. Otto Siburn (eds), *Instruments, Travel and Science: Itineries of Precision from the Seventeenth to the Twentieth Century*, (London: Routledge, 2002): 52.
[138] Bourguet, ‘A Portable World’, 393.
[139] For more on Murray’s influence on the travel narrative see: Keighren, Innes M., Withers, Charles W. J. and Bell, Bill. *Travels into Print: Exploration, Writing and Publishing with John Murray 1773-1859* (Chicago and London: University of Chicago Press, 2015).

a sharp difference between air and sea temperature and a coastal sea fog. Ross believed that this knowledge could be used to warn seamen in the future that they were nearing land in this part of the world. He included a table of the temperatures of air and sea to demonstrate his findings (Figure 18).



34 COAST CURRENT. [CHAP. II.

1840. fathoms; which being placed in order will serve to explain the arrangement of the following table.

| No. | Date. | Distance off Shore. | Temperature. | | Depth of Water. | Remarks. |
|---|---|---|---|---|---|---|
| | | | Air. | Sea. | | |
| | | Miles. | | | Fms. | |
| 1 | 7 | 120 | 71° | 70° | 400 | |
| 2 | 8 | 90 | 65 | 63 | 130 | No soundings. |
| 3 | — | 45 | 65 | 56 | 127 | No soundings. |
| 4 | — | 10 | 59 | 54 | 65 | Temp. at that depth, 45°. |
| 5 | 9 | 10 | 59 | 54 | 47 | |
| 6 | 10 | 60 | 64 | 61 | 200 | Temp. at that depth, 43°.5. |
| 7 | — | 20 | 61 | 55 | 130 | |
| 8 | 11 | 52 | 67 | 64 | 203 | |
| 9 | — | 32 | 60 | 54 | 142 | |
| 10 | 12 | 51 | 69 | 66·5 | 313 | |
| 11 | — | 36 | 67 | 67 | 202 | |
| 12 | — | 27 | 58 | 54·5 | 72 | |
| 13 | 13 | 7 | 63 | 55 | 58 | |
| 14 | — | 4 | 59 | 51·5 | 48 | |
| 15 | 14 | 27 | 62 | 57·5 | 115 | |
| 16 | 15 | 6 | 55 | 51 | 76 | W. N. W. from Cape. |
| 17 | 16 | 11 | 66 | 62 | 190 | W. S. W. from Cape. |
| 18 | 17 | 4 | 65 | 60 | 37 | In False Bay, S. E. from Cape. |

Figure 18: ‘Table to show the change in temperature of air and sea with distance to land’. (From James Clark Ross- *A Voyage of Discovery and Research* [London: John Murray, 1847], I: 34).

To Ross, ‘careful examination’ of the findings of his experimentation reflected their importance more than description alone, but he then went on to *describe* the data at length, ‘at forty-five miles from the land, and at a depth of one hundred and twenty fathoms, the temperature was found to be 45°'.[140] This recording of what had already been displayed in tabular form is a commonplace feature of Ross's narrative. Later, he described taking a series of temperature measurements at depth before including a table of this data (Figure 19). This table also included data obtained from Sir Edward Belcher, who performed the same experiments at different latitude, and whom Ross met, in 1843, at the Cape of Good Hope. In describing data on the deep sea in words rather than in graphs and tables the information became transferable, and in the inclusion in a travel narrative, portable, but it failed to have that impact over the transformation into an image that the tables of meteorological data were meant to achieve.

[140] Ross, *A Voyage of Discovery and Research*, I, 34.

152° W. longitude, and of which he kindly furnished me an account, when I met him at the Cape, in April, 1843. The following table will show the comparison at these three widely different positions.

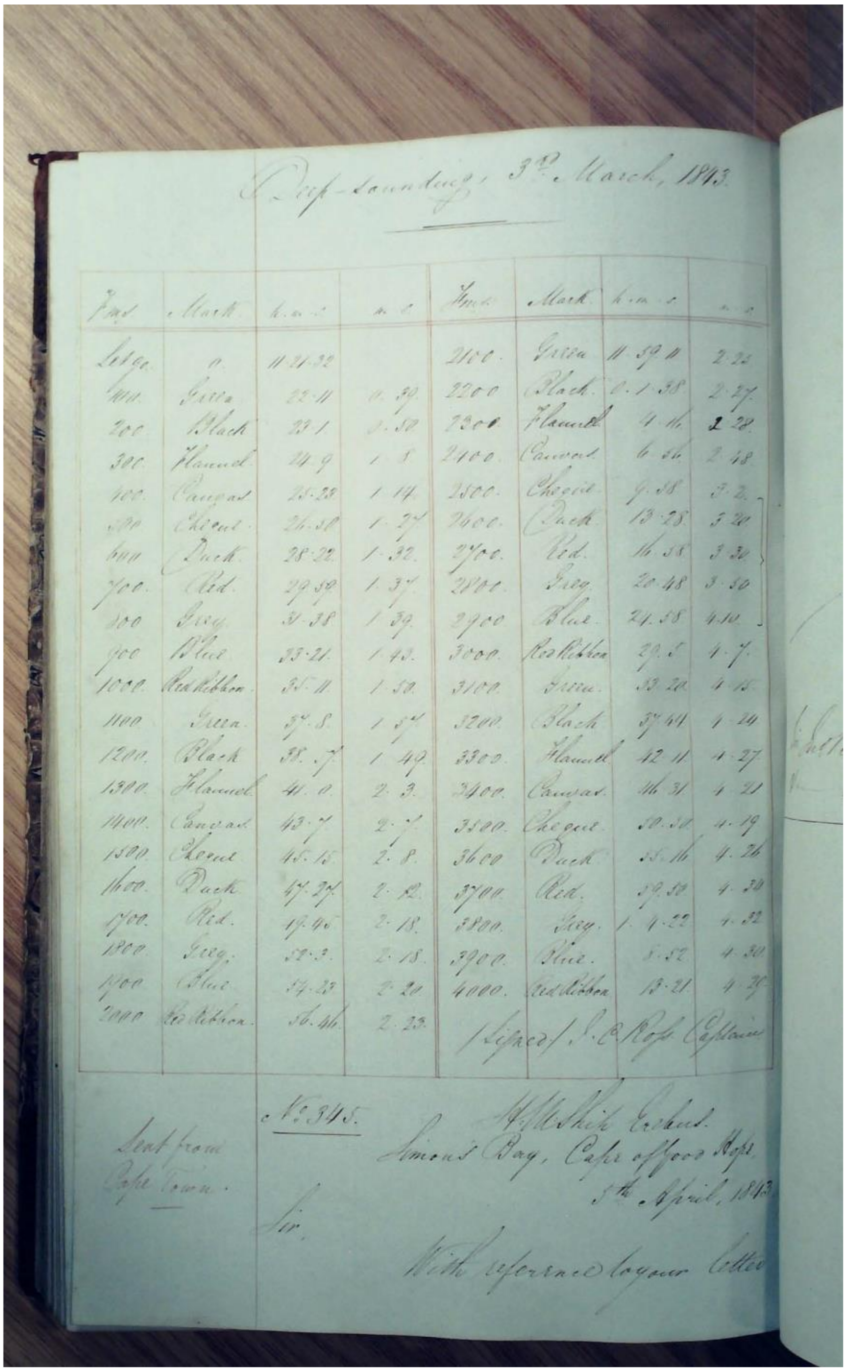
| Aug. 10th, 1841. Lat. 33° 41′ S. Long. 166° 23′ E. | Mar. 1st, 1840. Lat. 33° 23′ S. Long. 7° 41′ E. | Sir E. Belcher's Experiment. Lat. 32° 46′ N. Lon. 165° 53′ W. | Mean of all. Lat. 33° 27′ |
|---|---|---|---|
| Fath. ° ′ | ° ′ | ° ′ | ° ′ |
| 750 — 40 4 | — — — | — — — | 40 4 |
| 600 — 42 7 | 41 7 | 43 3 | 42 6 |
| 450 — 45 6 | 43 0 | 43 2 | 43 9 |
| 300 — 49 5 | 47 4 | 48 1 | 48 3 |
| 150 — 53 6 | 53 2 | 52 7 | 53 2 |
| 100 — 56 7 | 56 0 | 55 7 | 55 8 |

We were at the time of these experiments about two hundred and seventy miles from the islands called the Three Kings, off the north end of New Aug. 10.

E 3

Figure 19: Table to show change in temperature at depth. Comparison with work undertaken at the same coordinates by Edward Belcher. (From James Clark Ross- *A Voyage of Discovery and Research* [London: John Murray, 1847], II:53).

Whilst a not uncommon feature of the narratives, records of tables in the journals and correspondence of the British expedition are scarce (other than those of the meteorological log, which are numerous). One such example exists in a letter from Ross to Francis Beaufort (Figure 20). In keeping with his desire to explain the findings of the table in prose, however, it is accompanied by a length description of the findings. Nonetheless, the example is evidence of a systematic record taking of numerical information at sea, about the sea itself.



Deep-soundings, 3rd March, 1843.

| Fms | Mark | h. m. s | m. s | Fms | Mark | h. m. s | m. s |
|---|---|---|---|---|---|---|---|
| Let go. | 0. | 11.21.32 | | 2100. | Green | 11.59.11 | 2.25 |
| 100. | Green | 22.11 | 0.39 | 2200 | Black. | 0.1.38 | 2.27 |
| 200 | Black | 23.1 | 0.50 | 2300 | Flannel | 4.16 | 2.28 |
| 300. | Flannel | 24.9 | 1.8 | 2400. | Canvas | 6.56 | 2.48 |
| 400. | Canvas | 25.23 | 1.14 | 2500. | Cheque | 9.58 | 3.2 |
| 500 | Cheque | 26.50 | 1.27 | 2600. | Duck | 13.28 | 3.20 |
| 600 | Duck. | 28.22 | 1.32. | 2700. | Red. | 16.58 | 3.30 |
| 700. | Red. | 29.59 | 1.37 | 2800. | Grey | 20.48 | 3.50 |
| 800 | Grey | 31.38 | 1.39 | 2900 | Blue. | 24.58 | 4.10 |
| 900 | Blue | 33.21. | 1.43. | 3000. | Red Ribbon | 29.5 | 4.7. |
| 1000. | Red Ribbon. | 35.11 | 1.50. | 3100. | Green. | 33.20 | 4.15 |
| 1100 | Green. | 37.8. | 1.57 | 3200. | Black | 37.41 | 4.24 |
| 1200. | Black | 38.7 | 1.49 | 3300. | Flannel | 42.11 | 4.27 |
| 1300. | Flannel | 41.0. | 2.3. | 3400. | Canvas. | 46.31 | 4.21 |
| 1400. | Canvas | 43.7 | 2.7 | 3500. | Cheque | 50.30 | 4.19 |
| 1500. | Cheque | 45.15 | 2.8. | 3600 | Duck | 55.16 | 4.26 |
| 1600. | Duck | 47.27 | 2.12. | 3700. | Red. | 59.50 | 4.30 |
| 1700. | Red. | 49.45 | 2.18. | 3800. | Grey. | 1.4.22 | 4.32 |
| 1800. | Grey. | 52.3. | 2.18. | 3900. | Blue. | 8.52 | 4.30 |
| 1900 | Blue | 54.23 | 2.20 | 4000. | Red Ribbon | 13.21 | 4.29 |
| 2000 | Red Ribbon. | 56.46 | 2.23. | | | | |

(Signed) J. C. Ross Captain

No. 345.

Sent from Cape Town.

H.M. Ship Erebus.
Simon's Bay, Cape of Good Hope
5th April, 1843

Sir,

With reference to your letter

Figure 20. Table of soundings from a letter by James Clark Ross to Francis Beaufort describing the process of deep-sea sounding in Antarctic waters, 3 March 1843 (courtesy of the Scott Polar Research Institute, MS 1556 BJ, 344).

Tables of numerical data are conspicuous by their absence in the French narratives. In the entire ten-volume official narrative, d'Urville and his successor Clement-Adrien Vincent-

Dumoulin only include one table of numerical data (there are some inclusions of native words). Describing a sounding event in calm weather, d'Urville commented: '

> At some distance below the lead, I had suspended a canvas sail bag; I had placed in it a hermetically sealed bottle, and some pieces of various substances. The bottle was literally reduced to dust. Among the other substances, only the wood became heavier. But all the metals, gold, silver, copper, iron, pewter, zinc, the wax seal and the rubber, experienced no appreciable gain in weight, despite pressures of 156 atmospheres.[141]

Dumont d'Urville was so pleased with his experiment that he included in his narrative the following table showing the weight of various types of wood after submersion at depth (Figure 21). This lack of displayed data in the French narrative is in keeping with the often florid rhetoric of the narrative, in comparison with the more technical, formal language of Wilkes and Ross. Both of the latter were keen to highlight the scientific aspirations of their voyages. The inclusion of tables of numbers in the main body of the narrative (in Ross's case) or in appendices (in Wilkes's narrative) was, like their use of precision instrumentation, a means to show that rigorous and repetitive experimentation had been undertaken. The drawing-up of data in tabular form allowed brevity in the summation of quantitative results. The increased importance given to instruments in establishing scientific fact, however, had an effect upon the credibility of representations of scientific data without instrumental data to back it up. Dumont d'Urville was a keen practitioner of natural history, especially botany, and referred regularly to the types of experimentation undertaken on board. He did not, however, believe that the display of numbers in the main travel narrative was appropriate; perhaps it broke the flow of the narrative, was deemed uninteresting for the general reader, or merely inappropriate in a travel narrative, better suited to scientific volumes.

[141] Dumont d'Urville, *Voyage au Pole Sud*, I: 10.

| | Avant. | |
|---|---|---|
| Sapin, | 19 gr. | 30 |
| Noyer, | 11 | 82 |
| Chêne, | 14 | 30 |
| Orme, | 23 | 65 |
| Frêne, | 21 | 41 |
| Gayac, | 8 | 20 |
| Chêne vert, | 13 | 40 |
| Liège, | 2 | 01 |

* Note 10.

Figure 21: Table of change in weight of different materials at depth taken on the French expedition.. (From *Voyage au Pole Sud et dans l'Oceanie sur les Corvettes l'Astrolabe et la Zélée* [Paris: Gide, 1841]: I:10).

Ross and Wilkes recognised that the use of tables and figures was advantageous in communicating the results of scientific investigations, d'Urville relied heavily on prose to represent the landscapes witnessed. His words were carefully chosen; describing how he came to name the huge ice field encountered as they reached the Antarctic continent he explained, 'following the examples of our northern cod fishermen, I shall use the word 'banquise' to describe the edge of the compact motionless ice fields. No expression exists to present this idea and there is no point in creating a new one'.[142] He continued to depict the stark landscape of the Antarctic regions in emotive tones, commenting on the ship's position when caught in ice: 'our feelings were those a captive bird must experience'; 'the most profound silence reigns amongst the frozen plains, and life is represented by a few petrels, fluttering quietly, or whales whose dull and gloomy breath comes only to break this

[142] D'Urville, *Voyage au Pole Sud*, II, 47.

distressing monotony', and 'the appearance of the fields of ice was gloomy, though imposing.'[143]

Dumont d'Urville was a reluctant traveller in Antarctic waters. The instructions to travel south came directly from the French king and were, thus, incontestable. D'Urville himself had wanted only to explore the islands and coastlines of the South Seas. D'Urville's lack of personal interest in the Antarctic is reflected in the relative dearth of scientific information relating to the region: this comes across in his narrative as an impression that the voyage was to be endured not enjoyed. His own ill health and that of many of his crew who suffered from scurvy and dysentery also took its toll. D'Urville was aware of, and even in awe of, the sublime Antarctic, as his clear from his writing, but quantifiable scientific data is absent. His was an aesthetic not an arithmetic encounter with the Antarctic.

The use of graphs as a means of representing data first began in the 1820s but the 'graphical method', as Wise terms it, only became prominent around the mid nineteenth-century, firstly in the form of indicator diagrams which displayed the relationship between pressure and volume.[144] Laura Tiling has argued that graphs originated in connection with the use of self-registering recording apparatus, 'but there was, at least initially, very little actual analysis of the results, and that only at a very simple level'.[145] Humboldt was one of the first and most well-known scientific practitioners to use the graph, mapping not just variables such as temperature but rates of *change* of temperature; the mean temperatures rather than just the maximum.[146] To this end Humboldt made particular use of isometric lines, a product of averaging and interpolation, to reveal the actual pattern of average annual temperature across

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[143] D'Urville, *Voyage au Pole Sud*, II, 91; 50; 222.
[144] Wise, Norton. *The Values of Precision* (Princeton: Princeton University Press, 1995).
[145] Tiling, Laura. 'Early Experimental Graphs', *British Journal for the History of Science* 8 (1975): 193.
[146] Godlewsa, 'From Enlightenment Vision to Modern Science?', 236-267.

the western hemisphere. For Dettelbach, 'it was not at all obvious that temperature, magnetism, climate or vegetation could or ought to be mapped, like coastlines or rivers; that the discrete readings of instruments at particular points on the globe ought to produce lines on a page, that they draw; and yet for Humboldt it was imperative that such tangible and yet not geometrical variables do so, even if it was necessarily a human hand which moved the pencil'.[147]

As Tiling argues, 'for the experimenter a graph provides a rough and immediate check on the accuracy and suitability of the methods he is using'.[148] But despite the emergence of this form of representation, with which all of the expedition captains would have been familiar, as well as those involved in the writing of the scientific volumes on the voyages' return, there are hardly any instances of graphical form in the travel narratives or scientific volumes. The only clear instance of this is in the meteorology volume (1851) written by Wilkes (Figure 22).[149] Just why so little use is made of this most striking of visual tools is unclear. As Tiling argues 'even though graphs were not used for analysis, by the 1830s data could be displayed in graphical form without straining the understanding of the reader', continuing 'now it was becoming increasingly common to display tabulated data graphically.'[150] The graphs in the hydrography volume are beautifully compiled and show stark trends in the plotted data: but Wilkes makes virtually no mention of the graph, referring instead to the numbers in words. Commenting on the scientific information the American expedition collected, Wilkes wrote that they had 'obtained a large amount of information

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[147] Dettelbach, Michael. 'The Face of Nature: Precise Measurement, Mapping, and Sensibility in the Work of Alexander von Humboldt' *Studies in the History and Philosophy of Biology and Biomedical Science* 30 (4) (1999): 487.
[148] Tiling, 'Early Experimental Graphs', 195.
[149] Wilkes, Charles. *Meteorology*, (Philadelphia: C. Sherman, 1851).
[150] Tiling, 'Early Experimental Graphs', 201.

which will be more easily intelligible in a condensed form'.[151] He was aware, therefore, of the benefits of transforming the scientific data they had collected but used the graph as an aesthetic device more than an analytical one.

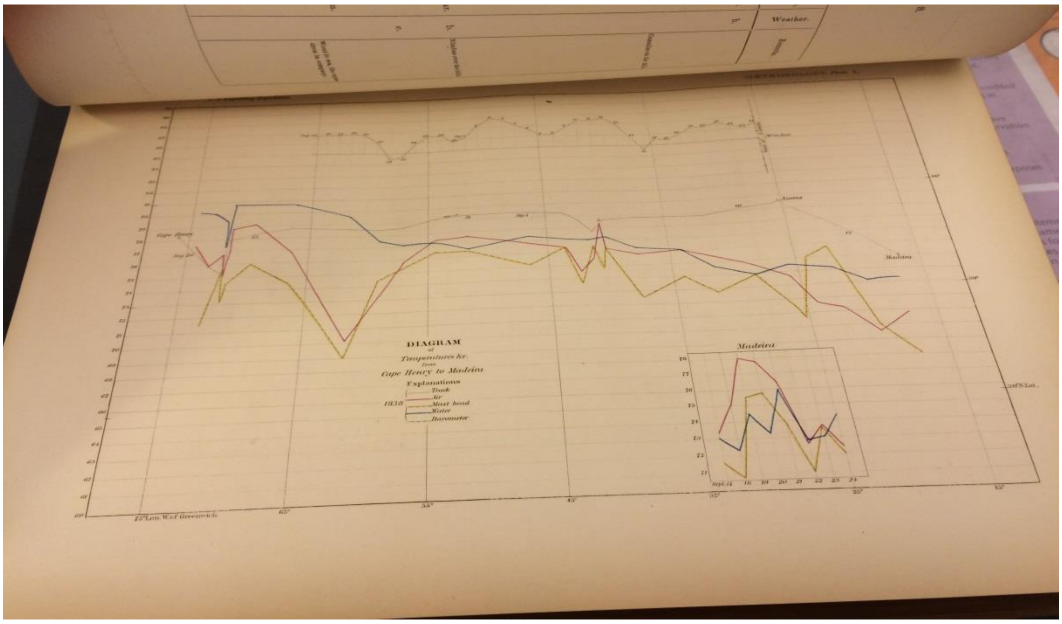


Figure 22: Diagram of Temperature from Cape Henry to Madeira. (From Charles Wilkes, *Meteorology*, [Philadelphia: C. Sherman, 1851].

### 'Eccentric inscriptions'[152]

The log-book, diary, journal and correspondence were the regular means of recording scientific information on board ship, but in these three voyages to the South Seas knowledge on the maritime world and the expeditions' endeavours were recorded in ways that depended on the material the ships' personnel had available: inscription was a real-time process.

[151] Wilkes, *Narrative of the United States Exploring Expedition*, II: 117.
[152] Craciun, Adriana. 'Oceanic Voyages, Maritime Books, and Eccentric Inscriptions', *Atlantic Studies* 10 (2013): 170.

In November 1840, the British ships laid anchor at Enderby Island (part of the Auckland Islands archipelago, New Zealand), and Ross recorded the sight of two posts in the ground which caught their attention. He recalled encountering them later:

> Two painted boards, erected upon poles in a conspicuous spot, attracted our attention, an officer was immediately sent to examine them. They proved to be records of the visits of the French expedition under D'Urville, and one of the vessels of the American exploring expedition. The first, a white board with black letters, as follows: - "Les corvettes Francoises L'Astrolabe et la Zélée, parties de Hobart town le 25 Fevrier, 1840, mouillees ici le 11 Mars, et reparties le 20 du dit pour la New Zealand. Du 19 Janvier au 1 Fevrier, 1840, decouverte de la Terre Adelie et determination du pole magnetique Austral!"
>
> The second, a black board with white letters, stated: - "U. S. brig Porpoise, 73 days out from Sydney, New Holland, on her return from an exploring cruise along the Antarctic Circle, all well; arrived the 7th and sailed again on the 10th March, for the Bay of Islands, New Zealand."[153]

Alongside this was a bottle, badly corked and damp, left by the *Porpoise*, that stated during their 'cruize' they had coasted alongside the Icy Barrier, and had landed for water. Ross continued 'we were all much surprised that no mention was made of the "Antarctic Continent" discovered by Lieutenant Wilkes'.[154] The French plaque was nailed alongside the American one on 20 March, after the American expedition had erected their plaque; the ships missed one another by one day. The order of their erection is telling; the Americans left a written record of their progress that testified to their wellbeing and safety. Whilst Ross puzzled over the fact Wilkes had not mentioned his discoveries, there had been no need to; the plaque was not meant as a symbol of their success and claims to new land, but as an 'all's well' statement that the squadron was intact. D'Urville, arriving a day later, however, took the opportunity that Wilkes had not, and laid claim, in writing, to their purported discovery of new land. D'Urville recognised that any opportunity to spread news of their claim would be

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[153] Ross, *A Voyage of Discovery and Research*, I: 133.
[154] Ross, *A Voyage of Discovery and Research*, I: 134.

to their later advantage. Although plaques posted on an inhospitable and isolated island harbour in the Southern Ocean may, to use Craciun's term, be regarded as an eccentric inscription device, they served their purpose well: Ross saw the plaques some months later and remembered to record their detail in his published narratives on his return, hinting as he did so that if Wilkes had found land at this point he would surely have mentioned it. Contemporaneous inscriptions coupled with records after the event helped cement the French claim to discovery, and, in parallel, helped erode the American's claim.

It was not just written inscriptions – outside and beyond the ship - that recorded the progress of the expedition. While resting in the Falkland Islands, the Ross expedition devised a system for measurement of the tides. Ross recounted this in his later narrative,

> the mean level of the sea was deduced from five months' observations; and two permanent makers were made 5 feet 8 inches above it, first by levelling the top of a rock a little to the southward of the pier and watering-place; and again by cutting a ledge in the face of the cliff close by it. Two copper plates were fixed in the rocks, marked thus: "5 feet 8 inches above the mean level of the ocean, August, 1842., H.B.M. Ships *Erebus* and *Terror*;" by which any difference that may occur in the level of the sea in those parts may readily be detected.[155]

Ross's efforts are of interest because they indicate that he was thinking beyond the confines of his own expedition. He had instigated an experiment to be continued after his ship had returned to England. Ross was aware that, in some instances, scientific knowledge could only be gained through extended periods of time: elsewhere he had commented that, of temperature, continuous series of measurements over two or three years rather than single points were required in order to make valid truth claims. The inscription on the copper plates was a permanent record of work that had been carried out and by whom. It left a 'trace' of the Ross expedition behind in the Southern Ocean. That it was a record of a measurement of the

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[155] Ross *A Voyage of Discovery and Research*, II: 319.

sea, at a time when the expeditions focused on land, points to the personal interest Ross had in the marine environment.

## Conclusion

In his discussion of the French captain Lapérouse, Bruno Latour was clear about the raison d'etre of the expedition and the explorer: 'he is passing through all these places in order to take something *back* to Versailles'.[156] For Latour, the numerous ship board practices that those on board engaged with were all for the sake of one thing: they produced a tangible record of the expedition that could be taken back to each countries own 'centre of accumulation', at which point they could be assessed, analysed, and, if need be, transformed again. Representing the scientific practices of the expedition was integral to the production of knowledge on the sea; it defined shipboard practice in the mid nineteenth century. It was the final tool by which knowledge gained its epistemological authority.

Transforming the specimen or collection of measurements into a two-dimensional, mobile and easily-portable object was part of the quotidian practices on board ship, whether such acts were specifically ordered in the official instructions, recommended in handbooks to sailors, or recognised as common sense by those on board. It was a task that was worked on and improved upon at home but which began on the ship. In a period where increasing emphasis was placed on observation from the field, a new importance was placed on those images that had come straight from the expedition vessel.

Those specimens and measurements transformed into the paper record of the expedition's scientific achievements were, however, fragile. Such items – the map, chart,

[156] Latour, 'Visualisation and Cognition', 6.

sketch, illustration – were easily mislaid and often damaged. Sending work back from the expeditions during their course was a mandate of all the expeditions, aiming to ensure work was protected from the vessels' testing conditions. The visual representations made it possible for those at home to gain control of distant ocean space and thus further imperial agendas. As such, its dispatch home was a serious concern. Wilkes, for example, was specifically instructed to locate American ships of war in order to send materials home.

Handing over an expedition's precious work did not necessarily ensure its safety. An extract from a letter by American expedition botanist Charles Pickering to Asa Gray, written a year after the expedition's return showed just how returning items could be difficult: 'The Oregon & California Plates were shipped in 1841 from the Sandwich Isl. Direct from the United States. The vessel as well as I have been able to make out, touched at Valparaiso & thence proceeded on a voyage to China! Then to Europe, where she was sold! And subsequently going on a voyage to the West Indies finally dropped our plants at Havana!' [157]

In addition to providing greater security for the paper record, sending items home helped ensured new discoveries were communicated and thus claimed by each nation as quickly as possible. In a letter to Monsieur le Ministre in February 1839, D'Urville wrote, 'The zeal of the officers is sustained, and most of the work collected is already incalculably valuable. However I will be content to send you here a portion of our work on the Solomon islands, with the hope that you give it publicity through the Annales Maritimes and the Bulletin de la Societe de Geographié; because, after our expedition to the icebergs and the Antarctic continent, this piece will be the most important of the voyage'.[158]

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[157] Haskell, Daniel. *The United States Exploring Expedition, 1838-1842 and its publications 1844-1874: A Biography* (New York: New York Public Library, 1942): 6.
[158] D'Urville, *Voyage au Pole Sud*, X: 162. Some this was work was published in the *Bulletin de la Société de Géographie*. *Deuxième Série. Tome Dixième*. (Paris: Arthus Bertrand:1838): 118; 249.

It was clear that those on such voyages, captains were already making decisions concerning the fate of their findings whilst at sea. In a letter to the Minister for the Marine, d'Urville reiterated the need to publish their work, sending back maps of the South West coast of New Guinea and the South East Coast of Borneo, 'as these are two important pieces of geography, I desire to insure against every chance of misfortune and I will be glad that they are given their publicity in the Bulletin de la Societé de Geographié and in the Annales Maritimes'.[159]

Obtaining specimens allowed two processes to occur: their representation in the form of sketches, and their preservation as specimens. Each mode of 'transformation' had its associated difficulties. Preserving a fish, bird, or other creature was a skilled process. It was time consuming and in warm climates had to be completed quickly before the specimen spoiled. In all climates the specimen was at risk of shipboard intervention: the predatory cat or rough seas that sent water even into the living quarters. Much was lost in translating the collected object to a specimen. Colour and form were lost when creatures were preserved in alcohol. Drying left only the hard parts and skin and the specimen became fragile. But such destructive techniques were all that was available to the naturalist: the trust engendered by producing the actual bodies of those creatures seen was vital if claims to knowledge over creatures of the southern marine environment were to be upheld.

Few of the original ship-board sketches have survived. Nor is it always straightforward to date or place which images were made at sea and which were altered at a later date, in a similar way as the journal and diary kept on board did not always reflect the true chronology of the expedition path. As Bonehill argues, 'it is difficult to tell which may

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[159] D'Urville, *Voyage au Pole Sud*, X: 180.

have been executed on the spot and which worked up later on-board ship'.[160] There is undoubtedly a gulf between the original sketch and the printed image, but in examining the images from official narratives and scientific volumes, as well as those in sketch books and journals, we can help understand the motivations behind their execution. The depiction of landscape was vital in scientific description and provided better navigational tools in the form of the topographic record and coastal profile. This required the skill of the surveyor and the empathy of the artist. Artists - official and unofficial - sought to represent their surroundings, but did so in ways that were of necessity a reflection of the pictorial conventions of the time. The Antarctic landscape, however, provided a setting so unlike any on board had seen before that conventional techniques could, at times, be laid aside. Ross's narratives were highly unusual in devoting so much space to illustrations of ice and sea, the effects of weather on the ocean, and little description of people. McCormick's narrative contained sketch after sketch of icebergs and sea.

Once something was committed to paper, it became, if not 'immutable', then much harder to refute. As Latour argues: 'Although in principle any interpretation can be opposed to any text and image, in practice this is far from being the case ; the cost of dissenting increases with each new collection, each new labelling, each new redrawing. This is especially true if the phenomena we are asked to believe are invisible to the naked eye'. Further, 'coast lines are never seen but through the "clothed" eye of inscription devices'.[161] Wilkes recorded in his volume on hydrography that there may have been human errors, 'but it is now beyond my power to determine: such the record books give, and they must stand'.[162]

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[160] Bonehill, 'New Scenes Drawn by the Pencil of Truth', 19.
[161] Latour, 'Visualisation and Cognition', 17.
[162] Charles Wilkes, *Hydrography* (Philadelphia: Lea and Blanchard, 1845): 21.

The most highly contested output of the expeditions were the maps and chart of Antarctic coastlines: each was claimed independently by each of the three countries. The books of tables of numbers, the visually pleasing but analytically vacuous graphs and sketches of new marine life, were less controversial. The time-consuming act of surveying was undertaken for the sole reason of producing better charts, aiding navigation, safe passage and highlighting sites of commercial significance. Representation could be more personal: sketching passed the time and distanced boredom, transporting the would-be artist from the literal drawing room of the ship to the imagined comforts of the drawing room at home, as well as allowing the honing of techniques that were, later, directed away from the ocean to botanical or terrestrial environments.

Coastlines, sea scenes and landscapes were familiar products of the expeditionary voyage. Their production brought distant scenes to domestic audiences, making the far away close for those who would never travel. Strict sets of practices, techniques and instrumental procedures helped ensure images and records were credible. The same is true of the depiction of specimens brought out of the sea. Those on board were aware that they needed to sketch everything from life as soon as it was brought on board. Weather could defeat the sought-for image: hot sun, cold winds and a drying atmosphere (not to mention the ship's cat) could combine to damage the objects of interest.

What is also the case, however, is that what was sketched, dried, pictured and stored was already a transformation from that which existed under the waves. Fish brought up from the deep sea were often already altered: those with swim bladders often burst due to the change of pressure, as did their soft parts and delicate structures such as the eyes and internal organs. Colours were different in bright sunlight than they were in the darkness of deep water. Specimens were already translated, already part of a cascade of representations. Tangible differences in structure and colour were not the only difficulty with representing samples. Remotely sensing the deep sea was a substitute for actually seeing it, but only a weak one. A few years after the end of these expeditions, the American hydrographer Matthew Fontaine Maury commented that, ‘Man can never see. He can only touch the bottom of the deep sea, and then only with the plummet. Whatever it brings up thence is to the philosopher a matter of powerful interest’.[163] The deep sea – effectively, the sea beyond a few fathoms – had not been directly witnessed. No one had seen with their own eyes, or even through a device, what ‘the space’ below the waves was like, let alone what the marine plants and animals looked like in their own habitat. The best that could be provided was a sample, something to be witnessed virtually. Unlike planetary science, which could be seen through the instrumental means of a telescope, maritime scientific investigation had no tools to enable the ship’s naturalist or officer to observe the contents of the oceans. The deep sea was unknown and unknowable: everything that came from it was a transformation.

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[163] Maury, M. F. *Explanations and Sailing Directions to Accompany the Wind and Current Charts*, (Washington, William A. Harris, 1858): 179.

# Chapter 7 Conclusions

> I feel after proceeding a few steps, far more inclined to return & turn in than go on. With regard to the Marine Zoophytes &c not one have[sic] been sent home, there cannot be less than 300 bottles & phials full of these things on board all bladdered down by myself, & chiefly collected too, none of the drawings are sent home & the notes I fear are very poor, which is another reason for my wishing to go South again to complete the subject.[1]

## Introduction

When the British expedition prepared to go south into the Antarctic Ocean for the third time in 1842, it marked the last such excursion by sail into the region. Joseph Dalton Hooker, chief naturalist and assistant-surgeon, was not alone in expressing his fatigue at the expected event: the expedition had already been away from home for three years. The French expedition returned to port in 1841, after a total of four years at sea. The Americans arrived home in June 1842 after a four year circumnavigation of the globe. The programme of scientific endeavour was extensive on all three expeditions. In the history of marine science, looked at with the advantage of hindsight, these voyages mark something of a watershed: a continuation and elaboration of the work directed at the ocean undertaken on the Pacific expeditions of the late eighteenth-century and the polar voyages of the 1820s and 1830s, but not yet, the scientific work that would be associated with Maury in the 1850s and HMS *Challenger* in the 1870s. In these voyages, attention was being directed at the ocean itself: it was seen to be an arena worth scientific investigation not merely a transport medium from one colony to another. Marine experiment and investigation on these voyages between 1837 and 1843 did not assume the importance of HMS *Challenger* 1872. Nor was this collective

[1] Joseph Hooker Correspondence Project. Archives of the Royal Botanic Gardens, Kew. Antarctic Correspondence. JDH/1/2 f.142-143. Joseph Hooker to Mary Boott, 28 November 1842.

endeavour a systematic programme of study that set out to further knowledge in the manner of the British quest for knowledge on terrestrial magnetism. What study of these three expeditions shows, however, is that that there was a consistent and sustained interest in the marine environment at this time by governments, scientific institutions and individuals, that was manifest in focus on the oceans. Study of the ocean was a constant negotiation with the running of the ship, a matter of order between personnel, and of managing fallible instruments and working in testing climatic conditions. But science was for each, an end in view. Thousands of miles of coastline were charted, a new continent discovered and laid down on the page for the first time, the greatest depth soundings yet taken achieved, hundreds of new species of plant and animal collected, and new knowledge on the oceans currents, temperature and composition produced.

The three expeditions studied here mark the end of large-scale exploring expeditions into the southern oceans. In many ways there were very different, specific national agendas and imperial imperatives dictating what facets of the marine environment would be investigated, how and by whom. These differences are evidenced in much of the work that was undertaken on board ship and importantly, by whom it was undertaken. But this thesis has shown what was *similar* between the three voyages, and what marks them out as being particularly important in the increasing specialisation of a ‘proto-oceanographic science’ that would take fuller shape at the end of the nineteenth-century. In discussion of this formation of discipline it is tempting to use terms such as ‘development’ and ‘advancement in knowledge’. It is important to keep in mind, however, the tenet of the ‘symmetry postulate’: analysis of the production of knowledge should be treated in the same way regardless of whether the resultant claims to truth were accepted or not. Focus on *practice,* rather than results, is one way this can be achieved. It can be seen through the work here that there were many instances of shipboard procedure that did not result in the production of knowledge widely accepted as ‘correct’ or ‘true’ today (the absence of life in deep water is one such example of knowledge later disproved when animals were brought up from great depths). I would argue, however, that in the development of a new specialization, all work on the subject was particularly vital: it was the increase in focused investigation of the oceans and the marine environment, rather than particularly noteworthy results, that marks this phase of ocean research as significantly different to that which had come before.

There were several decisive factors, shared by each country that contributed to the production of knowledge on the ocean on these three expeditions: government-funded ‘big-science’; institutional instruction, aspirations of precision and accuracy in measurement and record of measurement. These were achieved through a variety of tested and unproven instrumentation; an arena of investigation in the southern oceans that had been unexplored and about little was known; representation of the marine as a subject in its own right; a reliance on sail and vulnerability to changing weather conditions, and a hierarchical, predominantly naval social structure on board that brought men from different social ranks and training backgrounds into close contact for extended periods. The work of this thesis has been to identify and analyse these significant factors – scientific, social, and spatial - in marine expeditionary science in the 1830s and 1840s and their contribution to an emerging field of interest in the marine environment.

**Producing knowledge on the marine environment**

That scientific instruction required its own set of guidelines immediately marks it out as being different: it was important and specialised, but it was also importantly *not* the everyday work of the standard sailing ship. There were close ties in the 1830s between political authority and the scientific institutions at this time, especially, in France, with the Académie des Sciences and naval power, and, in Britain, between the Royal Society, the BAAS, the

Admiralty and the Navy. Although often cited as 'recommendations' the scientific desiderata had a strong political alliance to the state and their criteria to be addressed often had tangible economic and political motivation: species of commercial interest were to be observed closely, and better methods for preventing damage to vessels were to be investigated at every opportunity. This thesis has suggested that there was a conflict between the two sets of instructions each country issued to their expeditions, sailing and scientific, between which accommodations were frequently sought. Many of the scientific investigations and experiments recommended were lengthy and required ship resources (including personnel) that would need to be taken from the general running of the ship. This negotiation often involved a compromise between the officers and captain, on the one hand, and the men-of-science on the other. Discontent arose when naturalists felt they could not complete their task. They were not supplied with the correct materials. They were not given enough time, or help, to complete their job. What actually occurred on the ship once it had sailed was the result of the personal views of the respective captains rather than a direct response to what had been suggested in the scientific recommendations or instructed by the naval superiors. Scientific endeavour was reliant on successfully negotiating shipboard social structure – the *formal* instructions had made this clear by stipulating captains were trusted to organize their own programmes of scientific endeavour.

Procedural detail regarding how exactly scientific investigation on the ocean was to be conducted was brief or lacking in detail in much of the scientific instruction. The French instructions for *la Bonite*, re-used for *Astrolabe* and *Zélée*, were the most comprehensive, with some detailed passages on how to measure phenomena such as the height of waves and currents, but for other investigations there was a similar dearth of information as that in the French and British instructions. The captains and officers were often referred to publications and reference works for details. Citation of important works by respected authors was a claim to credibility: familiarity with the specific works was a type of proof that experiments and classification would be carried out correctly, according to pre-existing standards. In so doing responsibility for correct procedure was transferred to the author of the technical work, rather than the author of the recommendations. Lack of operational details, however, suggests a wider disengagement with *how* investigation was to be conducted on the sea. Whether the authors trusted in ship personnel to make these decisions at sea on their own, or whether they were unsure themselves how such new procedures would be carried out in an unfamiliar environment is unclear. What remained was a lack of formal instruction regarding process that meant the ship itself was the major space where decisions on marine investigation were made.

In some instances it was not just the procedural detail that was lacking but there was likewise little or no reference to instrumentation. The dredge, sounding line and towing net were not considered 'instruments' in the same way the intricately constructed chronometer or sympiesieometer were. They were omitted from instrument lists and their modes of operation were not mentioned in the instructions. Their use at sea were skilled practices learnt tacitly, on board ship, not specialist skills taught in institutions at home. They were practices predominantly undertaken by crew members. Even when Hooker claimed to be working the tow net unaided this was hardly the case: rather he worked in combination with nameless sailors, not men of rank, to complete his task.

Consideration of the anonymous crew member throws up a vital dimension of practical research: the activities and practices of the regular crew member have been obscured by the existing written record. Indeed, in many instances, practices are obscured by their recording. Diaries, journals and letters by crew members of the expeditions in the 1830s and 1840s are much less common than their more illustrious captains, officers and naturalists. In these records the procedural details, like in the instructions for sailing, are obscured. The voice of the author - is the only one we can discern with clarity. To affirm the authority of the captain over the collector, on the return home, the specimens were very often known only as those collected by the captain of the ship – 'Sir James Ross's specimen' rather than the naturalist or crew member who undoubtedly was the one to perform the act of physical collection and preservation itself. [2] The obscuring of key individuals in the production of knowledge at sea was a form of 'funneling', complicating the recovery of shipboard practices but also providing key evidence of the importance of the credible witness and recorder of events in establishing truth claims at this time.[3] Effacement of the local aids and everyday crewman were as commonplace as that of the 'native' in narratives of terrestrial exploration.

In addition to the obscuring of complicity in practice that is a feature of the written record of the expeditions, memory was clearly fallible, acknowledged to be so in the instructions for recording measurement – hence the emphasis on immediacy in drawing up surveying results and representing what had been seen 'on the spot'. Credible knowledge had to be shown to be exactly what had been witnessed. This was a requirement of objective representation. There was a real sense of urgency apparent in the record and representation of at-sea phenomena. In the process of representation the split between regular crew member and officer of man-of-science was heightened. The crew was not expected to be able to perform the complicated and skilled tasks of sketching animal life: specific training, usually at medical college, ensured certain officers would be adept at this. Preservation of specimens through taxidermy, drying and pickling were equally skilled tasks requiring specialist materials that even the naturalists, such as Hooker and Peale, found difficult. Officers trained

[2] Richardson, John and Gray, John. *The Zoology of the Voyage of the H.M.S Erebus and Terror, under the Command of Cpt Sir James Clark Ross, during the years 1839 to 1843* (1844): 38.
[3] Sponsel, Alistair, 'An Amphibious Being: How Maritime Surveying Reshaped Darwin's Approach to Natural History', *Isis* 107 (2) (2016): 260.

in the mathematical and physical sciences were required to present surveying methods as charts and maps. The ability and opportunity to represent what had been seen visually was a right almost exclusively reserved for those with training.

Collecting specimens, unlike their representation, was a task that in some respects transcended social order on board ship. It spanned the full range of practices: the act itself, the measurement of the obtained specimen and its representation, either on board ship or at home. These acts were pursued on deck via shooting, dredging and fishing – and continued below deck through the sketching, painting, mounting and stuffing of specimens. All recommendations refer to particular lacunae in institutional collections. Collection of tangible objects was still seen as an important way to establish trust in knowledge gained at a distance by the scientist and scientific institutions of the time. Instructions, however, also warned against focusing on 'rarities', instead recommending home collections would be enhanced by specimens that best represented the actual, specific, environmental make-up. None of the records I have analysed respond directly to any of the specific desiderata of specimens in the scientific instructions. Nor was there any direct acknowledgement by any individual that a typical, representative sample of the ocean environment had been taken. What was most often recorded was the exact thing that was counselled against: the rarity, the special item, the missing piece in an otherwise complete assemblage. Collection was one of the only undertakings recorded throughout the correspondence and diaries of crew members, officers and naturalists. It was a task that *could* be accomplished regardless of social position on the ship: in reality captains and officers kept a close eye on exactly how much time was devoted to the task and, in keeping with the institutional instructions, demanded everything for the governmental collections at home. In collection the conflict between formal instruction and shipboard practice was particularly highlighted, as was the tense relationship between the captain, officers and crew.

The expedition vessel was a complex assemblage of materials and people. The ship itself determined the scientific practices that could be performed on and below its decks. Where instruments were stored on the vessel reflected their importance: they were given the driest spaces, protected from the elements to ensure their good working order. They often took pride of place in the captain and high-ranking officers' cabins, which the officers themselves were sharing. Space was cramped, and resources for processing materials in short supply. Spaces on and below deck were spaces of constant and often fraught interactions between personnel. The prohibition on the use of space below deck for scientific purposes acted to discipline space and operatives alike, highlighting the strict hierarchical order of the ship as marine laboratory. The deck provided a platform for experimentation on the ocean, the space where information was gathered and shared, but also where the lives of specimen were ended. Death was a pervasive occurrence on board ship, and at times divisive circumstance given the reaction it elicited from different ship members even as it had useful ends: a specimen caught and killed was as likely, after study, to end up on the dinner table of captain and crew alike, as in the specimen bottle.

Ensuring safe passage of the ship was the paramount demand of the ships' captains. Scientific endeavour was frequently subordinated to the needs of the ship. But marine investigation could provide a means of ensuring safer travel and these experiments on the oceans were given a heightened importance, which in turn increased the frequency of their undertaking. Experiments on currents, both with a current meter and the more traditional technique of throwing bottles overboard, resulted in information on quicker and safer routes across the oceans. Taking the temperature indicated if land was near, both coastline and the mid-ocean 'viagas' that the American expedition had been specifically charged with uncovering. Water temperatures fell considerably in the vicinity of icebergs. The presence of animal life provided a strong visual clue that land was approaching: many species of birds were only seen near land, thus a good understanding of ornithology became an aid to safer travel. In the Antarctic, seals and penguins were an obvious clue that land was near. Changes in the colour of the water near coastlines were recorded in sketches and illustrations: carefully-depicted coastal profiles with attention to light and colour were a navigational aid to those on board. By supplementing and enhancing shipboard procedures for ensuring safety of the vessel, marine investigations were seen to be important. Advances in technology, such as Six's deep-sea thermometer, meant that new experiments on the oceans could be undertaken, yielding results that could aid safe passage. The results were tabulated, a new addition to travel narratives, presenting the information in an accessible form. As those on board began to see the benefits in investigation of the ocean to the more general running of ships, this became a more regular part of maritime practice.

For the sailing ship, negotiation of the weather was imperative. The South Seas expeditions of the 1830s and 1840s were the last of that scale to travel solely under the power of sail. This had important consequences for marine investigation: work was often conducted when the ships were at rest, in calm weather that made forward travel difficult. Time did not have to be put aside specifically for measuring the depth of the deep ocean or dredging shallower water for animal life (although this did also happen), in the way it would on ships powered by steam. A lull in the wind meant that voyage time would be lost, but this was compensated for by performing investigation at sea. The routine of experiment kept the crew busy and helped ward off boredom. The sailing instructions had specified this: restlessness at sea had been shown to be detrimental to expeditions and was to be countered by routine – be it scientific or maintaining the good order of the ship - investigation. Just as underwater experiments performed when the ship was hove-to provided a means of occupying the crew, so the representation of specimens provided similar occupation for the officers and naturalist on board. Specimens were prepared and preserved in moments of calm weather. Hooker spent many hours sketching the crustacean and marine invertebrates as a way both to occupy his time and to perfect his technique for when an opportunity arose to concentrate on his preferred subject of botany.

Speed in execution of representation, experiment and scientific investigation was an important skill. Animals brought up from the deep sea had to be processed immediately: sketched, described and preserved - before the atmospheric conditions altered their appearance. Interventions on board could rob the naturalist of a specimen before the full process of identification and classification had taken place: the ship's cat, the pervasive damp, the scorching sun or the disgruntled captain who forbid specimens to be taken below deck. The changing weather meant that a sounding or temperature measurement could be disrupted if the wind became stronger mid-experiment, and investigations were apt to take hours. In such conditions expensive instruments were damaged or lost. A sense of urgency accompanied many investigations of the ocean just as it had its record and representation: practices were described in mobile and embodied terms. The towing net was 'going constantly'. Sailors were 'fatigued' by their undertaking. Marine investigation was an elaborate and complex affair; an embodied, physically demanding practice that tested all those on board.

**New Spaces**

At sea, scientific goals were emergent. In the process of sounding, information was gained on marine life at depth. Tabulating series of data showed new patterns of ocean temperature at depth and distance from land. Temperatures thought to increase at depth were actually found to do the opposite after experimentation. Repetition lent credibility to the underwater measurements. Authority for the expeditions could be gained by the ability of those who followed to repeat what had been recorded: follow in the tracks of their ships and witness the same sights; sound in deep water and achieve the same measurement; sail along coast lines obscured by fog and navigate through means of temperature and current.

One of the most prevalent methods of ensuring authority for truth claims was the possession, and frequent use of, precision instruments, coupled with the representation of numerical information produced from that use. Precision instrumentation has become a byword for credible, reliable scientific experimentation, a catch-all term that sums up the increasingly quantitative and accurate nature of scientific experimentation in the nineteenth century. In order to produce authoritative results, a continuous referral to the use of precision instruments and their collected data was required. Trust in measurement was obtained through repetition.

Precision was an overwhelmingly important consideration for the voyage captains in forming knowledge about the deep sea. To be precise gave information about the unknown space that was the deep ocean, credibility. Historians of the sea and oceanic science such as Margaret Deacon and Susan Schlee have pointed to how close some of the depth soundings taken by the British expedition were to depths that have been recorded recently using much more advanced acoustic technology – claiming for these results the accuracy they sought at the time.[4] I would argue here, however, that the implied accuracy obtained by a precise measurement of sea depth in the nineteenth century was a side-effect of the process of sounding rather than a goal. As Goodwin has argued in his description of 'multiple perceptual frameworks', depth is dealt with not as an abstract, context-free measurement, but something that is defined indexically.[5] The operators on board ship are not interested in the depth per-se;

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[4] Deacon, Margaret. *Scientists and the Sea, 1650-1900: A Study of Marine Science* (Aldershot: Ashgate 1971) and Schlee, Susan. *The Edge of an Unfamiliar World: A History of Oceanography* (New York: E. P. Dutton and Co. Inc., 1973).
[5] Goodwin, Charles. 'Seeing in Depth', *Social Studies of Science* 25 (2) (1995): 237-274.

whether the deep ocean was 4200 or 4500 fathoms was of relatively low priority for Ross and his counterparts. In the mid nineteenth century, before underwater telegraph cables were being laid, the actual depth of water was operationally unimportant; what mattered was that a set of practices were followed, using a trustworthy and credible instrument, and a precise measurement was achieved and recorded. Once these criteria were fulfilled, the resultant measurement was itself credible and, importantly*, there was no other way of verifying depth of the deep sea than through sounding*.

The measurements of depth achieved by the expedition voyages, even in the deepest ocean, were trusted because the instruments used had been tested and credible and the specific characteristics of the deep sea underwater environment had been accounted for. Instruments, such as the sounding lead, had been shown to be trustworthy and accurate in shallow water, and there was an assumption that the instrument would be equally reliable in deeper water, so long as an understanding of the underwater environment was held by those involved. The captains knew what type of result to expect from previous investigations, and when their prior expectations were confirmed, this served as proof that their experiment had been successfully carried out, and was trustworthy. That we can show today their measurements were close to the mark is to miss the point: the accuracy of the measurement was implied by all the practice and performance that went into its execution. Adherence to tested procedure made the measurement credible.

The southern oceans represented a new arena of exploration for the voyages here considered, and were an important factor in how and why investigation of the ocean took place. In this space, opportunity was taken to investigate and experiment in a way that would have been less relevant in the familiar territories at home: the Atlantic Ocean, Mediterranean or North Sea. This can be seen particularly clearly in the collection and study of fish. Fishing had a wider impact than collection for purely scientific interrogation. John Richardson, in the zoological volumes of the British expedition wrote: 'Ichthyology has hitherto been considered as so secondary an object, that few or none of our surveying officers have pursued the search for fish with proper nets, and in a suitable manner; yet in a new colony especially, a knowledge of the neighbouring fishing-boats is of the first importance, any may be turned to great account'.[6] By its very vastness, in its very 'unknownness', the Pacific Ocean provided a space to think differently, without the ideals of home impinging on practice. Ichthyology was important to Europe's Pacific colonies in ways it was not at home. Empire, and the pursuit of new knowledge, had provided naturalists like Hooker and Peale with a glimpse of an environment that would otherwise have remained entirely unknown to them. In a similar way shipboard artists sought to depict the Antarctic landscape in ways both indelibly tied to the pictorial conventions of the time and remarkably different – concentrating on the often bleak landscape, devoid of human and animal life, with an exacting palette of muted colours. A strict set of practices, techniques and instrumentation helped ensure the images and records were accurate, aesthetically pleasing and scientifically valuable.

Whilst this thesis did not set out to directly compare the work and findings of the three different countries, this aspect of the research is worth considering briefly in conclusion. What I have disclosed in looking at the organization of the expeditions before sailing, in their crewing, choice of ships, records of instrumentation and scholarly works, is the struggle of countries undertaking full-scale, government-sponsored expeditions of exploration. Many of the choices made and experienced by the American fleet were decisions that had been trialled by the European countries decades earlier. In many ways America reflected a model of exploration more common in late eighteenth-century Europe, although,

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[6] Richardson and Gray, *The Zoology of the Voyage of the H.M.S Erebus and Terror*, 45.

in scale, the American expedition outweighed even the grandest of eighteenth-century European maritime voyages.

I suggest two reasons for this. First, America was a country just ‘finding its feet’ on the world stage as a scientific nation: she was still reliant on her European maritime rivals for information and most of her technology. Wilkes experienced difficulty in collecting the necessary instruments and unwillingness by British and French parties to share knowledge of the southern oceans, reflected in direct instructions the expeditions received before sailing prohibiting the sharing of information during the expeditions and the surrender of all record on their return. Secondly, there were persons and institutions in America who wished to prove their worth on the world-stage (although not all – Maholn Dickerson was adamant the Americans replicate the French expedition structure). This was to be achieved by endorsement of the grandest voyage possible, replete with all new precision instrumentation, maps and charts. Where America had previous experience, for instance in the detailed surveying work Wilkes had performed on George’s Bank, they excelled, producing over 100 charts of the Pacific coastlines that were still in use a hundred years later. But in the organization of the expedition, attention to many details was lost: the ships were unsuitable and there were too many of them. The civilian contingent disliked being overseen by the low-ranked Wilkes. Many persons on board were sceptical of his authority that rested predominately upon his scientific achievements rather than his naval capacity. For France and Britain, previous expeditions were akin to instructions manuals only they were privileged to see.

**Further work**

This thesis has not attempted to examine the dissemination of scientific knowledge on the expeditions’ return, nor to study how the published narratives, scientific volumes, and separate entities were read and gained credibility at that point. This could be a fruitful topic for future study. The three expeditions all returned with vast arrays of data, only some of which had been scrutinized and transformed at sea. As Lynch has argued, 'the 'observation is not complete until the participants get back to their offices, analyse the series of runs documented by a chart recording and gain the support of relevant colleagues'. Similarly, Livingstone and Withers argue that expeditionary science could not be regarded as complete or agreed upon until its claims had been debated, its findings published and reviewed and its leaders feted, or otherwise, in public.[7] Gaining the support of your peers was not straightforward or a forgone conclusion, as has been shown here of Wilkes's map of the Antarctic coastline.

There was certainly enthusiasm from many of those on board to deal with the materials personally on their eventual return, and a recognition that work completed at sea could be 'improved' upon in the relative comfort and safety of the home institution. D'Urville wrote in his narrative that, 'I occupied myself immediately with the drafting of the materials collected during the course of the campaign'.[8] In his final narrative Wilkes wrote that, 'all calculations on which the rate and direction of the current was founded, [are] made anew since the return of the expedition'.[9] Work undertaken at sea was re-assessed and represented afresh, in different terrestrial, and stationary, surroundings. That these processes of 'working-up', re-presenting and disseminating have tended to obscure the original

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[7] Michael Lynch, 'Representation is Overrated: Some Critical Remarks about the Use of the Concept of Representation in Science Studies' *Configurations* 2.1 (1994): 137; Livingstone, David N and Withers, Charles W. J., 'Thinking Geographically about Nineteenth-Century Science'. In David Livingstone and Charles W. J. Withers (eds), *Geographies of Nineteenth-Century Science* (Chicago and London: Chicago University Press, 2011). See also: Dritsas, Lawrence. 'From Lake Nyassa to Philadelphia: a Geography of the Zambezi Expedition, 1858-64', *The British Journal for the History of Science* 38 (1) (2005):35-52.
[8] D´Urville, *Voyage au Pole Sud,* X:29.
[9] Wilkes, *Narrative of the Unites States Exploring Expedition*, V: 458.

processes of production is clear. The Latourian 'immutable mobile' that works to take the place of the original situation also obscures the steps in the chain of transformation. Yet the requirement of circulating reference is that these processes can be re-traced and are replicable: therein lies the authority of the two-dimensional transformation. Many of the representations of measurement and natural history from the expedition vessel in the 1830s and 1840s mirrored formal instructions by neglecting to detail how, exactly, the results were achieved. Re-tracing the chain of transformation still required substantial tacit knowledge, gained by participation in a strong social network. Personal authority was slowly being superseded by authority of instruments and numbers, but, in the 1830s and 1840s, producing knowledge on the ocean has been shown to have been a complex affair involving sets of processes and the negotiation of on-board space to produce results, the significance of which, revealed at sea, would be made further sense of by others on land.

# Appendix I History of Pacific exploration and other notable maritime expeditions up until c.1835

European interest in the South Seas became more pronounced from the 1760s, and it was predominantly focused on astronomical and cartographic investigation. Captain James Cook's first voyage to the South Pacific set sail in 1768. It had been sponsored by the Royal Society to observe the Transit of Venus from Tahiti. Although the original aim of the expedition was not one of discovery, the expedition achieved many such feats: the position of several Polynesian Island groups was located; the coast of New Zealand was charted; the eastern littoral of Australia was established; and the expedition was able to confirm the existence of the Torres Strait. The expedition was unusual in that it carried a large complement of civilian scientists: the botanist Joseph Banks; the astronomer Charles Green; two pupils of Linnaeus – Daniel Solander and Herman Sporing – and the artists Sydney Parkinson and Alexander Buchan, the former to draw natural history and plants and the latter to record landscapes and people. Banks covered the cost of his scientific party himself, so keen was he to partake in the voyage. As well as the scientific mandate of the expedition, Cook had his own secret instructions: after observing the Transit, he was to search for land that sealers had thought they had seen some years earlier. On reaching Tahiti, particular attention was paid to the cultivated plants grown there: breadfruit, bananas, yam and sweet potatoes. Cook's expedition was much lauded and the work of Banks in particular was well received at home. This public and professional success ensured a second expedition, four years later, in 1772, again captained by Cook. This expedition was notable for the refutation of the theory of a great southern continent, and that the boats sailed closer to the South Pole than any vessel before.

Cook's third and final voyage left England in 1776, with a different mandate than his previous voyages: this time he was to search for a North West passage from the Pacific to the Atlantic. Neither of the boats taken, the *Resolution* or the *Discovery,* were strengthened for working in ice, as it was believed by those in charge that a passage would most certainly be found. There was no team of civilian scientists on this voyage as there had been on the previous two expeditions, probably in part due to the disagreements Cook had had with both Banks and Forster. Only an artist and an astronomer sailed, with the natural history work being conducted by interested naval surgeons. The instructions contained the usual recommendations for astronomy, ethnography and natural history but Cook saw the mission purely in terms of geographic discovery: not only would prestige be gained for finding a passage, but also £20,000 offered by Parliament. The mission ended unfavourably: no passage was found and Cook was killed in Hawaii.

The French were the rivals of Britain where maritime exploration and discovery was concerned. Since the expedition of Louis de Bougainville in 1766-1769, two expeditions had been sent by France to the South Pacific. In 1769, Jean-Francois Marie de Surville of the French Indian company sailed, and in 1771 Maride de Fresne, discovered the Marion and Crozet Islands, touching Tasmania and anchoring in New Zealand (where Fresne was subsequently killed).

The voyage of Jean-Francois de Galaup, Comte de Lapérouse, in 1785, took place five years after Cook's third journey to the Pacific, and with the strong support of King Louis XVI. Lapérouse's orders directed him to concentrate on the unknown areas of the north and west Pacific that had been overlooked during the voyages of Cook. Scientific exploration was now a part of national rivalry and the expedition was notable for the range and depth of scientific research and the detailed surveys that were conducted. The Lapérouse expedition carried fifteen civilian scientists: artists, astronomers, civil engineers, surveyors, botanists, an ornithologist and a clockmaker. Lapérouse received his scientific orders from the Académie des Sciences. These ran to 200 pages, and made provision for astronomy, physics, chemistry, mineralogy, astronomy, botany and zoology. The natural historian George-Louise Leclerc, Comte de Buffon met Lapérouse before the expedition set sail, and Andre Thouin, senior gardener at the Jardin du Roi, gave instructions on collecting and preserving plants. The head botanist on board ship was Joseph de la Martiniere. A gardener was also taken. Their mission was twofold: to collect new species and to introduce species from France. Instructions ordered them to ignore the beautiful and the exotic and focus on the useful.

Laperouse spent twenty months in the south Pacific, surveying the coast of New Holland, and the ocean's island groups. The expedition arrived at Botany Bay in 1788; the first fleet from Britain, carrying 750 convicts, had arrived just days earlier. At Botany Bay the French botanists planted seeds and collected specimens, the astronomers set up their instruments on shore, and Lapérouse sent back copies of his journal and charts to the Ministry of Marine in Paris. The expedition left Botany Bay on 10 March 1788, and was never seen again.

The Pacific was of commercial interest in the late eighteenth century for various reasons: it supplied parts, moved cargoes, introduced new social customs, offered food in the way of breadfruit, whaling, and offered new voyage routes. Before Cook's landing on the Australian continent, the British suffered from a lack of bases to repair their ships in the South Seas, especially their whaling boats and trade vessels. At this point Spain controlled much of the seas in the region and seemed more willing to aid American vessels than their British enemies. The Spanish circumnavigation of the globe led by Captain Alessandro Malaspina has long been the forgotten voyage of discovery into the Pacific in the late eighteenth century. The expedition set sail from Cadiz in July 1789, replicating the scientific and philosophical interest of the European Enlightenment held by Carlos III and with a determination to investigate the political and economic state of Spain's sprawling overseas empire. It was not a voyage of discovery in the traditional sense, as Malaspina felt the last great unknown parts of the world had been discovered by Cook – for him there was only filling in to be done, and comprehensive surveying of difficult coastlines. The ships were specifically built for the voyage and carried the latest navigational and hydrographic instruments. The scientific part of the voyage was to follow the model of Cook and Lapérouse and the naturalists were to collect specimens for the Real Jardin Botanico in Madrid.

The expedition's first major stops and work were along the coast of South America. Here, Malaspina conducted running surveys along the coast from the sea, triangulation surveys on land, rated the chronometers and set up portable observatories. Later, a specifically designed pendulum arrived from Europe for observations on gravity to take place. The naturalists were given time to collect specimens, and the artists sketched peoples and places as they went along. The artists, Pineda, Nee and Haerk made the expedition the best recorded in visual terms of any in the eighteenth century.

British attention had been diverted from the South Seas in 1775 by the American war of Independence, which stopped the transport of approximately 1,000 British convicts a year, mostly to Virginia and Maryland to work on the plantations. Upon America's visiting, Botany Bay was seen as a good replacement for these colonies and acted as a staging post and a base against French threats in the Indian Ocean, and Dutch interests in the East Indies. It also denied occupation to the French and offered new natural resources. The next large-scale British expedition that explored the Pacific Ocean after Cook set sail in 1791. Following the Nootka Sound convention in October 1790, an expedition was sanctioned to explore and survey the north west coast of north America and to receive restitution of the land seized by Spain at Nootka in 1789. This expedition was led by George Vancouver. The expedition sailed in April 1791, in the two ships, *Discovery* and *Chatham*. Vancouver, a veteran of Cook's third Pacific expedition, employed an advanced version of the running survey he had learned aboard the Cook voyage. This involved landing frequently to determine position by astronomical observations and measuring base lines on the beach to ensure their triangulations were correct. The charts he and his team produced from the intricate coastal surveys were detailed and accurate, and also expressive of British hegemony, inscribing 'a specifically British nomenclature on the place'.[1]

The turn of the century saw Britain and France again competing for glory in the Pacific, specifically in connection with charting, and claiming the southern coastline of the new Australian continent, then known as New Holland. The French captain, Nicolas Baudin sailed in 1800 in an expedition organised largely due to British advancement in the region. The expedition was more elaborate than that proposed at roughly the same time by the British Captain, Matthew Flinders. Flinders wanted to establish whether or not a north-south strait separated the New Holland of the Dutch discoveries from the New South Wales of Captain Cook, and he proposed a full scientific expedition to survey the entire coast of New Holland for possible harbours and rivers. On board he carried a party of scientists and artists to explore the land's natural resources, and broadly speaking operated in the same style as Cook had done, but with a more openly colonial purpose than Cook's original scientific intentions. In 1800, nervousness about French ambitions gave it the go ahead: Britain had just approved France safe passage for a scientific voyage to Australia under Baudin.

A novelty in the instructions for Baudin was the mandate to pursue anthropological investigations, presented by Joseph-Marie Degerando of the newly-founded Societe des

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[1] Rigby, N.,van der Merwe, P., and Williams, G. (eds), *Pioneers of the Pacific: Voyages of Exploration*, *1878-1810* (London: National Maritime Museum, 2005): 106.

Observateurs de l'Homme. There was also a requisite to bring back a special collection of living animals for Mme Bonaparte. The plants and animals collected during the expedition were to go to her private menagerie and garden. Francois Peron was chosen as the assistant and naturalist on the expedition and compiled the official narrative along with Louis de Freycinet on the expedition's return. The expedition had already reached Ile de France by the time Flinders set sail. Baudin decided to first chart the south coast of New Holland upon reaching it in 1802, where he met Flinders sailing west to east and having already done what they were proposing to do. Despite not being able to claim being the first to chart the south coast of Australia, Baudin's achievements in charting the coast of Victoria were substantial. They stayed five months at Port Jackson, where upon Baudin's ship the *Naturaliste* returned to France, with the natural history specimens. There were thirty-three large cases of zoological specimens and 70 tubs of live plants. When finished, the expedition sailed to Ile de France, where Baudin died a month later. Publication of the official narrative of the voyage was not approved by the Emperor until two years after the return due to the expenses of war. Finally publication took place, with the narrative written predominately by Louis de Freycinet. He disregarded Flinders's surveys and gave French names to all the places on the coast, whilst Flinders himself was imprisoned on Ile de France. Baudin's charts and accounts were also adjusted.

When Flinders' voyage ended in 1803 there was not to be a large scale voyage of discovery until war with France ended in 1815. War with Napoleonic France had ended the 'Age of Discovery' as exemplified by Cook but the end of the Napoleonic wars in 1815 had seen a revival of scientific expeditions, with the British concentrating on the North West Passage and the French on circumnavigation. By this stage Britain had a Pacific presence from Canton to the colonies of New South Wales, and from Van Diemen's Land across the Pacific to the North West coast of America. With the end of the Napoleonic wars, the Royal

Navy became an expensive burden on the state's finances. In 1815 there were 90 ships and 130,000 officers and men. Two years later there were only 13 ships and 20,000 men in the navy. In 1817 interest in the North West Passage had been re-sparked, following reports from the whaling captain William Scoresby that the Greenland Ice sheet had receded that year to a much greater extent than he had witnessed before. In May 1818, John Ross embarked on a mission to investigate such a possibility in the *Isabella*, with his second in command William Parry in the *Alexander*. James Clark Ross sailed with his Uncle. The expedition progressed through Davis's strait achieving the most northerly point of an expedition to that date of 77°N. On reaching Lancaster Sound, Ross reported sighting land, naming it Croker Mountains after the first secretary of the Admiralty and the expedition headed home.

In January 1819, Parry was given command of a second expedition into the same region. He was charged with going beyond Lancaster Sound, and once through the Behring Strait to proceed to Kamchatka.  The expedition was notable for its attention to details, taking warm clothing, canned food, lemon juice and plenty of rum. Bottles were thrown overboard each day with details of the ship's position. Ice however was encountered immediately on entering Davis Strait. Parry was able to show, however, that the Croker Mountains did not exist, but ice blocked the route west. Parry argued that there did look like a route might exist to the south, however. The ships wintered in ice, in the highest northern latitude any ship had attempted - Sabine made meteorological and magnetic observations throughout. Altogether, 850 miles of new coastline were charted, and all bar one man was brought home safely, but no passage was found. Parry made his third voyage north in 1821-23 in the *Fury*, with Lieutenant George Lyon in the *Hecla*, but with no further success.

Russia was also interested in the search for a North West Passage at this time, following on successes by Adam Ivan (Johann) van Krustenstern in 1803. The Naval Lieutenant Otto von Kotzebue was engaged to lead the expedition and a second between

1823 and 1826 on the *Predpriyatiye*. The first Russian expedition to the Antarctic was led by the Russian Fabian von Bellingshausen in the *Vostok* and the *Mirny*, sailing in July 1819. They reported seeing land, although through fog, at 67°S latitude, and were probably the first to see the Antarctic continent. As well as captaining the expedition, Bellingshausen worked as a naturalist, and was the first to observe the southern migration of whales at the beginning of the austral summer. They were also the first to capture an emperor penguin, and completed Cook's long tour by skirting the South Pole in the opposite direction.

The last full-scale exploring expedition into the Pacific Ocean before the French expedition in 1837 was also captained by Jules Dumont d'Urville, and was his second expedition into the South Seas, that set sail in 1826 and lasted three years. The expedition had two remits: publicly for science and hydrography, and more privately to find a site for a French penal colony and harbours to shelter French warships. Dumont d'Urville was charged with investigating and charting the coastlines of the Louisiade archipelago, New Guinea and New Britain. This list was subsequently added to include the North East New Zealand, the Tongan archipelago, the Fiji Islands and the Loyalty Islands. The expedition was ordered to verify reports of findings of the lost Lapérouse expedition. Five large shipments of natural history specimens were sent back to Paris during the voyage, thanks largely to the naturalist and doctor Jene Rene Constant Quoy.

# Appendix II *Dramatis Personae*

*France*

**Jules Dumont d'Urville** (1790-1842). Captain of the French expedition and l'*Astrolabe*. D'Urville was born at Condé-sur-Noireau. He joined the French navy in 1807. He sailed on numerous surveying voyages over the next fifteen years, mostly in the Mediterranean, displaying a keen interest in botany, insects and archaeology. He had been overlooked for Freycinet's Pacific expedition in 1817, but one of Freycinet's officers, Louis Isdore Duperry, realising there was unfinished work in the region, approached d'Urville about a possible new expedition. The two sailed together in 1822, returning in 1825. After two months back on French soil, d'Urville petitioned the Minister of Marine for command of his own ship. This he won, and spent three more years surveying the Pacific between 1826 and 1829. On his return he spent years before his last Pacific expedition writing the narrative of the first voyage of the *Astrolabe*. D'Urville died in a train crash with the rest of his family in 1842.

**Charles Hector Jacquinot** (1796-1879). Commander of the *Zélée*. He had impressed d'Urville as an *ensign* on the 1826-29 Pacific expedition.

**Clement Vincendon-Dumoulin** (1811-1858). Hydrographer. He drew the first map of Adélie land in 1840. Dumoulin took up the job of editing the publication of the voyage after d'Urville's death in 1842.

**Jacques-Bernard Hombron** (1798-1852). Surgeon on the Astrolabe and served as the expedition botanist.

**Pierre-Marie-Alexandre Dumoutier** (1797-1871). Naturalist and phrenologist. Dumoutier's collection of skulls from the voyage had significance for the field of physical anthropology, even when phrenology fell out of favour.

**Ernest-Auguste Goupil** (1814-1840). Artist on the *Zélée*. Trained in Paris. Already had sea-going experience when he applied for the position on the French exploring expedition, a fact that impressed d'Urville. Died from dysentery on 31 December 1841.

**Louise Le Breton** (1818-1866). Assistant surgeon and artist. Assumed the work of Goupil after his death.

*The United States of America*

**Charles Wilkes** (1798-1877). Commander. Captain of the *Vincennes*. Wilkes entered the US Navy as a midshipman in 1818. He had a strong interest in scientific work, and after completing a survey of Narragansett Bay in 1833, was appointed the first head of the new Depot of Charts and Instruments in Washington D C in 1833. In 1837 he completed a survey of Georges Bank. Wilkes was chosen to lead the exploring expedition since he was one of the few officers with a strong scientific interest but his command was unpopular.

**William L. Hudson** (1794-1862). Second in command, and in charge of the *Peacock.*

The American expedition took 83 officers and 342 enlisted men and when it finally set sail from Hampton Roads, Virginia on 18 August 1838, it carried only nine civilian men of science, reduced from an original twenty-five. Shortly before the departure of the United

States expedition, Wilkes dismissed Walter R Johnson the individual whose responsibility it would have been to study magnetism, electricity and astronomy.[2]

The civilians were:

**Horatio Hale** (1817-1896). Ethnographer and linguist.

**Charles Pickering** (1805-1878). Naturalist. Pickering, a physician, made a name for himself as a naturalist after working as librarian at the Academy of Natural Sciences in Philadelphia. Later served as its curator. He began as the ship's ichthyologist, then became the chief zoologist, being finally known as the ship's naturalist.

**Titian Ramsey Peale** (1799-1885). Naturalist. Peale, an excellent marksman, had already been on many bird collecting and other scientific expeditions between 1818 and 1832 (to Georgia, Florida and Colombia). He worked as assistant naturalist and painter on an expedition to the upper Missouri and Rocky Mountains in 1819-1820.

**Joseph P. Couthouy** (1808-1864). Conchologist. Couthouy was sent home from Honolulu in November 1840 by Wilkes for apparently disobeying orders. The two constantly disagreed on board ship over the time Couthouy was allowed for naturalising.

**James D. Dana** (1813-1895). Mineralogist. Dana had sea experience instructing midshipmen in mathematics on the U.S. Navy ship *Delaware,* as well as a Mediterranean surveying voyage. He held a position at Yale and had published widely on mineralogy. Dana's

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[2] Borthwick, Doris Esch. 'Outfitting the United States Exploring Expedition: Lieutenant Charles Wilkes' European Assignment, August-November, 1836', *Proceedings of the American Philosophical Society*, 109(3) (1965): 172.

reputation as a scientist of note led to an invitation from Jeremiah Reynolds for a position on the expedition.

**William Rich** (1800-1864) and **William D. Brackenridge** (1810-1893). Botanists. Rich was a plant collector in his spare time and raised plants for Washington's garden shows, which he organized. He was chosen by Mahlon Dickerson who thought his botanical knowledge, especially of local plants, sufficient for the expedition. When the well-known botanist Asa Gray dropped out of the expedition, Rich was promoted to chief botanists and the Scottish-born Brackenridge brought in as his assistant.

**Alfred Agate** (1812-1846) and **Joseph Drayton** (1795-1856). Artists. Agate was the portrait and botanical artist and Drayton the landscape painter.

*Britain*

**James Clark Ross** (1800-1862). Captain, HMS *Erebus*. Ross was the nephew of the polar explorer John Ross, and accompanied him on his 1818 expedition to the North Pole and on four more polar expeditions under William Parry between 1819 and 1827. In 1829 he again accompanied his uncle to the Artic, locating the position of the north magnetic pole on this voyage.

**Francis Rawden Moira Crozier** (1796-1848). Captain of HMS *Terror*. He sailed with Parry to the Arctic in 1821-23 and again in 1824 and in 1827 where he met and became friends with James Clark Ross. He had expereinece in magnetic and astronomical investigations.

**Joseph Dalton Hooker** (1817-1911). Assistant surgeon on *Erebus*. Hooker learned botany from his father. Ross promised to take Hooker if he first qualified as a surgeon. He was eventually taken as assistant surgeon and botanist, not naturalist. Hooker wrote to his father, ‘I saw at once that this would completely interfere with all my duties’.[3] If Hooker had not sailed with Ross, he would almost certainly have done so with Captain H D Troter to the Niger (where most died of fever). Hooker would go on to become Director of the Royal Botanical Gardens, Kew.

**Robert McCormick** (1800-1890). Surgeon on *Erebus*. McCormick had had experience sailing on *Hecla* on William Parry’s 1827 polar expedition and on the second voyage of the *Beagle* to South America in 1831.

**John E Davis** (1815-1877). Assistant surgeon on *Terror* and draftsman. Ross chose him to prepare the expedition charts after the artist Joseph Dayman was left to supervise the observatory in Tasmania.

[3] Huxley, Leonard. *Life and Letters of Sir Joseph Dalton Hooker: Based on materials collected and arranged by Lady Hooker* (London: John Murray Publishing, 1918): 41.

## Appendix III The instruments used for investigating the southern oceans and marine environment

*Thermometograph*

The thermometograph was used for ascertaining the temperature of the water directly above the sea bottom or obstructions under the water. This was of interest for the purpose of navigation. Humboldt and Jonathan Davy had ascertained that shoal water was colder than that of the open sea, and so recognised that this drop in temperature could be used to aid navigation and help prevent the possibility of the ship running aground.[4] Six's thermometer is a thermometograph. Ross carried six maximum-minimum thermometers. None of the thermometers carried were protected from pressure despite it being known that the pressure of water at depth compresses the thermometer forcing the mercury up so that no temperature below 39.5°F was ever recorded. This led to inaccurate theories about the ocean reaching a minimum temperature of roughly 4°C.[5]

*Self-registering thermometer*

The most ubiquitous of these instruments at this time was Six's self-registering thermometer, named after its inventor, James Six, in 1780. It consisted of a folded glass tube, with alcohol filling the central reservoir. The upper portion of the left-hand limb was separated by a mercury sector occupying the u-bend. In each outer limb light steel-in-glass indexes floated in the spirit as the temperature changed and the mercury sector was propelled up one or other of the limbs. It pushed the indexes before it, leaving them behind to mark the extremes of the

[4] *Edinburgh New Philosophical Journal* (1836).
[5] Rice, Tony. *British oceanographic Vessels 1800-1950* (Lee-on-the-Solent: Ray Society, 1999): 66.

temperature reached. It was originally designed to measure air temperatures and Six believed alterations were needed for its use at sea. As such, he constructed a version for deep-sea use, with thicker glass to resist pressure and indexes of a different type. After his death it was discovered the 'air' thermometer worked if the end of the tube was sealed to keep out seawater. The thermometer was first used on Krustenstern's voyage of 1802-1806 on the Russian vessels *Neva* and *Nadeshda.*[6]

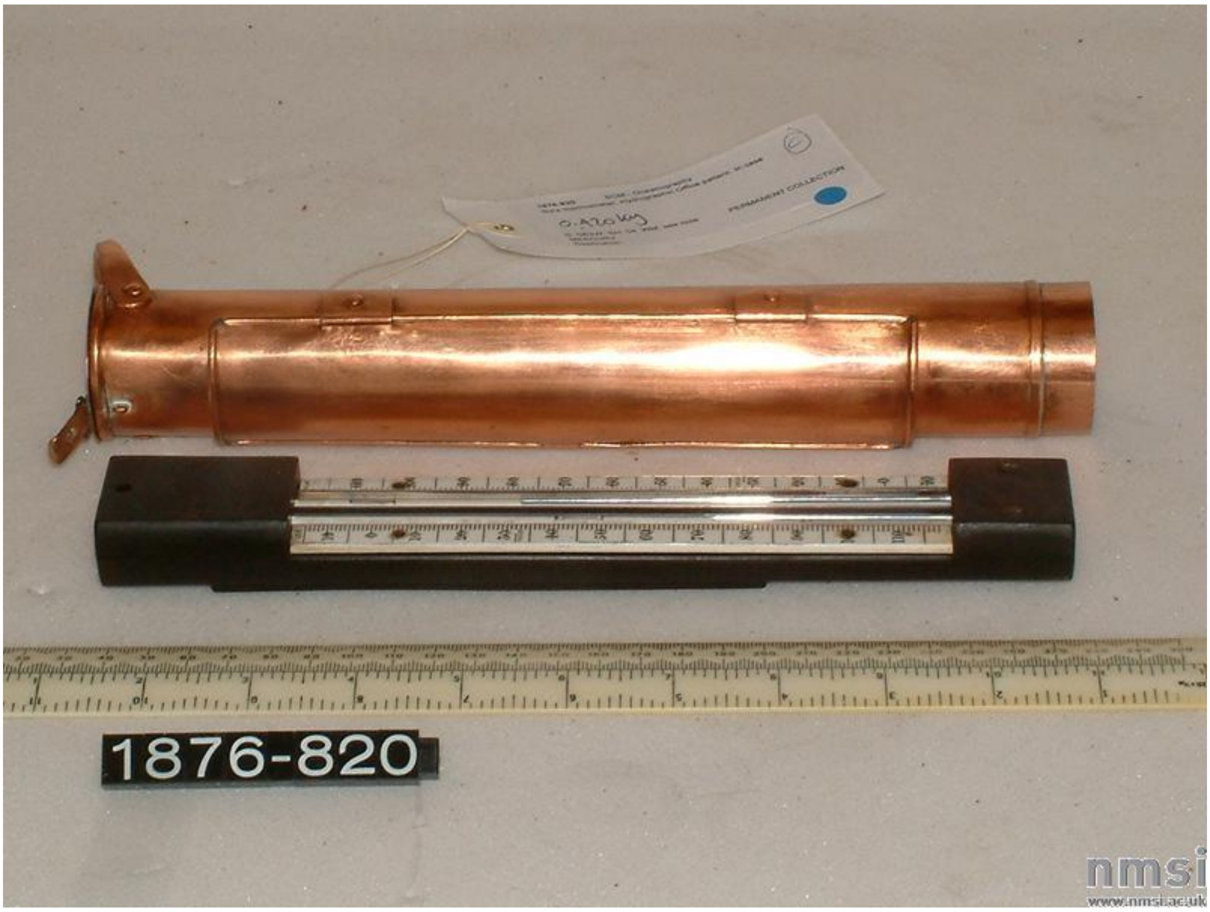


Figure 23: Six's self-registering thermometer from c.1850 (http://collectionsonline.nmsi.ac.uk/detail.php?type=related&kv=53633&t=objects) (accessed 12 December 2016).

[6] Austin, Jillian F. and McConnell, Anita. 'James Six F.R.S. Two hundred Years of the Six's Self-Registering Thermometer', *Notes and Records of the Royal Society of London*, 35 (1) (1980): 49.

*Microscopes*

Two types of microscope were taken aboard the expedition vessels: a simple type with a single lens, also called a dissecting microscope (as this was its primary purpose), and a compound microscope with two achromatic lenses. This latter had a higher magnification but there was additional work needed to prepare the specimen in order to use it successfully. Whilst the compound type could be much more expensive, the best quality single lens microscopes at this time were of a similar price to the cheapest compound microscopes.

Microscopes do not appear to have featured highly in Wilkes' list of instruments for the American expedition, For Rehn, writing in 1940 of the role of the Academy of Natural Sciences in the preparations for the voyage, 'unofficial information brought to the Academy's attention in recent years advises us that Dr. Paul B. Goddard, an active Member of the Academy and a well-known physician and photographic pioneer of Philadelphia, helped the Corps meet this deficiency by loaning his personal microscope to aid the field work of these investigators'.[7] Asa Gray pointed out to the Naval secretary before the ships sailed that Wilkes had purchased no microscopes at all on his European visit in 1836 to acquire instruments for the expedition.[8] The squadron ended up taking simple rather that compound microscopes, although these were deemed by many to be superior in construction at that time. "Wollaston doublets", then the best of microscopes, were carried alongside cheaper ones designed by F. V. Raspail.

[7] Rehn, James A. 'Connection of the Academy of Natural Sciences of Philadelphia with out First Natinal Exploring Expedition', *Proceedings of the American Philosophical Society 82* (5) (1940): 548.
[8] Eyde, Richard H. 'William Rich of the Great U. S. Exploring Expedition and how his Shortcoming Helped Botany Become a Calling', *Huntia* 6(2) (1986): 192.

Figure 24: A F.V Raspail designed microscope c.1837 (https://micro.magnet.fsu.edu/primer/museum/raspailsimple.html) (accessed 29 November 2016)

*Sounding equipment*

The most common and simple design for sounding in the early nineteenth century was the lead line, used primarily for shallow water around the coast. The job of sounding was performed by a crewman at the front of the ship, or in a small boat lowered onto the sea from the parent ship. The lead line was a piece of lead, or other weighty object, attached to a line that was cast over the side and allowed to run out through the hands of the crewman. The line usually had knots, or marks, at each quarter or half fathom to alert the sounder to how much line had gone down. When he felt the weight hit the sea floor, the line would be brought back on board, and the number of fathoms of line paid out counted. All boats at this time would carry this sounding equipment, often in tandem with a deep-sea sounding instrument, so that soundings could be taken quickly and easily in shallow water.

*The Naval Service Officers' Manual for Every Grade in His Majesty's Ships*, written by Captain W N Glascock in 1836, gave instructions to crewmen of all levels on various activities they would be required to undertake on board ship. The use of the sounding devices was included, under the heading of 'exercising the lead'. The midshipman was instructed to 'occasionally practise the art of heaving the lead, and make himself thoroughly acquainted with the several "marks and deeps" and the mariners method of holding and coiling the line'.[9] The master was advised that, 'previously to marking the log-lines, it is recommended to wet them well after they have been stretched, as to divide the knots into portions of forty-seven feet three inches to the twenty-eight second glass'.[10]

This ordinary system of sounding failed at great depths, and could not be depended upon for more than 6,000 feet. The weight was not sufficient to carry the line rapidly and vertically to the bottom, and, if a heavier weight was used, the line often broke. No impulse was felt when the lead struck the bottom, and the line continued to run out. If stopped, it was liable to break. Sometimes the line was carried along by submarine currents, forming loops or bights, and it often continued to run out and coil itself in a tangled mass directly over the lead. *Popular Science* magazine at the time claimed that these sources of error 'vitiate very

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[9] Glascock, W. N. *The Naval Service Officers' Manual for Every Grade in His Majesty's Ships*, (London: E. Stanford, 1836): 31.
[10] Glascock, *The Naval Service Officers' Manual,* 143-144.

deep soundings'.[11] To protect against some of these problems, James Clark Ross sounded from an open boat held in position against wind and surface current by a second rowing boat. A weight to pull the line off the drum freely was used. Detachable weights, wire lines rather than rope and a steam powered winch were not introduced until the 1850s.

James Clark Ross used a deep sea clamm for sounding and bringing up samples of the sea floor. This instrument was invented and constructed by John Ross on his 1818 expedition. In his own short book on the machine, John Ross wrote that it was designed to 'bring up substances of any description, in considerable quantity, from any depth; but it has also be found to preserve the temperature of these substances, if they are soft until they can be measured by the thermometer'.[12] Use of the clamms required whale lines, of two and a half inch circumference, 'very pliable and easily coiled'.[13] The weather was supposed to be calm if sending the clamms down to depths of 500 fathoms or more, but in a light breeze: 'the instrument may be hung to a boat and towed in the direction of the ship's drift'.[14]

The British expedition also recorded the use of a Massey's log: a brass rotor which trails in the water and spins around as it moves and gives readout of distance travelled in nautical miles.  Edward Massey, the British instrument maker, obtained at least six British patents on ships' logs and other nautical measuring instruments between 1802 and 1848.

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[11] *Popular Science Monthly* (3) (1873), 3.
[12] Ross, John. *A Description of the Deep Sea Clamms, Hydraphorus and Marine Artificial Horizon,* (London: Strahan and Spottiswoode, 1819): 5.
[13] Ross, *A Description of the Deep Sea Clamms,* 7.
[14] Ross, *A Description of the Deep Sea Clamms,* 8.

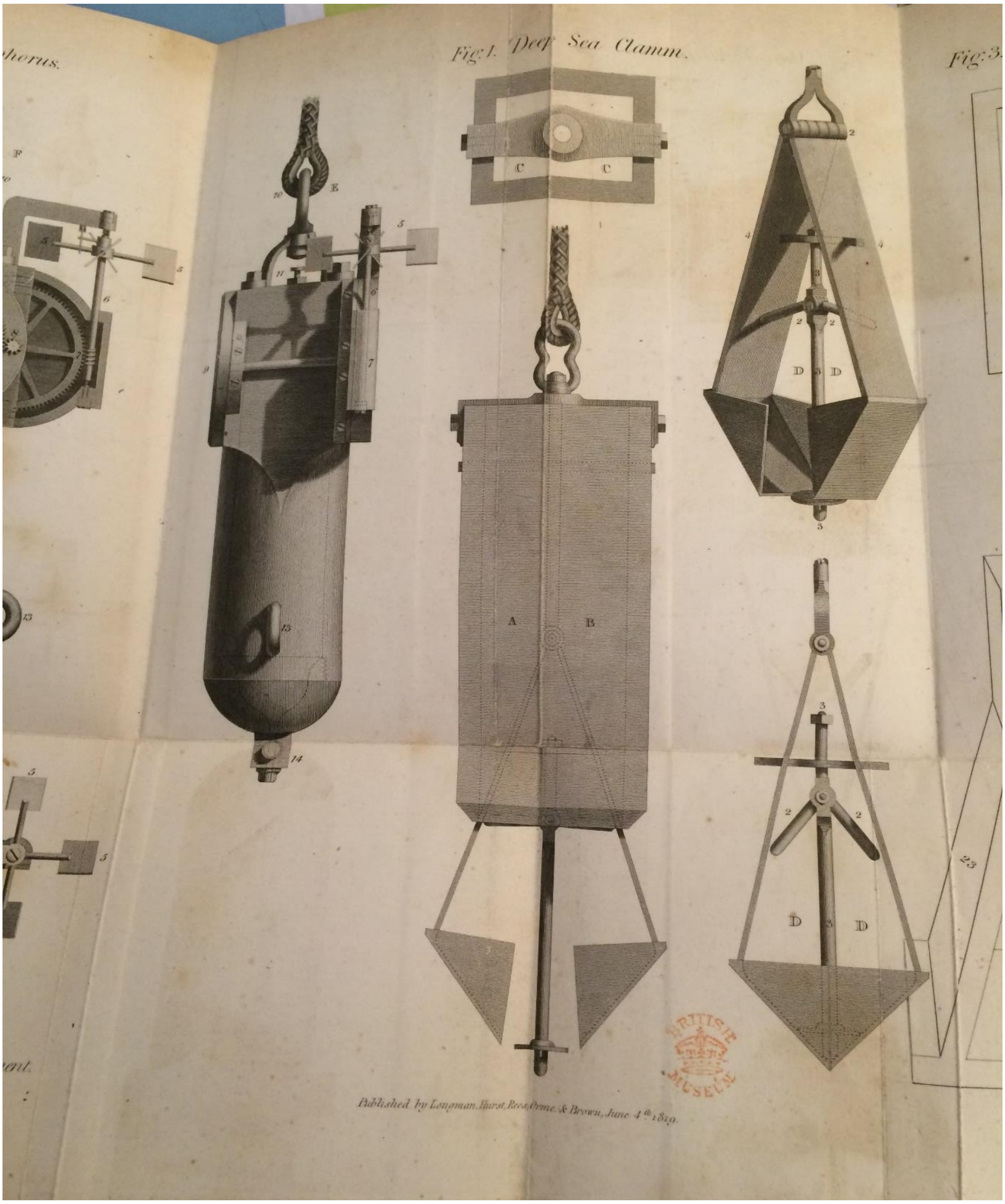


Figure 25: John Ross's 'Deep sea clamm'. (From John Ross. *A Description of the Deep Sea Clamms, Hydraphorus and Marine Artificial Horizon,* [London: Strahan and Spottiswoode, 1819].

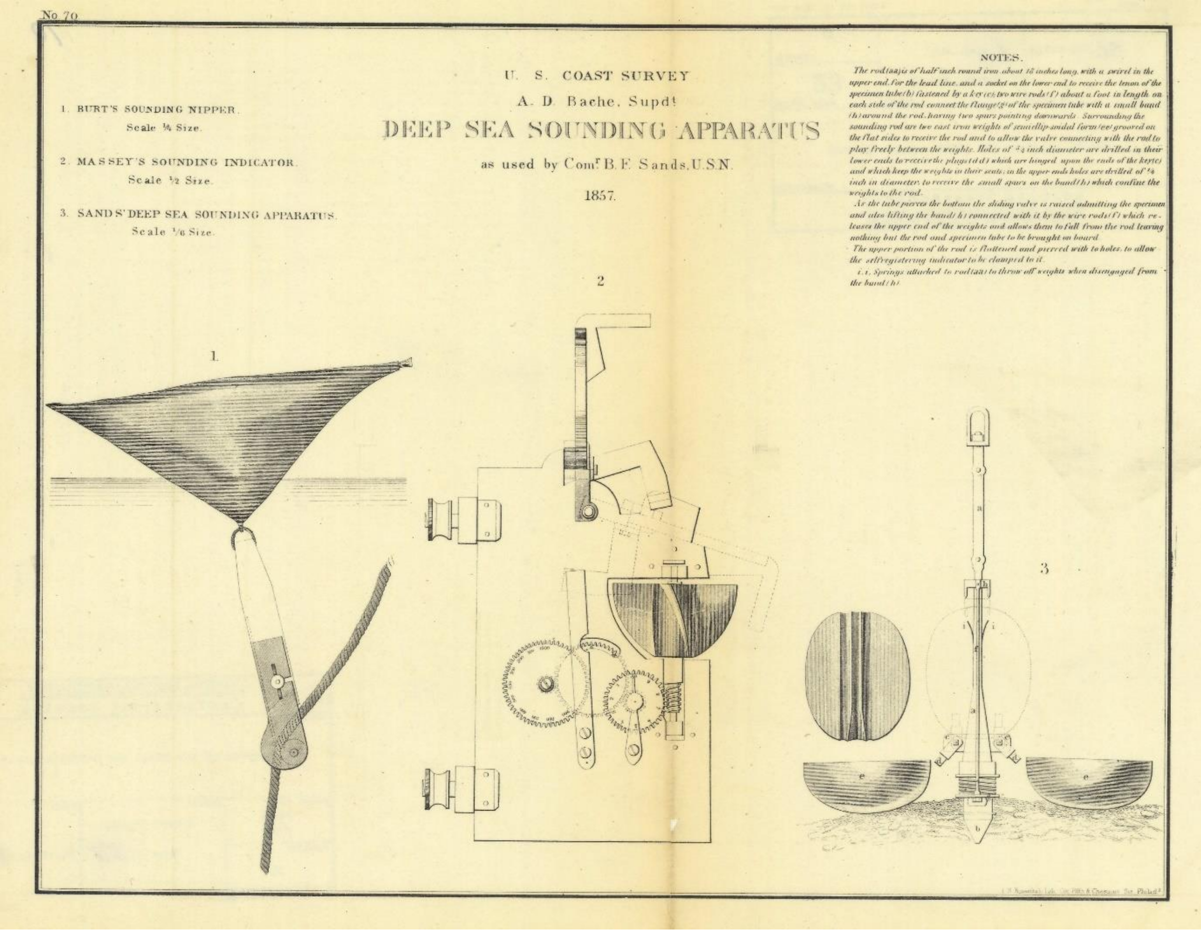


Figure 26: Massey sounder. http://www.photolib.noaa.gov/bigs/cgs06049.jpg (accessed 29 November 2016)

*Davy's water bottle*

This apparatus had been specifically designed by Sir Humphrey Davy for detecting the presence of a strong current at the surface of the ocean that would indicate a channel leading to a polar sea. It was a simple pear-shaped copper container ten inches long, with a valve at the top and a plug at the bottom which could be unscrewed to allow the water to drain out when the bottle was brought on deck. The bottle was not insulated. The valve at the top of the bottle was designed to close when the bottle sank into the ocean to trap the water, but this was not always the case in practice.[15]

*Botanical equipment*

Hooker recorded carrying three kinds of papers for his work: blotting, cartridge and brown as well as botanising vascula and two Wardian cases. Hooker recorded that, owing to his father, ‘I was further equipped with botanical books, microscopes, etc. to the value of £50’.[16] The microscope most commonly used by botanists was the simple microscope (one with a single lens) that could be used for examining and dissecting plants. For those concerned with physiology, a more expensive compound microscope was required (with two or more achromatic lenses). These gave higher magnification but required specimens to be prepared and mounted prior to examination.[17]

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[15] McConnell, Anita, *No Sea Too Deep: The History of Oceanographic Instruments* (Bristol: Adam Hilger Ltd, 1982): 40.
[16] Huxley, *Life and Letters of Joseph Dalton Hooker*, 47.
[17] Endersby, Jim. *Imperial Nature: Joseph Hooker and the Practices of Victorian Science* (Chicago and London: University of Chicago Press, 2008): 73.

Figure 27: Wardian Case

*Testing currents*

In deep water, far from land, sailors could detect a current only by the discrepancy between one's observed position and that reckoned from the ship's course and estimated speed. Massey's Patent Log was a device invented by Edward Massey for measuring the speed of ships. The whole device trailed behind the ship. At the end of a given period of time the Patent Log would be retrieved and the dials read. This would give an indication of the distance covered in that time, and hence the speed through the water. Comparing this to true speed calculated from sextant readings gave an idea of the strength of the sea current.

Another, less technical and immediate, way of detecting currents was by throwing bottles over the side of the ship that contained information on when and where it had been set afloat. This was performed almost every day on some ships. If the bottle were found at some point in the future it could be estimated how far it had travelled, in what space of time, and a rough estimate of the currents at work could be gained.

Figure 28: Massey's Patent log

(http://collectionsonline.nmsi.ac.uk/detail.php?type=related&kv=55409&t=objects)

(accessed 30 November 2016).

*Dredge*

From the end of the eighteenth century the type of dredge used on most ships was a modified version of the oyster dredge, with a reduced mesh size to stop the smallest objects and organisms escaping. This became known as the naturalist's dredge.[18] This type of dredge was first devised by Otto F. Müller, and so became known as the Müller dredge. In the early 1840s, Robert Ball designed a dredge that replaced this one: it was rectangular instead of square and had scrapers along both sides of the opening rather than just one, ensuring that the dredge would work regardless of the side that touched the sea bottom first. This adaptation required less skill to use than the one-sided dredge that would have been taken on all three voyages considered here.[19]

[18] Rehbock, Philip F. 'The Early Dredgers: "Naturalizing" in British Seas, 1830-1850', *Journal of the History of Biology* 12(2) (1979): 296.
[19] Rehbock, 'The Early Dredgers', 338.

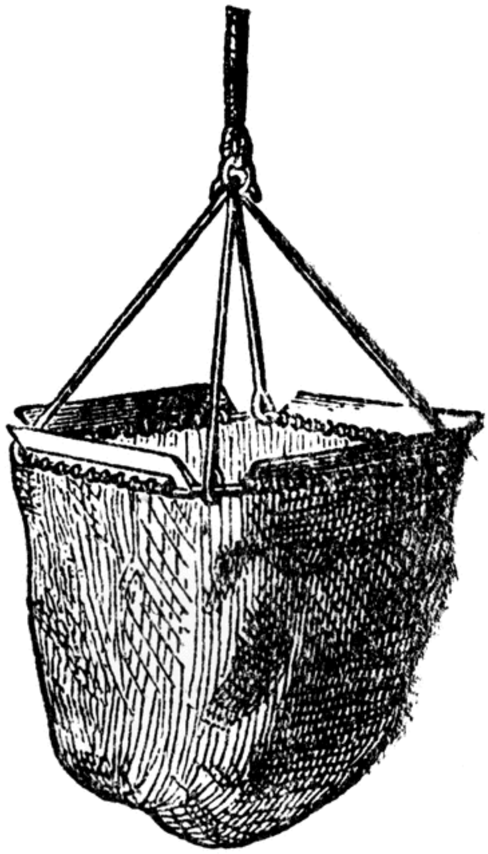

Figure 29: Müller's dredge (http://etc.usf.edu/clipart/26600/26638/muller_dredg_26638.htm) (accessed 30 November 2016).

**Astronomical and Surveying Instruments listed in Wilke's volume on Hydrography.**[20]

1 Three and a half feet transit, iron stand, &c., Dolland.

1 Altitude and azimuth circle (eighteen inch) two feet telescope, with microscope readings, by Dolland.

1 Repeating circle, twelve inch, by Ertel.

1 Five feet refracting telescope, six inch apparatus, with micrometers &c., by Meyer and Fraunhofer.

1 Three and a half feet refractor. Three inch ap., by Throughton.

2 Six inch repeating reflecting circles. Ertel.

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[20] Wilkes, Charles. *Hydrography* (Philadelphia: Lea and Blanchard, 1845): 2-4.

1 Twelve inch repeating reflecting circle, by Gambey, with depression mirror.

1 Variation transit. Dolland.

6 Sextants. Troughton and Simms.

2 Levels, staffs, &c. Troughton and Simms.

2 Plane tables.

6 Box sextants.

6 Schmaclcalder's prismatic compasses.

2 Dip sectors.

6 Mercurial horizons.

1 Glass horizon.

2 Massey's patent logs.

6 Surveying chains.

6 Barlow's compensating plates.

1 Amici collamator.

**Magnetic instruments**

1 Variation apparatus, by Gambey.

1 Variation apparatus, by Dolland.

1 Gauss's dirunal variation. Troughton and Simms.

1 Dirunal variation. Gambey.

1 Dirunal variation. Dolland.

2 Dipping needles, six inches, by Robinson.

2 Dipping needles, twelve inches, by Gambey.

2 Dipping needles, six inches. Dolland.

3 Intensity needles. Gambey.

2 Intensity needles. Dolland.

**Meteorological and physical instruments**

2 Standard barometers. Troughton and Simms.

6 Mountain barometers, with extra tubes.

1 Iron cistern. Jones.

2 Sympiesometeres. Adie.

6 Daniells' hygrometers.

2 Pouillet's hygrometers, a capsule.

9 Standard thermometers, by Simms, Jones and Dolland.

16 Six's self-registering thermometers, with copper cylinders for deep-sea sounding.

2 Scopeloscopes.

3 Pluviometeres.

1 Brass convertible axis experimental pendulum, by Jones,

1 Iron convertible axis experimental pendulum, by Jones.

1 Eight day astronomical clock, mercurial pendulum, by Jones.

1 Eight day clock, steel bar pendulum, for pendulum experiments, Molyneux.

1 Journeyman clock. Molyneux.

Iron frame to support the agate planes and its fixtures; also clock frames and stands. Molyneux.

Telescopes for observing coincidences, &c., &c. Jones.

Two weekly chronometers, Nos. 1567 and 1503. Charles Frodsham.

One Siderial chronometer, No.1615. Charles Frodsham.

Twenty-five 56hrs. Chronometers, viz.: Nos. 2075, 2085, 2203, 1839, 2204, 2066, 2093, 2095, 1964, 2105, 2052, 2083, 2096, 2037, by Parkinson and Frodsham; Nos. 2088, 3001, 1826, 2067, 2042, 2057, by Molyneux; Nos. 972, 766, by Arnold and Dent; Nos. 169, 170, by Chas. Young; No. 850, by James Murray; and four Pocket chronometers, viz.: Nos. 2124, 733 by Parkinson and Frodsham; No. 22 by Molyneux, and No. 786, By Cotterel and Co.[21]

**British instruments**

Whilst I have been unable to locate a copy of the list of instruments taken on board the British vessels, James Clark Ross does make reference to those instruments left at the Hobart Observatory in a memo to Lieutenant Dayman (left in charge of the observatory). This read as follows:

Magnometer

2 telescopes

2 thermometers

Vertical force magnometer

A maximum self-registering thermometer

1 minimum self-registering thermometer

1 actinometer

1 hygrometer[22]

[21] Wilkes, *Hydrography*, 2-4.
[22] Scott Polar Research Institute (SPRI), MS 1556: 182. James Clark Ross to Lieutenant Dayman.

# Appendix IV Instructions relating to investigation of the marine environment from government and scientific institutions

**France: Scientific recommendations for La *Bonite* from *l'Académie des Sciences* (1836).**

Phenomena of the Sea.

Temperature Of Currents.

Everyone is acquainted with the works of Franklin, Blagden, Jonathan Williams, M. von Humboldt, and Captain Sabine, on the Gulf-Stream. No one now doubts that this Gulf-Stream is an equinoctial current, which, after having made the circuit of the Gulf of Mexico, and issued from the Straits of Bahama, moves from south-west to north-east, at a certain distance from the coast of the United States, retaining all the time, like a river of warm water, a greater or less degree of the temperature it had acquired between the tropics. This current divides into two branches. One of these, it is said, ameliorates the climates of Ireland, the Orkneys, the Shetland Islands, and Norway; the other, gradually bending, returns to its former path, by crossing the Atlantic from north to south, generally to the west of the Azores, but sometimes at no great distance from the coasts of Spain and Portugal. After a very long circuit, the waters of this branch rejoin the equinoctial current from which they separated.

Along the coast of America, the position, breadth, and temperature of the Gulf-Stream have been so well determined under each latitude, that a work has been published, without any appearance of quackery, under the title of Thermometrical Navigation, for the use of seamen in these latitudes. It is very desirable that the returning branch should be known with equal certainty. Its excess of temperature is nearly lost when it reaches the parallel of Gibraltar, and it is only by the assistance of the means of great numbers of observations, that any hope of finding it again can be entertained. The officers of the Bovite would greatly facilitate this research, if, from the meridian of Cadiz to that of the most western of the Canaries, they could determine the temperature of the ocean every half-hour, to the tenth of a degree.

We have spoken of a tepid current, but our navigators will, on the other hand, meet with a current of cold water along the coasts of Chili and Peru. This current, after leaving the parallel of Chiloe, runs rapidly from south to north, and conveys, as far as the parallel of Cape Blanc, the refrigerated waters of the regions near to the southern pole. The temperature of this current was first noticed by M. von Humboldt, and was subsequently observed with very great care during the voyage of the Coquille. The frequent observations on the temperature of the ocean which the officers of the Bonite will not fail to make between Cape Horn and the equator, will serve to correct, to extend, or to complete the important results obtained by their predecessors, especially by Captain Duperrey.

Major Rennell has described, with minute attention, the current which emanates from the south-east coast of Africa, and runs along the bank of the Agulhas. According to the observations of Mr. John Davy, the temperature of this current is 7°- • • 9° Fahr. higher than that of the neighbouring seas. This high temperature is more deserving of the attention of navigators, from its being supposed to be the immediate cause of the cloud of vapour called the Table-cloth, which always envelops the summit of the Table Mountain, whenever the wind blows from the south-east.

Temperature Of The Sea At Great Depths.—It is not to be expected that a vessel such as the Bonite, despatched on a mission the express purpose of which is to convey some consular agents to the most distant parts of the globe, will ever suspend its progress to engage in physical experiment. At the same time, as hours, and even entire days, of dead calm may be anticipated by the navigator, particularly when he has to cross the line frequently, we conceive that this expedition will act wisely by providing thermometrographical and sounding apparatus, for the purpose of sinking instruments in safety to the greatest depths of the ocean. There is now very little doubt that the inferior cold waters of the equinoctial regions are conveyed thither by submarine currents from the polar zones; but even if a complete solution of this theoretical point had been obtained, it would be far from depriving the observations we now recommend of their interest. Who does not see, for example, that the depth at which the maximum of cold is found, (we will say more, that that and every other degree of temperature,) must depend, in every latitude, and that directly, on the total depth of the ocean,—if we are ever to hope that the latter quantity may be, some time or other, deduced from thermometrical soundings!

Temperature Of Shoals.—Jonathan Williams remarked, that water is colder on shoals than in the open sea. M. von Humboldt and John Davy confirmed the discovery of the American observer. Sir Humphry Davy attributed this curious phenomenon, not to submarine currents, which, interrupted in their course, rise up along the precipitous sides of banks and glide to their surface, but to radiation. By means of radiation, especially when the sky is clear, the superior beds of the ocean ought certainly to be greatly cooled; but every degree of cold, except in the polar regions, where the temperature of the sea approaches to the freezing point, occasions an increase of density, and a descending movement in the beds cooled. If we suppose an ocean without bottom, the beds in question would sink to a great distance from the surface, and could modify but slightly the temperature; but if there be a shoal, and the same causes operate, the cooled beds would accumulate, and their influence must then become very perceptible.

Whatever truth there may be in this explanation, everyone will perceive how much the art of navigation is interested in verifying the fact announced by Jonathan Williams, and which some recent observations seem to contradict; how eagerly also would meteorologists receive comparative measurements of the temperature of superficial waters in the open sea and above shoals; and, in particular, how acceptable it would be to them to see determined, by means of the thermometrograph, the temperature of the bed of water which rests immediately on the surface of the shoals themselves.

Height Of Waves.—The young officers of the *Bonite* will probably be greatly surprised if we assure them that none of their predecessors have fully answered the following questions: What is the greatest height of waves during tempests? What is their greatest transverse dimension? What is the rate of their progress?

Observers have generally been satisfied with forming an estimate of the height. But, in order to show how erroneous such estimates may be, and the influence which the imagination exercises in such matters, we may state, that navigators equally deserving of confidence, have some of them given sixteen feet as the greatest height of waves, others have stated it to be above a hundred. What science, therefore, now requires, is, not rough guesses, but actual measurements, of which it is possible to appreciate the correct numerical value.

These measurements, we are aware, are attended with great difficulties, but which, however, are not insurmountable; at all events, the question is of too great interest to permit of any efforts to be spared which may be necessary to solve it. We have no doubt that our young fellow countrymen will, in reflecting on the subject, devise themselves some means for performing the operation which we require of their zeal: a few brief considerations may assist in guiding them.

Let us suppose that for a moment the waves of the ocean were petrified and immovable; what should be done in a vessel also stationary and placed in a trough of the waves, in order to measure the real height, —to determine the vertical distance, of the crest of the wave, above the bottom of the trough? An observer should gradually ascend the mast, and stop at the point where the horizontal visual line, proceeding from his eye, appeared a tangent to the crest in question; the vertical height of the eye above the line of floatation of the vessel, always situated by the hypothesis at the bottom of the trough, would be the height required. This very operation it would be necessary to attempt in the midst of all the confusion and agitation of a tempest.

In a vessel at rest, so long as the observer does not change his place, the elevation of his eye above the sea remains uniform, and can be very easily determined. In a vessel tossed by the waves, the rolling and pitching incline the masts sometimes to one side, sometimes to the other. The height of any point of them, the main-top, for example,- varies incessantly, and the officer who may have taken his station there cannot ascertain the value of his vertical co-ordinate, unless assisted by a second person placed on the deck, whose duty would be to observe the movements of the mast. If this line could be ascertained, within a foot, for example, the problem would appear to us completely solved, particularly if the moments chosen for observation were those when the vessel was nearly in her natural position; now she is precisely so when at the bottom of the trough.

It now remains to discover the means of determining whether the visual line touching the summit of a wave be horizontal.

The crests of two contiguous waves are of the same height above the intermediate trough. A horizontal visual line from the eye of the observer, when the vessel is in the trough, I suppose to be directed to the summit of the approaching wave; if this line be prolonged on the opposite side, it will likewise touch the summit only of the wave already past. This last condition is necessary, and is sufficient to establish the horizontality of the first visual line. Now, with the instrument known by the name of the Dip-sector, having its ordinary circles provided with an additional mirror, there may be seen at the same time, in the same glass, and in the same part of the field, two images, situate at the horizon, one before, the other behind. The dip-sector, then, will show to an observer, who gradually ascends the mast, at what instant his eye arrives at the horizontal plane, which touches the crests of two neighbouring waves. This solves, precisely, the problem proposed.

We have supposed this observation to be made with all the precision that nautical instruments admit of. The operation will be more simple, and sometimes sufficiently exact, if the observer merely determine, with the naked eye, the greatest height to which he could ascend the mast, without perceiving, when the vessel is sunk in the trough, any other wave than the nearest to that which may be approaching or receding. In this way the observation is within the power of all persons, and may be made even during the most violent tempests, that is to say, in circumstances when the use of reflecting instruments would be attended with difficulties, and. when, moreover, perhaps no one but a sailor could venture with impunity to climb the mast.

The transverse dimension of a wave is easily determined, by comparing it with the length of the vessel as she passes through it. Its velocity may be measured by means well known. We have, therefore, in concluding this part, only to point out these two subjects of inquiry to the attention of the commander of the Bonite.

Visibility Of Shoals.—The bottom of the sea, at a given distance from a vessel, is more distinctly seen in proportion as the observer is elevated above the surface of the water: thus, when an experienced captain navigates a sea unknown, and abounding with shoals, he sometimes places himself near the summit of the mast, in order that he may direct his vessel with greater security.

The fact appears to us so well established, that we have nothing to request of our young navigators which relates to it in a practical point of view; but, by following the indications which we shall here point out, they may perhaps ascertain the cause of a phenomenon which affects them so nearly, and thence deduce more satisfactory means than casual observation has hitherto taught them to employ, for the purpose of detecting the position of shoals.

When a pencil of light falls on a diaphanous surface, whatever may be its nature, one portion of the light passes through, and another part is reflected. The latter is intense in proportion to the smallness of the angle formed by the incident ray with the surface. This photometrical law is not less applicable to rays which emanate from a rare medium, and meet the surface of a dense body, than to those which, moving in a dense body, strike the surface of separation of that body, and of a rare contiguous medium.

This being the case, let us suppose that an observer on ship-board wishes to perceive a shoal which is at a little distance, for example, a submarine shoal, situate at 100 feet of horizontal distance. If his eye be about a yard above the sea, the visual line by which the light emanating from the shoal can reach it after issuing from the water, will form a very small angle with the surface of the fluid; if his eye, on the contrary, be very much elevated, suppose 100 feet, he will see the shoal under an angle of 45°. Now, the interior angle of incidence, corresponding to the small angle of emergence, is evidently less open than that which corresponds to the emergence of 45°. Under small angles, as has been seen, the strongest reflections take place; the portion of light which emanates from the shoal, and is received by the observer, will therefore be greater, the higher he is placed.

The rays emanating from the submarine shoal are not the only ones that enter the eye of the observer. In the same direction, and confounded with them, proceed rays of atmospheric light, which are reflected exteriorly from the surface of the sea. If the latter were sixty times more intense than those of the former, they would totally conceal the effect of them. The shoal would not even be suspected, for it has been proved by the experiments of Bouguer, and which have often been repeated since, that the most experienced eye is not sensible of an augmentation of light. If there be a less proportion between these two lights, the appearance of the shoal may not be entirely lost, but it will be very feeble. When it is remembered that atmospheric rays reflected to the eye from the sea, have a degree of splendour, which is greater in proportion as the angle under which they are reflected is acute, everyone will perceive that two different causes concur to render a submarine object less and less apparent in proportion as the visual line approaches the surface of the sea.—namely, on the one hand, the progressive and real weakness of the rays which emanate from the object, and form its image in the eye; and, on the other, a rapid augmentation in the intensity of the light reflected from the exterior surface of the waters, or rather, if I may be allowed the expression, in the luminous curtain through which the rays issuing from the shoal must transmit their light.

On the supposition that the comparative intensities of the two superposed pencils are, as everything leads us to believe, the only cause of the phenomenon which we are now analyzing, we have it in our power to point out to the officers of the Bonite, a better and far more easy means of detecting submarine shoals, than has been enjoyed by their predecessors. This means is very simple; it consists of looking at the sea, not with the naked eye, but through a plate of tourmaline cut parallel to the edges of the prism, and placed before the pupil of the eye in a certain position. A few words will render evident the mode in which this crystalline plate acts.

Let us assume that the visual line is inclined to the surface of the sea at an angle of 37°. The light which is reflected from the exterior surface of the sea under this angle, will be completely polarized. Polarized light, as every physician knows, does not pass through plates of tourmaline suitably placed. A tourmaline, then, may eliminate entirely rays reflected by the water, which, mingling, in the direction of the visual line, with the light emanating from the shoal, either obstruct the view of it entirely, or at least greatly weaken it. When either of these latter effects is produced, an eye placed behind the plate will receive one kind only of rays, viz. those which emanate from submarine objects; and instead of two superposed images, a single image only will be formed on the retina; the visibility of the object which this image represents will thus be greatly facilitated.

The entire and absolute elimination of the light reflected from the surface of the water, is only possible under an angle of 37°, because it is under this angle alone that it is completely polarized; but under angles from 10° to 12° greater or less than 37°, the number of polarized rays which the tourmaline can arrest in the reflected light is still so considerable, that the use of the same means of observation cannot fail to be attended with very advantageous results.

By engaging in the trials which we now propose to them, the officers of the *Bonite* may throw light on a curious question of photometry; they may probably confer on navigation a means of observation which may prevent many shipwrecks; and by introducing polarization into the nautical art, they may furnish a new instance of what those individuals expose themselves to, who unceasingly receive experiments and theories which may have no present practical application with a contemptuous cui bono?

Water-spouts.—Has electricity any influence in producing waterspouts? A distinct and indisputable answer to this question would possess great interest. The officers of the Bonite ought therefore to exert themselves to discover, whenever this phenomenon presents itself, if it produce thunder and lightning.

Depressions Of The Horizon.—The distinctly-defined blue line, forming the apparent separation between the sky and the sea, to which sailors refer the position of the stars, is not in the mathematical horizon; but the distance at which it appears below the latter, and which is called the depression, may be calculated exactly, since it depends merely on the height of the observer's eye above the sea, and the dimensions of the earth. It is unfortunately not so easy to appreciate the effects of atmospheric refraction. It must even be stated, that in the calculations of the tables of depression usually employed, the mean refraction relative to a certain state of the thermometer and barometer, is the only one taken into account. Officers of great skill, Captain Basil Hall, Captain Parry, and Captain Gautier, have determined, by observations, the errors to which navigators are exposed by following the common rule. They measured, either with the dip-sector of Wollaston, or with ordinary instruments furnished with an additional mirror, and in the most varied states of the atmosphere, the angular distance of one point of the horizon from another diametrically opposite. Admitting, as is generally done, that the state of the air and of the sea are the same all around the observer, the difference of the distance measured, and of 180°, is evidently double the real depression of the horizon. The half of this difference, compared with the depression of the tables, gives, therefore, the possible error of every angular observation of altitude made at sea.

The positive and negative errors observed by Captain Parry in the northern regions, were all comprised between + 59" and — 33". In the Chinese and Indian Seas, Captain Hall found greater deviations, viz., from + 1' 2" to — 2* 58". Finally, Captain Gautier, in the Mediterranean and Black Seas, observed still greater differences, viz., from + 3' 35" to — 1' 49". If it be recollected that the variation of a single minute in latitude corresponds to a deviation of above 2100 yards on the globe, it will be universally acknowledged how deserving of attention is the investigation which we have mentioned.

By examining with care all the observations of MM. Gautier, Basil Hall, and Parry, a conclusion is attained, that the error of the Calculated depression is not Positive, and that this depression does not exceed that which is observed, Except in the degree that the temperature of the air is higher than the temperature of the mater.

With regard to the negative errors, they present themselves indiscriminately in all the comparative thermometrical states of the sea and atmosphere, without the possibility of attributing these anomalies to any apparent cause, and, in particular, to the state of the hygrometer. Here is, therefore, a very curious problem for solution, and which is equally interesting to the physician and the seaman.[23]

**The United States of America**

The Ocean.

Currents: Careful observations on these are of great interest and importance; they will be made by comparing as frequently as possible, the change of place of the ship as estimated by Astronomical observation and by dead reckoning.

Tides: It is hoped that these will be observed with great care, whenever the opportunity is presented. The time and amount of the greatest and least elevation above any fixed level should be noted, with a statement, at the same time of the direction and strength of the wind. The tides in the Pacific, it has been asserted, obey the influence of the Sun, rather than of the Moon. If this be so, it is very desirable to know whether this influence may not be exerted through the medium of the land and sea breezes.

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[23] *The Magazine of Popular Science and Journal of the Useful Arts* (3) (London: John W. Parker, 1837): 27-33.

Depth of the Sea: It is hoped that opportunities of solving this interesting problem will not be neglected; and we would suggest that copper wire might be more suitable for the purpose than hempen cord. It is strong, it is not buoyant in water, and it is so thin that a vast length of it may be wound upon reels without occupying much space.

Temperature of the Sea at great depths: This may be determined either by sinking a self-registering thermometer, or by drawing up a sufficiently large quantity of water from the depth, as practised by Dr. Jno. Davy. The instruments for such experiments will be found described in several of the works of which a list is subjoined.

Salt and Air in Sea Water: Biot has described a method of determining the quantity of salt, and the amount and kind of air contained in sea water, which we would recommend to be used, in this expedition, at different depths, extending to the greatest that can be reached.

Sound: When the air is extremely cold, it is stated that sounds may be heard at a much greater distance than when it is warmer; but no means of exact comparison have yet been used. It is desirable, then, that experiments be made, under these different circumstances, in calm weather, as to the distances at which the same persons hear the ringing of the same bell, or the explosions of percussion caps of the same kind fired in the same manner. It is also of great interest to determine the velocity of sound through air of extreme coldness.[24]

**ZOOLOGY [By TITIAN R. PEALE]**

The Zoologists should observe, draw and describe the various animals inhabiting the countries which may be visited by the Expedition. The assistants should be qualified to

[24] Conklin, Edwin G. 'Connection of the American Philosophical Society with Our First National Exploring Expedition', *Proceedings of the American Philosophical Society* 82 (5) (1940): 524.

collect, draw, or prepare specimens for preservation. The selection of such assistants should be made by the Principals with the approbation of the Secretary of the Navy.

The Zoologists should be instructed to collect information of the habits, localities, times of gestation, food &c. of all the large mammiferous animals, such as Seals and Cetacea, that inhabit the southern oceans, and which constitute the great source of commerce in those seas; to extend their observations to the various branches of Ornithology, Entomology, Conchology &c., to make themselves particularly acquainted with the times, and places where the numerous Sea Fowl of those regions resort to breed, the eggs and young of which are known to add largely to the health and comfort of the seamen engaged in the above commerce; to observe the various Turtles, and Molluseae with the same views; the Pearl fisheries; to dredge in deep as well as shallow water for the numerous inhabitants of the ocean, and to ascertain as nearly as possible, the different depths at which those animals exist; the depths from which the various species of Zoophytes erect their fabrics and form Islands, many of which in after-times become the residence of Man; to ascertain the time requisite for the maturity of such; their food; and in fact to collect all the information which can be reasonably obtained of that race of animals, which though among the smallest, hold notwithstanding one of the most important places in the chain of created beings.

The Insects of the various Islands should be collected and preserved, and as far as possible their metamorphoses should be observed and recorded. Drawings should be made on the spot, particularly of those animals, of which prepared specimens cannot be brought home.

In observing the Fish, it will be important that the Zoologists should particularly remark, when, where and how they are taken, and whether they will be likely to be worthy of consideration in a commercial point of view, like the Cod, Mackarel [sic], Herring &c.

To accomplish all the above views, it will be requisite for the persons employed to collect and prepare specimens, as far as practicable, of all the animals noticed, both as vouchers to the accuracy of the observations made, and to correct errors which might be committed in the hurry of a varied occupation:-It will be imperatively necessary that the Zoologists be liberally provided with appropriate Nets, Dredges, Boxes, Casks, Spirits, and all the various instruments and materials used for procuring and preserving specimens; They should also be provided with Books of reference, which they will require in order to be constantly aware of the labours of their predecessors in the same field.[25]

List of Books, recommended to be taken on the Expedition for the use of the Officers and Scientific Corps.

Lord Anson's Voyage round the World in H. M. S. Centurian [sic]. (1740.)

Beechey's Narrative of a Voyage to the Pacific and Beerings Straits &c. (1828.)

Bougainville's Voyage round the World (Forsters translation) 1769.

Ellis's Polynesian Researches, 1829.

Freycinet's Narrative of a Voyage rd the World. 1820.

Kotsbue's Voyage of Discory in the Sth Sea.

Morrell's Narrative.

Parry's Journals in search of N.W. Passage.

Peron's Voyage de decouvertes aux terres Australes.

Porter's Narrative.

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[25] Conklin, 'Connection of the American Philosophical Society', 530-31.

Yate's New Zealand, 1835.

Bennett's Wanderings in N. South Wales &c. 1834.

Tyerman's Journal of Voyages and Travels &c. (South Sea Islands, China and India), 1831.

Weddell's Voyage towards the South Pole. 1825.

Adanson's Senegal.

Bennett's New South Wales.

Chronological History of discoveries in the Sth Sea by Capt. Burney, R.N.

Desmarest's Mammalogie.

Cuvier's Animal Kingdom.

do Dents de Mammiferes.

Traite d'Ornitholoaie par R. P. Lesson.

Cuvier's Histoire et Anatomie des Mollusques.

Dillwyms Catalogue of Shells.

Lumark's [Lamarek's] des Allimaux sans vertebres.

Latreille's Histoire Nature. des Crustaces et des Insectes.

De la Beche's Geological Manual.

De la Beche's Theoretical Researches.

De la Beche's How too observe Geology.

Lyell's Principles of Geology.

Humbolt’s [Humboldt’s] Works.

McCulloch’s Classification of Rocks.

Dr. Danberry on Volcanos [sic].

Von Buck’s Work upon Volcanos [sic].

Elie de Baumont.

Transactions of the Geological Society of London.

Article, Geology in the Encyclopedia Metropolitana.

Besides the Standard Works on Mineralogy.

In Silliman’s Journal, Vol. ls, page 71, and Vol. 3rd, page 249 useful instructions are to be seen relative to the choice and preservation of Geological Specimens.[26]

**Britain: Scientific Recommendations for HMS Erebus and Terror from the Royal Society (1839).**

**‘Section 1: Physics and Meteorology**

3. Tides

With regard to *tides*, it is not likely that Capt. Ross’s other employments will allow him to pursue observations on that subject with any continuity; nor is it desirable that he should do so, excepting he were able to carry on his observations to a much greater extent than is consistent with the nature of the Expedition. There are, however, certain objects which may be answered by occasional and detached observations, which may be briefly stated.

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[26] Conklin, ‘Connection of the American Philosophical Society’, 537-538.

1. At all stations on the coasts visited, and especially at all detached islands in the middle of wide seas, it is desirable to obtain the *correct establishment* of the place, or mean lunitidal interval. This may be done with tolerable accuracy by a few observations.

5. Distribution of Temperature in the Sea and Landscape

That like the currents in the atmosphere were produced by differences in the temperatures in polar and equatorial parts, so may be the currents of the ocean, as M. Arago had contended in his 'elaborate instructions for the voyage of the Bonite.'

'The sun's rays are totally absorbed at the surface, and no ray reaches the bottom of any sea deserving the name. No deep stratum of water, therefore, can be permanently maintained by the sun's direct heat at a temperature greatly above what it would have independently of its direct action.'

'Practically speaking the question resolves itself into one fact, which observations only can decide. Is there in the whole column of water between the surface of the ocean and its bed at the poles, as compared with a column of equal depth at the equator and *in free communication with it*, a descentional power or not? And what is its amount? These questions can only be resolved by observations of the temperature and saltness of the sea, at various and considerable depths, in different latitudes and under a great variety of local circumstances. The procuring of such observations, and the preservation of specimens of the water, or the determination on the spot of their specific gravities, will afford a useful occupation in calms, and may be recommended as well worthy of attention'.

'Opportunities for determining the temperature of the ocean at great depths must of course be rare; but at moderate depths it can always be done with comparatively little trouble, and we would therefore suggest the propriety of making observations of this element at two moderate and constant depths (say 150 and 300 fathoms), by the aid of a self-registering thermometer attached to a sounding line whenever the ship's way shall be such as to allow their being made with precision'.

### 6. Currents of the Ocean

'The practice of daily throwing overboard a bottle corked and sealed with the latitude and longitude of the ship at noon ought not to be neglected. A single instance of such a record being found may suffice to afford indications of the utmost value, while the trouble and cost are too trifling to mention.'

'Should any superficial variation in temperature be observed in passing over a shoal or bank, it could only be ascribed to radiation. The subject is one of considerable interest to the navigator, as the approach to land or shoal water is indicated by the thermometer with a high degree of sensibility'

Re-examine temperature measurements made at Table Bay in 1834 on the Earl of Hardwick.

Distribution of temperature over the globe: 'Connected with the transcalescence of the air, is the transparency of the sea. The stimulus of the solar light no doubt affects the surface of Mollusca at great depths, and numerous points of physical inquiry would be elucidated if we knew the co-efficients of extinction of the solar rays by pure sea water. As far as the luminous rays are concerned (or at least the chemical), the actual intensity of these rays at various depths might be very easily ascertained, both for direct sunshine and that of cloudy daylight, by the aid of Mr. Talbot's sensitive paper; which duly guarded from wet by varnish and interposition between glass plates, might be sunk, face upwards in a small frame, while a portion of the same paper, cut from the same sheet, should be similarly exposed on deck, and partially shaded inch by inch, from minute to minute'.

'Paper duly prepared for these purposes will be supplied for the use of the expedition'.

7. Depth of the sea

Soundings to as great a depth as practicable should be taken whenever opportunity may offer. Great difficulty, however, is well known to exist in the way of procuring any exact result, or indeed any result at all in very deep seas; and various methods (all objectionable) have been proposed and tried. Could any means be provided to keep out the water from a shell, and at the same time ensure its explosion on striking the bottom, the time elapsed, between casting the shell overboard and hearing the explosion, would indicate the depth with great precision; nor need we fear that, if the explosion took place, the sound would not be heard, sound being propagated through water with infinitely greater sharpness and clearness than through air. To overcome the enormous external pressures, and to enable the charge to burst the shell, it is probable that mere gunpowder might not suffice. Should this be apprehended, a mixture of fulminating mercury with the charge in about equal proportions, would probably affect the object. At least we know, from experience the vast increase of bursting power which is communicated to powder by such addition. It has also been suggested that an echo from the bed of the ocean might be heard, were a shell exploded just beneath the surface (as an echo from the earth is heard in the car of a balloon); and attempts, though imperfect ones, have been made to subject this proposal to trial, the reason of the failure of which does not very distinctly appear. The maximum depth of the sea is a geological datum of such value, that a few failures incurred in attempts may very well be tolerated when places in competition with the interest of even partial success'.

**Section V-. Instructions for making meteorological observations**

2. Thermometers

‘The self-registering thermometers should be placed with the same precautions as the standard, and so fastened as to allow of one end being detached, and lifted up to allow for the indices within the tubes sliding down to the ends of the fluid columns, which they will readily do with the assistance of occasional tapping.

The self-registering thermometers are apt to get out of order by the indices becoming entangled, or from the breaking of the column of fluid. When this happens with the spirit thermometer it may be rectified with ease by jerking the index tube down to the junction of the bulb and tube. The whole of the tube will at the same time become wetted with the spirit, and by setting it on end with the bulb downwards the spirit will run together into one continuous column’.

‘The surface temperature of the water of the sea or of rivers may be conveniently obtained by taking up a bucket-full of water and stirring round the thermometer in it’.[27]

[27] *Report of the President and Council of the Royal Society on the Instructions to be Prepared for the Scientific Expedition to the Antarctic Regions* (London, 1839): 19-48.

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### *Abbreviations*

RGS: Royal Geographical Society (with the Institute of British Geographers), London

TNA: The National Archives, Kew

JDH: Joseph Hooker Correspondence Project, Royal Botanic Gardens, Kew

SPRI: Scott Polar Research Institute, Cambridge

Wellcome: The Wellcome Institute, London

CDV: Chateau du Vincennes, Paris

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BJ2/5. Letters from Ross to his wife at the time of his Antarctic expedition.

BJ2/12. Miscellaneous undated diagrams, notes and memoranda relating to Ross and his expedition.

***The Royal Botanical Gardens, Kew***

| | |
|---|---|
| JDH/1/2. | Joseph Hooker Correspondence Project. Archives of the Royal Botanic Gardens, Kew. Antarctic Correspondence. |
| S-HOO. | Joseph Hooker Antarctic Journal 1839-43. 1 volume. |
| L-HOO. | Joseph Hooker correspondence 1839-45 from Antarctic expedition. 1 volume, 225 docs. |

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