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Lamps, Maps, Mud-Machines, and Signal Flags: Science, Technology, and Commerce in the Early United States

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LAMPS, MAPS, MUD-MACHINES, AND SIGNAL FLAGS:
SCIENCE, TECHNOLOGY, AND COMMERCE IN THE EARLY UNITED STATES

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DEDICATION

To Ann Johnson (1965-2016): mentor, colleague, and friend.

ACKNOWLEDGEMENTS

I would like to acknowledge my original advisor, the accomplished and adept Ann Johnson, who passed away December 11, 2016. Ann's expertise and knowledge were an invaluable resource. Her insight and intuition provided the opportunity for me to pursue my doctorate. Ann saw something in me that others overlooked. She believed in me, pushed me to broaden my perspective, and refused to let me rest on my prior accomplishments. This dissertation is a small gesture of thanks to her for helping me grow intellectually and professionally as a historian. Ann was my biggest advocate and I am forever grateful for that.

Allison Marsh stepped in and took over the advising responsibilities when Ann passed away. I am thankful for Allison making the transition as smooth as possible, but I am especially grateful for Allison's willingness to take me on as an advisee when she already had a full commitment of responsibilities. With Allison's guidance, the structure and thesis of the dissertation became much clearer. Additionally, Allison helped me sharpen the language and writing.

Carol Harrison, Cary Mock, and Joseph November provided constructive criticism as my committee members. Andrew Berns and Thomas Brown read early drafts of sections well before the project even took shape. Each brought a different perspective to the table and I hope I have adequately addressed their critiques.

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My wife Lori read many drafts of my work throughout my academic career. She and our son James have kept me grounded over the years. I owe them the greatest debt of gratitude for their patience. I have travelled this journey for them in hopes of providing them a better future. My brother John gave constructive feedback on the drafts of the dissertation. My sisters, Carolyn and Jennifer, and my Dad listened to my trials and tribulations. Pat Albano's friendship, mentoring, and faith in my abilities has been a pillar of strength in my intellectual pursuits. Ann Phillips' motherly advice and early mentoring provided a model I can only hope to emulate. Pat and Ann are rocks to whom I have periodically returned when I needed confidence, strength, and tranquility.

Finally, I would like to thank my Mom who continued to watch over me from her heavenly home. I wish she could see what I have become. I know she would be proud.

ABSTRACT

As the United States looked forward to its future as an independent nation at the end of the eighteenth century, many saw commerce as a way to secure the nation's future. American commerce, however, was plagued by a number of commercial problems. Solving these commercial problems facilitated an interest in science and the practical arts as engineers, inventors, mechanics, public officials, and everyday tinkerers innovated new apparatuses to preserve, promote, and protect American commerce. Many of America's commercial problems in the early nineteenth century, however, resulted from the young nation's varied geography and environments. Combating the environment's unrelenting forces often exceeded the resources of private citizens and necessitated the involvement of the state. This can be seen in the advent of government agencies such as the Army Corps of Engineers, the Coast Survey, and the Light-House Establishment. Notwithstanding, the government's involvement in practical science and innovation proceeded cautiously and unevenly. This caution and uneven involvement on the part of the government derived from societally held values of Jeffersonian republicanism. Republican values of civic duty, prudence, honesty, and self-reliance, thus shaped the government's role in advancing practical science and the arts in the early nineteenth century United States.

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LIST OF ABBREVIATIONS

APS	American Philosophical Society
BCA	Baltimore City Archives
BCA-CCR.....	Baltimore City Archives, City Council Records
BCA-CCAP ...	Baltimore City Archives, City Commissioners, Applications, and Petitions
Cong.....	Congress
DelHS.....	Delaware Historical Society
GPO	Government Printing Office
GWBW	G. W. Blunt White Research Library
HABS	Historic American Buildings Survey
HAG	Hagley Library and Museum
H. Doc.	United States House of Representatives Document
JHU	Johns Hopkins University
JRPC	John Rowe Parker Correspondence
KUPL	Kislak Center for Special Collections, University of Pennsylvania Libraries
LOC.....	Library of Congress
MdHS	Maryland Historical Society
MeHS	Maine Historical Society
MIT	Massachusetts Institute of Technology
NARA	National Archives and Records Administration, Washington, DC
NARA-II	National Archives and Records Administration, College Park, MD
NHA.....	Nantucket Historical Association

NMAH	National Museum of American History
NOAA	National Oceanic and Atmospheric Administration
OCS	Office of Coast Survey
OLHB	Office of the Light-House Board
OML	Osher Map Library
PRHC	Penrose R. Hoopes Collection
qtd	quoted
repr	reprint
RG	Record Group
RIHS	Rhode Island Historical Society
S. Doc	United States Senate Document
sess.	session
UC	University of Chicago
UMBC	University of Maryland Baltimore County
UNC	University of North Carolina
UPenn	University of Pennsylvania
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USLHB	United States Light-House Board
USLHE	United States Light-House Establishment
WPA	Works Progress Administration

CHAPTER 1

INTRODUCTION

Currently in the United States there is a debate over the value of science and technology. Scott Pruitt, the newly confirmed head of the Environmental Protection Agency (EPA), for instance, denies the existence of global warming despite the wealth of scientific evidence that the planet is undergoing severe changes in climate. The Administration has expressed its desire to eliminate the EPA. According to the Administration, eliminating the EPA benefits business by reducing the costly burden of complying with environmental protection policies. In addition to the Administration's plans for the EPA, the Administration's proposed budget drastically cuts funding for science, technology, engineering, and mathematics (STEM) education and the National Aeronautics and Space Administration (NASA) has voiced similar concerns over the devaluing of science. Scientists have organized a protest march at the Nation's capital in April to push back against the Administration's stance on science and to demonstrate the importance of science to the public good.

The current debate over science and the government's involvement in scientific practice is nothing new. Between the late eighteenth century and the middle of the nineteenth century, a similar debate raged over the government's involvement in practical science and the mechanical arts. The eighteenth and nineteenth century debate, however, did not question the validity of science and it did not see science as a hindrance to business and commerce. Rather, in the early 1800s, science was seen as a boon for

commerce. The debate from two centuries ago sought justification for the government's involvement in science and whether or not the military was better suited for scientific production than the artisan craftsmen, merchants, and everyday tinkerers. Similar to the present Administration's focus on business, commerce and the economy were major concerns for the government that ultimately shaped their decision to become involved.

The environment also played role. Dissimilar from the current Administration's views that environmental regulations are an obstacle to business, early nineteenth-century Americans saw the environment itself as challenging commerce and economic growth. In many instances, however, the unrelenting forces of nature proved too much for private enterprise. The natural world forced the government into pursuing practical science and innovation in order to protect the nation's commerce.

The project that follows is a study of the interaction between science, technology, commerce and the state in the early United States. As commerce in the first half of the nineteenth century relied heavily on maritime shipping this project examines the Army Corps of Engineers' work in constructing port infrastructure, the Coast Survey's charting of the coastal boundaries and hazards, the Light-House Establishment's attempts to protect maritime commerce from navigational hazards, and the private network of marine telegraphs efforts to improve port efficiencies. The following chapters examine the interaction of these institutions in defining the role of public and private involvement in commerce and science. The wreck of the *Union* on Baker's Island in Massachusetts provides an excellent illustration of the interaction between science, technology, commerce and the state.

In the wee hours of the early morning on February 27, 1827, the *Union* began its final approach toward the harbor at Salem, Massachusetts. Captained by a 31-year old shipmaster named William Osgood, the *Union* and its crew were returning home after a nine-month voyage to Pulo Penang in the Far East.¹ The *Union* carried a cargo of pepper and block tin valued at \$80,000 (\$1.47 million in 2015 dollars).² Unfortunately, as the *Union* was nearing the end of its journey, the ship encountered a surprise snowstorm. The sea became rough as a result. Combined with the darkness of the new moon, the snowstorm made it impossible for the crew to ascertain their location. The *Union*'s only hope for determining their exact position was the lighthouse on Baker's Island. Yet, when Osgood and the crew spotted the beacon, they mistook it for the Boston Harbor Light. In what proved to be a fatal mistake, Osgood ordered the crew to turn south causing the *Union* to run aground on Baker's Island. As the grounded *Union* lay helpless, the storm surge almost immediately began ripping the ship apart. Within hours, the cargo was strewn along the island's shore and the *Union* was a complete loss. Osgood however was not entirely at fault for causing the disaster by ordering the crew to turn southward. Eight months earlier, the government announced plans to make extensive repairs the Baker's

¹ Pulo Penang is located in the Strait of Malacca off the coast of Malaysia. Historically, Pulo Penang has been known as the Prince of Wales Island, Areca Island, and many other names. Today, Pulo Penang is known simply as Penang Island.

² George Granville Putnam, *Salem Vessels and Their Voyages: A History of the Pepper Trade with the Island of Sumatra* (Salem, MA: The Essex Institute, 1922), 43. "Baker's Island Lights," *Salem Gazette* (Massachusetts) May 29, 1818. Dollar values for 1817 were converted to current values using Samuel H. Williamson, "Seven Ways to Compute the Relative Value of a U.S. Dollar Amount, 1774 to present," *Measuring Worth*, 2015, <http://www.measuringworth.com> (accessed December 18, 2016). Use of Williamson's currency converter is for illustrative purposes only to aid in comprehension of the ship's value.

Island Lighthouse.³ The repairs included altering the height of the tower and extinguishing the light's second lamp, which had been a fixture on Baker's Island since the government established the lighthouse there in 1798. Osgood expected the lighthouse at Baker's Island to confirm his position within the approaches of the harbor, but it did not. The lighthouse failed to meet Osgood's expectations because the alterations made the Baker's Island Light indistinguishable from the Boston Harbor Light. Osgood and the crew of the *Union* were unaware of the alterations. The *Union* had already set sail for the Far East when the notice of the proposed changes was published. Fortunately, Osgood and all of the crew survived the wreck despite the loss of the ship and cargo.⁴ Stephen Phillips and George Pierce, the owners of the *Union*, carried insurance on the ship and its cargo, but the loss exceeded the insurance coverage by \$35,000.⁵ After three years of ongoing complaints by mariners that the Baker's Island Lighthouse was inadequate for its intended purpose, the government was forced to relight the second lamp. It did nothing in regards to restoring the light to its original height.⁶

As previously stated, the wreck of the *Union* illustrates the relationship between science, technology, commerce, and the state in the United States in the first half of the nineteenth century. Several factors influenced innovation and the development of practical science in America. Commerce, for instance, was a driving force behind the state establishing its authority over the navigation in 1789 with the just the ninth act of

³ H.A.S. Dearborn, "Notice to Mariners," *Nantucket Gazette* (Nantucket, MA), July 1, 1816.

⁴ Putnam, 43-5.

⁵ Putnam, 44. James Risk, "Ship to Shore: Infrastructure and the Growth of American Seaports, 1790 – 1850, (MA thesis, UMBC, 2011), 25-6.

⁶ Risk, 26. Edward Rowe Snow, *The Lighthouses of New England*, (1945; repr., Beverly, MA: Commonwealth Editions, 2002), 154.

the new constitutional Congress. This act stipulated that the federal government would assume all responsibilities for the administration, maintenance, and support of the buoys, lights, and public piers to ensure safe navigation “within any bay, inlet, harbor, or port of the United States.”⁷ Previous to the act, these assets were administered by the individual states under the Articles of Confederation. In passing the act, Congress showed its intent to facilitate commerce and the economic growth of the young nation. Congress saw the protection of the nation’s commercial interests as means of securing and protecting the nation itself. Nearly 90 percent of the nation’s revenue came from customs duties in the late eighteenth and early nineteenth centuries.⁸ Shipwrecks impacted the state’s revenues through lost customs duties. They also impacted the local economy through lost wages and profits on sellable goods. A single shipwreck could mean financial ruin for a merchant or ship owner.

In 1802, Congress established the Army Corps of Engineers at West Point. In the beginning, the Army Corps of Engineers primarily focused on building defenses for the nation’s major ports. Harbor defenses were not only necessary for the security of the nation; they were also important for the safety of American commerce. This was especially true for a young developing nation like the United States, making American ports more susceptible to attack. One of the surest ways to cripple an enemy combatant is to cripple their economy and attacking American ports was sure to cripple its ability to fight. As previously mentioned, the majority of economic activity around the world remained tied to the maritime sector and the ocean’s access to global markets in the first

⁷ United States Congress, *An act to provide for the establishment and support of Lighthouses, Beacons, Buoys, and Public Piers*, 1st Cong., 1st sess., ch. 9, sec. I, 1789.

⁸ Ron Chernow, *Alexander Hamilton*, (New York: Penguin Press, 2004), 339.

decades of the nineteenth century.

Five years later, Congress, at the request of President Thomas Jefferson, created the Coast Survey to chart harbors, shipping lanes, shoals, and other aspects of the coast related to navigation. Here again, the government's primary concern was for the preservation of commerce. As Samuel Whittlesey Dana, a Federalist Congressman from Connecticut, argued, the coast survey would be in the "interest of our merchants" and benefit the nation's revenue. Dana also believed a survey of the coast would protect mariners engaged in commercial shipping from being impressed by the British into the Royal Navy. An accurate survey might force the British to respect America's sovereignty within twenty leagues of the land where most of the impressments occurred.⁹

Early American ports were vulnerable because of the young nation's fledging military. Although the American colonies had defeated the most powerful nation on earth to establish their independence, the threat of war continued to loom large for the United States in the last decade of the eighteenth century and the first decades of the nineteenth century. Americans divided their political loyalties between two of Europe's most bitter enemies – Britain and France – who were either at war themselves or on the verge of war until the fall of Napoleon in 1815. This division left the United States without a firm ally. Britain had not forgotten the American rebellion and eyed any opportunity to reassert its power and reclaim its former colonies. France, who aided the American colonies in their bid for independence, turned against the United States in a quasi-war because of America's refusal to reciprocate the aide during France's war with Britain. For these

⁹ *Annals of Congress*, 9th Cong., 2nd sess., 1807, 152.

reasons, the United States Army Corps of Engineers focused their efforts on protecting the young nation's port cities by building fortresses and improving harbor defenses.

The federal government's concern for commerce and the government's actions in response to that concern therefore made it the state's responsibility to ensure the Baker's Island Lighthouse provided protection against the possibility of shipwreck. Yet, Osgood and others blamed the inadequacy of the Baker's Island Lighthouse for doing the exact opposite – causing shipwrecks. The alterations of the Baker's Island Lighthouse and the wreck of the *Union* that followed is a classic example of James C. Scott's argument in *Seeing Like a State*. Scott argues the state's good intentions did not always square with the reality of the situation and sometimes good intentions by the state led to bad outcomes.¹⁰

The government's involvement in innovation and practical science, however, was also quite uneven. This was due in part to the how the state appropriated money to science and the arts as well as how the state managed its involvement in those fields. In terms of appropriations, the state was limited in its financial resources at the end of the eighteenth century and for a significant portion of the early nineteenth century. Congress had to prioritize those resources and divide them as they saw fit. This often left the agencies involved in practical science short of the money they needed to adequately perform their duties and engage in science. On the management side, Congress did not legislate science and the arts, but instead left decisions of agency oversight to the superintendents of the various organizations. These superintendents took it upon

¹⁰ James C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition have Failed*, (New Haven, CT: Yale University Press, 1999), 247, 258, 287, 408.

themselves to craft scientific agendas and pursue science within their departments. Thus, the state built its knowledge base through scientific-minded institutions such as the Army Corps of Engineers, the Coast Survey and the Light-House Service. As these institutions gained a respect for their scientific endeavors, their skills became more valuable to the general good of the nation and the demand for their expertise grew exponentially.

STRUCTURE OF DISSERTATION

Chapter 2 examines the role of commerce in innovation, practical science and the arts in the early United States. This opening chapter introduces commerce as an important factor shaping American innovation and identifies some of the problems facing the nation's commerce. The chapter also looks at what science and the practical arts meant to inventors, merchants, and even consumers. Individuals were undoubtedly concerned with profits, but they were also interested in solving everyday problems. Maritime disasters and port efficiency were major concerns for the individuals. Many of the inventors discussed in the following chapters were actually merchants who tinkered on the side. Others were retired shipmasters whose maritime experience provided them with an intimate insight into the commercial needs of their local communities, states, and the nation as a whole. A few of the innovators were even government agents. Most of these inventors, however, engaged in tinkering because they saw an opportunity to solve commercial problems and possibly make a small profit from their efforts. Few expected to get rich or to make innovation their livelihood.

Chapter 3 introduces the environmental need for practical science and the involvement of the state. The chapter identifies ways in which the natural world shaped innovation and science in the early nineteenth century United States. The environment

posed many challenges for Americans with regard to commerce. From the dangerous shoals and maritime hazards to the obstructed views of approaching ships, the natural world created both a need for science and the arts as well as a space in which science and innovation could thrive. The environment provided resources for innovation and science. Contractors used the environment's natural resources to build lighthouses and marine telegraph stations, often drawing on the immediate area surrounding the structure for the necessary building materials. Elevated spaces gave these structures the height needed to observe or warn approaching ships. In other cases, the environment presented challenges that individuals and the state sought to overcome. At Carysfort Reef off the Florida Keys, the hollow shoal forced engineers to redesign the foundation of an offshore lighthouse in order to properly anchor it to the sea floor. For the marine telegraph, the environment influenced the use of particular colors on signal flags due to those colors' higher visibility in various weather conditions.

Chapter 4 provides a scientific and technological solution to the commercial and environmental challenges laid out in the first two chapters. That solution was the Light-House Establishment. Chapter 4 examines the science and innovation that occurred in the Light-House Establishment prior to the 1850s. Similar to Hugh Richard Slotten, Thomas G. Manning, and Todd Shallat's narratives of the Coast Survey and Army Corps of Engineers, Chapter 4 argues the Light-House Establishment was one of the state's first scientific enterprises. This argument goes against many of the mainstream histories of the

Light-House Establishment, which portray the agency as anti-science.¹¹ At issue with the previous narratives is what constitutes science in the early United States to make the assumption that the Establishment was anti-science. Chapter 4 looks at a variety of innovations and experiments conducted under the aegis of the Light-House Establishment to demonstrate the extent that the establishment engaged in scientific practice. Many of the innovations and experiments discussed in this chapter not only meet the criteria of science in the early nineteenth century, but would also qualify as science in a more modern twentieth century understanding of the term.

The state's involvement in innovation and science was also influenced by the political climate of the time. Republican values, such as civic duty, prudence, honesty, and self-reliance, played an important role in shaping the state's involvement with science. Chapter 5 looks specifically at these republican values and argues for their role in shaping the state's involvement in innovation, practical science and the arts.

Americans articulated these republican values during the revolutionary period. After the American Revolution, republicanism continued to dominate political thought well into the nineteenth century. The irony of American republicanism is that the ideology often appeared opposed to science even though its leader, Thomas Jefferson, was intimately engaged in natural philosophy, practical science, and the arts. This, however, was clearly not the case and Chapter 5 makes an argument for how Jeffersonian republicanism shaped scientific progress in the United States in the first half of the nineteenth century.

¹¹ Francis Ross Holland, Jr., *America's Lighthouses: An Illustrated History*, (1972; repr., New York: Dover Publications, 1988). Theresa Levitt, *A Short Bright Flash: Augustin Fresnel and the Birth of the Modern Lighthouse*, (New York: W. W. Norton & Company, 2013). Eric Jay Dolin, *Brilliant Beacons: A History of the American Lighthouse*, (New York: Liveright Publishing, 2016).

Most scholars of Jeffersonian republicanism, including Drew R. McCoy and Lance Banning, fail to discuss republican values in relation to science in the early United States.¹² John Lauritz Lawson and Daniel Walker Howe may be two exceptions. Lawson and Walker discuss republicanism in broad terms as they discuss internal improvements, but their narratives imply the relationship between science and republicanism more than implicitly stating the connection.¹³

The final chapter examines the state's uneven involvement in scientific practice by exploring the three aforementioned state agencies, how they interacted with each other, and how they used innovation, practical science, and the arts to meet the nation's needs and advance the scientific enterprise in the United States. This chapter shows how science and innovation were part of a broader system of commercial governance. Previous histories of the Army Corps of Engineers, Coast Survey, and Light-House Establishment have examined the institutions in isolation and have looked internally at

¹² Drew R. McCoy, *The Elusive Republic: Political Economy in Jeffersonian America*, (1980; repr., Chapel Hill: UNC Press, 1996). Lance Banning, *The Jefferson Persuasion: Evolution of a Party Ideology*, (Ithaca, NY: Cornell University Press, 1980).

¹³ John Lauritz Larson, *Internal Improvement: National Public Works and the Promise of Popular Government in the Early United States*, (Chapel Hill: UNC Press, 2001). Daniel Walker Howe, *What Hath God Wrought? The Transformation of America, 1815-1848*, (New York: Oxford University Press, 2009).

the individual agencies.¹⁴ The final chapter seeks to remedy those errors.

CHRONOLOGICAL AND GEOGRAPHICAL SCOPE

I set the perimeters of the project between the establishment of the constitutional government in the United States and the American Civil War. I set these perimeters, because of how I define the state's involvement in innovation and practical science. Generally, in referring to the state, I am referring to the federal government and all of its entities. Prior to the ratification of the constitution, the individual states held more power under the Articles of Confederation. This limited the federal government's relationship to science, technology, and commerce. At the other end of the spectrum, the American Civil War marked a drastic turning point in the history of the United States. By the outbreak of hostilities in 1860, the state was fully engaged in commerce, science and technology. Additionally, by the mid 1850s, most of the historical actors in this study were dead.

¹⁴ Hugh Richard Sloten, *Patronage, Practice, and the Culture of American Science: Alexander Dallas Bache and the U.S. Coast Survey*, (New York: Cambridge University Press, 1994). Todd Shallat, *Structures in the Stream: Water, Science, and the Rise of the U.S. Army Corps of Engineers*, (Austin: University of Texas Press, 1994). Thomas G. Manning, *U.S. Coast Survey vs. Naval Hydrographic Office: A 19th Century Rivalry in Science and Politics*, (Tuscaloosa, AL: University of Alabama Press, 1988). Henry E. Barber and Allen R. Gann, *A History of the Savannah District U.S. Army Corps of Engineers*, (Savannah, GA: Savannah District USACE, 1989). Frank N. Schubert, ed., *The Nation Builders: A Sesquicentennial History of the Corps of Topographical Engineers, 1838-1863*, (Fort Belvoir, VA: USACE, 1988). Aubrey Parkman, *Army Engineers in New England: The Military and Civil Work of the Corps of Engineers in New England, 1775-1975*, (Waltham, MA: USACE New England Division, 1978). Harold Kanarek, *The Mid-Atlantic Engineers: A History of the Baltimore District U.S. Army Corps of Engineers, 1774-1974*, (Washington: Superintendent of Documents GPO, 1975). George Rockwell Putnam, *Lighthouses and Lightships of the United States*, (New York: Houghton Mifflin Co., 1917). Francis Ross Holland, Jr., *America's Lighthouses: Their Illustrated History Since 1716*, (Brattleboro, VT: Stephen Greene Press, 1972). Dennis L. Noble, *Lighthouses and Keepers: The United States Lighthouse Service and Its Legacy*, (Annapolis, MD: Naval Institute Press, 1999).

Geographically, this study is mostly limited to the Atlantic coast, Great Lakes, and Gulf coast where the majority of the Army Corps of Engineers, Coast Survey, Light-House Establishment, and private marine telegraph's work took place between 1789 and 1860. This is not meant to discount the scientific work of these institutions occurring on the Pacific coast, which for the most part, did not occur until the very latter part of this study. Including work on the Pacific coast may be an area of consideration should this dissertation ever become a published manuscript.

CAST OF IMPORTANT CHARACTERS

The individuals highlighted in this study were a diverse lot. They came from every walk of life – rich, poor, and middle-class –, included various ethnicities and races, and comprised both men and women of every age. Children were not excepted. A few individuals make repeated appearances throughout the narrative. It is therefore necessary to introduce this important cast of characters here.

James Elford was a retired sea captain and prominent figure in Charleston, South Carolina until his death in 1826. Elford migrated to Charleston from Bristol, England. In the late 1810s, Elford established a navigational school on East Bay Street directly across from the Merchant's Exchange. Understanding the commercial needs of Charleston's merchants and shipmasters, Elford designed a semophoric system for communicating between ships and the shore, which he patented in 1823. While most others involved in marine telegraphs applied the science locally, Elford envisioned a universal system that could be used by any ship, in any port, at any time and still be understood by all who were familiar with the system.

Ferdinand Rudolph Hassler was a Swiss mathematician who immigrated to the United States after conducting several government-sanctioned surveys in Europe. Hassler's presence in the United States was instrumental in the establishment of the Coast Survey. Thomas Jefferson and the American Philosophical Society both supported the creation of the Coast Survey as a means for providing Hassler with employment for his scientific expertise. Congress approved Hassler's appointment as the first Superintendent of the Coast Survey in 1807. Hassler was removed as Superintendent of the Coast Survey in 1816 when an act of Congress prohibited civilians from participating in the survey, but was reappointed as superintendent of the survey in 1832 because of the lack of progress made by the military. Hassler remained the Superintendent of the Coast Survey until his death in 1843.

Benjamin Henry Latrobe was the United States' "first" architect and engineer. He studied in England under Samuel Pepys Cockerell and John Smeaton, respectively before coming to the United States. Latrobe was appointed the Chief Surveyor of Public Buildings, oversaw the construction of the Bank of Philadelphia and the dome on the United States Capitol Building. In the first decade of the 1800s, Latrobe designed an elaborate lighthouse structure for the mouth of the Mississippi River. His designs were held up by the inaction of Congress and the War of 1812. The Treasury Department, which oversaw the Light-House Establishment, ultimately approved a design by Latrobe's son, however because Latrobe's son succumbed to yellow fever, the elder Latrobe later supervised construction of the lighthouse. Latrobe succumbed to yellow fever in 1820.

Lieutenant Isaiah William Penn (I. W. P.) Lewis was an engineer in the Army Corps of Engineers' Topographical Bureau and the nephew of the Light-House Establishment's main contractor, Winslow Lewis. In the mid-1830s, Lieutenant Lewis was commissioned to conduct a survey on the condition of the Light-House Establishment. His report was extremely critical of Stephen Pleasonton's administration of the Establishment and of his uncle's contract work for the agency. Lieutenant Lewis invented an oil lamp for use in the Light-House Establishment and was a staunch supporter of importing the French-made Fresnel lens to improve coastal lighting. Lieutenant Lewis also designed the Carysfort Reef Lighthouse in the late 1840s.

Winslow Lewis was a retired sea captain from Wellfleet, Massachusetts who tinkered with inventing and improving lighting apparatuses for ships and coastal navigations. In 1810, Lewis patented a knock-off of Ami Argand's oil lamp and sold the patent to the United States government. Lewis' contract with the government called for him to maintain the lamps and provide oil to all of the nation's lighthouses. He later began contracting to build lighthouses for the Light-House Establishment. Lewis maintained his contract for supplying the Establishment with his patented lamp and reflector system until the early 1850s. In the mid to late 1810s, Lewis became embroiled in a patent lawsuit with his business partner, David Melville.

Lieutenant George Gordon Meade was an engineer in the Army Corps Topographical Bureau. He later became known as the Union general who opposed General Robert E. Lee at the Battle of Gettysburg. Lieutenant Meade was assigned to build the Brandywine Shoal Lighthouse in the Delaware Bay in 1848, where he first learned of and used the screwpile foundation pioneered by Alexander Mitchell, a blind

Irish engineer. In the early 1850s, Lieutenant Meade was assigned to build lighthouses in Florida. One of Lieutenant Meade's assignments was the completion of the Carysfort Reef Lighthouse. Captain Howard Stansbury started construction on the Carysfort Lighthouse, but was reassigned to survey the Great Salt Lake in Utah. During the construction of the Carysfort Reef Lighthouse, engineers had to modify the proposed screwpile foundation design and created what is now known as the diskpile foundation. Due to the change in leadership at Carysfort, some historians credit Lieutenant Meade with the invention of the diskpile foundation. It is more plausible to believe the diskpile foundation was already installed by the time Meade arrived. Meade invented a hydraulic oil lamp that he installed at the Sand Key Lighthouse, which was later adopted by the Light-House Board for general use.

David Melville was a Newport, Rhode Island stationer and hardware merchant. In the first and second decades of the nineteenth century, Melville became interested in natural gas lighting. He formed a business partnership with Winslow Lewis to promote natural gas lighting for homes and businesses. In Melville's spare time, he tinkered with improvements to the Argand style oil lamp.

Lemuel Moody was a retired sea captain from Portland, Massachusetts (Maine after the Missouri Compromise of 1820) who established a marine telegraph station in 1807 based on Captain David Porter, Sr.'s signals in Baltimore. Moody also created maps and charts of Portland's harbor in 1825. Moody ran the telegraph until his death in 1846.

John Rowe Parker was a Boston merchant who invested in the marine telegraph, particularly the system designed by James Elford of Charleston, South Carolina. Parker's main business was the Franklin Music Warehouse, which sold musical instruments and

sheet music. As an agent of Elford's system, Parker sought to universalize the marine telegraph from the 1823 until his death in 1844. His telegraph operators, Charles Beck, Frederick W.A.L. Brown, and Jonathon Bruce all conducted scientific experiments on cloths and dyes.

Stephen Pleasonton served as the Fifth Auditor of the Treasury from 1820 until the early 1850s. During his tenure as Fifth Auditor, Pleasonton was charged with overseeing the Light-House Establishment. His administration came under heavy criticism in the mid to late 1830s because of his failure to import the superior Fresnel lighthouse lens and the poor overall condition of the nation's lighthouses.

Captain David Porter, Sr. established the first marine telegraph in the United States on Federal Hill overlooking the Patapsco River in Baltimore in 1797. He was the grandfather of Admiral David Porter and the great-grandfather of Commodore David Dixon Porter. Admiral Porter served in the Barbary Wars and the War of 1812. Commodore David Porter served in the American Civil War.

Captain Howard Stansbury was an engineer with the Army Corps of Engineers Topographical Bureau. Stansbury was assigned to build the Carysfort Reef Lighthouse, which utilized a design by Irish engineer Alexander Mitchell known as the screwpile foundation. Sources appear to support Stansbury as the originator of the diskpile innovation that derived from the screwpile, but as stated earlier, some historians claim the invention was the work of Lieutenant George Gordon Meade.

RELEVANT HISTORIOGRAPHY

As Ann Johnson noted in her essay “STEM in the EAR,” science and technology are mostly invisible in the historiography of the early United States.¹⁵ Johnson argues this invisibility is due to the “ubiquity, as much as its poor resemblance to post-WWII science.”¹⁶ A small handful of works from the late 1980s to the present confirm Johnson’s assessment. These works include Judith McGaw’s *Most Wonderful Machine* (1989), Carroll Pursell’s edited volume *Technology in America* (1990), Eda Kranakis’ *Constructing a Bridge* (1996), John F. Kasson’s *Civilizing the Machine* (1999), David E. Nye’s *American Technological Sublime*, and Andrew J. Lewis’ *A Democracy of Facts* (2011).¹⁷ Aside from Lewis, most of the works discussing science and technology in the early United States do not limit themselves to that period and go well into the latter part of the nineteenth century. McGaw’s narrative, for instance, chronicles papermaking in Berkshire, Massachusetts through the mid 1880s and Nye’s study includes a discussion on the sublimity of electricity in the late nineteenth century. Science and technology in the history of the early United States is thus scattered and sporadic in the literature and historians must attempt a scavenger hunt of sorts to locate relevant information.

¹⁵ Ann Johnson, “STEM in the EAR,” *Journal of the Early Republic* 36, no. 1 (Spring 2016), 2.

¹⁶ Johnson, 3.

¹⁷ Judith A. McGaw, *Most Wonderful Machine: Mechanization and Social Change in Berkshire Paper Making, 1801 – 1885*, (Princeton, NJ: Princeton University Press, 1992). Carroll Pursell, *Technology in America: A History of Individuals and Ideas*, 2nd Edition (Cambridge, MA: MIT Press, 1990). Eda Kranakis, *Constructing a Bridge: An Exploration of Engineering Culture, Design, and Research in Nineteenth-Century France and America*, (Cambridge, MA: MIT Press, 1996). John F. Kasson, *Civilizing the Machine: Technology and Republican Values in America, 1776 – 1900*, (New York: Penguin Books, 1999). David E. Nye, *American Technological Sublime*, (Cambridge, MA: MIT Press, 1999). Andrew J. Lewis, *A Democracy of Facts: Natural History in the Early Republic*, (Philadelphia: UPenn Press, 2011).

Johnson's own work examines the role of engineers in "shaping the nation – both physically and culturally – in the early republic."¹⁸ Johnson asks scholars to consider "what counted as science?" and "why did a particular activity or body of knowledge count as science?"¹⁹ If scholars follow Johnson's advice and consider the stakes for "making a claim of being scientific" in the period, it becomes easier to identify science and technology in the history of the early United States and thus easier to write about it.²⁰ Science was not just practiced by great men such as Thomas Jefferson, Joseph Henry, and Alexander Dallas Bache. It was also practiced by the James Elfords, Winslow Lewises, David Melvilles, and Lemuel Moodys of the world. This study thus adds to the history of science and technology in the early United States with its attempt to answer Johnson's question of "what counted as science" and considering the work of everyday people in those terms.

¹⁸ Johnson, 3.

¹⁹ Johnson, 4.

²⁰ Johnson, 4.

CHAPTER 2

SCIENCE, TECHNOLOGY, AND AMERICAN COMMERCE

Commerce was the driving force behind many Americans' involvement in practical science and the mechanical arts. Commerce, however, was intricately tied to shipping and navigation in the late eighteenth and early nineteenth centuries. Shipping and navigation came with its own set of challenges. Navigating the open sea required mariners to understand the principles of astronomy because they used the stars to pinpoint their location. Navigating the shipping lanes and coastal waters were fraught with numerous hazards. Protecting commerce meant having to solve these commercial challenges and many Americans found solutions to these challenges by engaging in scientific practice. In fact, solving commercial problems drove many Americans to science and the arts who otherwise might not have ventured into those fields. What follows are examples that illustrate the types of commercial problems Americans faced and the solutions they created for those problems using practical science and the mechanical arts.

In 1798, a Wellfleet, Massachusetts shipmaster named Winslow Lewis wrote to the Secretary of the Treasury, Albert Gallatin, that he, Lewis, "was passing a Barber shop in Boston and observed an Uncommon Light being thrown into the street from the window." Lewis' curiosity with the light led him into the barber's shop where he discovered the shop owner "had got a Lenses [sic] about two inches in Diameter Placed into the Window behind which he had a Candle." Lewis realized the lens caused the light

to be thrown “a great distance altho the Night was Unusuly [sic] Dark.” He surmised that a similar apparatus “would have a good effect in a Light house.” Lewis set about creating a lens and reflector unit that could be used in coastal beacons. To Lewis’ dismay, however, he “found that the Lenses Could Not be made in this Country of the size Suitable for Light houses.”¹

Lewis returned to the sea following his “discovery.” For the next several years Lewis was “constantly Employed in Foreign Voyages.”² The Embargo Act of 1807, signed into law by Thomas Jefferson, abruptly ended Lewis’ time at sea and Lewis resumed his work in the mechanical arts hoping to support his growing family. Lewis’ tinkering in the mechanical arts resulted in the invention of his “Patent sky Light for ship[’]s decks.” A year later in 1808, Lewis created his “Patent Reflecting bin[n]acle illuminator.”³

Lewis’ inventions met with such great reception that word of his work came to the attention of Commodore John Rodgers. Rodgers was interested in finding a way to provide better lighting for the ammunition magazines on the navy’s ships of war. The naval officer asked Lewis if he could construct an apparatus to that effect. Lewis said he could and for the next several months Lewis tinkered with various materials to construct

¹ Winslow Lewis to Albert Gallatin, March 10, 1812, RG 26, Entry 17E, Box 1, NARA.

² Ibid.

³ Ibid. *Columbian Centinel* (Boston), August 3, 1808, 4. *Boston Commercial Gazette* (Boston), September 29, 1808, 4. *New England Palladium* (Boston), January 17, 1809, 3. A binnacle is a raised platform on a ship’s deck placed near the helm to hold and protect navigational instruments.

something that would satisfy the commodore's request. After four months, Lewis presented his reflecting magazine lantern to Commodore Rodgers.⁴

After patenting his reflecting magazine lantern, Lewis spent a year perfecting his lamp and reflector system (Figure 2.1) for lighthouses that he envisioned in 1798. In May 1810, Lewis received permission from Albert Gallatin to test his lamp and reflector in the Cape Ann Lighthouse north of Boston. The experiment proved successful and Lewis patented his lamp and reflector system that summer.⁵

There are no records indicating how much Lewis made off his binnacle illuminator and reflecting magazine lantern patents. It does not appear that he entered into manufacturing them long term. His patent for the lighthouse lamp and reflector system did not pay dividends until 1812 when the government purchased the rights to the patent. Thus, it appears Lewis did not profit much from his tinkering in the mechanical arts. In November 1810, Lewis returned to the sea and his livelihood as a shipmaster engaged in foreign and transatlantic voyages.⁶

Lewis' November voyage took him to Holyhead, England. While there, Lewis found the lighthouse at Holyhead fitted with reflectors. This discovery must have alarmed Lewis, for upon his return to the United States, Lewis defended his lens and reflector as being solely his idea.

I am confident that there was never a reflector made
before my invention in any Optical principal[.] Now I

⁴ Lewis to Gallatin, March 10, 1812. Lewis writes of Commodore Rogers. It is understood that he means Commodore John Rodgers.

⁵ Ibid.

⁶ Ibid.

have no idea that the principle of reflecting and magnifying by reflectors [&] lenses was ever before attempted. The principle of my reflector is allowed by all scientific men to be a thing not before known. that the Whole Combination of the apparatus is not an invention of mine never has been doubted. I can aDD no stronger proof than my oath on the specification [sic] – Mr. Loy [&] Mr. Quincy, Mr. Turner [&] Mr. Green - all have long known me [&] are well acquainted with my character [&] the progress of my inventions from the commencement of them.⁴

Although Lewis installed his lamp and reflector in the Cape Ann lighthouse before his visit to Holyhead, the impulsiveness of his defense seems suspicious; almost self-incriminating. According to the British lighthouse engineer Alan Stevenson, Britain had been using a parabolic reflector in their lamps since at least 1794, or almost 20 years before Lewis patented his system in the United States.⁵ Captain R. R. Crocker testified in a letter to revenue collector John P. Norton that “Captain Winslow Lewis, of Boston, took the plan of the house and reflectors at Holyhead.”⁶ Several historians, including Amy K. Marshall, Terry Pepper and Wayne Wheeler, have also claimed Lewis “stole”

⁴ Lewis to Gallatin, March 10, 1812. In the original text, Lewis used the capital letter Q to represent the ampersand symbol.

⁵ United States Congress, *Documents in relation to the Light-house establishment*, 25th Cong., 2nd sess., 1838, S. Doc. 258, 19.

⁶ S. Doc. 258, 18.

the design for his lamp from that of François Pierre Aimé Argand.⁷ Marshall cites Lewis' nephew, Army Corps of Engineers Lieutenant I.W.P. Lewis, who charged his uncle with plagiarizing the lighting of the South Stack Lighthouse at Holyhead.⁸

François Pierre Aimé Argand was a Swiss physicist who patented an oil-burning lamp in 1781. Argand died in 1803, but his lamp had been installed in English lighthouses as early as 1792 and was widely adopted in non-maritime applications throughout Europe.⁹ (It was also introduced in the United States among early republic elites including Thomas Jefferson, James Madison, and George Washington.)¹⁰ As Winslow Lewis had been a shipmaster prior to his inventions in the first decade of the nineteenth century, it is conceivable that he witnessed Argand's lamp on a previous trip to Europe before he installed his lamp and reflector at Cape Ann. Argand's patent in England, however, was invalidated due to similar lamps being in use prior to issuing the patent. Correspondence of Johann Sabastian Clais in the Conservatoire des Arts et Metiers in Paris indicate Argand witnessed a demonstration of Benjamin Franklin's oil lamp in England and returned to Paris to construct a lamp of Argand's own design.¹¹

⁷ Amy K. Marshall, "Frequently Close to the Point of Peril: A History of Buoys and Tenders in U.S. Coastal Waters, 1789 – 1939, (MA thesis, East Carolina University, 1997), 11. Terry Pepper, "Argand and Lewis Lamps: The Intriguing Story of the First lamps used in US Lighthouses," *Seeing the Light: Lighthouses of the Western Great Lakes*, December 2, 2007, <http://terrypepper.com/lights/closeups/illumination/argand/lewis-lamp.htm>, (accessed June 2, 2015). Wayne Wheeler, "Winslow Lewis: A Nineteenth-Century Lighthouse Scalawag," *Keeper's Log* (Summer 2005): 18-24.

⁸ Marshall, 11.

⁹ John J. Wolfe, *Brandy, Balloons, & Lamps: Aime Argand, 1750-1803*, (Carbondale, IL: Southern Illinois University Press, 1999), 117, 119, 124, 139, 170.

¹⁰ *Ibid.*, 46.

¹¹ *Ibid.*, 81.

After Argand's patent was invalidated in Britain, the French Minister forced Argand to end his patent dispute with Ambrose L'Ange and file joint ownership of the invention.¹²

Regardless of the origin of Lewis' lighthouse lamp, its successful use in beacon at Cape Ann prompted him to solicit the federal government for adoption in all of the nation's lighthouses.

The Patent having always had in mind the view the Service he might render the public and in particular navigation more than pecuniary emoluments will convey his Patent right to the United States for twenty thousand dollars, this to include the Patent rights for the Lights already fitted as he has never received any compensation whatever for his time employed in fitting the three lights now in operation.¹³

The success of Lewis' lamp was the reduction in oil consumption. According to a Mr. W. Carrington, Lewis' workman who attended to the lamps at Cape Ann, the twelve lamps in Lewis' new system consumed 30 gallons of oil from May 15, to June 23, 1811. Previously, the lighthouse consumed 28 gallons per week.¹⁴

Lewis further agreed to eliminate the government's risk in purchasing his patent rights by giving "satisfactory Bonds such as shall be deemed good security to reimburse the money paid for the Patent as well as every Expense government may have been at [sic] in Fitting up the Light houses in the New system if they should be found not to

¹² Ibid., 98-9.

¹³ Winslow Lewis to Albert Gallatin, February 1812, RG 26, Entry 17E, Box 1, NARA.

¹⁴ W. Carrington, "Affidavit," RG 26, Entry 17E, Box 1, NARA.

answer the purpose now calculated & that the saving of oyl [sic] is not equal to one half the quantity consumed in the present system.” Lewis also warranted his system for seven years after it had been installed in a lighthouse. At the time, the Treasury Department could not authorize wider adoption of Lewis’ lamp as “extending the improvement to all the light houses...would however exceed the ordinary appropriations.”¹⁵

Albert Gallatin deemed Lewis’ scientific enterprise as a “great success” for the United States “both as to the brilliancy of the light and the saving of the oil.” As Secretary of the Treasury and the man responsible for overseeing the nation’s lighthouses, Gallatin begged leave of Congress to “lay the subject before the committee of commerce and manufactures,” for a decision on the expense.¹⁶ The Committee on Commerce and Manufactures responded favorably to Gallatin’s request finding it “proper to authorize the expense” and “introduce an item to that effect in the general appropriation law.”¹⁷ Lewis’ contract with the federal government, commenced March 26, 1812.

The contract called for Lewis to be paid “the sum of Twenty Four Thousand Dollars” plus “a rate of five hundred dollars a year, for keeping all apparatus as aforesaid in repair during seven years.”¹⁸ By 1817, Lewis had fitted up every lighthouse in America

¹⁵ Albert Gallatin to Thomas Newton, December 4, 1811 in United States, Department of the Treasury, *Documents accompanying a bill to authorize...purchase of Winslow Lewis his patent-right to the new and improved method of lighting....*, (Washington, DC: R.C. Weightman, 1812), 3, PRHC, no. 338, HAG.

¹⁶ Ibid.

¹⁷ Ibid.

¹⁸ “Contract with Winslow Lewis for Lighting the Lighthouse Service in the United States, 26 March 1812 revised 9 March 1813, Conveying Winslow Lewis Patent to the United States,” RG 26, Entry 17E, Box 1, NARA.

with his lamp and reflector system. The government renewed Lewis' contract that same year for fitting up any new lighthouses that were to be built.¹⁹

As Lewis' lighthouse lamp and reflector example demonstrates, science and commerce were intricately related in the early United States; a fact that could be the subject of an entire book. This chapter seeks to explore two aspects of the science – commerce relationship in the first half of the nineteenth century in America. First, Americans used practical science and the mechanical arts to solve commercial problems. Although the United States was expanding westward, the nation's commerce remained heavily dependent on shipping and global trade. Commercial problems were often shipping problems. Sometimes solving commercial problems meant protecting commerce from the natural world. Lewis almost immediately recognized the utility of placing a lens in front of a lighthouse lamp to protect shipping. The lens provided for a stronger illumination by projecting the light further into the darkness, which in turn allowed better visibility in adverse weather and better discernibility of underwater hazards. At other times, solving commercial problems might mean improving port operations. The marine telegraph, for instance, solved the problem of ships arriving unannounced. The arrival or unannounced ships delayed the collection of customs duties, unloading of cargoes, and selling of imported goods. These delays directly impacted the efficiency of shipping by indirectly causing ships to lay idle in port for longer periods of time.²⁰ As most merchants

¹⁹ Winslow Lewis, *Description of the light houses on the coast of the United States*, (Boston: Thomas G. Bangs, 1817), 16, PRHC, no. 427, HAG.

²⁰ According to Jennifer Karns Alexander, "efficiency" did not obtain its quantitative definition until the late nineteenth century. I use the term here for ease of understanding despite its ahistorical nature for the period under consideration. Jennifer Karns Alexander, *The Mantra of Efficiency: From Waterwheel to Social Control*, (Baltimore: JHU Press, 2008), 2.

and shipmasters knew, a ship only makes money while it is sailing. Ships lying idle in port for extended periods of time was, and still is, a drag on the commercial economy.

Second, science and the practical arts provided commercial opportunities for those engaged in scientific practice. Science allowed individuals, such as Lewis, to profit from their ideas and skills. Whether or not Lewis was entitled to a patent on his lamp and reflector system is a separate issue. The fact that Lewis profited handsomely from his patents illustrates the types of opportunities created by science and the mechanical arts. Science and the mechanical arts did not limit who could participate in the scientific enterprise. Early republic entrepreneurs with little to no scientific training or background in the practical arts seized upon these opportunities. In the United States, science and mechanical arts were not limited to the educated elite natural philosophers, but instead were performed by anyone who had the financial means or the intellectual ability to work in those fields. Andrew J. Lewis's study of natural philosophy in the early American republic indicated this was the democratization of natural philosophy.²¹

HISTORIOGRAPHY

Literature on intersection of science and commerce in the early United States is spread sporadically throughout historical narratives on the history of science. Christopher Beauchamp's *Invented by Law* (2015), for instance, dedicates the first chapter of his narrative on Alexander Graham Bell and the invention of the telephone to the exploring the role of United States patent law in promoting commerce in the early American republic. Beauchamp argues, "patenting activity grew less from specific developments in

²¹ Andrew J. Lewis, *A Democracy of Facts: Natural History in the Early Republic*, (Philadelphia: UPenn Press, 2011), 2-4.

technology than from broad-based economic factors.”²² Similarly, the final chapter in James Delbourgo’s *A Most Amazing Scene of Wonders* (2006) explores the world of physicians selling electrotherapies to the public for improved health. Delbourgo claims charlatan doctors sold electric tractors to unsuspecting consumers for as much as \$25 dollars a set. The tractor was a set of two small metallic rods measuring approximately three inches in length. The rods were constructed of iron and brass which the quack physician claimed used electricity to cure certain ailments when the rods were passed over the body.²³ And Andrew J. Lewis’s *A Democracy of Facts* (2011) uses a single chapter to explore the market economy of plants and rocks in the expansion of knowledge. Lewis puts forth the idea that naturalists bought plant and rock specimens from “ordinary Americans” as a means for increasing the naturalists’ knowledge.²⁴

Full length narratives on the intersection of science and commerce often focus on manufacturing and distribution. Judith McGaw’s *Most Wonderful Machine* (1987), for instance, explores the social and cultural impact of mechanization in the early American paper making industry. Part of that social change was the advent of steamboat transportation and the opening of the Erie Canal. McGaw argues these forces, along with improvements in factory mechanization, opened new markets for the Berkshire paper manufacturers and increased Berkshire’s share of business in New York City. Daniel Walker Howe’s *What Hath God Wrought* (2007) examines how improvements in transportation and communication expanded the American economy between the War of

²² Christopher Beauchamp, *Invented by Law: Alexander Graham Bell and the Patent that Changed America*, (Cambridge, MA: Harvard University Press, 2015), 19.

²³ James Delbourgo, *A Most Amazing Scene of Wonders: Electricity and Enlightenment in Early America*, (Cambridge, MA: Harvard University Press, 2006), 239-41.

²⁴ Andrew J. Lewis, 48.

1812 and the Mexican-American War. Howe argues these developments helped diversify the American economy, placing industry on the same foothold as agriculture. Perhaps the best narratives exploring the intersection of science and commerce is Paul Lucier's *Scientists and Swindlers* (2008). Lucier argues American men of science were entrepreneurs engaged in self-promotion. Lucier sees this scientific entrepreneurship as the foundation for the rise of the consulting industry and subsequently the rise of scientific corruption.²⁵

While the importance of McGaw's and Howe's studies are unquestioned, they diminish the fact that America remained tied to the ocean for much of its commerce and economy. This chapter focuses on the shipping side of commerce and seeks to demonstrate the role of science and the practical arts in promoting commerce within a maritime context. Additionally, this chapter most closely fits with Lucier's *Scientists and Swindlers* in arguing that those engaged in science and the practical arts were merchants and businessmen more than they were scientists and artisans. Similar to Lucier's narrative, this chapter also looks at the commercial corruption the merchants' innovations.

SOLVING COMMERCIAL PROBLEMS

Commerce in the early American nineteenth century was fraught with many problems. First, physical geography and the environment posed obstacles that endangered cargos and the lives of mariners. Mariners, merchants, shipmasters, public officials, and anyone with an interest in commerce sought to reduce these dangers, or at least the losses associated with these hazards. Additionally, the Light-House Establishment and Coast

²⁵ Paul Lucier, *Scientists and Swindlers: Consulting on Coal and Oil in America, 1820 – 1890*, (Baltimore: JHU Press, 2008), 2-4, 7-8.

Survey were established with these ends in mind, while the Army Corps of Engineers eventually assumed the role of building the public infrastructure for ensuring the safety of commerce. Second, British impressment of American sailors robbed the young nation's commerce of much needed labor. Political leaders, such as Connecticut Congressman Samuel W. Dana, believed accurate charts and maps could reduce these infractions on American commerce. Finally, inefficient shipping processes caused merchants and ship owners to lose money when their vessels lay idle in port for extended periods. Although efficiency is rarely mentioned specifically in the historical documents, (it is often masked in the language of expediency), the concern over inefficient processes is easily found in the actions of those concerned with commerce. Several historians, including John K. Moulton, Marc Levinson, Kenneth Pomeranz, and the trio of Alex Roland, W. Jeffrey Bolster, and Alexander Keyssar all acknowledge the importance of efficiency in shipping in the first half of the nineteenth century, even though, as previously noted, the term itself did not obtain its quantitative definition until later in the nineteenth century.²⁶ Solving these commercial problems, and others, became a priority for many Americans and pushed them to pursue scientific endeavors to preserve America's commercial enterprise.

THE PROBLEM OF SHIPWRECKS

One of the biggest commercial problems of the early United States was providing for safe passage of cargoes, passengers, and crew. As commerce and shipping increased

²⁶ John K. Moulton, *Captain Moody and His Observatory*, (Falmouth, ME: Mount Joy Publishing, 2000), 17-8. Marc Levinson, *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger*, (Princeton: Princeton University Press, 2008), 10-2. Kenneth Pomeranz, "An Inventory of Success," *World Trade* 9, no. 9 (September 1996): 112. Alex Roland, W. Jeffrey Bolster, and Alexander Keyssar, *The Way of the Ship: America's Maritime History Reenvisioned, 1600-2000*, (Hoboken, NJ: John Wiley & Sons, Inc., 2008), 88. Alexander, *The Mantra of Efficiency*, 2.

with the growth of the United States in the early nineteenth century, the rate of maritime disasters increased. According to historian Donald Shomette, the Chesapeake Bay, upon which Baltimore was the leading port, witnessed nearly 140 shipwrecks between the 1790 and 1850.²⁷ The approaches to Boston fared worse. Minot's Ledge near Cohasset Harbor south of Boston became a graveyard for more than 40 ships between 1832 and 1841; an average of more than four groundings annually. Cape Cod proved even more hazardous claiming an average of 50 wrecks annually in the 16 years between 1843 and 1859 and a high of more than 82 marooned ships in 1844 alone.²⁸

Shipwrecks disrupted the local economy. In the early nineteenth century United States, a ship's cargo averaged between \$300,000 and \$400,000 with the ship owner realizing at least a 30% profit.²⁹ With so much money riding on a single voyage, the loss of even one ship could easily bankrupt a local merchant. This was the case with the wreck of the *Union* in 1817, which was highlighted in the previous chapter. Although the ship's owners, Stephen Phillips and George Pierce, carried insurance on the *Union* and its cargo, the loss exceeded the insurance by \$35,000 (\$599,000 in 2013 dollars).³⁰ This loss reverberated through the local economy in the loss of income, employment, and tax

²⁷ Donald Shomette, *Shipwrecks of the Chesapeake: Maritime Disasters on the Chesapeake Bay and Its Tributaries, 1608-1978*, (Centerville, MD: Tidewater Publishers, 1982), 248-52.

²⁸ Edward Rowe Snow, *Great Storms and Famous Shipwrecks of New England*, 3rd ed. (Boston: The Yankee Publishing Co., 1946), 368-74.

²⁹ Victor St. Laurent II, "Newport: Revival and Decline, 1783-1876," (MA Thesis, University of Rhode Island, 1969), 85.

³⁰ James Risk, "Ship to Shore: Infrastructure and the Growth of American Seaports, 1790 – 1850," (MA Thesis, UMBC, 2011), 24-7, 36, 38. Samuel H. Williamson, "Seven Ways to Compute the Relative Value of a U.S. Dollar Amount, 1774 to present," *MeasuringWorth*, 2015, <http://www.measuringworth.com/uscompare/> (accessed May 15, 2015).

revenues.

The loss of a ship disrupted the national economy as well through the loss of customs duties. As United States Congressman James Jackson of Savannah acknowledged, “commerce would be embarrassed and our revenue will be lessened and destroyed” by the failure to provide safe passage for shipping.³¹ Jackson noted, “the revenue of the United States is to be derived from navigation and commerce.”³² In 1823, for instance, annual customs duties accounted for slightly more than 88 percent of the total federal income.³³

In addition to disrupting the local and national economies, historian Jamin John Wells notes shipwrecks also impacted the social, material, and cultural world.³⁴ The loss of life, or even the possibility of loss, brought communities closer together in mourning and the concern over the fate of loved ones. The hardships of loss were often comforted and relieved through churches or charitable organizations such as the Portland Marine Society. Material goods lost in shipwrecks could be replaced, at an expense, with another shipment, but until then, the loss of material goods left a void in the lives many. Rich socialites would have to survive a little while longer without the manufactured goods that gave them their societal status while the less privileged would have to do without

³¹ Risk, “Ship to Shore,” 28-9.

³² Ibid.

³³ Christopher Chantrill, “Government Revenue Details: Federal State Local for 1823 – Charts,” *US Government Revenue*, http://www.usgovernmentrevenue.com/year_revenue_1823USmn_13ms1n#usgs302 (accessed February 16, 2013).

³⁴ Jamin John Wells, “The Shipwreck Shore: Marine Disasters and the Creation of the American Littoral,” (Ph.D. Diss, University of Delaware, 2013), 17.

altogether. Culturally, shipwrecks impacted the exchange of knowledge. As goods and lives were lost, so was the knowledge gained from travels to foreign countries.

Ship wrecks nudged Americans toward science as solving this commercial problem immediately became a priority. For the previously stated reasons, Americans sought to protect commerce from shipwrecks and other maritime hazards and they used practical science and the mechanical arts to achieve those ends. The scientific work of private citizens is seen most prominently in the Light-House Establishment, where regional superintendents relied heavily on merchants and inventors for improvements to lighthouse apparatuses. In November 1816, for instance, David Melville, a Newport, Rhode Island businessman, met with Winslow Lewis, William Simons, and Captain George Shearman, the keeper of the Newport Lighthouse. As all four men were either intimately involved with maintaining the lighthouses or were interested in their efficient operation, their conversation turned to the difficulty of keeping the lights lit in sub-freezing temperatures of winter.³⁵ Captain Shearman acknowledged he had experienced difficulties in the winter because the spermaceti oil used by the United States Light-House establishment congealed in temperatures below 30 degrees Fahrenheit, causing the light to extinguish itself.³⁶ Lewis' solution had been to recommend placing a small stove in the lantern room of the lighthouse to keep the air warm and thus the oil in a liquid

³⁵ David Melville, *An exposé of facts... relating to the conduct of Winslow Lewis...addressed to the Hon. the Secretary of the Treasury*, (Providence, RI: Miller & Hutchins, 1819) 4, PRHC, no. 470, HAG.

³⁶ Ibid. Stephen Pleasonton to Thomas Corwin, March 8, 1852 in United States Treasury, *Light-Houses: Letter from the Secretary of the Treasury...in Reply to a Report Made to Congress by the Light-House Board*, by Thomas Corwin, 32nd Cong., 1st sess., 1852, H. Doc. 88, 7.

state.³⁷ While Lewis' suggestion worked in theory, it was hardly a very practical solution. Most lighthouse lanterns barely have enough room for the keeper and the light let alone the addition of a wood- or coal- burning stove. Additionally, carrying a stove up the narrow, often spiral, staircases to the top of the lighthouse was a cumbersome task. The safety of the ships, however, left the keepers with little choice. The preservation of life and commerce mandated they carry out the task regardless of the difficulty.

During the conversation, Melville asked Lewis if there was a way to keep the oil heated without a stove in the lantern of the lighthouse. Lewis responded, "no, my dear Sir, that is impossible." Melville then proceeded to explain to Lewis how one might go about heating the oil using the same flame that burned the oil. Melville then, at Lewis' request sketched out his plan.³⁸

While Melville fully intended to profit from his idea, his improvement to the lighthouse lamp was also driven by the need to protect commerce and the lives of mariners. If the spermaceti oil congealed from the cold winter temperatures, the flame in the lighthouse lamp would extinguish itself. An extinguished beacon created a hazard to mariners and their cargos. Mariners used the lights not only to navigate coastal and underwater hazards, but also to pinpoint their location. An unlit lighthouse could easily result in a shipwreck similar to the previously mentioned wreck of the *Union*. Melville recognized this fact and the importance of his invention, but he only stood to profit from the invention if the congealing of the oil were a real problem for commerce. As will be discussed later, Lewis adopted Melville's plan for adding an oil heating tube to the lamp.

³⁷ Melville, 4.

³⁸ Ibid.

Other industrious individuals also sought to protect commerce through science and the mechanical arts. In 1844, Alonzo Farrar of Boston, for instance, devised a method of protecting a lighthouse's parabolic reflectors from losing their reflective power. Farrar pointed out the reflectors then in use were made of copper and coated with silver. As smoke and dust accumulated on the apparatus, the reflectors required frequent cleanings. Farrar noted that the silver coating often tarnished or wore off as a result of these repeated cleanings. His improvement to protect the reflective finish was to apply a "surface of flint glass, or in fact, what may be termed a parabolic lens (when the reflector is parabolic), and when it is of any other shape, a lens made perfectly symmetrical with the reflecting surface of the mirror" which was then "cemented or hermetically sealed to the mirror or reflector around its perimeter or edge."³⁹ Farrar's patent attempted to provide for the safety of commerce and mariners lives by ensuring a lighthouse's reflector remained consistently brilliant and therefore allowing for the most powerful light.

Protecting commerce was not limited to lighthouse innovations. Throughout the early 1800s, many local entrepreneurs, such as Lewis Brantz of Baltimore and Lemuel Moody of Portland, Maine, took it upon themselves to survey their ports and the surrounding waters for the safety of commerce. In the 1810s, Brantz surveyed Baltimore's harbor and the Patapsco River leading into the port. Brantz's survey employed the latest scientific methods including using lead weights to take depth soundings of the river's bottom. By documenting the depth soundings on his map, which

³⁹ Alonzo Farrar, "United States Patent No. 3,518 – Metallic Reflector," April 4, 1844, 2.

Brantz published in 1819, the cartographer gave mariners an accurate picture of the deep-water shipping lanes approaching the harbor to help guide ships safely to the docks.⁴⁰

Lemuel Moody produced a similar map of Portland in 1825.⁴¹ Moody's map indicated the position the underwater shoals off Stanford Point, Spring Point, and near Little Hog Island (present day Little Diamond Island). Moody charted the shallow shipping lane between Banges Island (present day Cushing Island) and Peake's Island and the narrow passage between Peake's Island and Little Hog Island showing the depth of the water in each instance.⁴² Prior to the Coast Survey's first chart in 1835, it is logical to assume every port had a local entrepreneur who charted the waters for the safety of commercial shipping.

Another problems hindering commerce was the buildup of silt and debris in the harbor. Pile-driven wharves restricted the flow of water adding to the buildup of silt and debris that accompanied normal runoff. Silt and debris reduced the depth of shipping lanes and wharfage making it difficult to conduct business on the water. In 1827, civil engineer Edward Clark proposed building a floating dock

by forming a float of timbers, which is intended to constitute the bottom of the structure, and which, by its buoyancy, is to support a vessel within the dock, with its keel above the surface of the water...this float is to be

⁴⁰ Lewis Brantz, *This Survey of the River Patapsco and part of the Chesapeake Bay*, 1819, BCA, RG 12, Series 11, Folder 8, Item MB3697, Baltimore, MD.

⁴¹ Lemuel Moody, *Chart of Portland Harbour...drawn from the survey of Des Barres with additions and corrections*, (1825), Map FOS 39, MeHS.

⁴² Ibid. Lemuel Moody, *Portland Harbor and Islands and Harbors Adjacent*, (1825), MeHS. Little Hog Island is known today as Little Diamond Island.

made in the form of a large hollow box, formed of strong logs firmly joined together and calked so as to render it water tight. The capacity of the hollow part must be such that when exhausted of water, by means of pumps, it shall be sufficiently buoyant to sustain itself with its load.⁴³

Clark believed his floating dock would provide for the safety of commerce by preventing this build up. The civil engineer submitted his proposal to his peers at the Franklin Institute for their opinion on the expediency, feasibility, and practicality of his proposal, to “which the committee award to the inventor much credit for the ingenuity which the plan displays.” The committee, however, were unable to support the idea of a floating dock, noting that ships “undergo in nearly every instance a change in form after they are launched” causing the floating dock to “be much more liable” because the lift was “calculated to resist the effects of the purpose to which they are to be subjugated.”⁴⁴

From the federal government’s point of view, the task of providing safe passage was left to the Army Corps of Engineers, the Coast Survey, and the Light-House Establishment. Their efforts were sometimes aided by the private marine telegraph. The Army Corps of Engineers removed underwater obstacles, consulted on the dredging of harbors (or physically performed the act of dredging

⁴³ Franklin Institute Committee on Science and the Arts, “Records of the CSA of the Franklin Institute, 1824-1900,” Microfilm Reel 2, “SCI, CIMD, and CIUR Files 1-10, 12, 18, 52: CSA Roll Book, CSA Files 1-204,” CIUR 11, 1, HAG.

⁴⁴ Ibid., 1-3.

themselves), and constructed protective breakwaters all for the safety of commerce.⁴⁵ In 1815, for instance, a hurricane completely destroyed all the docks, several ships, and many warehouses in Newport, Rhode Island because the port lacked the necessary breakwater piers to protect the harbor from storm surges.⁴⁶ In Cape May, New Jersey, businessmen, residents, and public officials feared a similar situation. In 1838, several Cape May individuals, many of them pilots responsible for bringing ships safely into port, petitioned the government for a breakwater to “decrease, if they cannot entirely remove, the evil” of “the repeated and extensive loss of lives and property.”⁴⁷ They argued that although a breakwater existed at Cape Henlopen and Lewistown, the “number and extent of the shoals” in the Delaware Bay made the Bay “far more dangerous...in windy weather, than the main ocean.” Cape May residents saw existing breakwaters “as useless as if [they] were at Cape Henry [Virginia],” because the existing breakwaters, constructed under the supervision of the Corps of Engineers in the early 1800s to the benefit of Philadelphia’s merchants and shipping, were situated

⁴⁵ William Jones, *Remarks on the Proposed Breakwater at Cape Henlopen*, (Philadelphia: William Fry, 1826), 30. Charles Henry Davis, “A Scientific Account of the Inner Harbor of Boston, with a Synopsis of the General Principles to be observed in the Improvement of Tidal Harbors,” *Memoirs of the American Academy of Arts and Sciences*, New Series Vol. 5, no. 1 (1853): 93, HAG. William Willis, *The History of Portland*, (1865; repr., Somersworth, NH: New Hampshire Publishing Company, 1972), 568. Todd Shallat, *Structures in the Stream: Water, Science, and the Rise of the U.S. Army Corps of Engineers*, (Austin: University of Texas Press, 1994), 102-3, 150, 163.

⁴⁶ “Violent Storm,” *The Rhode Island Republican* (Newport), September 27, 1815. “Great Gale,” *The Yankee* (Boston), October 6, 1815. St. Laurent II, 63-4. Risk, 77-9.

⁴⁷ United States Congress, *Breakwater – Crow Shoal – Pier and Light-House*, 25th Cong., 2nd sess., 1838, H. Doc. 433, June 18, 1838, 3.

on the opposite side of the channel leading into the Bay.⁴⁸ The petitioners believed a “stone pier from half to three-quarters mile in length” constructed by a skilled engineer could obviate many of the serious difficulties associated with their shipping in the Delaware Bay.⁴⁹

The New Jersey petitioners also argued that the breakwater was not only in their best interests, but that the Western states were also interested in protecting shipping on the Delaware Bay “as a large quantity of tobacco, pork, lard, hams, bacon, flour, grain, and other articles of western produce poured into Philadelphia through those channels, which find a market in Eastern States by the Delaware coasters, which bring back fish, of which an immense quantity is shipped west through these channels.”⁵⁰

Building lighthouses, breakwater piers, and wharves required more than just basic engineering knowledge and knowing the strength of various building materials. Engineers also needed to have an understanding of the natural world. Breakwaters had to withstand the impact of ice floes, which were essentially miniature icebergs. They had to be able to withstand the powerful crashing waves of storm surges. For these, and many other reasons, engineers needed to have knowledge of tidal currents, winds, and the mass of potential ice floes. They had to understand the differences in the sea floor to understand how to anchor structures for safety and stability. Captain Henry Stansbury

⁴⁸ Ibid., 2-3. John Whiteclay Chambers II, *The North Atlantic Engineers: A History of the North Atlantic Division and its Predecessors in the U.S. Army Corps of Engineers, 1775-1975*, (New York: North Atlantic Division, USACE, 1980), 10.

⁴⁹ H. Doc. 433, 1.

⁵⁰ Ibid., 4.

understood this when he developed the diskpile anchoring system for offshore beacons.⁵¹ Stansbury added iron flanges to the screwpile foundation invented by British engineer Alexander Mitchell. Stansbury's flanges, or disks, provided additional security for the screwpile foundation by diffusing the weight of the structure on the disks when the structure was anchored in hollow shoals. Because engineers had to understand tidal currents, winds, the mass of ice floes, and the differences in the sea floor, the Treasury Department and the Army Corps of Engineers created a set of rigid standards for the construction of lighthouses and expected engineers to adhere to the standards. The specifications provided general standards regarding the type of lighthouse being constructed (brick tower, screwpile, etc.) and specific standards related to the geographic location of the light, such as those at Atchafalaya Bay, Louisiana and Cape Canaveral, Florida.⁵²

The state also sought to provide safe passage for commerce through the placement of buoys, daymarks, and other aids to navigation. These aids provided a visual signal of

⁵¹ As noted in the introduction, there is some debate over who actually developed the diskpile foundation. Several sources imply that Lieutenant George Gordon Meade developed the diskpile foundation after finding the Carysfort Reef hollow. Others simply acknowledge the development of the innovation, but remain silent on naming the inventor. Meade worked with Alexander Mitchell and Major Hartman Bache on constructing the screwpile lighthouse at Brandywine Shoal in the Delaware Bay. Meade's arrival at Carysfort, however, appears to be too late. Meade was assigned to Carysfort to complete the project and it seems likely Stansbury had already installed the diskpile foundation by the time of Meade's arrival.

⁵² OLHB, *Specifications for Screw-Pile Light-Houses to Replace Light-Vessels*, (Washington, DC: Geo. W. Bowman, 1860). OLHB, *Specifications for a First Order Light-House (Brick Tower)*, (Washington, DC: GPO, 1861). OLHB, *Specifications for a Second Order Light-House (Brick Tower)*, (Washington, DC: GPO, 1862). OLHB, *Specifications for a Third Order Lantern*, (Washington, DC: GPO, 1862). OLHB, *Specifications for Atchafalaya Light-House*, (Washington, DC: William A. Harris, 1858). OLHB, *Specifications for an Iron Light-House for Cape Canaveral, FLA*, (Washington, DC: Geo. W. Bowman, 1860).

nearby hazards when visibility was clear and helped mariners confirm their position similar to how Global positioning systems are used to pinpoint a ship's location today. When adverse weather affected the visibility of these navigational aids, bells and cannons were used as audio warnings. This became the responsibility of the Light-House Establishment in 1789 when Congress passed *An act for the Establishment and support of lighthouse, beacons, buoys, and public piers* for the purpose of rendering navigation “within any bay, inlet, harbor, or port of the United States... easy and safe.”⁵³ Although these aids could not prevent all shipwrecks, they drastically reduced the number of disasters along the early American coasts. Beginning in 1834, the Corps of Engineers built beacons for the Light-House Establishment, reported on the condition of existing lighthouses, and surveyed sites to determine the practicality of constructing navigational aids.⁵⁴

Lastly, the state established the Coast Survey to address commercial issues and to be “subservient to the commercial interests” of the nation. The Coast Survey’s responsibilities included charting the “islands and shoals, with the roads or places of anchorage, within twenty leagues of any part of the shores of the United States; and also the respective courses and distances between the principal capes or head lands, together with other such matters” as deemed necessary for the complete and accurate charting of

⁵³ United States Congress, *An Act for the Establishment and Support of Light-Houses, Beacons, and Buoys*, 1789, 1st Cong., 1st sess., ch. 9, sec. I, 1789.

⁵⁴ Frank N. Schubert, ed., *The Nation Builders: A Sesquicentennial History of the Corps of Topographical Engineers, 1838 – 1863*, (Fort Belvoir, VA: USACE, 1988), 24. United States Congress, *Examination – Light-House Establishment*, 27th Cong., 3rd sess., 1843, H. Doc. 183.

the coast.⁵⁵ Surveying and navigation were the premier sciences in the early nineteenth century United States. The Coast Survey's mapping of the physical environment provided for the safety of commerce through very precise mathematical calculation known as triangulation. In the early 1850s, the surveying of sites for lighthouses had been added to the list of Coast Survey responsibilities.⁵⁶

These surveys resulted in more accurate charts than had been previously available. Prior to the U.S. Coast Survey's charts, commercial shipping relied on the charts of foreign nations, sailing directions published in *The American Coast Pilot*, or as previously mentioned, charts and maps of local entrepreneurs. Foreign-made charts and maps were heavily relied on in the early nineteenth century because the foreign nations had more experience in the field of cartography. When Benjamin Henry Latrobe designed the lighthouse at the mouth of the Mississippi River in 1805, Albert Gallatin, the Secretary of the Treasury, ordered "A copy of a Spanish chart of the coast published at Madrid," for Latrobe's assistant Lewis Dumain to use in surveying the site of the lighthouse.⁵⁷ Foreign maps, however, were often regional or local in nature and were frequently outdated due to the constantly changing environment. Many were drawn years earlier during America's colonial period by the British, French, or Spanish Empires.

The marine telegraph also provided some measures for the safety of commerce. According to the New York Spectator and Eastern Argus newspapers, "Vessels entering

⁵⁵ United States Congress, *An act to provide for surveying the coasts of the United States*, 9th Cong., 2d sess., ch. 8, sec. I, 1807.

⁵⁶ Hugh Richard Sloten, *Patronage, Practice, and the Culture of American Science: Alexander Dallas Bache and the U.S. Coast Survey*, (New York: Cambridge University Press, 1994), 105.

⁵⁷ Albert Gallatin to Lewis Dumain, June 23, 1805, RG 26, Entry 18, Vol. 3, 329, NARA.

[the port] in distress, which require immediate assistance from the city, often for the preservation of lives as well as property” can “communicate their wants and distress to the shore” through the marine telegraph.⁵⁸ Several years earlier, *The Columbian* reported that marine signals “may prove the salvation of both vessel and crew, as the necessary aid can in that case be always promptly afforded.”⁵⁹ In fact, that is precisely what happened at Cohasset rocks to the south of Boston in January 1827. According to the *Eastern Argus*, the marine telegraph communicated “a vessel ashore on Cohasset rocks,” causing the port of Boston to respond by sending a cable and anchor via the schooner *Ardent*. The grounded vessel was towed off the ledge and brought safely into port.⁶⁰ The rescue of the grounded ship saved the ship owner, merchants, and insurance company from the loss that would have been sustained at the hands of the pounding sea by a prolonged grounding on the ledge. In another incident, the ship *Undine* of Doxbury arrived at New York from Cadiz in “great distress” after 57 days at sea. The captain of the *Undine* requested the aid of six men to help bring her into port because the ship’s crew was “unable to work.” The port of New York responded by sending the men and other necessary requisites within two hours, avoiding the possibility of the ship encountering further disaster.⁶¹

Whereas lighthouses, beacons, and buoys sought to eliminate shipwrecks, marine telegraphs were used to communicate wrecks when they did occur so that assistance could be sent to the marooned vessel. In advocating for the establishment of the marine

⁵⁸ “New Telegraph,” *New York Spectator* (New York), June 29, 1821. “Telegraphic Signals,” *Eastern Argus* (Portland, ME), December 18, 1827.

⁵⁹ Taomas R. Mercein, “Report,” *The Columbian* (New York), October 25, 1815.

⁶⁰ “Untitled,” *Salem Gazette*, January 26, 1827.

⁶¹ “Boston Observatory,” *Salem Gazette*, September 12, 1834.

telegraph in New York, Taomas Mercein, the Comptroller of the Port, noted, “it frequently happens that vessels are becalmed off the Hook for many days unknown to their owners.” Mercein believed telegraphic communication from Sandy Hook could relay information about the stranded vessels and alleviate some of the uncertainty.⁶²

The establishment of the marine telegraph was believed to reduce the indirect costs of doing business. In both of the previously mentioned incidents, ship owners, merchants, and insurers were saved the high cost of an insurance claim. According to economic historian Christopher Kingston, some early nineteenth-century insurers, such as the Insurance Company of North America, refunded a portion of the premium to the ship owner upon the ship’s safe return.⁶³ In New York, Comptroller Mercein claimed that communication of stranded vessels could relieve ship owners, “who supposing them *out of time* are induced to effect additional insurance at advanced premiums,” from having to take costly extra precautions.⁶⁴

The use of science and the mechanical arts to protect commerce extended beyond maritime shipping. According to James B. Calvert, railroads began considering telegraphic signals as early as 1845. In that year, civil engineer Ashbel Welch inquired of Joseph Henry, one of premier scientists in the United States at the time, about the practicality of using telegraphic signals on the Pennsylvania Railroad.⁶⁵ Calvert notes the first fixed semaphore signals were “the well-known ball signals derived from nautical

⁶² Mercein.

⁶³ Christopher Kingston, “Marine Insurance in Philadelphia During the Quasi-War with France, 1795-1801,” *The Journal of Economic History* 71, no. 1 (March 2011): 180.

⁶⁴ Mercein.

⁶⁵ J. B. Calvert, “Notes on Pennsylvania Railroad Operation and Signaling,” *Pennsylvania Railroad*, Denver University, October 10, 2000, last revised December 27, 2008, <http://mysite.du.edu/~jcalvert/railway/prr/prrsig.htm> (accessed August 20, 2016).

tide signals.”⁶⁶ Additionally, Farrar’s patent method for protecting the polished surfaces of reflectors was also used on railroads.⁶⁷ By the mid-1840s, the time of Farrar’s patent and Welch’s inquiry of Joseph Henry, railroads were emerging as a commercial force. They had already proved more viable than canals for transporting goods to the interior of the continent and were on their way to becoming the dominant form of distributing goods over land.

THE PROBLEM OF BRITISH IMPRESSMENT

British impressment of American sailors also threatened the safety of commerce and pressured the United States to engage in the practical science of coastal surveying. Impressment was the forced recruitment and service of mariners for naval service in the British Royal Navy. Forced recruitment and service often came without notice. It robbed commerce of the much-needed maritime labor that looked after the ships employed in the nation’s commerce and the cargoes that fueled the economy. Despite the crown’s defeat in the American Revolution, Britain did not recognize naturalized American citizenship. The crown and parliament considered Americans to be British citizens, which made them subject to naval impressment. Jay’s Treaty in 1795 sought to address grievances between the two nations in the decade and a half following the American Revolution, but it failed on the point of impressment. In the early 1810s, the issue of impressment remained a contentious subject between the two nations, resulting in the United States declaring war on Britain in 1812.

⁶⁶ Calvert.

⁶⁷ Farrar, 2.

Some thought British impressment of American sailors might cease with the establishment of the Coast Survey. In particular, Connecticut Representative Samuel Dana argued the Coast Survey would be useful for the establishment of maritime precincts within the United States “within which, of course, the navigation ought to be free from the belligerent searches and seizures” of foreign nations.”⁶⁸ In other words, Dana believed by establishing accurate boundaries of the United States coast, American ships, particular those involved in the coastal trade, could be free of British impressments simply by remaining in U.S. waters and therefore under U.S. law and jurisdiction.

Unfortunately, Dana did not seem to realize the scope of the task at hand and the improbability that the Coast Survey would ever impact the impressment of American sailors. Due to the continual shifting of responsibilities for the Coast Survey in its early years, and the monumental task set before it, the Survey would not produce its first chart of the American coast until 1835 and even then, it was only a chart of Bridgeport Harbor.⁶⁹ Britain ceased impressing American sailors in 1814, some twenty-one years earlier. Still, the perception was that science could solve this important commercial problem, even if in reality the problem ceased to exist before the survey had the opportunity to resolve it.

THE PROBLEM OF PORT EFFICIENCY

Similarly, the problem of port efficiency pushed many Americans toward practical science as a way to solve this costly commercial problem. Although this issue is

⁶⁸ *Annals of Congress*, 9th Cong., 2nd sess., 1807, 152. Gaye Wilson, “Jefferson Authorizes the Survey of the Coast,” *Monticello Newsletter* 18, no. 2 (Fall 2007): 1.

⁶⁹ Aaron L. Shalowitz, *Shore and Sea Boundaries* Vol. 2, (Washington, DC: GPO, 1964), 13, 89, 276 n13, 552, 564, NOAA, OCS, “Important Dates in History,” <http://www.nauticalcharts.noaa.gov/staff/important-dates.html>, (accessed July 24, 2015).

not specifically mentioned in any of the primary source documents, time in port had to weigh heavily on merchants and ship owners' minds. Ships only make money when they are at sea, trading goods in a network of economic exchanges. Unless ships returned immediately to the sea upon unloading their cargo, they lost money sitting idle in port through wharfage fees, lost profits and wages, and the ship's slow depreciation and decay at the hands of the marine environment. Time was money and in early American seaports, time cost ship owners a great deal of money. In April 1828, the owner of the schooner *Two Sisters* paid 20 cents per day for the privilege of docking at the John Gladding's wharf in Providence, Rhode Island.⁷⁰ While 20 cents per day may not seem like a lot of money, comparably is it equal to about \$151.00 in 2015.⁷¹

Idle time in port resulted from one of three things – waiting to unload merchandise, making necessary repairs to the ship, and securing an export cargo. One of the advantages science and the mechanical arts had with commerce was the ability to reduce port idle time. As historians Alex Roland, W. Jeffrey Bolster, and Alexander Keyssar note, even modest improvements in port operations, “translated into increases in overall economic productivity, even without improvements in production.”⁷² Technologies, such as the construction of warehouses, the advent of the American packet ship, the the establishment of a marine telegraph station greatly impacted a ship's time in port.

⁷⁰ John Gladding, “An Account of Money Received by Jn^o Gladding for and on Account of Heirs of Joseph Tillinghast for Wharfage, Storage, Water, &c,” (Providence, RI, April 10, 1828), Mss 9001-G *Miscellaneous Manuscripts*, Box 3, Folder “John Gladding,” RIHS.

⁷¹ Williamson.

⁷² Roland, Bolster, and Keyssar, 88.

Kenneth Pomeranz surmises the simple establishment of a storage facility cut shipping idle time to “50 days.”⁷³ Roland, Bolster, and Keyssar found, “time in port was reduced, sometimes by half,” with the advent of storage facilities.⁷⁴ Warehouses eliminated the ship as a holding facility by allowing merchants a place to store unsold merchandise. Having a place to store cargoes also allowed stevedores to unload cargoes sooner, thus reducing a ship’s time in port by freeing the ship for acceptance of the outbound shipment. Additionally, warehouses allowed for merchants to store their goods prior to export, further reducing a ship’s idle time in port because the outbound shipment was already near the docks and ready for loading.

Packet service provided an additional reduction in port time. As Andrew Gibson and Arthur Donovan note, strict adherence to schedules took priority over a full cargo hold. Packet ships left precisely on schedule regardless of whether or not they were full.⁷⁵ The packets’ routine schedule of arrivals and departures improved port operations by standardizing processes associated with time schedules such as loading and unloading and freeing wharves for other ships.

Prior to the establishment of regular packet service in the 1830s, the marine telegraph provided a similar modest improvement in port operations. The marine telegraph was a communication system that used flags, pendants, burgees, and balls to send messages between ships at sea and the shore. It required a visual line of sight, usually with the aid of a telescope, and a vantage point that allowed the signaler an

⁷³ Pomeranz, 112.

⁷⁴ Roland, Bolster, and Keyssar, 89.

⁷⁵ Andrew Gibson and Arthur Donovan, *The Abandoned Ocean: A History of United States Maritime Policy*, (Columbia: University of South Carolina Press, 2000), 44-6.

unobstructed view of the ocean. The marine telegraph was primarily used in American port cities to announce the arrival of a ship into port while it was still a great distance away, but it could also be used to bring other news from passing ships to the port. Two of the factors responsible for extended port idle times (unloading and securing an export cargo) could be reduced with the assistance of an early communication system. By announcing the arrival of a ship earlier, the marine telegraph gave ship owners and merchants the additional time they needed to hire stevedores for unloading, sell their goods, secure storage for unsold merchandise, and arrange for an outbound shipment.⁷⁶

Today, these improvements in port operations would be known as efficiencies. However, just as the box container of Malcom McLean and Leslie Harlander did not exist in the nineteenth century, neither did the concept of efficiency. According to Jennifer Karns Alexander, efficiency is a twentieth-century notion that developed out of “an obscure philosophical concept” concerned “with the causes of change and the ways of God, and only during the Industrial Revolution was it linked with human powers and abilities.” Thus, efficiency, as we conceive it today, first concerned itself with the mechanics of nineteenth-century industrialization as “engineers and physicists [sought] to measure the performance of machines, and, in particular, to relate a machine’s output to the inputs it had used.”⁷⁷ This concept was instrumental in the early twentieth century as men such as Henry Ford and Fredrick Winslow Taylor applied science to the management of production.⁷⁸

⁷⁶ Risk, “Ship to Shore,” 17-8.

⁷⁷ Alexander, 2.

⁷⁸ Ibid., 4.

Alexander sees two distinct types of efficiency – one static and one dynamic. First is Alexander’s notion of efficiency as control. According to Alexander control is static and is based on Samuel P. Hays’ thesis regarding conservation.⁷⁹ The second is efficiency as progress, or dynamic transformation. This type of efficiency is focused on changing processes. As Alexander notes, the historical actors did not use terms like efficiency, but rather spoke in a language of terms that lacked clear definitions such as “mechanical power,” “natural effective power,” and “used effect.”⁸⁰ She continues stating that the term “efficiency” did not receive a clear quantitative definition until the late nineteenth century.⁸¹ The historical actors in this study were not necessarily men of science and it would be hard to classify some of them as mechanical or practical artists. They were mariners and entrepreneurs who used technology to solve their commercial issues. They spoke in even more ambiguous terms of “advantages,” and “expedients.” Use of the term efficiency here will simultaneously mean both control of and transformation of processes. The marine telegraph controlled port operations by directing merchants and shipowners to action once their approaching vessel was reported. The marine telegraph transformed the port operations by changing when men were moved into action. Rather than acting when the ship arrived at the dock, interested parties began acting at the first sign of arrival.

Two case studies of idle time in port indicate the science and technology of the marine telegraph may have played a significant role in improving port operations, thus

⁷⁹ Samuel P. Hays, *Conservation and the Gospel of Efficiency: The Progressive Conservation Movement, 1890 – 1920*, (Cambridge, MA: Harvard University Press, 1959.)

⁸⁰ Alexander, 15.

⁸¹ *Ibid.*, 18.

intersecting with commerce by reducing ship idle times. Looking at ship arrivals and departures in the year immediately preceding and following the establishment of a marine telegraph to calculate idle time in port isolates ships' time in port to the improvement in ship to shore communication. Analysis of port time in Baltimore indicates a noticeable increase in port efficiency through the decline in port idle time, while a similar analysis in Portland (Maine) demonstrates the possibility of a downward trend for a ship's idle time in port. Statistically, however, the data for Portland is not enough to make the claim for improved efficiency. The small data set and smaller variance in port idle times for each ship in the data set renders such a claim statistically insignificant.

Baltimore and Portland were chosen for several reasons. Both ports held status as year-round ports, eliminating concerns over weather closures affecting port idle time. The availability of ship arrival and departure records for Baltimore and Portland, as well as a discernable date for the establishment of the marine telegraph, were important considerations for calculating the port idle time before and after the establishment of the observatories.⁸² At this time, it has been impossible to establish the exact date for the establishment of the marine telegraph at Charleston, Newport, and Philadelphia, while the ship departures at New York were not available for the periods immediately preceding

⁸² It should be noted that departures are different from clearances. A ship could be cleared for departure by the customs house and still remain in port a few days to complete its preparations for the voyage. For this reason, the case studies are based on newspaper reports of departures, which were routinely published in each edition rather than customs house records of clearances. Additionally, the ship arrivals and departures used in these case studies have been verified across multiple newspapers to ensure accuracy.

and following the establishment of the telegraph in 1812.⁸³ The observatories at Baltimore and Portland were also established in different economic times. David Porter's telegraph in Baltimore was established in a time of economic prosperity, whereas the "brown tower" in Portland was completed just two months before the start of Jefferson's embargo.⁸⁴ Additionally, Baltimore was one of the four primary seaports in the early American republic, while Portland ranked as a secondary port. The diversity of economic times and port size add to the validity of the data by showing studies of both primary and secondary ports in different economic times obtained similar results. Lastly, the telegraph at Baltimore and Portland served a single port unlike that at Boston. Boston's signal station served the entire area including the smaller ports of Beverly, Salem, and Marblehead. Therefore, it was impossible at this time to conduct case studies of those ports for comparison.

⁸³ There is some debate on the date of establishment for New York's marine telegraph. Richard Allen Schwarzlose and Alvin F. Harlow date the New York telegraph to 1812. Richard Allen Schwarzlose, *The Nation's Newsmakers: The Formative Years from the Pretelegraph to 1865, Volume 1*, (Evanston, IL: Northwestern University Press, 1989), 15. Alvin F. Harlow, *Old Wires and New Waves: The History of the Telegraph, Telephone, and Wireless* (New York: D. Appleton-Century Company, Inc., 1936), 27-9. These sources are referring to the semaphore of Christopher Colles. Newspapers in 1815 refer to Colles' telegraph, but the language of the articles imply the telegraph was still being considered and not yet adopted by the city. Robert G. Albion and the *New York Spectator* (New York City, NY) both pinpoint the establishment of the New York marine telegraph as June 1821. Robert G. Albion, *The Rise of New York Port*, (New York: Charles Scribner's Sons, 1939), 217. "New Telegraph," *New York Spectator* (New York City, NY), June 29, 1821. This later telegraph is also referred to in John Rowe Parker's correspondence with James Elford of Charleston, SC. Various letters, August 1, 1826 – February 27, 1827, Box 3, Folder 97, Ms. Coll. 186, Parker, John R. (John Rowe), 1777-1844 Correspondence, 1802 – 1840, KUPL.

⁸⁴ "Communication: The Spirit of the Brown Tower: A Tale of these Times," *Eastern Argus* (Portland, Maine), September 24, 1807.

Both case studies found similar results in the average time in port, indicating at the very least there is some validity to the argument marine telegraphs improved commercial operations in early American seaports through the advanced notification of ship arrivals. In both cases studies, only ships which could be positively identified as the same ship (ship type, ship owner, shipmaster, port of call, destination, etc.) arriving and departing the port were used. While this methodology reduced the usable samples, it assured the accuracy of the data sets.

Captain David Porter commenced signaling at his marine telegraph on Federal Hill in Baltimore, on April 9, 1797.⁸⁵ In the year prior to Porter erecting his flagstaff, Baltimore's vessels remained in port an average of 28 days. While this is significantly lower than Pomeranz's "50 Days," it was still a substantial amount of time for a ship to lay idle in port and a considerable loss for merchants and ship owners. Immediately following the founding of Porter's signal station, ships lingered in port an average of only 16 days, a reduction in idleness of almost two full weeks.⁸⁶ This is similar to Roland, Bolster, and Keyssar's claim that warehouses reduced ship idle time by half. It is

⁸⁵ David Porter, "The Subscribers of the Observatory," *Federal Gazette and Baltimore Daily Advertiser* (Baltimore, MD), May 10, 1797. M. V. Brewington, "The Observatory," *Maryland Historical Magazine* 44, no. 2 (1949): 104.

⁸⁶ Risk, "Ship to Shore," 65. Mean (\pm SEM) idle time in port was 27.6 ± 4.4 days ($n=33$) prior to the establishment of the marine observatory, versus 15.9 ± 3.5 days ($n=14$) after establishment of observatory ($p=0.0426$, unpaired student's t -test). Data compiled using the ship arrivals and departures reported by the *Federal Gazette and Baltimore Daily Advertiser* from the American Historical Newspapers Database. In September 1797, five months after Porter established the marine observatory, the *Federal Gazette and Baltimore Daily Advertiser* began to publish reports of arrivals and clearances very sporadically. Presumably it was no longer necessary to report this information in the paper because the observatory reported it the day before. With the observatory in sight of nearly the entire town, most people already knew the business of the port on the previous day. This is no indication, however, that the observatory reported ship departures.

impossible to put a dollar amount on this improvement in port time, however, the reduction in the average idle time undoubtedly contributed to the rise in the economy. Less time in port meant more voyages, which in turn translated into an expansion of the economy.

A similar reduction in port time was found in Portland after the establishment of its observatory. Prior to the construction of Captain Lemuel Moody's lookout station, Portland's vessels lay idle an average of 50 days, consistent with Pomeranz's estimate. Moody began signaling arrivals in August 1807, just months before Jefferson convinced Congress to pass the Embargo Act of 1807. The Embargo had a profound effect on shipping, especially in New England, where ports such as Portland relied almost solely on its maritime industries. Despite the Embargo, many ships continued to sail into and out of Portland, as witnessed by the continued reporting of ship departures in the local newspapers. After Moody began signaling ship arrivals, Portland's average idle time fell by approximately 10 days, as vessels remained in port an average of 40 days.⁸⁷ Some of this decline can be attributed to Portland's conversion to the coastal trade, however, the rate of decline being similar to that in Baltimore suggests the possibility of a trend related to the establishment of the marine observatory. Portlanders continued to engage in the global market through illicit smuggling, but the arrival and departure records for these illegal shipments would not have been published in the city's two most prominent

⁸⁷ Mean (\pm SEM) idle time in port was 49.53 ± 5.4 days ($n=28$) prior to the establishment of the observatory versus 39.875 ± 7.4 days ($n=16$) after the establishment of the observatory ($p=0.2953$, unpaired student's t -test). Data compiled using the ship arrivals and departures reported by the *Eastern Argus* (Portland, ME) and *Portland Gazette* (Portland, ME) from microfilm at the MeHS.

newspapers, the *Eastern Argus* and the *Portland Gazette*.⁸⁸ Therefore, it is only possible to speculate the possibility of a reducing trend in port idle time following the establishment of the marine observatory.

With similar results between two ports of different commodities, geographies, size, and economic times, it seems plausible that other ports might have experienced a reduction in port idle time with the establishment of their local marine telegraph stations. Unfortunately, the methodology cannot be carried forward to other ports at this time for the reasons previously stated. As additional research resolves those issues, additional case studies can be added to validate the findings in Baltimore and Portland.

As the previous examples demonstrate, solving commercial problems was a driving force for early Americans engaging in practical science, innovation, and the mechanical arts. That is not to say those same individuals rejected the idea of making a profit. Some, if not most were interested, in profiting from their tinkering. Rather, the intent is to recognize the importance of commerce in the production of science and the arts in the early United States. Commercial problems needed solutions that could only be provided by practical science and the mechanical arts. Commercial problems, thus justified many Americans' venture into innovating new mechanical apparatuses and performing science.

⁸⁸ Matthew Thomas, *Historic Powder Houses of New England: Arsenals of American Independence*, (Charleston, SC: The History Press, 2013), 33. Peter Andreas, *Smuggler Nation: How Illicit Trade Made America*, (Oxford, UK: Oxford University Press, 2013), 79. Joshua M. Smith, "The Rogues of Quoddy: Smuggling in the Maine – New Brunswick Borderlands, 1783-1820," (Ph.D. diss., University of Maine, 2003), 117. Harvey Strum, "Smuggling in Maine During the Embargo and the War of 1812," *Colby Library Quarterly* 19, no. 2 (June 1983): 90-2.

CREATING COMMERCIAL OPPORTUNITIES

If solving commercial opportunities pushed many Americans toward scientific practice, their engagement in science and the mechanical arts created many commercial opportunities in the early nineteenth-century United States. Merchants and entrepreneurs with little or no scientific background tinkered in science and the practical arts with the hopes of someday profiting from their ideas. David Melville, for instance, is best known for his natural gas patents in the early 1800s. Yet, Melville's primary business was selling hardware and stationary.⁸⁹ Melville hoped to profit handsomely from his gas lighting and the wide spread introduction of gas lighting. Melville was particularly interested in a government contract with the Light-House Establishment for his gas lights.⁹⁰

It does not appear, however, that Melville ever profited much from his venture in gas lighting. According to gas light historian David Mattausch, sales of gas lamps and lighting equipment were slow for Melville. Melville charged \$13.00 per light, which many found too costly.⁹¹ Melville's equipment was also crudely manufactured and often defective. In some lights it was impossible to get the gas to flow "from the condenser to the cistern," whereas others leaked gas from poorly crafted pipes.⁹² In 1813, an explosion resulting from Melville's gas lighting at the Arkwright mill in Providence, Rhode Island, caused the death of Abraham Churchill and the complete destruction of an out building.⁹³

⁸⁹ Advertisement, *Rhode-Island Republican* (Newport, RI) III, no. 117, December 25, 1802, 3. Daniel W. Mattausch, "David Melville and the First American Gas Light Patents," *Rushlight* 64, no. 4 (December 1998), 2.

⁹⁰ Melville, 6-8.

⁹¹ Mattausch, 6.

⁹² *Ibid.*, 6-7.

⁹³ *Ibid.*, 6.

This incident led many to question the safety of natural gas lighting and Melville's gas enterprise never fully recovered from the accident.

Additionally, Melville's experiment at the Newport lighthouse in 1817 lost money for the inventor. The government contract for the experiment did not allow for reimbursement of any of Melville's expenses. Melville paid for the entire year-long experiment out of his own pocket, including the installation of the gas piping and the building of the gas house. Winslow Lewis, who in addition to supplying the Light-House Establishment with his patented lamp and reflector system also held a very lucrative contract (\$35,000 per annum) for delivering spermaceti oil to the lighthouses, suggested that Melville could make a larger profit if his experiment failed. Lewis recommended Melville "make the best bargain he can with the Nantucket people" believing Melville could "no doubt...obtain ten thousand dollars from them."⁹⁴ Melville refused.

Others, however were more successful in their tinkering. Winslow Lewis, for instance, sold the rights to his patent lighthouse lamp and reflector system to the United States government for \$24,000. Lewis agreed to fit up all of the lighthouses with his system and maintain the system in each lighthouse for a period of seven years. The government extended Lewis a contract for \$600 per annum for maintaining the lights. As new lighthouses were built, Lewis's contract for fitting up the lighthouses and maintaining the lights became a long-term renewable contract that provided Lewis with a source of income for more than three decades. As Lewis was now responsible for maintaining the lights and therefore had to make routine visits to each lighthouse, the government awarded Lewis another contract for delivering the spermaceti oil to each

⁹⁴ Melville, 47.

beacon. As previously noted, Lewis' oil contract was worth \$35,000 annually.⁹⁵ Lewis later turned his commercial opportunity into a contract for building coastal beacons.

Similarly, James Elford of Charleston, South Carolina used science and the practical arts to create a commercial opportunity for himself. In 1823, Elford patented a universal code of signals for his marine telegraph in the copula of the Charleston Merchant's Exchange Building. Unlike existing signaling systems of the time which were often unique to a specific port, Elford's system was universal. It could be used in any port, foreign or domestic, that adopted his system.

Elford profited from his efforts by licensing his system to an agent in Boston Massachusetts. John Rowe Parker, the proprietor of the Central Wharf marine telegraph in Boston, paid "one hundred dollars" per annum payable in two installments of fifty dollars every six months for the right to sell Elford's system throughout New England. Elford also offered to let Parker "have the State of New York at \$100," and allowed Parker to "Supply Vessels with Flags & books belonging to New Hampshire State" without further compensation, as "it may add a little to [the] profits."⁹⁶ In turn, Elford supplied Parker with signal flags and signal books, which Parker resold to shipmasters and merchants subscribing to the telegraph service. Elford sold these items to Parker at a 25 per cent discount, believing "a handsome profit [could] be made" if the telegraph were "properly managed."⁹⁷

⁹⁵ Ibid., 7.

⁹⁶ James M. Elford to John Rowe Parker, January 4, 1826, Box 3, Folder 97, Ms. Coll. 186, Parker, John R. (John Rowe), 1777-1844 Correspondence, 1802-1840, KUPL. Hereafter cited as JRPC.

⁹⁷ Elford to Parker, January 4, 1826. James M. Elford to John Rowe Parker, June 21, 1824, Box 3, Folder 97, JRPC.

Indeed, proprietors of marine observatories could make a “handsome profit.” Parker, for instance, grossed at least \$4,400 in 1834 in annual subscriptions to the marine telegraph alone, not counting the profits made from the sale of flags and signal books.⁹⁸ Samuel Topliff, the city’s primary news broker from 1814 to 1842, paid Parker \$200 annually for shipping information.⁹⁹ The Merchant’s Exchange paid \$150 per year, while insurance companies were charged \$50 per annum. Individual merchants paid Parker \$10 annually for their subscriptions to the service.¹⁰⁰ In other ports, such as Baltimore and Portland, proprietors of the marine telegraph charged subscribers between \$2.50 and \$3.00 annually.¹⁰¹

Once the subscription was paid, the proprietor of the marine observatory outfitted each vessel with a set of signal flags and a codebook. Subscriber’s purchased a set of six flags in ports utilizing Elford’s system. If the subscriber owned more than one ship, they purchased a set of flags for each vessel. According to the *Salem Gazette*, “The cost of a suit of signal flags with the dictionary is \$15.” Since Elford sold the signal flags and codebook to Parker at a 25 per cent discount, Parker netted \$3.75 for every set he sold.¹⁰² Captain Porter’s telegraph in Baltimore required five signal flags and an unnamed number of basketwork balls.¹⁰³ Moody’s system in Portland utilized five flags and three

⁹⁸ “Boston Observatory.”

⁹⁹ Schwarzlose, 14-5. “Boston Observatory.”

¹⁰⁰ “Boston Observatory.” John R. Parker, “Receipt from the Semaphoric Telegraph to George Bond,” (Boston, April 1842), Doc. 1120, Ms. 0119 *Document Collection*, Bostonian Society: Boston, MA.

¹⁰¹ Brewington, 105. Moulton, 29.

¹⁰² “Boston Observatory.” James M. Elford to John Rowe Parker, March 13, 1828, Box 3, Folder 97, JRPC.

¹⁰³ Brewington, 104.

balls when it first began operation in 1807.¹⁰⁴ Porter's telegraph in Baltimore required four flags.¹⁰⁵

Elford's dictionary of codes included a list of subscribed ships and their corresponding signals. The South Carolinian updated the codebooks as more ports adopted the system and as more ships subscribed to its universality. At times, the system expanded so rapidly Elford was forced to update the signal book several times a year. These updates, in turn, forced shipmasters to purchase the latest edition of the codebook in order to identify and communicate with other ships. This process of was not so different from purchasing software updates in today's digital electronic age. The constant updates provided a regular demand for the codebook, thus keeping the proprietor of the marine telegraph with a steady flow of income.

The marine telegraph provided an additional commercial opportunity for manufacturing and selling flags. Each subscribing vessel needed a set of signal flags. The task of manufacturing flags varied from one port to another. In Baltimore, for instance, David Porter caused "suitable signal flags [to be] prepared," indicating he contracted with a local flag maker for their manufacture.¹⁰⁶ In Portland, the proprietor of the telegraph, Lemuel Moody, appears to have manufactured the flags himself, but "sent [the cloth] to be coloured" by someone else.¹⁰⁷ Moody contradicted Elford's claim that one could make a handsome profit selling signal flags when the former complained, "I get but little for

¹⁰⁴ Lemuel Moody, Signal Flags used in Portland Harbor in the early 1800s, Doc. 174, Folder 1, Ms. Coll. 902 Signal Books and Thermometrical Records at the MeHS.

¹⁰⁵ Brewington, 104.

¹⁰⁶ David Porter, "Proposal," *Federal Gazette & Baltimore Daily Advertiser* (Baltimore, MD), March 16, 1797, 2.

¹⁰⁷ Lemuel Moody to John Rowe Parker, June 27, 1827, Box 6, Folder 209, JRPC.

my trouble, the flags cost me but little short of the amount I receive” and that “it was with great difficulty, I could obtain in the small sum of 50 dollars per year...finding my own flags.”¹⁰⁸ In Boston, John Rowe Parker original purchased his flags from Elford, but when Elford was unable to supply the signal flags, Parker delegated the task of making the flags to his signaling agents on Little Brewster Island and Long Island.¹⁰⁹ Parker’s agents were responsible for all aspects of manufacturing the flag including dyeing the cloth.¹¹⁰ Regardless of who manufactured the flags, the marine telegraph offered an opportunity for commercial gain.

Additionally, vessels usually carried a private signal flag, also referred to as a house flag, that identified the merchant, his port, and sometimes a specific ship. These flags were unique in design within the maritime community of the merchant’s home port (although a study of more than a thousand house flags from nineteen different nineteenth-century United States ports indicates many designs were duplicated in other ports).¹¹¹ The flags represented a shipping family in much the same way a coat of arms represented a clan of nobility and often had been passed down through many generations of the family. Each local marine telegraph allowed merchants to deposit their flag with the observatory so that the vessel could be identified and signaled more easily with a single flag than with

¹⁰⁸ Moody to Parker, July 12, 1827.

¹⁰⁹ Charles Beck to John Rowe Parker, May 23, 1824, Box 1, Folder 24, JRPC. Jonathan Bruce to John Rowe Parker, November 12, 1824, Box 2, Folder 42, JRPC.

¹¹⁰ Bruce to Parker, November 12, 1824.

¹¹¹ Ms. 282 William Crothers Collection, GWBW. Ms. 335 Edouard A. Stackpole Collection, 1750-1900, NHA. Ms. 139 Signal Flag Books, 1800-1860, NHA. Ms. 902 Signal Books and Thermometrical Records at the MeHS. F. Gray Griswold, *The House Flags of the Merchants of New York, 1800 – 1860*, (Norwood, MA: The Plimpton Press, 1926).

a series. By having a copy of their flag deposited at the marine telegraph station, at least two private signal flags were needed for every merchant or shipmaster.

Elford's system appears to be the only one adopted for use in multiple ports, but not all ports utilized the universal system. As each port originally had its own unique system of signals, merchants and shipmasters outfitted their vessels with the various signals used in each port of call. According to an 1838 inventory of the Charles W. Morgan, the whaling ship carried as many as 500 signal flags on board.¹¹² If the Charles W. Morgan's flag inventory is typical of ships for this period, the telegraph created a vast commercial opportunity for the textiles and dyes needed to make the flags, the flag makers, and those merchants selling the flags.

Similar to the marine telegraph, science and the practical arts provided opportunities for enterprising merchants and skilled cartographers to profit from making charts and maps of America's harbors, shipping lanes, and surrounding coastline. Although the Coast Survey was authorized in 1807, it did not publish its first map until the 1830s.¹¹³ Prior to the establishment of the Coast Survey and in the years leading up to the Survey's first map after its establishment, individuals with a knowledge of science created maps of their local ports and sold them to shipmasters, merchants, and public officials. Moody saw "the great necessity of a correct Chart of Portland Harbour and the dangerous Rocks near Cape Elizabeth, also of Winter Harbour and the numerous islands in Casco Bay" and took it upon himself to create a new map of Portland's coastal region

¹¹² "Inventory of Flags, nd - Charles W. Morgan (Ship 1841)," *Misc. Vol. 112*, GWBW.

¹¹³ Aaron L. Shalowitz, *Shore and Sea Boundaries* Vol. 2, (Washington, DC: GPO, 1964), 13, 89, 276 n13, 552, 564. NOAA, OCS, "Important Dates in History," <http://www.nauticalcharts.noaa.gov/staff/important-dates.html>, (accessed July 24, 2015).

in 1825.¹¹⁴ Moody sold his map by subscription. Subscribers bought more than 100 copies of Moody's *Chart of Portland Harbor* at \$3.00 each, generating at least \$300 income for the mapmaker.¹¹⁵ Moody used his mapmaking as a supplement to his main source of income as proprietor of the marine telegraph at Portland and instructor of navigation.

James Elford, Lemuel Moody, David Porter, and Winslow Lewis were all retired mariners. When mariners retired from the sea, they could turn to science and the arts to carve out new lives for themselves. Most mariners were exposed to science and the practical arts through navigation and onboard ship repairs.¹¹⁶ Their engagement in science and the practical arts for a new sense of livelihood complicates the narratives of maritime and labor historians W. Jeffrey Bolster, Paul Gijle, Marcus Rediker, and Daniel Vickers. Each of these historians have argued sailors had few employment opportunities off the ship and that many were forced to return to the sea for their livelihood as a

¹¹⁴ Lemuel Moody, "Commissioning of Chart of Portland Harbor, 1825," Box 1, Folder 10, Ms. Coll. 1931 Lemuel Moody Collection, MeHS.

¹¹⁵ Ibid.

¹¹⁶ Marcus Rediker, *Between the Devil and the Deep Blue Sea: Merchant Seamen, Pirates, and the Anglo-American Maritime World, 1700 – 1750*, (Cambridge, MA: Cambridge University Press, 1989), 85.

result.¹¹⁷ These arguments overlook the fact that mariners received training in science and the practical arts through their everyday sailing experiences. In nearly every seaport, mariners translated their skills of repairing ships to building construction. As Portland historian Moulton points out, many of the homes in that seaport were built by mariners waiting for their next voyage. Although the individuals discussed here, (Elford, Moody, Porter, and Lewis) were all shipmasters, they were not exceptional. They engaged in the same sciences of navigation and the practical arts as other mariners. The biggest difference between Elford, Moody, Porter, Lewis and other mariners was not their higher status as ship captains, which undoubtedly taught them skills of management, but their self-motivation to accede to a higher position in life. Elford, Moody, Porter, and Lewis' self-motivation allowed them to use science and the arts to create lasting careers as landlubbers.¹¹⁸

Not all commercial opportunities were positive. As Winslow Lewis noted in his dinner conversation with David Melville, Captain George Shearman, and William Simons, “patents [are] useless under the present patent law, as they [are] so easily

¹¹⁷ For more information on the re-employment of mariners in land-based careers, please see the following works: W. Jeffrey Bolster, *Black Jacks: African-American Seaman in the Age of Sail*, (Boston: Harvard University Press, 1998), 158-9; Paul A. Gijle, *Liberty on the Waterfront: American Maritime Culture in the Age of Revolution*, (Philadelphia: UPenn Press, 2007), 13, 27-29; Marcus Rediker, *Between the Devil and the Deep Blue Sea: Merchant Seamen, Pirates, and the Anglo-American Maritime World, 1700 – 1750*, (Cambridge, MA: Cambridge University Press, 1989), 289; Seth Rockman, *Scraping By: Wage Labor, Slavery, and Survival in Early Baltimore*, (Baltimore: JHU Press, 2008), 49-56; Danny Vickers, *Young Men and the Sea: Yankee Seafarers in the Age of Sail*. (New Haven, CT: Yale University Press, 2007), 111. Rockman's study is more of an examination of general labor, but he uses two examples of men with shipboard experience in the stories of James Richardson and Aaron Bunton.

¹¹⁸ Porter returned to the sea after nearly a decade on land, but the other three individuals continued in their landlubbing careers until their deaths.

evaded.”¹¹⁹ As previously noted, Lewis’ patented lamp and reflector system was hardly his own invention. Many of Lewis’ contemporaries considered Lewis somewhat of a charlatan when it came to his inventions and patents. Several, including Lewis’ nephew Lieutenant I.W.P. Lewis, claimed the elder Lewis had stolen the concept of the lamp and reflector system from the lighthouse at Holyhead in Great Britain, thus invalidating his patent.¹²⁰ All evidence indicates, Britain’s Trinity House and Northern Lighthouse Board had implemented lenses with their reflectors for several years ahead of Lewis’ invention.

Lewis’ patented lamp and reflector system is not the only instance of Lewis committing commercial fraud. In 1819, Lewis became embroiled in a patent lawsuit with his friend David Melville. Three years earlier in 1816 in the same conversation that Lewis stated the uselessness of patents, Melville described a principle improvement to the argand oil lamp that would prevent the spermaceti oil from congealing and thus causing the light to extinguish itself. Melville made a rough sketch of the plan and gave it to Lewis. Melville later registered the idea and sketch with a local notary, but did not have the means to pursue a costly patent of the apparatus at the time. Lewis took out a patent in January 1817 for an oil heater based on Melville’s description and sketch. In fact, Melville claimed, “on examining the drawing and specification of yours [Lewis’], I

¹¹⁹ Melville, 5.

¹²⁰ I. W. P. Lewis, “Catalogue of Lights on the Coast of Maine, New Hampshire, and Massachusetts,” in H. Doc. 183, 51. George M. Bache to Levi Woodbury, November 22, 1838, “Extracts from the Report of Lieutenant George M. Bache, U.S.N., November 22, 1838,” in United States Congress, *Report of the Officers Constituting the Light-House Board*, 3rd Cong., 1st sess., 1852, S. Doc. 28, 523. Theresa Levitt, *A Short Bright Flash: Augustin Fresnel and the Birth of the Modern Lighthouse*, (New York: W. W. Norton & Co., 2013) 140.

find it exactly similar to mine.”¹²¹ Melville sued Lewis for the infringement and eventually forced Lewis to vacate the patent.

Others also engaged in commercial fraud using science and the practical arts. In 1824, an unscrupulous Mr. Lawrence sought to profit from the marine telegraph in Boston without just cause. According to Jonathan Bruce, the telegraph agent stationed at Boston Lighthouse on Little Brewster Island, Mr. Lawrence “made a seemingly generous offer” for Bruce to concede his proposition as the telegraph agent. Mr. Lawrence’s offer was to collect “2 thirds of the money,” while Bruce continued to do “two thirds of the work.”¹²² Mr. Lawrence, however, was not entitled to collect any profits from the telegraph. John Rowe Parker was the legal proprietor of the telegraph in Boston and held the exclusive rights to profit from Elford’s universal signal code in that harbor. Additionally, Charles Beck, the signal agent on Long Island in Boston Harbor, noted an S. Winson made signals “Which only Answer to Destroye [sic] the Conector [sic] of your Telegraph & mak [sic] Sport for Spectators.”¹²³ Beck and Bruce both claimed men like Lawrence and Winson were “no friends to the Telegraph establishment” and that such men were “Woolves [sic] in Sheep Clothings [sic]” who did not “wish for the Telegraph to succeed” with the “perpos [sic] to Destroye [sic] the credit of the telegraph.”¹²⁴

Building contractors often tried to profit fraudulently from their engagement in engineering and the mechanical arts for the purposes of advancing commerce. In 1825, for instance, the Grand River Harbour Company in Ohio and its contractors saw a

¹²¹ Melville, 20.

¹²² Johnathan Bruce to John Rowe Parker, October 9, 1824, Box 2, Folder 42, JRPC.

¹²³ Charles Beck to John Rowe Parker, January 22, 1825, Box 1, Folder 24, JRPC.

¹²⁴ Johnathan Bruce to John Rowe Parker, November 12, 1824, Box 2, Folder 42, JRPC.
Charles Beck to John Rowe Parker, December 28, 1824, Box 1, Folder 24, JRPC.

commercial opportunity for profit and attempted to bilk the state out of thousands of dollars for the completion of a public pier. Congress appropriated “one thousand dollars for completing it.” The pier was owned by the Grand River Harbour Company, which contracted with Abraham Skinner for the repairs. The intent was that once the pier was complete, the Treasury Department would pay the money to the Grand River Harbour Company. Skinner, however, sought payment directly from the federal government. He also attempted to collect the payment in advance of completing the work. The Grand River Harbor Company in turn expected to sell the pier to the United States government, thus fraudulently getting the state to pay twice for the same pier. Fortunately for the United States, Stephen Pleasonton, the Fifth Auditor of the Treasury, recognized the unscrupulous scheme and refused to pay for anything other than the original construction.¹²⁵

CONCLUSION

Although the nation had already begun expanding westward by the time the Constitution was ratified, eastern seaports remained the nation’s economic centers. As commercial interests increased, so did the problems facing commerce. With seaports anchoring the nation’s economic activity, commercial problems were shipping problems. British impressment of American sailors, safe passage for cargos and crew, and the loss of income from idled ships were just a few of the commercial problems facing early Americans. Merchants, public officials, ship owners, and others concerned with the economic livelihood and commercial advancement of their city and nation turned to

¹²⁵ Pleasonton to Thomas Foster, May 26, 1825. RG 26, Entry 18, Vol. 6, 416, NARA.

science and the practical arts to solve these commercial problems as “a matter of serious importance.”¹²⁶

Protecting the lives of mariners, valuable cargos and even the ship itself were the most important issues for American commercial interests. The loss of life was a personal tragedy, but it also impacted the economy by reducing the labor pool needed work the commercial ships. The loss of cargo had a more direct impact on the economy in that the lost goods would not generate the profits, taxes, or wages necessary for churning the economy. A lost ship often had the larger impact of losing both lives and cargo and the potential of financial ruin for local merchants and ship owners. For these reasons, many believed “commerce should receive all the protection possible” and “for this purpose, a safe harbor...is all-important.”¹²⁷

Science and the arts were necessary components to providing safe harbors and protecting commerce. In the early years, individuals who had an interest in protecting and advancing commerce took up this task. Men, such as Winslow Lewis and David Melville, invented new apparatuses or made improvements to existing technologies with the intent of advancing commerce. Government entities, such as the Treasury Department, utilized the practical expertise of such individuals. By mid-century, however, science and the practical arts in the United States had begun to mature. The Light-House Establishment began relying more heavily on the science of the Coast Survey for selecting lighthouse sites rather than petitions from locals as they had in the past. They began relying on the

¹²⁶ H. Doc. 433, 1.

¹²⁷ Ibid.

technical expertise of the Corps of Engineers for constructing breakwaters, lighthouses, piers, and wharves rather than the practical expertise of men such as Lewis.

To build this infrastructure, the Corps of Engineers needed to understand the various elements of the natural world, including tides, currents, winds, and the makeup of the ocean floor in order to properly protect commercial interests. The Coast Survey provided much of this information with its scientific studies of the harbors and inlets along the coast and its mathematical calculations charting the precise location of the coastline. Some of the information came from the Corps of Engineers' own work as they built the infrastructure of the ports and learned from their practical experience.

In the private sector, entrepreneurs participated in science and the arts to advance their commercial interests through the improvement of port efficiencies. Through the advanced reporting of ship arrivals, the marine telegraph made it possible for merchants and ship owners to pre-arrange unloading of cargoes, the sale of imported goods and merchandise, and identify outbound freights. This allowed for a faster turnaround in shipping and reduced the amount of time ships sat idle in port by as much as two weeks. The reduction in port idle time meant more voyages and more profit as ships and crews spent more time working in the economy than sitting idle in port.

CHAPTER 3

ENVIRONMENTAL CONSIDERATIONS

“They are insensible to the wonders of inanimate nature and they may be said not to perceive the mighty forests that surround them till they fall beneath the hatchet,” wrote Alexis de Tocqueville of the American public in his 1835 study of American society, *On Democracy in America*.¹ “Their eyes are fixed upon another sight: the American people views its own march across the wilds, draining swamps, turning the course of rivers, peopling solitudes, and subduing nature,” the Frenchman continued.² De Tocqueville was right. Throughout the first half of the nineteenth century, most Americans were hostile towards the environment.³ They showed little concern for the natural world. Several historians of science and technology, including Leo Marx, David E. Nye, John F. Kasson, and Judith McGraw, confirm de Tocqueville’s sentiments.⁴ Leo Marx’s *The Machine in the Garden* (1964, 2000), for instance, argues evidence of de Tocqueville’s concerns could be found much earlier in Tench Coxe’s ambitions for American manufacturing. Coxe overlooked the wonders of nature when he promoted harnessing the

¹ Alexis de Tocqueville, *Democracy in America*, ed. Richard C. Heffner, (New York: Penguin Books, 1984), 181. Roderick Frazier Nash, *Wilderness and the American Mind*, Fourth Edition, (New Haven, CT: Yale University Press, 1982), 23-4.

² de Tocqueville, 181. Nash, 23-4.

³ Nash, 44.

⁴ Environmental historian John Steele Gordon and political historian Drew R. McCoy make similar arguments. John Gordon Steele, “The American Environment,” *American Heritage* 44, no. 6, (October 1993): 30-51. Drew R. McCoy, *The Elusive Republic: Political Economy in Jeffersonian America*, (1980; repr., Chapel Hill: UNC Press, 1996).

environment for manufacturing. “By wind and water machines we can make pig and bar iron, nail rods, tire, sheet-iron, sheet-copper, sheet-brass, anchors, meal of all kinds, gunpowder...”⁵ Coxe believed factories were necessary else the “great *natural powers* of the country will remain inactive and useless.”⁶ It is true manufacturing could highlight the wonders of nature, but Coxe saw the environment in terms of economic development, not with the awe and wonder of someone sensitive to the natural world.

Similarly, Marx’s protégé, David E. Nye argues eighteenth and early nineteenth century Americans sought to “subdue the land.” Nye contends that the majority of Americans held the environment as an obstacle “to be overcome” by the industrious.⁷ According to Nye, hostility toward the environment was the dominant view held by Americans throughout the early republic and well in to the Jacksonian era of the 1830s.⁸ Nye’s interpretation, however, cuts short the timeline along which Americans held a hostile viewpoint towards the environment. Although romantic era literarists, such as Henry David Thoreau, began sympathizing with the environment by mid-century, the establishment of the Carysfort Reef Lighthouse in the early 1850s, discussed in the final chapter, indicates the idea of mastering nature continued to be a factor in Americans’ relationship with the natural world for at least another twenty years beyond Nye’s estimation.⁹

⁵ Qtd. in Leo Marx, *The Machine in the Garden: Technology and the Pastoral Idea in America*, (1964; repr., Oxford: Oxford University Press, 2000), 153.

⁶ Qtd. in Marx, 157.

⁷ David E. Nye, *American Technological Sublime*, (1994; repr., Cambridge, MA: MIT Press, 1999), 17.

⁸ Ibid.

⁹ For more on Thoreau’s sympathetic views of the environment, please see Henry David Thoreau, *Cape Cod*, (1851; repr., New York: W. W. Norton & Co., 1951), 13-15.

Lastly, John F. Kasson and Judith A. McGaw argue early American industrialists, such as Francis Cabot Lowell, Nathan Appleton, and Zenas Crane, sought to “exercise exclusive control over the environment,” as they advanced their industry.¹⁰ The environment played a central role in America’s industrial revolution as industrialists built mills near waterfalls or river rapids and dams to harness the water’s power.¹¹

Political historian Drew R. McCoy substantiates these claims. McCoy’s study of the political economy in the early American republic argues the Jeffersonian republican idea of a peaceful agrarian republic was never a real possibility. America had already achieved a “relatively advanced commercial society” by the outbreak of the American Revolution.¹² Many of the nation’s founding fathers, including John Adams and Benjamin Franklin were well aware of this fact.¹³ McCoy argues the republican vision was not one of Sparta, but rather one that was closely integrated with larger global commercial society.¹⁴ A greater discussion of republican values and practical science in the early United States follows in Chapter 5.

If solving commercial problems served as the foundation for Americans venturing into practical science and the mechanical arts, the environment played a similarly important role. The environment created many of the commercial problems for which Americans sought solutions and thus created a need for science and the arts. This chapter examines the environment’s impact on the development of American science, illustrating

¹⁰ John F. Kasson, *Civilizing the Machine: Technology and Republican Values in America, 1776-1900*, (1976; repr., New York: Hill & Wang, 1999), 69. Judith A. McGaw, *Most Wonderful Machine: Mechanization and Social change in Berkshire Paper Making, 1801-1885*, (Princeton, NJ: Princeton University Press, 1987), 22-7.

¹¹ Kasson, 69. McGaw, 22-7.

¹² McCoy, 70.

¹³ *Ibid.*, 70, 75.

¹⁴ *Ibid.*, 75.

how the environment mandated the involvement of the state, shaped innovation and created a need for science and the arts.

To solve the commercial problems created by the environment, many Individuals tapped into the natural properties of the landscape's resources and exploited those properties and resources to give themselves an advantage over their surroundings. Additionally, Americans adapted, innovated, and used their knowledge of natural philosophy and the arts to solve problems in nature. These innovations targeted specific elements of the environment that allowed man to co-exist with the natural world. Lastly, many individuals went so far as to alter the environment to best suit their own needs. Altering the environment, however, also presented the greatest opportunity for the environment to fight back against man's encroachment. This constant struggle between man and the environment necessitated the involvement of the state.

EXPLOITING THE LANDSCAPE'S RESOURCES

As individuals sought to solve the various commercial problems outlined in Chapter 2, natural forces presented their own set of problems. Forces of nature, such as winds, storm surges, and erosion, created a need for a scientific understanding of the world. Americans had to keep this in mind as they worked to solve commercial issues. Sometimes this required using the landscape's natural resources to tame nature's forces, keep the forces of nature in check, or at the very least, prevent those forces from becoming bigger issues. Captain Lemuel Moody and the Portland Observatory are a case in point. In the spring and summer of 1807, Moody took charge of building a marine telegraph station. The station, then known as the Portland Monument Ground, provided

the seaport with advanced notice of ship arrivals.¹⁵ Building the tower proved quite a challenge for Moody. Moody was not an engineer. He was a retired shipmaster. Presumably, Moody learned the art of construction during his twenty-plus years plying the oceans, rising from a lowly waterboy in the American Revolution to a sea captain before the turn of the century. As a mariner, Moody undoubtedly had to make repairs to his ship at some point in that career. Although few records exist documenting Moody's career at sea, it is unrealistic to think his ships escaped the ravages of storms and the sea. If Moody's did not encounter such concerns in a career spanning more than twenty years, Moody would have had one of the most remarkable seafaring careers of any mariner in the history of sailing.

Storms and the ravages of the sea caused a great deal of damage to ships on the water. Often times repairing damages at sea could not wait until the ship reached the next port, but rather the repairs had to be completed while the ship was en route. This necessitated that mariners learned the art of construction. Through this learning, sailors gained knowledge of construction techniques, strength of materials, and practical engineering experience. They also learned to take their environment into consideration and they applied their knowledge to combating the effects of the environment. This practical experience is evident in Moody's construction of the Portland Observatory and the tower's longevity. The observatory has lasted 210 years and still remains standing in its original location today.

Moody not only considered the tower's purpose, he also thought intently about the coastal environment and the forces of nature affecting the observatory. Although

¹⁵ Lemuel Moody, "Meeting Notice, April 24, 1807" (Portland, ME), Ms. Coll. 1931, Lemuel Moody Collection, Folder 6, MeHS.

Portland's harbor is protected by Cape Elizabeth to the south and the barrier islands of the Casco Bay to the east, the city of Portland sits on an inclined peninsula that leaves it exposed to the harsh coastal elements. For this reason, Moody decided to build his marine lookout "in the form of a lighthouse."¹⁶ Tapered lighthouse towers, such as those at Portland Head and Cape Henry, had proven effective against coastal elements regardless of the locale. Moody understood the task at hand and proceeded with the knowledge that "the form of a lighthouse," provided the best option for the tower's long term survival.

The fields of architecture and engineering were just beginning to emerge in the United States when Moody built his marine observatory.¹⁷ Moody was not formally trained in either field and his only knowledge of architecture and engineering was what he knew about ship design and repair from his days of sailing. Moody also lacked the knowledge of the strength of materials. Ann Johnson notes that strength of materials testing was also emerging in the United States alongside the field of engineering.¹⁸ Similar to his knowledge of architecture and engineering, Moody's knowledge of

¹⁶ Lemuel Moody, "Portland Observatory Subscriber Agreement, 1807." (Portland, ME, March 20, 1807), Ms. Coll. 1931, Lemuel Moody Collection, Folder 1, MS 179, MeHS.

¹⁷ Ann Johnson, "Material Experiments: Environment and Engineering Institutions in the Early American Republic," in *National Identity: The Role of Science and Technology, Osiris 24*, ed. Carol Harrison and Ann Johnson, (Chicago: UC Press, 2009), 59. Terry S. Reynolds, "The Education of Engineers in America Before the Morrell Act of 1862," *History of Education Quarterly* 32, no. 4 (Winter 1992): 459-82. Terry S. Reynolds, ed., *The Engineer in America: A Historical Anthology from Technology and Culture*, (Chicago: UC Press, 1991), 11-2, 16. Peter Michael Molloy, "Technical Education and the Young Republic: West Point as America's Ecole Polytechnique, 1802 – 1833," (Ph.D. Diss., Brown University, 1975).

¹⁸ Johnson, 59-69.

strength of materials was limited to what he may have gained from working on seafaring vessels and making any necessary repairs while the ship remained at sea.¹⁹

What Moody did possess was an intimate knowledge of Portland's physical geography. Moody understood his lookout tower needed to withstand the violent hurricanes and ravaging nor'easters that constantly plagued Portland's coastal community. He understood the benefits the local environment provided as well as the challenges it posed to the success of his operation. This double-edged sword pushed Moody to consider every aspect of the environment in building his signaling station. Portland's physical environment was both friend and foe.

Portland's physical environment provided two major benefits for Moody's tower. First, the natural resources in and around the seaport provided Moody with an abundance of strong building materials that proved ideal for standing up against the harsh conditions of the coast. For instance, Moody ballasted the foundation of the signal tower with 122 tons of granite rubblestone quarried from the coast and the fields surrounding the port.²⁰ Moody knew from his seafaring days that a strong, heavy ballast helped stabilize a ship and kept it upright against rolling waves and violent storms. Because Moody had no formal training in architecture or engineering, he drew on his experience and practical knowledge of shipping in building his marine telegraph. He surmised that a heavy ballast of granite rubblestone would keep the observatory tower upright against the constant

¹⁹ James Risk, "Lemuel Moody and the Portland Observatory: A Case Study in Knowledge Transfer in the Early American Republic," *Society for the History of Technology Annual Meeting*, October 13-15, 2013, Portland, ME.

²⁰ John K. Moulton, *Captain Moody and His Observatory*, (Falmouth, ME: Mount Joy Publishing, 2000), 27.

punishment of the coastal winds similar to the way a ship's ballast keeps the vessel from rolling.²¹

Moody chose the granite rubblestone not only for its prevalence around Portland, but also its weight. Aside from basalt, granite is the heaviest stone common to Portland. Given a sample of equal dimensions, granite is five times heavier than pinewood, Portland's other abundant natural resource.²² Once completed, the observatory eclipsed seven stories and stands more than 85 feet tall.²³ It needed a heavy ballast to provide a sufficient counterweight to the prevailing winds. Moody's decision proved an admirable choice.

Contractors harvested the wood for the tower, including the "eight sticks of prime timber of sixty-five feet in length, fourteen inches square at the butt and ten inches at the top" used for the corner support posts, from the forests near Sebago Lake and Windham, both just to the northwest of Portland.²⁴ Here again, the abundance of white pine in and around the port made it the obvious choice, but Moody was also aware of pine's strength from his sailing days. White pine was the same material used for ships' masts. Moody knew that pine was strong enough to endure the hurricanes and harsh nor'easters that

²¹ Risk, "Lemuel Moody and the Portland Observatory."

²² Amlink Marble, "Amlink Material Weight Calculator,"

<http://www.amlinkmarble.com/weightcalculator/weightcalculator.htm> (accessed September 17, 2013).

²³ "HABS ME, 3-Port, 7- (sheet 4 of 4) – Portland Observatory, 138 Congress Street, Portland, Cumberland County, ME," LOC Prints and Photographs Division, Washington, DC <http://www.loc.gov/pictures/item/me0024.sheet.00004a/> (accessed November 8, 2015).

²⁴ Lemuel Moody, "Notes related to the construction of the Portland Observatory," (Portland, ME, 1807), Ms. Coll. 1931, Lemuel Moody Collection, Folder 11, MS 173, MeHS. Moulton, 22.

were common to Portland, but also light enough to allow for relative ease in raising the tower's eight 65-foot tall corner support posts.

Second, the physical geography of the port provided Moody with an ideal location. As previously mentioned, the city of Portland sits on a hill sloping towards a sheltered harbor while the Casco Bay is full of islands. The coastline extending from Portland to the Portland Head Lighthouse at Cape Elizabeth is lined with rocky cliffs. In thinking about the intended purpose of the marine observatory, Moody knew the tower needed to be elevated in order to have an unobstructed view of the harbor, bay, and cape. He chose the highest elevation in the city, an "elevated [sic] part of Mountjoy's Neck." Mountjoy Hill was a windswept barren wasteland used primarily for grazing cattle.²⁵ Moody chose the hill not only because of its excellent 360-degree views, but also because it had a clear line of sight with the city's wharves.²⁶ Merchants and dock workers easily saw the observatory and its signals and knew what was going on with shipping beyond their limited view of the bay.

Moody also considered the environment in his design of the tower. Moody designed the observatory on a compass rose with each of the eight sides aligning directly with a point on a compass – N-S-E-W and NE-SE-SW-NW. He then tapered the observatory near the top to provide the least wind resistance. Designing the lookout was an important task. Moody knew that designing the observatory "in the form of a lighthouse" gave it the best chance of surviving the coastal elements.²⁷

²⁵ Moulton, 22, 26.

²⁶ Moody, "Subscriber Agreement."

²⁷ Ibid.

Others were not so sure. For many, the observatory was the tallest building they had ever seen. Moody's tower bested the Portland Head light by a full story.²⁸ Calvin Day and Nathaniel Willis, editors of Portland's *Eastern Argus* newspaper, were two such skeptics. In the month after the observatory was completed, Day and Willis questioned the stability of Moody's tower claiming, "at some period hence forward the tower will blow over like a summer cloud."²⁹ Moody proved the editors wrong. As previously noted, Moody's observatory continues to tower over the city today, some 210 years after its construction, despite Portland's harsh coastal environment. The Portland Observatory is the only remaining nineteenth-century marine telegraph station in the United States. Two reasons the observatory remains are because of its excellent design and Moody's choice of materials.³⁰

The Portland Monument Ground invoked a sublimity among residents and visitors alike. The awe and wonder experienced by the tower's visitors were not so much because of the technology itself, but rather because of what the structure represented. The observatory illustrated both man's conquest of nature and man's place within it. Moody conquered the environment by utilizing the environment's own natural resources against its climatic elements. He invited spectators to climb to the top of his tower where they were taken abreath by the vast panoramic views of the expansive oceanic scene. Nowhere else on earth could one take in the vastness of the ocean except at sea.

²⁸ When Moody built the observatory, Portland Head Light was only 72 feet tall. It is currently 80 feet tall.

²⁹ "Communication: The Spirit of the Brown Tower: A Tale of these Times," *Eastern Argus*, September 24, 1807. Moulton, 26.

³⁰ Preservation efforts in the 1930s and the early 2000s helped save the tower from destructive wood-eating beetles.

SOLVING ENVIRONMENTAL ISSUES THROUGH ADAPTATION AND INNOVATION

If men like Captain Moody used the environment against itself, they also invented technologies to solve specific problems created by the landscape. In this, some might see the environment as advancing science and the arts in the early United States, while others might argue the natural world dictated the science performed and the technologies used by America's scientific minds. The power of the natural world dictating outcomes is well-argued by environmental historians. Mark Fiege's *Irrigated Eden*, for instance, argues the environment of Idaho's Snake River Valley compromised any chance of engineers controlling the natural world and their plans for an ordered agricultural landscape. These engineers sought to bring water to the valley's desert and turn it into an agricultural mecca. As engineers altered the natural world, the environment pushed back with its own change.³¹ William Cronon asserts Chicago's rapid growth was directly influenced by its position within nature. Cronon begins his argument showing how Chicago's location was a desolate wasteland unworthy of such a great city, yet the natural world provided the city with access to farmland, forests, and water that fueled the city's economy. The location of these natural resources naturally dictated the location of Chicago's granaries, meat packing plants, stockyards, and other amenities that turned Chicago into the gateway to the west more than the Mississippi River cities of St. Louis and New Orleans.³² Ari Kelman's *A River and Its City* and Matthew Klinge's *Emerald*

³¹ Mark Fiege, *Irrigated Eden: The Making of an Agricultural Landscape in the American West*, (Tacoma, WA: University of Washington Press, 2000).

³² William Cronon, *Nature's Metropolis: Chicago and the Great West*, (1991; repr., New York: W. W. Norton & Co., 1992).

City make similar arguments about the environment's ability to influence development in New Orleans and Seattle respectively.³³

Arthur McEvoy's *The Fisherman's Problem* illustrates how the environment dictated government policy in California. By arguing the environment was as much of a factor in the degradation of natural resources as human interaction, McEvoy demonstrates how natural world phenomenon, such as El Nino, contributed to policymakers' misunderstanding of the environment and therefore negatively influenced legislation aimed at reversing landscape degradation.³⁴ Richard White extends this argument by illustrating how the Columbia river dictated the development of electrical, nuclear, and steam power technologies.³⁵

The development of the mud machine, the marine telegraph, the diskpile foundation and oil heaters and lens defrosters for America's New England lighthouses are good examples of the environment's interaction with science and the arts. The mud machine, for instance, was developed to dredge harbors and deepen shipping lanes so that shipping could move in and out of port unimpeded by the natural world. The marine telegraph provided advance notification of ship arrivals in ports where the view from the wharf was obstructed by barrier islands, rocky cliffs, and other geographical features. The diskpile foundation allowed engineers to secure offshore structures to hollow reefs on the

³³ Ari Kelman, *A River and Its City: The Nature of Landscape in New Orleans*, (Berkeley, CA: University of California Press, 2003). Matthew Klinge, *Emerald City: An Environmental History of Seattle*, (New Haven, CT: Yale University Press, 2007).

³⁴ Arthur F. McEvoy, *The Fisherman's Problem: Ecology and Law in the California Fisheries, 1850 – 1980*, (Cambridge, UK: Cambridge University Press, 1986).

³⁵ Richard White, *The Organic Machine: The Remaking of the Columbia River*, (New York: Hill & Wang, 1996), 31-8, 49-58, 79-80.

ocean floor. Cold northern winters necessitated the development of oil heaters and lens defrosters in coastal beacons.

Mud Machines

One technology influenced by the environment was the development of the steam powered dredger, often referred to as the “mud machine.” John and Andrew Ellicott, first introduced the horse powered mud machine when they opened their wharf in Baltimore’s harbor to export flour in 1783.³⁶ Before they could build their wharf, the Ellicott brothers needed to dredge the harbor at the construction site so they could accommodate larger vessels. To achieve this, John and Andrew constructed a horse-drawn bucket scoop and placed it on a barge. The bucket scoop consisted a horse-powered treadwheel attached to a chain-driven winch. As the treadwheel turned, the winch coiled the chain and raised the bucket scoop of dredge from the depths of the harbor. The operator then dumped the spoil on a large scow positioned next to the barge. When the scow was full, it sailed down the Patapsco River where it would dump the dredge back into the water.³⁷

The Ellicotts’ venture with the mud machine was a private one. They used it specifically to clear the harbor for the construction of their wharf. Other merchants, however, quickly realized the utility of the machine and pushed the city of Baltimore to invest in its own mud machine. The city’s board of Port Wardens levied a one cent tax on every ton of cargo moving through the harbor. Five years later, the Port Wardens doubled

³⁶ Robert C. Keith, *Baltimore Harbor: A Picture History*, (1982; repr., Baltimore, MD: JHU Press, 1991), 164.

³⁷ *Ibid.*

the tax. By the turn of the decade, the Port Wardens had raised enough money to order the construction of the Ellicotts' mud machine for general use in the harbor.³⁸

The horse-drawn mud machine was a slow process. According to Seth Rockman, a labor historian of early Baltimore, workers standing in shallow water guided the mud machine's bucket scoop and "emptied the foul-smelling muck into waiting scows." This operation required as many as 60 laborers a day.³⁹ Emptying the scow was equally difficult. The entire process was inefficient.⁴⁰ Adding to that was the continual need for keeping the harbor and shipping lanes clear of dredge buildup. Baltimore's harbor is fed by the Jones Falls. As the Falls flowed through the city, it brought dirt and debris with it, which were deposited on the floor of the harbor at the end of the Falls' run. The velocity of the Jones Falls meant the harbor filled up very quickly. Floods, such as the one in 1796, caused the harbor to fill up faster than the mud machine could remove the debris. Overdevelopment of Jones Falls in the early nineteenth century exacerbated the problem by reducing the paths for runoff and drainage, thus channeling it into the Falls and increasing the velocity of the river.⁴¹ Something better was needed.

In 1824, the city of Baltimore contracted with Watchman and Bratt to build a steam engine, which was placed on the dredging machine.⁴² The steam-powered dredging machine proved more efficient than its horse drawn predecessor. It was not only faster,

³⁸ Ibid. Seth Rockman, *Scraping By: Wage Labor, Slavery, and Survival in Early Baltimore*, (Baltimore, MD: JHU Press, 2009), 23.

³⁹ Rockman, 23.

⁴⁰ Keith, 164.

⁴¹ James Risk and Kevin Attridge, "Garitee vs. Mayor and City Council of Baltimore: A Gilded Age Debate over the Role and Limits of Local Government," *Maryland Historical Magazine* 109, no. 4 (Winter 2014): 455.

⁴² "A Supplement to an Ordinance for Building a Steam Engine for Dredging, etc.," 1824, BCA - CCR, WPA Item No. 733, RG 16, Series 1, Box 26, Baltimore, MD.

but also more powerful. Unfortunately, the steam engine required a great deal of maintenance to keep it running. The Port Wardens originally paid Watchman and Bratt \$2,500 for the steam engine, but within a few years the Wardens had to replace the steam power dredging machine with a new one. The estimated repairs nearly exceeded the cost of a new machine.⁴³

The conflict between nature and technology is a contentious one and the mud machine was no different. As the mud machine removed debris and opened the shipping lanes, it also cleared the path available for the silt and debris to run off. By reducing the the barriers to runoff and erosion, the mud machine made it easier for silt and debris to build back up. The mud machine demonstrates that nature necessitates the development of newer, more advanced technologies, but those technologies in turn also interfere with nature. The cycle of conflict between nature and technology is infinite. Man will never win the ultimate battle against the environment and the forces of nature.

Telegraphic Science

Although telegraphic science had been around for several centuries in the old world, it was still in its infancy in the United States at the turn of the nineteenth century. David Porter established the first telegraph station in the United States in 1797 on Baltimore's Federal Hill.⁴⁴ Other seaports soon followed. Around the turn of the nineteenth century, a semaphoric telegraph existed between The Vineyard and mainland

⁴³ "Supplement to an Ordinance." "Report of the Joint Committee on the Harbor," February 7, 1831, BCA-CCR, WPA Item No. 1111, RG 16, Series 1, Box 42, Baltimore, MD.

⁴⁴ David Porter, "Proposal," *Federal Gazette & Baltimore Daily Advertiser* (Baltimore, MD), March 16, 1797. David Porter, "The Subscribers of the Observatory," *Federal Gazette & Baltimore Daily Advertiser* (Baltimore, MD), May 10, 1797. M.V. Brewington, "The Observatory," *Maryland Historical Magazine* 44, no. 2 (1949): 102.

Massachusetts, although the name of the proprietor is unclear.⁴⁵ Lemuel Moody built the Portland observatory in 1807.⁴⁶ Most east coast telegraph stations in the United States, however, were established between the 1810s and 1830s.⁴⁷

The environment played a significant role in furthering telegraphic science in the United States. In most cases, proprietors like David Porter and Lemuel Moody established telegraph stations to compensate for the lack of a visual line of sight.⁴⁸ Many American ports were established because the physical geography of the landscape provided a shelter from violent ocean storms and sea surges that resulted from those storms. Yet, the protective nature of the landscape also created challenges for merchants and port officials. In many ports, the sheltering nature made it impossible for the port to see approaching ships and vice versa. The port environment provided the opportunity to develop and expand telegraphic science. The natural world dictated a need for marine observatories to spot incoming ships and telegraph their arrival to the merchants, stevedores, and other interested parties. In Baltimore for instance, the approach to the inner harbor runs the length of the Patapsco River, however the towering height of Federal Hill blocks the view of the Patapsco from the docks. Merchants, public officials, and dock workers were unable to see ships approaching the harbor until those ships had

⁴⁵ Samuel Eliot Morison, *A Maritime History of Massachusetts, 1783-1860*, (1921; repr., Boston: Northeastern University Press, 1979), 166. William U. Swan, "Boston's First 'Wireless' Telegraph Brought News from Vineyard in 1801," *Boston Sunday Globe* (Boston, MA), April 21, 1929.

⁴⁶ Moody, "Meeting Notice." Moody, "Subscriber Agreement."

⁴⁷ John R. Parker, "Telegraph Notice," *Eastern Argus* (Portland), April 13, 1830. Robert G. Albion, *The Rise of New York Port*, (New York: Charles Scribner's Sons, 1939), 217.

⁴⁸ Moody, "Subscriber Agreement." Porter, "Proposal."

almost reached the docks. This late notice impacted every aspect of the ships' unloading from the hiring of stevedores to the selling and storage of the imported merchandise.⁴⁹

If the natural landscape dictated the need for marine telegraphs, the physical environment also determined how the telegraph stations were built and where they were located. David Porter, for instance, built his his marine telegraph on top of Federal Hill. By placing the signal station on such a high vantage point, Porter was able to see both the inner and outer harbors of Baltimore and several miles of the Patapsco River leading into the port. Federal Hill's height above the surrounding area, however, allowed Porter to build a modest tower of approximately two stories. In contrast, Moody's observatory in Portland eclipsed six stories despite being situated on the highest elevation in the city. The high rocky cliffs and Casco Bay islands mandated the height of Moody's tower. In Boston, the lay of the land and the various islands of the harbor mandated a network of signal stations.⁵⁰

Additionally, the natural world limited the colors, shapes, and designs that could be used on signal flags due to the principles of atmospheric refraction.⁵¹ The concept of atmospheric refraction can be traced back to Claudius Ptolemy of the ancient Greco-Egyptian civilization. In its simplest terms, atmospheric refraction is the aberration of light and other electromagnetic waves passing through the earth's atmosphere. The effects of atmospheric refraction, however, are much more complicated. For instance, as

⁴⁹ Moulton, 17-8. Brewington, 101. James Risk, "Ship to Shore: Infrastructure and the Growth of American Seaports, 1790-1850," (Master's thesis, UMBC, 2011), 56-8.

⁵⁰ Ms. Coll. 186, Parker, John R. (Rowe) 1777-1844, Correspondence 1802-1840, KUPL. Hereafter cited as JRPC. Morison, 166.

⁵¹ Rob Raeside, "Maritime Signal Flag History," *Flags of the World*, last updated November 19, 2015 <http://www.crwflags.com/fotw/flags/xf~sfh.html> (accessed July 3, 2016).

astronomer Andrew T. Young notes, refraction “lets us see a little further, if the ray is concave toward the earth,” but that air quality, the curvature of the earth, and temperatures can all affect atmospheric refraction.⁵² This says nothing of adverse weather conditions, which in themselves could cause problems with the identification of colors, shapes, and designs. Young also notes, refraction is “particularly variable over water, because of the high heat capacity of water” and that “temperature contrasts are particularly marked near the shore.”⁵³ Observations from the maritime signal towers would have been directly impacted by weather conditions and the laws of atmospheric refraction.

Red, white, and royal or navy blue were the most common colors used on maritime signal flags throughout the nineteenth century. A survey of over 1,000 signal flags and private merchant house flags from 19 different American ports show more than 90% of the flags used by the marine telegraphs limited their colors to some combination of red, white, and blue.⁵⁴ Although dyes of the early nineteenth century may not have contrasted as much as they do today, the limited use of colors resulted from the distance at which the colors could be seen and discerned from one another rather than from the

⁵² Andrew T. Young, “Distance to the Horizon,” last updated 2012, http://www-rohan.sdsu.edu/~aty/explain/atmos_refr/horizon.html (accessed July 9, 2016).

⁵³ Young.

⁵⁴ Survey data comes from Ms. 282 William Crothers Collection, GGBW; Ms. 335 Edouard A. Stackpole Collection, 1750-1900, NHA; Ms. 139 Signal Flag Books, 1800-1860, NHA; Ms. 902 Signal Books and Thermometrical Records at the MeHS; and F. Gray Griswold, *The House Flags of the Merchants of New York, 1800 – 1860*, (Norwood, MA: The Plimpton Press, 1926). Ports included in the data are Baltimore, Boston, Charleston (SC), Dartmouth, Edgartown, Fair Haven, Groton (CT), Marion, Nantucket, New Bedford, New London (CT), New York, Norfolk (VA), Philadelphia, Portland (ME), Provencetown, Sag Harbor, Salem, and Westport.

inability to manufacture dyes of other colors.⁵⁵ Black and yellow appeared less frequently on American signal flags than on European signals. Green was found on fewer than five flags from the previously mentioned survey of 19 American port cities.⁵⁶

Although yellow was found on a few flags, the hue was one of those colors that observers found hard to distinguish. In 1824, Charles Beck, the signaling agent stationed at Long Island in Boston Harbor, informed John Rowe Parker, the proprietor of Boston's marine telegraph, that he was replacing the yellow flags with "Some thing Bather [sic]."⁵⁷ Jonathan Bruce, another Boston signaling agent stationed at the Boston lighthouse, wrote to Parker asking for cloth of red, white, and blue, stating that he could make the flags "so plain that you will not mistake them in whether [sic]."⁵⁸ Barnard Lindsay Watson's signals from Holyhead to Liverpool between 1827 and 1839 and Frederick Marryat's signals for British merchants first published in 1817 were similarly colored. One-third of Marryat's signals also incorporated yellow.

Atmospheric refraction and the inability to distinguish colors at great distances also impacted the designs that were used on signals. In 1780, Captain Walter Young of the *HMS Sandwich* noted, "Chequed flags should be abolished. Quartered, halved, three-striped, striped corner ways, half up and down, and pierced are the only ones that are

⁵⁵ Dominique Cureau, comment March 20, 2006 on Raeside. David Prothero, comment March 21, 2006 on Raeside. Cureau's comment refers to European flags from the 1700s, but trade networks make this equally applicable to American flags throughout the 19th century.

⁵⁶ Ms. 282 William Crothers Collection, GWBW; Ms. 335 Edouard A. Stackpole Collection, 1750-1900, NHA; Ms. 139 Signal Flag Books, 1800-1860, NHA; and Ms. 902 Signal Books and Thermometrical Records at the MeHS; and F. Gray Griswold, *The House Flags of the Merchants of New York, 1800 – 1860*, (Norwood, MA: The Plimpton Press, 1926).

⁵⁷ Charles Beck to John Rowe Parker, May 23, 1824, Box 1, Folder 24, JRPC.

⁵⁸ Jonathan Bruce to John Rowe Parker, November 12, 1824, Box 2, Folder 42, JRPC.

properly distinguished at a distance.”⁵⁹ This sentiment was shared by Rear Admiral Richard Kempenfelt. Kempenfelt believed tri-colored flags of vertical stripes were the easiest to distinguish and noted that red-yellow combinations on flags resulted in poor identifications.⁶⁰ According to Andries Burgers, “Simple signal flag design is an imperative at sea and it is the practical seamanlike requirement to be able to identify signal flags at the longest possible distance.”⁶¹

Similarly, the natural world limited the shapes that could be used on signal flags. Kempenfelt, for instance, wrote that pendants should not have swallowtails. In 1814, Vice-Admiral Sir Samuel Hood wrote Sir Home Popham, “The Broad Pendants give great relief to the observer, the flag wafting out with every change of view, the colours are more perfectly distinguished. There certainly is not that advantage in triangular flags; they are in general difficult to discern.”⁶²

While these examples pertain to European signal codes, they can be easily applied to the American systems. When Porter and Moody established their signaling stations in Baltimore and Portland, they drew on their knowledge of the European systems they encountered in the Caribbean.⁶³ John Rowe Parker claimed, Samuel C. Reid’s New York telegraph was “nearly similar” to Watson’s signals at Holyhead.⁶⁴ Through their knowledge of the European signal systems, proprietors of the marine telegraph already understood that certain colors, designs, and shapes were indistinguishable in the marine environment.

⁵⁹ Prothero.

⁶⁰ Ibid.

⁶¹ Andries Burgers, comment March 20, 2006 on Raeside.

⁶² Prothero.

⁶³ Brewington, 102. Moulton, 30.

⁶⁴ John Rowe Parker to James Elford, n.d. (June 27, 1828?), Box 3, Folder 97, JRPC.

In order to give the observer the best advantage at discerning colors, shapes, and designs, the observatories used the most advanced telescopes of the day. Porter and Moody both utilized telescopes made by Peter and John Dollond of London⁶⁵ Minutes of the organizational meeting for the Portland Monument Ground indicate Moody spent \$500 on the Dollond and Son telescope used at the observatory on Munjoy Hill.⁶⁶ The environment thus not only dictated the colors, shapes, and designs used on flags, but also the equipment needed to identify those characteristics.

One might wonder why Moody and Porter sent away to London to procure their telescopes rather than purchase them domestically. The answer is simple. Although glass manufacturing was one of America's first industries, the United States simply did not have the capability of producing high quality optical glass. The state of science and the arts in the United States limited American access to knowledge and American glass manufacturers lagged behind their European counterparts. In fact, few Americans knew the art of glassmaking. According to Pamela O. Long, "Glassmaking involved much tacit knowledge especially as it related to firing in the furnaces."⁶⁷ This limited American production and quality. Most gaffers, skilled master artisans who oversaw a teams of glassmaking laborers, had to be brought over from Europe. Enticing Europeans to immigrate to the United States and paying for their passage made glass production in the

⁶⁵ Brewington, 103. Moulton, 31.

⁶⁶ Moody, "Meeting Notice." Moulton, 22.

⁶⁷ Pamela O. Long, "Invention, Secrecy, and Theft: Meaning and Context in the Study of Late Medieval Technical Transmission," *History and Technology* 16, no. 3 (2000), 228.

United States more expensive.⁶⁸ The Dollond's of London, on the other hand, were producing top quality optical glass. Their telescopes were considered among the best in the world at the time.

Although certain colors, shapes and designs were indistinguishable at sea or between the land and the sea, there were fewer issues with discerning colors, shapes, and designs between the observatory and the port. In Baltimore, for instance, the observatory agent flew a triangular pendant to signal the arrival of an unknown brig.⁶⁹ In Portland, a yellow triangular pendant signified an approaching sloop.⁷⁰ One reason for there being fewer issues was the distance. At sea and between the land and the sea, the distance between the signal and the observer was greater than it was between the observatory and the port. Greater distances allowed for atmospheric refraction to distort images, colors, and shapes.

Issues surrounding the colors, shapes, and visibility of signal flags illustrates how the environment impacted even the littlest things. To the uninformed observer, the color or shape of a flag might seem inconsequential. Individuals participating in the mechanical arts and practical science, however, understood that they had to consider the environment in nearly every aspect of the scientific and mechanical work.

Stansbury's Diskpile Foundation

If the environment played a significant role in the marine telegraph, it played a similar role in the construction of the lighthouse at Carysfort Reef in Florida. On the

⁶⁸ Brooke Hindle, "The Exhilaration of Early American Technology," in Judith A. McGaw, ed., *Early American Technology: Making and Doing Things from the Colonial Era to 1850*, (Chapel Hill: UNC Press, 1994), 63. Arlene Palmer, *Glass in Early America*, (Winterthur, DE: The Henry Francis du Pont Winterthur Museum, 1993), 9-10.

⁶⁹ Brewington, 104.

⁷⁰ Moulton, 32.

recommendation of the Army Corps of Engineers, the Lighthouse Service intended to build a screwpile style structure at Carysfort. A screwpile foundation is a tubular cast or wrought iron skeletal frame. It is an adaption of the standard straightpile construction. The screwpile foundation was first used by Alexander Mitchell, a blind Irish architect and engineer, in 1838. Mitchell added threads to the end of the wrought iron tubes allowing them to be screwed into the ground for greater rigidity and stronger structural support. Although the straightpile construction had been used in both onshore and offshore structures, the screwpile proved especially ideal for muddy, sandy, or swampy soft-bottomed floors. The design was also highly touted in exposed and wave-swept areas because it allowed the wind and waves to sweep through the foundation almost unobstructed.

The lighthouse at Carysfort Reef proved more challenging than the screwpile light built by Major Hartman Bache and Lt. George Gordon Meade at Brandywine Shoal in the Delaware Bay. While it was intended that the Army Corps of Engineers would build a screwpile structure for the Light-House Service at Carysfort, the environment made that task impossible. Engineers originally believed Carysfort Reef was solid and would provide a suitable base for the screwpile foundation. Upon closer inspection, however, Captain Howard Stansbury found the reef hollow. The engineers had nothing to which they could anchor the screwpiles.

Stansbury went to the drawing board. He determined that by driving the piles through steel disks he could anchor the piles in the hollow reef. By adding disks to the piles, Stansbury extended the reach of the screwpile threads and ensured the piles bored into the solid portions of the reef when they were screwed into the sea floor.

Additionally, the disk helped distribute the weight of the structure giving it stability and making it more secure in the face of hurricanes and other environmental elements. Stansbury's diskpile innovation shows the impossibility of a one-size-fits-all technology suitable for every environment. The screwpile foundation proved successful in many other applications, but the innovation did not work for the Carysfort Reef because the shoal was hollow at its core. The same can be said for other innovations. Technology must be adapted to each unique landscape. Engineers, inventors, and others responsible for designing mechanical apparatuses cannot account for every geographic feature or variance between two different physical environments. It is an unreasonable expectation to believe that man can, or will someday, accomplish this impossible task.

Oil Heaters and Lens Defrosters

Stansbury's diskpile construction is not the only instance when the environment dictated the development of new technologies. As mentioned in Chapters 2 and 4, several individuals tinkered with inventing an oil heater for lighthouse lamps in the mid to late 1810s. Chapter 2 looks at the oil heater as a commercial opportunity for the inventors, whereas Chapter 4 looks at the innovation in terms of mechanical arts in the Light-House Establishment. Here, the oil heater is discussed as a product deriving out of environmental factors.

Tinkering in the mechanical arts was directly influenced by the environment. Unlike other countries, specifically France, that used colza oil to fuel their lighthouse lamps, the United States primarily used spermaceti oil. Spermaceti oil is a waxy substance derived from the head of sperm whales that is much denser, and in the early

nineteenth century much cheaper, than colza.⁷¹ Colza, also known as rapeseed, is extracted from cabbage, mustard, turnips, and other vegetables of the Brassicaceae family. During the cold winter months northern United States lighthouse keepers struggled to keep the oil from congealing. Once the spermaceti oil congealed, the lighthouse lamp's flame is greatly reduced and often extinguished altogether. Mechanics, such as Alexander Black, Winslow Lewis, and David Melville, attempted to solve this problem of congealing oil, which was created by their local environment. Melville, for instance, devised a small tube to direct the heat of the lamp's flame to the oil. The heat from the flame was just enough to keep the oil warm and prevent its congealing. Lewis and Black attempted to copy Melville's invention, but ultimately, Melville innovation was installed on all of the northern lighthouses.

The environment also influenced Melville in developing a method for defrosting and dehumidifying the lighthouse lens. Moisture from the humid summer and cold winter airs caused condensation and frost to accumulate on the lighthouse lantern, which reduced the visibility of the light at sea. Melville installed a small scuttle door on the lamp that could be opened or closed to admit or exclude the vapors of the external air and thus prevent the accumulation of humidity and frost "from collecting on the windows at all seasons and in all states and temperatures of the atmosphere." This small adaptation could even dislodge frost after it had already accumulated.⁷²

⁷¹ Stephen Pleasonton to Thomas Corwin, March 8, 1852, in United States Treasury Department, *Light-Houses: Letter From the Secretary of the Treasury...in Reply to a Report Made to Congress by the Light-House Board*, by Thomas Corwin, 32nd Cong., 1st sess., 1852, H. Doc. 88, 15.

⁷² David Melville, *An exposé of facts...relating to the conduct of Winslow Lewis...addressed to the Hon. the Secretary of the Treasury*, (Providence, RI: Miller & Hutchins, 1819) 10, PRHC, no. 470, HAG.

As Baltimore's mud machine, the colors of the telegraphic flags, Captain Howard Stansbury's diskpile foundation, and David Melville's inventions illustrate, American's used science and the arts to overcome environmental challenges. These examples also demonstrate how the natural world dictated the need for specific technologies to solve everyday problems in the landscape. The interaction between the environment and early republic science and the arts was a give and take relationship.

ALTERING THE ENVIRONMENT AND INVOLVING THE STATE

If Americans used science and the arts to overcome environmental challenges, they also altered the environment to solve problems created by the natural world in an attempt to realize their vision for America. The dredging of Baltimore's harbors is a case in point. As previously mentioned, debris and silt from the Jones Falls continuously filled the harbor basin making it difficult for shipping to navigate in and out of the port. Port officials, contractors, and even the Army Corps of Engineers removed dredge buildup from the harbor using steam powered mud machines. These spoils were then dumped along the Patapsco River reshaping the river's geography and altering the area's ecosystem. Harbor officials, however, showed little concern with their impact on the environment. They only had their long-term vision for the port in mind.⁷³ Similar

⁷³ *Barron v. City of Baltimore*, 33 US, 243, 244 (1833). Although *Barron v. City of Baltimore* pertains to the constitutionality of taking of private property without just compensation, the case provides evidence of the City only having concern for their vision for the port. The city "in an asserted exercise of its corporate authority over the harbor" purposely adapted and diverted the natural course of streams to bend the water to Barron's wharf.

situations could be found in other American ports from Portland, Maine to Savannah, Georgia.⁷⁴

Dealing with the environment necessitated the involvement of the state, whether federal or local. Overcoming challenges presented by the natural world was a monumental task. As nature fought back against the encroaching advances of man, the struggle became too great for many individuals. Where private enterprise had once conducted surveys of local harbors, built port infrastructure, and removed debris buildup from the floor of the harbor, they increasingly lacked the financial resources to conduct these projects on an ongoing basis. Private individuals could only do so much. Industrious entrepreneurs, such as Lemuel Moody, may have conquered their local environment to establish marine telegraphs or chart the depth of local ports, but most lacked the expertise, finances, and material resources to carry out larger projects or to fight what became the endless struggle against nature. Moody, in fact, had to finance his marine observatory and charts of Portland's harbor through subscriptions of local merchants. (Moody would eventually payback all of the original subscribers, but it took him almost 40 years to do so.)⁷⁵ Projects that were intensively integrated with the environment, such as canal building, harbor dredging, or a broader survey of the coast, were simply unattainable by private means. For these projects, private enterprise divested themselves of responsibility for subduing nature and came to rely on the state. The

⁷⁴ William Willis, *The History of Portland*, (1865; repr., Somersworth, NH: New Hampshire Publishing Company, 1972), 565-9. Henry E. Barber and Allen R. Gann, *A History of the Savannah District U.S. Army Corps of Engineers*, (Savannah, GA: Savannah District USACE, 1989), 47.

⁷⁵ Moulton, 20.

government was the only entity, public or private, that either possessed the necessary resources or had the political clout to commandeer them.⁷⁶

In Baltimore, for instance, the Port Wardens notified the City Council on August 13, 1849, “That it required the expenditure of the amount appropriated \$2,500.00 to remove the large amount of dirt at the mouth of the falls, to enable the machine to operate in cleaning out the falls.”⁷⁷ In a second letter dated the next day, the Port Wardens requested an additional \$17,000.00 “for the removal of dirt from the bed of Jones Falls from its mouth” to the Madison Street Bridge.⁷⁸ It was not uncommon for the Port Wardens to request appropriations to the tune of \$2,500.00 to \$5,000.00 on a regular basis.⁷⁹ These expenditures proved too much for private enterprise as evidenced by the Baltimore City Council 1828 resolution authorizing the Port Wardens to “deepen and clean the Navigation at any wharves or docks” when “they shall be called on by the

⁷⁶ Peter Way, *Common Labor: Workers and the Digging of North American Canals, 1780-1860*, (Baltimore: JHU Press, 1993), 18, 22-3, 52-4. Carol Sheriff, *The Artificial River: The Erie Canal and the Paradox of Progress, 1817-1862*, (New York: Hill & Wang, 1996), 17. Peter L. Bernstein, *Wedding of the Waters: The Erie Canal and the Making of a Great Nation*, (New York: W. W. Norton & Co., 2005), 24, 27. John Lauritz Larson, *Internal Improvement: National Public Works and the Promise of Popular Government in the Early United States*, (Chapel Hill: UNC Press, 2001), 5-6, 10, 12, 15.

⁷⁷ Port Wardens to the President and Members of the Second Branch City Council, August 13, 1849, BCA - CCR, WPA Item No. 780, RG 16, Series 1, Box 84, Baltimore, MD.

⁷⁸ Port Wardens to the President and Members of the Second Branch City Council, August 14, 1849, BCA - CCR, WPA Item No. 781, RG 16, Series 1, Box 84, Baltimore, MD.

⁷⁹ Note, 1846, BCA - CCR, WPA Item No. 692, RG 16, Series 1, Box 77, Baltimore, MD. Note, 1846, BCA - CCR, WPA Item No. 693, RG 16, Series 1, Box 77, Baltimore, MD., Note, 1833, BCA - CCR, WPA Item No. 1010, RG 16, Series 1, Box 47, Baltimore, MD. “Report on resolution from the Joint Com on the Harbor relating to the Dredging Machine,” 1843, BCA - CCR, WPA Item No. 599, RG 16, Series 1, Box 71, Baltimore, MD.

occupiers, occupancy owners or owners.”⁸⁰ In fact, numerous private owners, such as George Westman and Alexander Brown, petitioned the Baltimore City Council to have the debris removed from their wharves.⁸¹

The direct costs of overcoming natural world challenges were exacerbated by the indirect costs of purchasing and maintaining the necessary equipment. As previously noted, the city of Baltimore originally paid the company of Watchman and Bratt \$2,500 for a steam engine dredging machine in 1824.⁸² Two years later, the city accepted bids “for the making of two good & sufficient steam Engines, one of not less than six horse power - and the other not less than Twelve horse power with the necessary apparatus for the purpose of deepening the Harbor.”⁸³ By 1833, Baltimore’s dredging operations required four discharging machines, three digging machines, 12 horses, 19 large scows, 3 small scows, 8 small skiffs, a small boat, several dozen shovels, picks, wheel barrows, carts, and oars, and a single steam dredging machine.⁸⁴

The city owned all of this equipment and held the responsibility of maintaining and repairing it. Daily engagement with the environment took its toll on the machines. Maintenance and repair costs alone sometimes amounted as much as the cost of new equipment or the cost of performing the work. In 1831, repairs to the steam dredging machine were so considerable, the Port Wardens found the dredging machine “entirely

⁸⁰ “A Bill entitled An additional supplement to An ordinance to preserve the navigation of the Harbor of Baltimore,” 1828, BCA - CCR, WPA Item No. 1075, RG 16, Series 1, Box 37, Baltimore, MD.

⁸¹ “Report of the Harbour Committe relation to deepening the Harbor,” BCA - CCR, WPA Item No. 691, RG 16, Series 1, Box 77, Baltimore, MD.

⁸² “Supplement to an Ordinance.”

⁸³ “Resolution Relative to a Steam Engine,” March 14, 1826, BCA - CCR, WPA Item No. 995, RG 16, Series 1, Box 32, Baltimore, MD.

⁸⁴ “Inventory, 1833,” BCA - CCR, WPA Item No. 1011, RG 16, Series 1, Box 47, Baltimore, MD.

unworthy of repairs” and sought authorization from the city to purchase a new machine. The repairs to the old machine “would amount to within a few dollars of what a new iron boiler would” cost.⁸⁵ After making their case for a new steam dredging machine, the Port Wardens then argued for a new machine with a copper boiler. “Taking into consideration the great difference of the durability of copper over that of iron boilers, and the relative values when unfit for use; the copper being worth, say one half its present cost, [and] the iron little or nothing,”⁸⁶ The City Council agreed with the Port Wardens and passed a resolution on February 8, 1831 authorizing the Port Wardens to contract with Watchman and Bratt for the copper boiler.⁸⁷ Yet, the copper boiler fared little better against a demanding environment. In the 1833 inventory, just two years after its purchase, the copper boiler steam dredging machine is listed as needing “some repairs.” Additionally, two of the four discharging machines in the city inventory “required considerable repairs,” while one digging machine needed “thorough repairs,”⁸⁸ The cost of these repairs added up quickly. They often exceeded the financial resources of private enterprise, meaning only the government could muster the financial clout to battle the environment continuously.

Even when private enterprise could afford the expense of combating the environment, they still deferred to the government. William Patterson, and later his heirs, continued to have his private dock dredged by the City of Baltimore even though the

⁸⁵ “Report of the Joint Committee on the Harbor,” February 7, 1831, BCA - CCR, WPA Item No. 1111, RG 16, Series 1, Box 42, Baltimore, MD.

⁸⁶ “Report of the Joint Committee on the Harbor.”

⁸⁷ “Resolution making an appropriation for a copper boiler to the Steam dredging machine,” February 8, 1831, BCA - CCR, WPA Item No. 1112, RG 16, Series 1, Box 42, Baltimore, MD.

⁸⁸ “Inventory, 1833.”

Pattersons had amassed the second largest fortune in Maryland behind Charles Carroll.⁸⁹ Other private enterprises such as John S. Brown & Company and the Canton Company also requested the City dredge their wharves.⁹⁰ William A. Dunnington went so far as to request “about Twenty five scow loads taken up” at his dock.⁹¹ Throughout the 1830s and 1840s the Port Wardens and Baltimore City Council were regularly leasing the dredging machine and its services for as much as \$15.00 a day.⁹²

While many individuals saw port improvements as a function of the state, the private sector also deferred on issues dealing with the natural world because they lacked the technical expertise for environmental concerns. The government, on the other hand, possessed the scientific knowledge for interacting with the environment, or at the least, possessed the ability to obtain the expertise.

From its inception as a federal republic on March 4, 1789, the government worked to build its scientific knowledge base through the Army Corps of Engineers, the Coast Survey, and the Light-House Establishment. As the Corps, Survey, and Establishment gained respect for the scientific knowledge they obtained, their value to the general welfare of the nation increased exponentially and the demand for their

⁸⁹ Pamela Bond, “Really and Truly: A Baltimore Femme Fatale,” *Examiner* (February 17, 2012) <http://www.examiner.com/article/really-and-truly-a-baltimore-femme-fatale> (accessed December 23, 2015).

⁹⁰ “Application of Jn^o. S. Brown Co. for hire of Mud Machine,” 1849, BCA - CCPA, WPA Item No. 72, RG 3, Series 1, Box 1, Baltimore, MD. “Application of Canton Co., Wm Harrison, Agent, for Hire of Mud Machine, May 16, 1849,” BCA - CCPA, WPA Item No. 73, RG 3, Series 1, Box 1, Baltimore, MD.

⁹¹ “Application of Wm A. Dunnington for the hire of Mud Machine, May 30, 1849,” BCA - CCPA, WPA Item No. 75, RG 3, Series 1, Box 1, Baltimore, MD.

⁹² “Application of Henry W. Cottrell, November 26, 1834,” BCA, Reports and Returns, WPA Item No. 2505, RG 41, Series 1, Box 28, Baltimore, MD. “Application for Mud Machine Samuel Fenby, 1838,” BCA - CCPA, WPA Item No. 53, RG 3, Series 1, Box 1, Baltimore, MD.

expertise grew exponentially. Many individuals petitioned the federal government for assistance in building port infrastructure, surveying the coast, or deepening harbors because of the government's expertise. When Philadelphia merchants petitioned the federal government in 1826 for a breakwater on the Delaware River, they acknowledged the Corps of engineers as "most distinguished and experienced." Philadelphians noted the Corps' expertise when they detailed the Corps' "full conviction of the insufficiency of the plan contemplated by the appropriation" while suggesting a revised plan that "would completely answer the intended purpose" and serve as "a lasting monument of the [state's] provident wisdom."⁹³

Other seaports similarly acknowledged the federal government's expertise when they petitioned the government for assistance. In 1838, city officials in Bridgeport, Connecticut praised the harbor improvement plans made the previous year by Colonel Joseph Totten when they petitioned for more appropriations to expand the work.⁹⁴ Two years later in an obvious recognition of the government's growing expertise, the Baltimore City Council petitioned Congress for assistance in deepening the port's harbor.⁹⁵ Baltimore dredged the port annually for nearly twenty years on its own before requesting assistance from the federal government.⁹⁶ And in 1854, when Portland merchants applied to the city for an ordinance on private wharves extending too far into the harbor, the municipal government saw fit to commission the federal government for

⁹³ "Memorial of the Chamber of Commerce of Philadelphia," in William Jones, *Remarks on the Proposed Breakwater at Cape Henlopen*, (Philadelphia: William Fry, 1826), 30.

⁹⁴ *Message from the President of the United States to the Two Houses of Congress, at the Commencement of the Third Session of the Twenty-Fifth Congress*, 25th Cong., 3d sess., 1838, H. Doc. 2, 387.

⁹⁵ Note, 1840, BCA - CCR, WPA Item No. 700, RG 16, Series 1, Box 66, Baltimore, MD.

⁹⁶ "Supplement to an Ordinance."

its expertise. The federal government dispatched its three most distinguished experts - Professor Alexander Dallas Bache of the Coast Survey, then Commander Charles Henry Davis of the United States Navy, and now General Joseph Totten of the Army Corps of Engineers. The government's report detailed "the method for increasing [the port's] accommodations, and at the same time maintaining its depth and capacity."⁹⁷ The city recognized the federal government's expertise in petitioning the Maryland legislature for an act implementing the federal government's recommendations.⁹⁸

The involvement of the government in concerns of the environment in the early nineteenth century might be thought of as "big science." Generally, the term "big science" is used to refer to the large scale scientific enterprises of the post-World War II era originating out of the Manhattan Project. However, if we define "big science" as scientific research on so large a scale that it exceeds the abilities of private enterprise and requires the government's involvement for financial, labor, and natural resource support "big science" existed well before the dawn of the twentieth century. One only has to look at the scientific institution of the United States Coast Survey to find "big science" in nineteenth century America. The Coast Survey required a very sophisticated scientific expertise unavailable amongst the general public and large scale financial and material support from the federal government. The Survey may well be considered the first "big science" project in the United States.

As the government gained its technical expertise in dealing with environmental concerns, it often meant trying to simplify nature. The government approached its task of overcoming environmental challenges with a blind eye toward the varied landscape.

⁹⁷ Willis, 566.

⁹⁸ Ibid., 569.

Despite the vast amount of scientific research conducted by the Coast Survey, Corps of Engineers, and the Light-House Establishment, the government failed to acknowledge the geographical differences of individual locales. Shoals in Boston Harbor were treated the same as shoals off the coast of southern Florida, even though Boston Harbor experiences somewhat fewer hurricanes and Florida's coast sees no ice floes. Republican values of expediency and frugality took precedent as time and money became the primary factors for the government in all concerns.⁹⁹ The government standardized on materials, scientific methods and technological designs based on costs estimates that disregarded local environmental conditions. The rocky cliffs and island-filled bays of the New England ports were dramatically different from the low-lying, wind-swept, sea-level coast of southern seaports.

Throughout the 1850s, the Light-House Board collaborated with the Army Corps of Engineers to create a set of standards for lighthouse construction which they published in the early 1860s. They classified coastal beacons on characteristics of design rather than on environmental concerns. They published pamphlets with construction specifications that gave little regard to the local variances of the natural world. First order brick tower lighthouses, for instance, were expected to be 150 feet “from the level of ground to the focal plane of [the] lantern.”¹⁰⁰ Offshore structures utilizing the screwpile technology were to “rest on and be secured to five wrought iron piles screwed vertically in the

⁹⁹ According to James F. Nagle, awarding government contracts to the lowest bidder became routine by the late 1790s. James F. Nagle, *The History of Government Contracting, Vol. I*, (Washington DC: George Washington University Press, 1999), 68.

¹⁰⁰ USLHB, *Specifications for a First Order Light-House (Brick Tower)*, (Washington DC: GPO, 1861), 3.

shoal...arranged in the form of a square.”¹⁰¹ Additionally, the specifications required “the four struts radiating from the center pile to be rolled iron, 4 ½ inches in diameter.”¹⁰²

These specifications failed to take into consideration the various environmental differences of the localities. A 150-foot tall brick tower lighthouse may have sufficed for the low-lying coasts of the south, but it would be too tall for the ships to see in the fog when placed on the rocky cliffs of New England. Similarly, offshore screwpile lighthouses were common in both the northern bays and the open ocean of the southern coasts, but they were effected by different elements. Ice floes proved catastrophic to the design of screwpile foundation in northern environments. Southern screwpile beacons faced no such adversary. The 4 ½ inch struts radiating from the center pile may have been sufficient for the hurricane-prone south, but it was no match for the heavy ice floes of the north. In 1873, an inspection of the Brandywine-Shoals Lighthouse in the Delaware Bay showed “the lower horizontal system of braces, at about the plane of low water have in many localities dropped to the bottom; the cast-iron collars which held them having been broken apparently by the weight of superincumbent ice, and the momentum of masses of such ice acted on by waves. In this way, the lower system of braces is almost completely gone on the northern side to an east and west line, just south of the north pile of the main structure (of 1848).”¹⁰³ In fact, many northern screwpile lights failed to survive ice floes. Beginning in the early 1870s, these beacons were replaced with lights built on concrete filled caissons. Caisson foundations were much more expensive to build, but proved more

¹⁰¹ USLHB, *Specifications for Screw-Pile Light-Houses to Replace Light-Vessels*, (Washington DC: Geo. W. Bowman, 1860), 3.

¹⁰² *Ibid.*, 4.

¹⁰³ John D. Kurtz and Micah R. Brown, *Report on the Effects of the Sea-Water and Exposure upon the Iron-Pile Shafts of Brandywine-Shoal Light-House*, (Washington DC: GPO, 1874), 9.

durable in northern environments.¹⁰⁴ Public officials, however, did not initially see the varied environment as an issue. They determined the screwpile design was the best foundation for all offshore locations because it allowed for destructive waves to pass through the foundation almost unobstructed during violent storms. Government officials failed to consider the environmental differences of individual localities. In standardizing on construction design and methods, the government tried to simplify nature.

The government did not always hold a universal view of nature. In 1801, William Miller, the Commissioner of the Revenue, wrote to Henry Dearborn, Benjamin H. Latrobe, and John McComb regarding the construction of lighthouses at Smith's Point, Old Point Comfort, and New Point Comfort in the Chesapeake Bay. Miller acknowledged the three beacons were "adjacent to each other and connected by the same waters," but he also recognized the construction of the lighthouses "must depend upon circumstances" of each locale. He left the final decision on building materials to Dearborn, Latrobe, and McComb who had surveyed the sites and knew the variances of the local environment.¹⁰⁵ Throughout the 1820s and 1830s, the Light-House Establishment under Stephen Pleasanton repeatedly acknowledged the environmental differences of the various seaports. Yet, by the late 1840s when Congress appropriated funds for the Carysfort Reef Lighthouse, the government's view of the natural world had changed. The federal

¹⁰⁴ Robert Browning, "Lighthouse Evolution & Typology," *Historic Light Stations*, USCG, United States Department of Homeland Security, October 17, 2014 <http://www.uscg.mil/history/weblighouses/LHevolution.asp> (accessed December 31, 2015).

¹⁰⁵ William Miller to Henry Dearborn, Benjamin Latrobe, and John McComb, November 17, 1801, RG 26, Entry 18, Vol. 2, 411-2, NARA-II. Dearborn was the regional customs collector and lighthouse superintendent for the Chesapeake area. Latrobe served as the architect and engineer for the three navigational aids. McComb was the building contractor for each of the three lighthouses.

government had standardized the screwpile design using interchangeable parts.¹⁰⁶ It expected the engineers and contractors to build the Carysfort Reef beacon along the same premise as the Brandywine Shoals Lighthouse in Delaware despite the uniqueness of the two environments.

The circumstances of the Carysfort Reef Lighthouse should have factored into the government's specifications, yet when the Light-House Board wrote the specs for navigational aids, it used a universal language and did not take local variances into consideration. The specifications contained no allowances for contractors to use their expert judgment or make adjustments based on surveys of the local environment.¹⁰⁷ Any deviations from the specifications required contractors to notify the Light-House Board in writing and await approval before proceeding. If the contractor's proposed changes were significant, the whole project could be put on hold while waiting for Congress to pass a new appropriation. Rather than publish rigid specifications, the Light-House Board should have created guidelines that left important decisions regarding the local environment to the individual contractors building the navigational aids. The Light-House Board opted for the rigid specifications to prevent corruption among dishonest contractors, which the Board believed created many of the problems that plagued Pleasonton's administration and resulted in the establishment of the Board. To the Light-House Board, the rigid standards were simply an extension of republican values.

¹⁰⁶ Love Dean, "Carysfort Reef Lighthouse," in Thomas W. Taylor, ed., *Florida Lighthouse Trail*, (Sarasota, FL: Pineapple Press, 2001), 69.

¹⁰⁷ USLHB, *Specifications for Screw-Pile Light-Houses*. USLHB, *Specifications for a First Order*. USLHB, *Specifications for a Second Order Light-House (Brick Tower)*, (Washington DC: GPO, 1862). USLHB, *Specifications for a Third Order Lantern*, (Washington DC: GPO, 1862).

THE ENVIRONMENT FIGHTS BACK

The changing landscape proved to be one of the biggest challenges for both private enterprise and the government. Between the man-made alterations and the natural world phenomenon, the environment of the United States' seaports was in constant influx. Wharves blocked or slowed the natural flow of the water resulting in buildup of sediment against the man-made structures. This build up reduced the depth of the harbor and necessitated additional dredging. Harbor dredging, in turn, reshaped both the physical geography of the port and the environments where contractors dumped their spoil. Additionally, natural world processes, such as erosion constantly shifted the environment. Charts and maps had to be updated more frequently than possible under auspices of individual cartographers to ensure the safety of commerce and navigation more generally. As Coast Survey Lieutenant Charles Henry Davis remarked of Boston Harbor, "Some changes must necessarily have followed from the great diminution of the water receptacle above the channel, from the construction of wharves and piers, from neglect, and from the constant operation of those laws of tidal deposit." Davis admitted that the "gradual deterioration of Boston Harbor" was now well known "and apprehensions are felt that the consequences of this deterioration may be, if it is suffered to continue, seriously injurious to the future prosperity of the city."¹⁰⁸

Apprehensions of the constantly changing environment gave reason for local communities to consult with the federal government, which was better equipped to deal with shifting landscapes. Davis acknowledged throughout his survey of Boston Harbor,

¹⁰⁸ Charles Henry Davis, "A Scientific Account of the Inner Harbor of Boston, with a Synopsis of the General Principles to be observed in the Improvement of Tidal Harbors," *Memoirs of the American Academy of Arts and Sciences*, New Series Vol. 5, no. 1 (1853): 93, HAG.

he had “been occasionally consulted as to certain proposed changes in the upper part of the harbor.”¹⁰⁹ To these inquiries, Davis recommended “lay[ing] down those principles of hydraulic engineering which must be consulted in order that any future constructions, demanded either by the business of the city or the preservation of the channels, may prove beneficial, and answer the purposes for which they are designed.”¹¹⁰ According to engineering historian Terry S. Reynolds, attempts to integrate engineering into the curriculum of mainstream colleges faltered until at least the 1850s.¹¹¹ Most civil engineers learned through practical hands on training.¹¹² Thus, many communities, even large ones such as Boston, lacked the expertise to oversee projects such as the one suggested by Davis. The federal government, however, offered engineering curriculum through its military academies since 1802, giving the state the technical expertise needed to make such recommendations.¹¹³ In fact, in making his recommendations, Davis noted, “in the preparation of this Memoir, I have only consulted my associates in the Academy” and that he had “no other responsibility than that which appertains to me as a member of this Academy.” Davis claimed his responsibility, “demands I should make no statement of facts that do not appear to be well authenticated” nor “advance [any] principles that are not admitted or easily proved.”¹¹⁴ Such high standards helped convince local communities of the federal government’s expertise.

¹⁰⁹ Ibid.

¹¹⁰ Ibid.

¹¹¹ Terry S. Reynolds, “The Engineer in 19th Century America,” in Terry S. Reynolds, ed., *The Engineer In America: A Historical Anthology From Technology and Culture*, (Chicago: UC Press, 1991), 20.

¹¹² Ibid., 13.

¹¹³ Ibid., 11.

¹¹⁴ Davis, 94.

Man-made alterations created some of the environmental issues. As previously noted in Portland, private wharves extended too far into the harbor. Portland historian and former mayor of that city, William Willis, claims Portland Harbor contained “about one million” superficial feet of wharves, which “was seriously affecting its capacity and shoaling its water.”¹¹⁵ Indeed, the development of Portland’s wharves in the 1830s and 1840s created a narrow shipping lane through which increasingly larger vessels had to pass while at the same time causing greater accumulation of silt and debris that reduced the depth of the harbor. The federal government’s survey conducted by Bache, Davis, and Totten in 1854 noted, “the creation of a sort of bar reaching across from Fish Point to the middle ground, making it much shoaler in this spot now than it was in 1820.”¹¹⁶ Willis noted that a “system of dredging” commenced and ordinances were passed prohibiting the throwing of “ballast or dirt of any kind into the harbor.”¹¹⁷

Natural phenomenon, such as the “constant operation of those laws of tidal deposit,” which Davis referred to in his report on Boston Harbor also proved to be of great concern for the government.¹¹⁸ Erosion not only threatened America’s seaports, it also threatened the navigational technologies that made the ports safe for commerce. Throughout the first half of the nineteenth century, correspondence between the Fifth Auditor of the Treasury and the Revenue Collectors in various Atlantic ports regularly spoke of the effects of erosion and how the government was dealing with the issue. In the port of Washington, North Carolina, for instance, the customs collector, Thomas Harvey

¹¹⁵ Willis, 566.

¹¹⁶ Alexander Dallas Bache, Charles Henry Davis, and Joseph G. Totten, *Report of the Portland Harbor Commission*, (Washington DC: GPO, 1855) qtd. in Willis, 568.

¹¹⁷ Willis, 568.

¹¹⁸ Davis, 93.

Blount, suggested stabilizing an aid to navigation by “placing 300 perches of stone around it.”¹¹⁹ Unfortunately, “those stone are not to be had in probably all of North Carolina” and the cost carry them “two or three hundred miles” from another location “would cost more than to remove” the aid.¹²⁰ The Fifth Auditor of the Treasury, Stephen Pleasanton, who was responsible for the superintendence of the nation’s navigational aids, suggested placing piles around the beacon, “if piling the foundation will secure it.”¹²¹ Pleasanton made a similar suggestion for the beacon at Cape Henlopen ensuring safe navigation into the port of Lewes, Delaware.¹²² In other instances, the government recommended moving navigational aids away from the dangers of the encroaching waters.¹²³

Erosion has proved exceptionally important in the area of the Chesapeake Bay. As William B. Cronin notes, Poplar Island has lost more than 99 percent of its land mass due to erosion. In 1627, the island consisted almost 1,500 acres. By 2005, Poplar Island was a little more than 5 acres.¹²⁴ The rapid disappearance of this island throughout the early 1800s created a hazardous shoal for ships approaching the ports Annapolis, Baltimore, and St. Michaels. When erosion threatened federal property at Cove Point in the late

¹¹⁹ Stephen Pleasanton to Winslow Lewis, November 14, 1837, RG 26, Vol. 12, 413, NARA. A perch is a British unit of measure. For stone, it usually indicates volume equal to 16 ½ feet long by 12 inches high and 12 inches deep.

¹²⁰ Ibid.

¹²¹ Ibid.

¹²² Pleasanton to Winslow Lewis, November 4, 1839, RG 26, Vol. 15, 123, NARA.

¹²³ Pleasanton to William Frick, April 4, 1837, RG 26, Vol. 12, 55. Pleasanton to Winslow Lewis, January 14, 1842, RG 26, Vol. 17, 239. Pleasanton to Winslow Lewis, June 27, 1837, RG 26, Vol. 12, 173. Pleasanton to Winslow Lewis, May 27, 1840, RG 26, Vol. 15, 446.

¹²⁴ William B. Cronin, *The Disappearing Islands of the Chesapeake*, (Baltimore: Johns Hopkins, 2005), 60. An image of Poplar Island on Google Maps from January 2016 indicates the island may be much larger than five acres.

1830s and early 1840s, the government spent “several thousand dollars” erecting a stone breakwater between the land and the bay “to arrest its further progress.”¹²⁵ Although erosion continues to threaten Cove Point to this day, the government’s efforts proved successful. Cove Point remains an active aid to navigation on the Chesapeake Bay.

The constant changes in the environment of American ports necessitated surveys of the ports to ensure accurate navigational information. Although the Coast Survey was authorized in 1807, it did not publish its first map until the 1830s.¹²⁶ Before that time, local seaside communities commissioned learned men, such as Lewis Brantz in Baltimore, to conduct surveys of their harbors. In some cases, industrious entrepreneurs with an interest in shipping, such as Lemuel Moody of Portland, took it upon themselves to survey their respective ports and the surrounding coastlines. In either instance, the surveyors not only mapped the docks, islands, and peninsulas of the ports, they also took depth soundings and charted the shipping lanes.

The cost of charting the ports, however, proved quite expensive. Many communities and individuals had to settle for a single chart, despite the constantly changing environment. Lewis Brantz, for instance, only produced one chart for the port of Baltimore in 1819.¹²⁷ Similarly, Lemuel Moody produced a single chart for Portland. Moody saw “the great necessity of a correct chart of Portland Harbor,” however, the cost

¹²⁵ Pleasanton to the Honorable Alexander Randall, August 26, 1841. RG 26, Vol. 17, 61, NARA.

¹²⁶ NOAA, OCS, “Important Dates in History,” <http://www.nauticalcharts.noaa.gov/staff/important-dates.html>, (accessed July 24, 2015). Aaron L. Shalowitz, *Shore and Sea Boundaries* Vol. 2, (Washington, DC: GPO, 1964), 13, 89, 276 n13, 552, 564.

¹²⁷ Lewis Brantz, *Survey of the Harbor of Baltimore and Waters Adjacent*, 1819, in Lewis Brantz, *This Survey of the River Patapsco and part of the Chesapeake Bay*, 1819, BCA, RG 12, Series 11, Folder 8, Item MB3697, Baltimore, MD.

of producing the chart was so great, Moody had to advertise for subscriptions to pay the cost of engraving and printing his map of the port.¹²⁸ In fact, Moody incurred great personal expense in publishing the map. According to Moody historian John K. Moulton, the advertisement resulted in \$189 for 63 copies from 58 individual subscribers.¹²⁹ The cost of engraving and printing the map, however, totaled \$300.¹³⁰ The subscriptions, however, did not take into account Moody's time or personal expenses. Between May and October 1825, Moody personally spent more than \$75 conducting the survey.¹³¹ Moody continued to incur expenses after the publication of the chart and by 1836, his personal outlay totaled \$681.31.¹³² As a result, Moody only completed one chart of Portland's Harbor. It was the first chart of Portland's harbor since the British Navy published their map in 1776. They had surveyed the area 16 years earlier.¹³³

Moody's and Brantz's single surveys highlight the importance of the government in dealing with an ever changing environment. Infrequent updates of charts could be detrimental to commerce. Mariners needed accurate information, but outdated charts and maps exposed ships to the hazards of the natural world. Nathaniel Bowditch's *The New American Practical Navigator* and *The American Coast Pilot* published by Edmund March Blunt provided some recourse, but they were not enough. Both publications began in the late 1790s as a comprehensive handbook for mariners. They included sailing

¹²⁸ Lemuel Moody qtd. in Moulton, 53.

¹²⁹ Moulton, 53.

¹³⁰ *Memorandum of an Agreement Entered into this 30th Day of May 1825 between Seward Porter, Lemuel Moody, & Geo. Derring on One Part & D. G. Johnson on the Other Part*, Mss. OS-1819-9.6, OML.

¹³¹ Lemuel Moody, *Expences Incurred by Lemuel Moody in the Survey and Publishing Chart of Casco, 1825*, Mss. OS-1819-9.12, OML.

¹³² Lemuel Moody, *Expense Sheet for Travel, Surveying and Creating Charts, 1836*, Mss. OS-1819-9.13, OML.

¹³³ Moulton, 53.

directions into the most important ports and were updated every few years. However, the publishers were unable to conduct surveys of the various ports included in their book. Publication updates were at the mercy of local communities and individuals because they relied on second-hand information they gathered from men such as Brantz and Moody. Only the government could afford to finance the ongoing need for surveying the nation's harbors. And even they struggled to meet the needs of the republic.

CONCLUSION

The natural world interacted with early American science and technology in many ways. To begin with, individuals interested in advancing science and the arts recognized the environment as an adversary that needed to be tamed. They approached the environment antagonistically in an attempt to conquer it for their own good. Even as the attitudes of the romantics changed toward the environment near mid-century, those engaged in the practice of science and the arts continued to hold a hostile view of the environment. They remained steadfast in their attempts to subdue their physical surroundings. They carefully considered how their vision for the world interacted with their environment.

These same individuals also recognized that the natural world could provide them with the means for overcoming challenges. They used the environment for its natural resources to solve everyday problems, many of which were caused by the natural world itself. In the process, they gained knowledge and advanced their understanding of science and the arts.

Interacting with the environment, however, was a never ending process. The landscape constantly changed the nature of the seaports through the addition of man-

made alterations and natural phenomenon. Because of this, the time, money, and energy expended in dealing with the natural world was often more than most individuals, or even communities, could bear. They necessarily turned to the government for assistance. The government not only possessed the expertise for subduing nature, it also had deeper pockets and the political means for taking on projects concerning the environment. This expertise was then shared with individuals and local communities in the form of building port infrastructure. Internal improvements became a responsibility of the federal government as a result of its expertise as much as it did for its ability to commandeer the necessary resources for combating the environment.

As the government expanded its role in dealing with the environment, they necessarily sought to simplify nature. Republican values of frugality and expediency won out over best practices. This often resulted in the complications or failures for the government. Generally, the government tried to wash its hands of the responsibility, but in the end it paid for its failures.

CHAPTER 4

SCIENCE IN THE UNITED STATES LIGHT-HOUSE ESTABLISHMENT

In October 1851, Charles Babbage, the renowned English mathematician and inventor of the difference engine, wrote to Alexander Dallas Bache promoting one of the Englishman's original mathematical theories. Babbage believed his theory would be useful in the United States for distinguishing navigational beacons and "night telegraphic communication between ships at sea."¹ Babbage chose Bache for his correspondence because the latter was the Superintendent of the Coast Survey, a member of the Light-House Board, and one of the most prominent scientists in America at the time.² Babbage's theory numbered the lighthouses irregularly and made each navigational aid "continually repeat its own number during the whole night by means of occultations."³ Babbage proposed eclipsing the beacon's light in short pauses and long intervals equal to that lighthouses' number, making it easier for mariners to identify the lighthouse and ascertain their navigational position. To further avoid mistakes, the renowned mathematician suggested, "*Light-houses must not be numbered in the order of their position*" and that adjacent lights "*must have such a number assigned to it, that no digit occurring in the number denoting the several lighthouses nearest to it on*

¹ Martin Campbell-Kelly, ed., *Charles Babbage: Passages from the Life of a Philosopher*, (New Brunswick, NJ: Rutgers University Press, 1994), 245.

² Babbage to Bache, October 20, 1851, Mss. B. B123 Alexander Dallas Bache Collection, Box 1, Folder 30, APS.

³ Ibid.

either side shall have the same digit in the same place of figures.”⁴ Babbage believed his theory was superior to the systems then in use by both Britain and the United States because the theory promised to make it “almost impossible” for mariners “to mistake any casual light, on shore or at sea, for a lighthouse,” and to ever “mistake *one* light-house for another.”⁵ The Englishman acknowledged his theory was, “crude in many respects and merely suggestive in others,” but noted, “a little inquiry might produce still a better arrangement.”⁶

As a member of the newly formed Light-House Board, Bache forwarded Babbage’s proposal to the Board’s president, William Branford Shubrick. Shubrick promised to “use every endeavor to have a full trial made of the method.”⁷ Shubrick and the Board charged John Henry Alexander, an American engineer and physicist, with conducting the experiments. Alexander was to report back on “how far the alternation of light and darkness in the occultations...tends to increase or diminish the efficiency of a given light.”⁸ Congress appropriated \$5,000 for the experiments.⁹ Alexander choose the “Merchants’ Observatory on Federal Hill” in Baltimore for his illumination experiments

⁴ Charles Babbage, “Plan for Distinguishing Seacoast and Other Lights by Occultations,” in *Papers on the Comparative Merits of the Catoptric and Dioptric or Catadioptric Systems of Light-House Illumination and Other Subjects Relating to Aids to Navigation*, (Washington, DC: GPO, 1861), 45. In Babbage’s example, five adjacent lights would be numbered 361, 517, 243, 876, and 182. Emphasis in original.

⁵ Babbage, “Plan for Distinguishing Seacoast and Other Lights,” 44.

⁶ *Ibid.*, 46. Babbage to Bache, October 20, 1851.

⁷ Babbage, “Plan for Distinguishing Seacoast and Other Lights,” 43.

⁸ J. H. Alexander, *Experiments on Mr. Babbage’s Method for Distinguishing Lighthouses Reported to a Committee of the United States Light-House Board*. (Washington: GPO, 1861), 9.

⁹ Campbell-Kelly, 343.

because the signal tower allowed for a “wide extent of the harbor” to be viewed from a single vantage point.¹⁰

In conducting his experiments, Alexander observed that the light from a fixed signal proved less intense than the light from a revolving signal. As Babbage’s proposal called for all of the lights to be fixed lights, altered only by the occultations, Alexander sought “to define what is the amount of this difference in general; and also to ascertain how far the actual or possible mechanical arrangements of the proposed plan tend to increase or diminish” the difference.¹¹

Babbage believed one minute would be sufficient for a light to signal its number, repeating once every minute following. After performing the experiment at the observatory on Federal Hill and calculating the duration of illumination and occultations, Alexander found that Babbage’s one-minute interval to have practical advantages and felt it “would be hardly advisable to increase” the intervals proposed by the English mathematician. Additionally, Alexander observed three seconds for the occultations “as affording the maximum of advantage.”¹² Three seconds allowed an observer to clearly distinguish the number being signaled, but it limited the range of numbers that could be displayed in the given interval of one minute. Signaling a nine, for instance, required 27 seconds of darkness from the occultations. If the observer first witnessed the signal in the middle of its revolution, Alexander surmised it would take four minutes and thirty-two seconds to convey the number 299. Alexander supposed the number 345 would be the

¹⁰ Alexander, 9.

¹¹ Ibid., 5. The committee which Alexander refers to included Alexander Dallas Bache, Superintendent of the Coast Survey, and Joseph Henry, Secretary of the Smithsonian Institute.

¹² Ibid., 11.

highest number needed on the American coast, making 299 the longest number requiring conveyance.¹³

Although Alexander could not answer whether or not signaling the number 299 took too long, he did voice concerns that in certain circumstances “where the mariner cannot afford to be so long as five minutes without an identification of the light,” that an alternative might need to be considered. Alexander also expressed concern that an observer would have to simultaneously observe, “two phenomena, viz: the disappearance of the light, and the movement of the index of the time-keeper.” Under the present system, mariners only needed to observe the light.¹⁴ Alexander noted the Commissioners of the Northern (Scottish) Light-Houses of Great Britain advised against the system for similar reasons.¹⁵ Based on his scientific findings and despite his concerns, Alexander believed the system to be “advantageously applied at any and all points where the range demanded does not transcend the power of a first order Fresnel lens.”¹⁶

The Fresnel lighthouse lens was an optical apparatus invented by a French civil engineer, Augustin Jean Fresnel, in 1821. Fresnel worked for the Corps des ponts et chaussées (bridges and roads) and conducted experiments in optical diffraction in his spare time. Three years before the invention of the lens, Fresnel confirmed that light traveled in waves. Fresnel used this knowledge to improve France’s coastal lighting for navigation. Fresnel’s lens worked in conjunction with an open flamed oil lamp and reflector. By placing several glass polyhedrons above and below a centrally positioned bullseye lens, Fresnel was able to capture more of the light from the lighthouse lamp as it

¹³ Ibid., 12, 14-6.

¹⁴ Ibid., 13, 16.

¹⁵ Ibid., 13.

¹⁶ Ibid., 19.

was reflected outward (Fig. 4.1). The polyhedrons bent the reflected light into a more concentrated beam, producing a brighter light that could be seen further out to sea. Fresnel developed the lens in three different orders (later expanded to six) which varied in size and weight depending the location of the lighthouse and its importance to commercial activity. A first order lens, the largest of the Fresnels, stood eight and a half feet tall and weighed more than six tons.¹⁷ The lens represented the very best scientific knowledge of the time in optical diffraction and illumination.

Alexander's experiments were fraught with problems. Two in particular stand out. First, Alexander conducted his experiments in ideal weather conditions. He acknowledged that he had, "no means of estimating" what allowance, "should be made for storm and darkness on ship-board," and he made no reference to the role that fog may play in hindering the identification of lights using this method. This alone would have rendered Alexander's experiments invalid, or at the very least inconclusive. Alexander, however, made no effort to redress the flaws in his methodology and he made no explanations for this oversight.

Second, Alexander conducted his experiments with the help of an assistant. The assistant operated the machinery in the experiment while Alexander made his observations. Operating the machinery by hand would never work in reality due to the duration of the occultations and the necessity of the occultations occurring without interruption. Self-acting machinery was the only proper way to ensure the accuracy of Alexander's findings. Alexander acknowledged this fact when he asked to conduct

¹⁷ "Fresnel Lens Orders, Sizes, Weights, Quantities, and Costs," United States Lighthouse Society, <http://uslhs.org/fresnel-lens-orders-sizes-weights-quantities-and-costs> (accessed April 1, 2017).

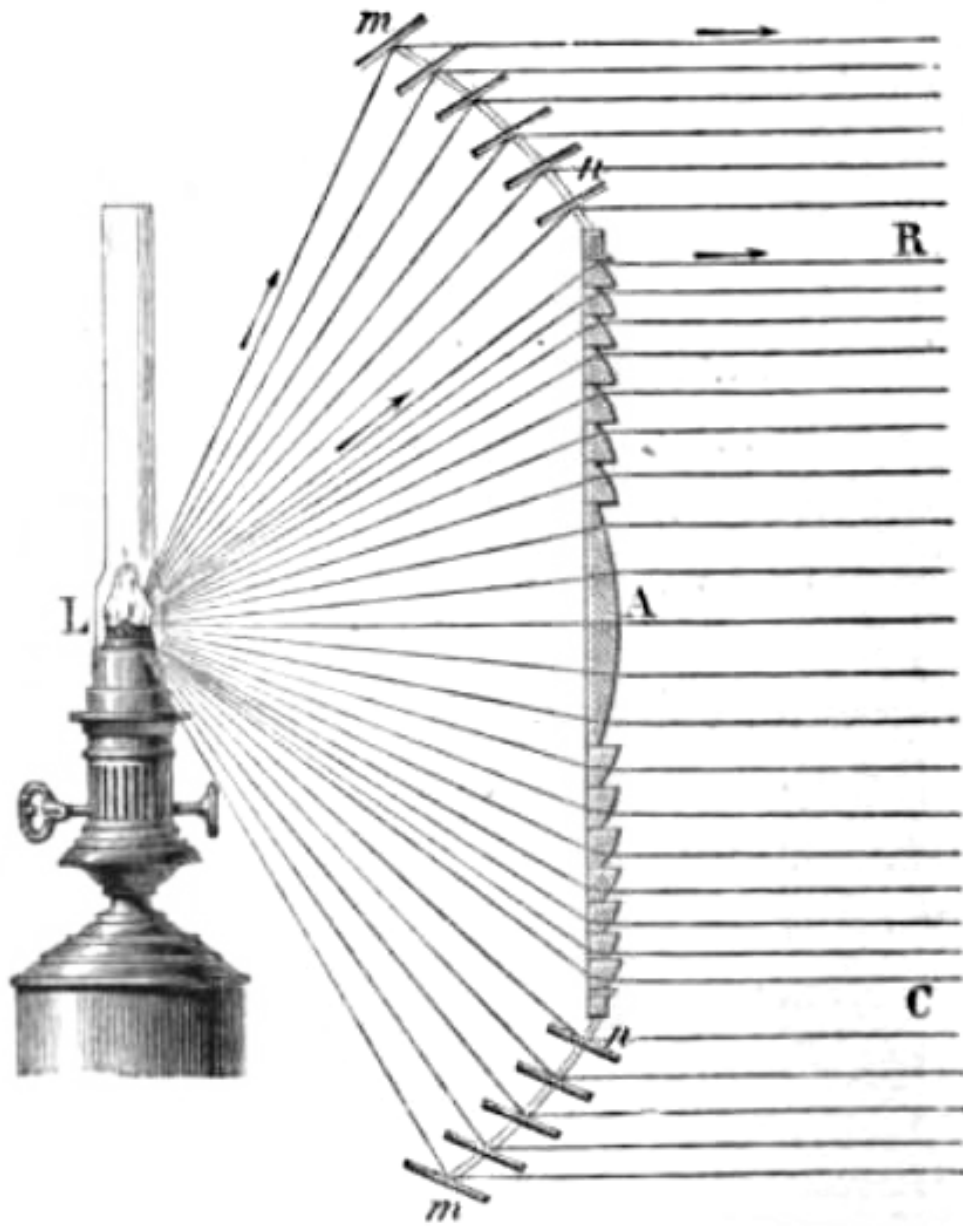


Figure 4.1 Fresnel Lens Diagram by Adolphe Ganot [Public Domain], 1872 via Wikimedia Commons.

further experiments using self-acting machinery. Additionally, the use of an assistant limited the range by which Alexander was able to make his observations as the two needed to communicate with each other in the dark of night. With the self-acting machinery, Alexander proposed he could conduct the experiments over a “distance about 15 miles across land and water, adequate to developing all the good and bad points of the system as cannot be predicated of the limited range I have been able to use hitherto.”¹

The Light-House Board followed the recommendations of the Scottish Commissioners and rejected Babbage’s plan for use in the United States. The Board’s decision resulted from the concerns raised by Alexander and the Scottish Commissioners as well as the incompleteness of Alexander’s experiments. The decision disappointed Babbage, who believed the system was “so simple that the only wonder seems to be that it has not been proposed and adopted long ago.”² Babbage had hoped Britain and the United States would “unite in adopting the numerical system” and make it universal noting, “few things would give me more pleasure than that you should successfully carry into execution the principle I have pointed out.”³

If the commercial problems discussed in Chapter 2 pushed Americans to engage in science and the mechanical arts, and if environmental concerns examined in the previous chapter created a need for scientific engagement, the solutions were explored in the homes, workshops, and ideas of the average American. These skilled artisan, laborers, merchants, and tinkerers innovated new mechanical apparatuses to solve the commercial and environmental problems facing the young nation. Nowhere is that more obvious than

¹ Alexander, 17.

² Babbage to Bache, October 20, 1851.

³ Ibid.

in the United States Light-House Establishment, which was one of the nation's leading scientific organizations in the early nineteenth century.

In making the claim the United States Light-House Establishment was a scientific organization prior to the 1850s, it is important to understand what counted as science and by whom. Few individuals of the time would disagree that Alexander's testing of Babbage's theory was science. The experiments were authorized, overseen, and peer reviewed by some of America's most prestigious scientific minds. Alexander was chosen by these men of science to perform the experiments because he himself was recognized as a man of science. But the testing of Babbage's numerical theory of illumination does not count as science just because it was performed by educated men engaged in scientific practice. Alexander's experiment counts as science because the test used an objective, repeatable method and the results were based on observable facts. Theoretically, anyone could have performed the experiments in place of Alexander and those experiments would still have been considered science. Some individuals however, disagreed on what counted as science. Men such as Edmund Blunt, Lieutenant Thornton Jenkins and Lieutenant I. W. P. Lewis believed science could only be conducted by those who were formally trained in such fields as engineering, surveying, and navigation. These men

claimed the the Light-House Establishment was unscientific.⁴ Historians of the Light-House Establishment have tended to side with this assessment.⁵ Their assessment fails to consider Andrew J. Lewis' argument of natural philosophy in the early American republic. According to Andrew J. Lewis, despite the naturalists' claims to a "unique expertise to catalog and explain the natural world," natural philosophy in the early United States was "founded on the convictions of Americans' everyday engagements with nature."⁶ Natural philosophy, thus, was as much the work of ordinary Americans as it was the educated and trained naturalists. If we accept Andrew J. Lewis' argument that the collecting of natural world specimens by the average American counted as natural philosophy, then similarly we must accept the experiments in fuels, illumination, and air temperatures conducted by everyday American inventors and tinkerers as science. As noted in the previous chapter, Stephen Pleasonton, the Fifth Auditor of the Treasury and

⁴ E. and G. Blunt to Levi Woodbury, November 30, 1837, in USLHE, *Compilation of Public Documents and Extracts from Reports and Papers relating to Light-Houses, Light-Vessels, and Illuminating Apparatus, and to Beacons, Buoys, and Fog Signals, 1789 – 1871*, (Washington, DC: GPO, 1871), 104. Walter Forward to John White, February 24, 1843 in United States Congress, *Examination – Light-House Establishment*, 27th Cong., 3rd sess., 1843, H. Doc. 183, 3. I. W. P. Lewis, *Report of I. W. P. Lewis, Civil Engineer*, 1842, in H. Doc. 183, 53. George Poindexter and W. A. Bradley to Walter Forward, September 24, 1842, *Report of Evidence*, 1842, in H. Doc. 183, 26 (252). Thornton A. Jenkins, *Report*, January 30, 1852 in United States Congress, *Report of the Officers Constituting the Light-House Board*, 32nd Cong., 1st sess., 1852, S. Doc. 28, 54.

⁵ Wayne Wheeler, "Winslow Lewis: A Nineteenth Century Lighthouse Scalawag," *Keeper's Log* 21, no. 4 (Summer 2005), 18-24. Wheeler has also made similar claims in personal correspondence with this author. Francis Ross Holland, Jr., *America's Lighthouses: An Illustrated History*, (1972; repr., New York: Dover Publications, 1981), 32. Theresa Levitt, *A Short Bright Flash: Augustin Fresnel and the Birth of the Modern Lighthouse*, (New York: W. W. Norton & Company, 2013), 109. Amy K. Marshall, *Frequently Close to the Point of Peril: A History of Buoys and Tenders in U.S. Coastal Waters, 1789 – 1939*, (MA thesis, East Carolina University, 1997). Michael J. Rhein, *The Anatomy of the Lighthouse*, (Glasgow, Scotland: Saraband, 2001).

⁶ Andrew J. Lewis, *A Democracy of Facts: Natural History in the Early Republic*, (Philadelphia: UPenn, 2011), 6.

Superintendent of the Light-House Establishment, promoted science within the Establishment. Pleasonton authorized, monitored, and even suggested scientific experiments and practical improvements. These included Winslow Lewis' experiments with David Melville's oil heater, the testing of various types of fuels, and Captain Howard Stansbury's innovative diskpile foundation for off shore structures such as the Carysfort Reef lighthouse. Through these experiments and ground breaking construction techniques, the Light-House Establishment was a significant contributor to the fields of science and engineering in early nineteenth-century America.

The Light-House Establishment was therefore one of the leading scientific institutions in the United States in the first half of the nineteenth century. This mirrors the arguments of Todd Shallat, Ann Johnson, and Hugh Richard Slotten regarding the Army Corps of Engineers and the United States Coast Survey. Shallat sees the Corps of Engineers as the premier American institution in the sciences of geology and hydrology. Johnson claims the Corps lead the nation in strength of materials testing.⁷ Slotten argues the Coast Survey was the premier institution for scientific practice in astronomy, cartography, and surveying.⁸ The primary difference between the Light-House Establishment and these other institutions was the nature of the scientific work. The Corps of Engineers and Coast Survey engaged in previously established scientific fields. The Light-House Establishment's work, however, occurred in fields that were still

⁷ Todd Shallat, *Structures in the Stream: Water, Science, and the Rise of the U.S. Army Corps of Engineers*, (Austin: University of Texas Press, 1994). Ann Johnson, "Material Experiments: Environment and Engineering Institutions in the Early American Republic," in *National Identity: The Role of Science and Technology, Osiris 24*, ed. Carol Harrison and Ann Johnson, (Chicago: UC Press, 2009): 53-74

⁸ Hugh Richard Slotten, *Patronage, Practice, and the Culture of American Science: Alexander Dallas Bache and the U.S. Coast Survey*, (New York: Cambridge University Press, 1994).

emerging, such as chemistry and what is known today as physics. The Establishment's work in the mechanical arts paralleled that of the Franklin Institute. Bruce Sinclair argues the Franklin Institute was the leading enterprise for advancing mechanical arts in the United States, but the Institute's work lay more in the evaluation of the mechanical arts.⁹ The Light-House Establishment, on the other hand, provided an arena for the development of the practical arts.¹⁰

SCIENTIFIC EXPERIMENTS

Scientific experiments were the foundation for finding solutions to the commercial and environmental problems facing the United States. As one of the leading scientific institutions in the early nineteenth century, the Light-House Establishment conducted numerous experiments with lamps, lenses, fuels, and other apparatuses designed to keep the nation's coastal navigation safe. These experiments gave the average American an outlet for bring science into the public realm and helped solidify the involvement of the state to scientific practice when these individuals promoted their solutions through government agencies like the Light-House Establishment.

Oil Burning Lamps

Experiments with lamps and coastal lighting began as early as 1810 and possibly earlier, when on May 8, members of the Boston Marine Society conducted an experiment similar to Alexander's, but without the occultations. Their experiment tested the

⁹ Bruce Sinclair, *Philadelphia's Philosopher Mechanics: A History of the Franklin Institute, 1824 – 1865*, (Baltimore: JHU Press, 1974).

¹⁰ Records of the USCG Service, RG 26, Entry 18, Vol. 12, NARA.

illumination of a new lamp and reflector system “invented” by Winslow Lewis.¹¹ Chapter 1 previously looked at Lewis’ lamp and reflector as a commercial opportunity for the retired shipmaster. Here, Lewis’ innovation is examined as part of the scientific experiments taking place in the Light-House Establishment prior to 1850.

The Boston Marine Society’s three-member committee “proceeded about five leagues into the bay, bringing the Boston light to bear about W. S. W. and Baker’s Island light to bear about N. N. W. both nearly at the same distance.”¹² Both lights were lit in their usual manner until about 10 PM, at which time, the Boston Light was extinguished. Lewis then set up his lamp and reflector system and relit the light. The difference was “as great as would appear between a well-trimmed Argand lamp and a common candle.”¹³ The committee moved about the harbor and “saw no sensible diminution of the brilliancy.”¹⁴ The light was extinguished after an hour and relit in the usual manner. The committee found “The effect produced by this change from light to comparative darkness was more striking than the first.”¹⁵ At midnight Lewis’ Argand lamp and reflector system was relit with the usual light still burning. At two and a half leagues, the power of Lewis’

¹¹ The term “invented” is used loosely here as Lewis’ lamp was really nothing more than a variation of an oil lamp designed and manufactured in Europe by François Pierre Aimé Argand. In a letter to the United States Secretary of the Treasury Albert Gallatin, Lewis claimed his lamp was an original invention, however in later discussions of the lamp and in his patent applications for improvements to the lamp, Lewis specifically calls his oil lamp by the Argand namesake. Winslow Lewis to Albert Gallatin, March 10, 1812, RG 26, Entry 17E, Box 1, NARA. Winslow Lewis and Benjamin Hemmenway, “United States Patent No. 3,692 – Light-House Lamp,” August 7, 1844, 1.

¹² United States Department of the Treasury, *Documents accompanying a bill to authorize... purchase of Winslow Lewis his patent-right to the new and improved method of lighting...*, (Washington, DC: R.C. Weightman, 1812), 7, PRHC, no. 338, HAG. Here after cited as United States Treasury, “Authorization to Purchase Lewis Patent.”

¹³ *Ibid.*, 7.

¹⁴ *Ibid.*

¹⁵ *Ibid.*

new lamp and reflector “was so great as to throw a strong shadow upon the deck of the vessel.”¹⁶

The committee found other advantages to Lewis’ system, including a reduction in emission of smoke. Smoke from the usual lamps diminished the light’s effectiveness by clouding the glass windows on the lantern room, thus reducing the distance the light could be seen at sea.¹⁷ The committee deemed the experiment a success and recommended the adoption of Lewis’ system to General Henry Dearborn, the Collector of Customs and Regional Lighthouse Superintendent in Boston.

The success of Lewis’ experiment earned him the contract for fitting up all the lighthouses in the United States. Despite the exclusivity of this contract, Lewis was not the only mechanic to experiment with lamps and reflectors for the Light-House Establishment. Many complaints befell Lewis because of the poor quality of workmanship in his lamp and reflector system. These complaints compelled other mechanics, such as Edmund March Blunt of New York, Benjamin F. Greenough of Boston, and David Melville of Newport, Rhode Island to pursue their own experiments in the science of luminosity and the mechanical arts.¹⁸

Chemicals, Natural Gas, and Other Fuels

In addition to experimenting with lamps, the Light-House establishment also experimented with various fuels to find which fuel produced the best light. In 1812, the

¹⁶ Ibid.

¹⁷ Ibid., 8.

¹⁸ Stephen Pleasonton to Levi Woodbury, November 12, 1838, RG 26, Entry 18, Vol. 14, 29, NARA. Pleasonton to George Bancroft, November 23, 1838, RG 26, Entry 18, Vol.14, 45-6, NARA. Pleasonton to Woodbury, December 3, 1838, RG 26, Entry 18, Vol. 14, 61, NARA. Pleasonton to F. Mallory, October 3, 1838, RG 26, Entry 18, Vol. 13, 505, NARA.

company of Ward, Wilson, and Waldron of New York petitioned David Gelston, the Customs Collector and Regional Lighthouse Superintendent for the Port of New York, to conduct an experiment with “inflammable gas.”¹⁹ Albert Gallatin, the Secretary of the Treasury wrote Gelston, authorizing him to allow the experiment if “you think it advisable,” but warned “no obligation on our part will be given, whatever the success may be, to employ them for other Light Houses.”²⁰

Unfortunately, no other records exist regarding Ward, Wilson, and Waldron’s experiment. Five years later, however, David Melville of Newport, Rhode Island, similarly petitioned the Commissioner of Revenue to experiment with using natural gas in instead of spermaceti oil. Melville argued natural gas would eliminate many of the problems associated the illumination in American lighthouses such as the condensation of humid air, the high cost of oil, and the need to warm winter pressed oil to a liquid state for continuous burning. Melville believed an experiment would show the utility of natural gas and prove its worth. An apparatus designed to burn natural gas was installed in the Newport Lighthouse in October of that year and Melville recorded his daily observations, noting every kind of weather and its effect on the light. At the conclusion of the yearlong experiment Melville found natural gas afforded “mariners an increased and more certain light.”²¹ He also confirmed his beliefs that natural gas was cheaper than spermaceti oil and that natural gas lamps did not allow for the accumulation of frost or humidity on the

¹⁹ Gallatin to Gelston, March 12, 1812, RG 26, Entry 18, Vol. 4, 165, NARA.

²⁰ Ibid.

²¹ David Melville, *An exposé of facts...relating to the conduct of Winslow Lewis...addressed to the Hon. The Secretary of the Treasury*, (Providence, RI: Miller & Hutchins, 1819), 7, PRHC, no. 470. HAG.

lens or lantern windows as it did with traditional Argand style oil lamps.²² In 1830, Charles W. Morgan, a New Bedford, Massachusetts whaling entrepreneur and spermaceti oil manufacturer, acknowledged the superiority of natural gas in a speech to the Lyceum, stating, “Carburetted Hydrogen Gas is now extensively used, and possesses advantages for fixed lights and when greater brilliancy or intensity is desirable.”²³ Melville’s findings were confirmed more than three decades later when the United States Light-House Board commissioned John Henry Alexander to test Babbage’s theory on identifying lights. Alexander preferred to use natural gas in his experiment because “the gas light was the more brilliant” and it “preserved the normal volume of flame corresponding to the capacity of the lens.”²⁴

Despite Melville’s conclusions and the potential benefits of switching, the United States Light-House Establishment did not universally adopt natural gas for its coastal beacons. There are several reasons why Melville’s experiment received a disapproving nod from the Light-House Establishment. First the use of natural gas as a fuel was still in its infancy in 1817. As Mimi Sherman notes, gas “was very new in the second decade of the nineteenth century,” and that its use was “cutting-edge technology 1830.”²⁵ Many feared natural gas was unsafe.²⁶ Charles W. Morgan noted in his lecture to the lyceum the

²² Ibid.

²³ Charles W. Morgan, “The Natural History of the Whale: Address before the New Bedford Lyceum,” 1830, qtd. in Dan Bouk and D. Graham Burnett, “Knowledge of Leviathan: Charles W. Morgan Anatomizes His Whale,” *Journal of the Early Republic* 28, no. 3 (Fall 2008), 446.

²⁴ Alexander, 9.

²⁵ Mimi Sherman, “A Look at Nineteenth-Century Lighting Devices from the Merchant’s House Museum,” *APT Bulletin* 31, no. 1 Lighting Historic House Museums (2000), 38.

²⁶ Daniel Mattausch, “David Melville and the First American Gas Light Patents,” *The Rushlight* 64, no. 4, December 1998: 3422-29 <http://www.rushlight.org/research/gas.html> (accessed September 29, 2015).

“the liability to explosion is a great objection to its use.”²⁷ Sherman notes “the flame could follow the receding gas, causing a flashback.”²⁸ Second, early natural gas burners were “primitive and inefficient” and the distribution system was subject to leakage; a problem Daniel Mattausch notes plagued the gas industry “well into the 1870s.”²⁹ In addition to leakage, Sherman notes that problems with delivery sometimes caused the flame to involuntarily extinguish itself “by a sudden drop in pressure.”³⁰ Mariners’ relied on the light as a matter of life and death. A light extinguishing itself involuntarily because of “a sudden drop in pressure,” was not only problematic, it was potentially catastrophic.

Although many feared the safety of natural gas, political reasons most likely caused the state’s inaction on adopting natural gas. Melville lacked the political clout of Lewis within the Light-House Establishment. The former had to rely on his friendship with the latter to promote interest natural gas. Melville’s interests, however, were in conflict with Lewis’. Lewis held an exclusive contract with the government to supply spermaceti oil to all of the nation’s lighthouses for \$35,000 a year. Lewis worked against Melville and the superiority of natural gas to protect his own interests. According to Melville, Lewis expressed an “unfavorable opinion” of natural gas, vehemently “combated the utility of introducing them in the light houses,” and declared “he would not relinquish his contract to furnish the light houses with oil.”³¹ Eventually, the state

²⁷ Morgan, qtd. in Bouk and Burnett, 446.

²⁸ Sherman, 42.

²⁹ Mattausch, 3427.

³⁰ Sherman, 42.

³¹ Melville, 7.

approved the permanent use of natural gas for the lighthouse at Portland Harbor, New York on Lake Erie (present day Barcelona Light at Westfield, New York).³²

Acknowledging the possibility that the government might not adopt natural gas as the fuel of choice for lighthouses, Melville simultaneously conducted other experiments on oil. He analyzed the combustion of fuels and found “the intensity of light is not as has generally been supposed, in proportion to the quantity of oxygen consumed but in proportion to the carbon and caloric contained in the material used.”³³ This experiment showed that summer strained oil produced a stronger light than winter pressed oil. Summer strained oil was not only cheaper than winter pressed oil, it also burned at a slower rate. Melville figured the Argand style lamps used by the Light-House Establishment consumed strained spermaceti at a ratio of 7:8 to the pressed oil.³⁴

In 1838, the Light-House Establishment conducted several tests using colza oil. Colza oil, alternatively known as carcel oil after the carcel lamps that burned it, is extracted from vegetables. Colza oil provides a superior light, but many contemporaries, including Stephen Pleasonton and Army Corps of Engineers Lieutenants. I. W. P. Lewis and Thornton A. Jenkins, noted colza oil was much harder to manufacture than other types of fuel. American farmers were also less inclined to grow vegetables for the oil

³² Ibid., 6-7.

³³ Ibid., 9.

³⁴ Ibid., 9.

market because they were less profitable than growing other crops, such as wheat.³⁵

Pleasanton thought “very highly of the principle upon which the carcel lamp is made.”³⁶

In a letter to the Secretary of the Treasury, Levi Woodbury, Pleasanton noted,

“According to experiments already made with the improved carcel lamp...it affords 2 ½ times more light than the astral light, with the consumption of the same quantity of oil.”

Pleasanton was convinced that when the carcel lamp and oil was combined with the parabolic reflector “it will not only afford a light to be seen sufficiently far, if not as far as any other light, but that it will be more to be relied on, and at the same time more economical than any other yet discovered.”³⁷ Despite Pleasanton’s praise for the carcel lamp, he would wait until the trial was complete to ascertain whether or not the oil and lamp should be adopted universally within the Establishment.

The following year, the Light-House Establishment allowed Benjamin F. Greenough to experiment with a “chemical oil.” Greenough’s “chemical oil” was a “chemical mixture or compositions of alcohol, spirits of turpentine, and such other matters or fluids as are generally substituted for common oil.”³⁸ Greenough’s began his experiment at the Boston [Harbor] Lighthouse, but renovations to the light forced

³⁵ Pleasanton to Thomas Corwin, March 8, 1852, in United States Congress, *Light-Houses: Letter From the Secretary of the Treasury...in Reply to a Report Made to Congress by the Light-House Board*, by Thomas Corwin, 32nd Cong., 1st sess., 1852, H. Doc. 88, 15. I. W. P. Lewis to H. L. Ellsworth, n.d., in United States Congress, *Report of the Commissioner of Patents*, by Edmund Burke, 29th Cong., 1st sess., 18, S. Doc. 307, 402. Thornton A. Jenkins, *Report*, January 30, 1852, in United States Congress, *Report of the Officers Constituting the Light-House Board*, 32nd Cong., 1st sess., 1852, S. Doc. 28, 554.

³⁶ Pleasanton to Winslow Lewis, October 24, 1838, RG 26, Entry 18, Vol. 14, 8, NARA. Pleasanton to Woodbury, December 3, 1838, RG 26, Entry 18, Vol. 14, 61, NARA.

³⁷ Pleasanton to Woodbury, December 3, 1838.

³⁸ Benjamin F. Greenough, “United States Patent No. 2,039 – Lamp,” April 10, 1841, 1.

Greenough to transfer his research to the light on Long Island.³⁹ While there is no solid evidence that Winslow Lewis interfered with Greenough's experiment, Lewis was the individual who reported to Pleasonton which lighthouses were in need of repair. Given Lewis' opposition to Melville's natural gas experiments in Newport, Rhode Island, it seems plausible that Lewis might have fraudulently reported to the Boston Lighthouse as needing repairs in hopes of forcing Greenough to abandon his experiments and protecting his own oil contract. Sherman, however, notes chemical fuels had "very real drawback," particularly the potential for the volatility of the fuel to lead to conflagrations.⁴⁰

Southerners also got involved with finding alternative oils for the Light-House Establishment. According to H. C. Nixon, planters in South Carolina began promoting cottonseed oil as early as 1815, with the major push coming from experiments in Virginia and the Carolinas 1820s and 1830s. Nixon notes when Professor Olmsted of the University of North Carolina tested cottonseed oil in lamps, he found "a fine illuminating gas" could be obtained from the seed. Southern planters they found the seed oil "decidedly" better than spermaceti oil.⁴¹ Many suggested that if New England mariners were risking their lives searching for oil on the seas, perhaps cottonseed oil could be used without so much danger.⁴²

In the time between Melville's experiment with natural gas in the 1810s, the experiments with carcel oil, and Greenough's "chemical oil" in the late 1830s, the United

³⁹ Pleasonton to Greenough, August 21, 1839, RG 26, Entry 18, Vol. 14, 494, NARA. Pleasonton to George Bancroft, June 10, 1839, RG 26, Entry 18, Vol. 14, 384, NARA. Long Island refers to the Long Island in Boston Harbor, not Long Island in New York.

⁴⁰ Sherman, 40.

⁴¹ H. C. Nixon, "The Rise of the American Cottonseed Oil Industry," *Journal of Political Economy* 38, no. 1 (February 1930), 74.

⁴² *Ibid.*, 75-6.

States Light-House Establishment ran numerous experiments on the quality and viscosity of spermaceti oil to ensure consistency in the nation's navigation aids.⁴³ These experiments began with the oil manufacturers. Oil manufacturers experimented with blending spermaceti with other substances, including whale blubber and fish oil. Most of the time these experiments were designed to increase the manufacturer's profit by combining the spermaceti with lower quality additives or by substituting for the spermaceti altogether. Upon arrival at the various lighthouses, local superintendents, naval officers, lighthouses keepers, and private citizens tested samples from each barrel. In their experiments, these individuals observed the consistency of the oil, noted how quickly it burned, and commented on how much smoke each sample of oil produced.⁴⁴

Others individuals conducted scientific experiments to see how the Establishment might make better use of its spermaceti oil. Whalers harvested the headmatter from Sperm whales in the fall. They then boiled the headmatter to remove any impurities and reduce the amount of water in the final product. Once this was done, the liquid was drawn off, producing the clearest sperm oil. This became known as winter pressed oil. Winter pressed spermaceti oil was considered the best of the spermaceti oils and therefore was also among the most expensive.⁴⁵ Summer strained oil came from the third pressing.

⁴³ It should be noted that while the primary source documents refer to the oil used by the USLHE as "spermaceti oil," spermaceti is a wax that is extracted from sperm oil. It is believed that the documents are referring to the actual sperm oil and not to the waxy spermaceti that come from processing the oil. Winter oil is strained for impurities and then pressed. Summer oil is only strained to remove the impurities.

⁴⁴ Pleasonton to Woodbury, December 3, 1838. Pleasonton to James Hunter, August 1, 1841, RG 26, Entry 18, Vol. 17, 33, NARA. Pleasonton to Edward Curtis, March 4, 1842, RG 26, Entry 18, Vol. 17, 306, NARA.

⁴⁵ Patty Jo Rice, "Beginning with Candle Making: A History of the Whaling Museum," *Historic Nantucket* 47, no. 3 (Summer 1998), 22. Emily Irwin, "The Spermaceti Candle and the American Whaling Industry," *Historia* 21, (Spring 2012), 52.

Despite its purity, summer stained oil was considered by many to be inferior because it could not be burned during the winter months. Summer oil was too thin and congealed too quickly. For this reason, summer strained oil was much cheaper than the winter oil. David Melville, however, sought ways to use cheaper summer strained spermaceti oil during the winter months. Melville's experiments with both summer and winter oil led to his discovery of a mechanical solution, but he did not discover a chemical method for using summer oil in the winter.

The Light-House Establishment and private marine telegraph shared similar interests in shipping, and as such, some lighthouses keepers served double duty as agents signaling the arrival of ships for the telegraph. These included Jonathan Bruce and Charles Beck in Boston, and Michael Mabrity in Key West, Florida. By serving in the dual role of lighthouse keeper and signaling agent, the Light-House Establishment was able to extend its scientific experiments in illumination and the chemistry beyond the lighthouse service. In 1824, the lighthouse keeper at Boston's Long Island, Charles Beck, conducted experiments on fabrics and dyes used in the making of the telegraph's signal flags. Fabrics had to be strong enough to stand up to the strong winds blowing in from the ocean, while dyes had to resist fading in sun. Beck tested a white cotton fabric and found it "very unfit" for its purpose.⁴⁶ The fabric frayed too easily to be of any use to the telegraph.

Worn and faded flags were difficult to distinguish, often resulting in communication errors. As previously mentioned in Chapter 3, atmospheric refraction

⁴⁶ Beck to John Rowe Parker, May 23, 1824, Box 1, Folder 24, Ms. Coll. 186, Parker, John R. (Rowe), 1777-1844 Correspondence 1802-1840, KUPL. Here after cited as JRPC.

affected the ability to see certain colors, shapes, and flag designs. Worn and faded flags exacerbated this problem. In 1831, Frederick W.A.L. Brown, the telegraphic agent on Georges Island in Boston, feared “my communications may in thick weather be misunderstood,” because of the “contraction and expansion” of the yarns “according to the state of the weather.”⁴⁷ Brown, himself, had mis-communicated the arrival of the ship Triton as the ship Mercury just two weeks earlier.⁴⁸ Using “every exertion in my power from eleven A.M. till two P.M.,” Brown attempted to obtain accurate intelligence of the arriving ship. Unfortunately, “the wind was then blowing very fresh at west north west and the tide also being at ebb.” Brown “had little prospect of being able to announce the name of the ship before sunset,” due to his inability to read the ship’s worn flag. Brown took the intelligence from the Point Aderton Station. Regrettably, the Point Aderton Station mistook the Triton’s worn flag for the signal of the Mercury. As the Mercury was expected, neither station supposed the signal could be incorrect.⁴⁹

Beck, Bruce, and Mabrity also experimented with improvements to the signaling code. Beck and Bruce both suggested changing colors within Boston’s signal code to improve the visibility of the signal. In a letter to his superior, John Rowe Parker, Beck acknowledged he altered the numerals on the number 2 and number 3 flags so that they were easier to read.⁵⁰ Presumably he did the same with the other numerals. Bruce, on the other hand, suggested changing the colors for each number “viz. No. 1 – Blue / No. 2 – Red / No. 3 White / No. 4 – blue & white / No. 5 – blue & red / No. 6 – black green or

⁴⁷ Brown to John Rowe Parker, May 28, 1831, Box 2, Folder 38, JRPC.

⁴⁸ Brown to Parker, May 12, 1831, Box 2, Folder 38, JRPC.

⁴⁹ Ibid.

⁵⁰ Beck to Parker, May 26, 1825, Box 1, Folder 24, JRPC.

yellow...”⁵¹ There is no indication that Parker accepted either of these changes, and perhaps did not because he was in negotiations with James Maud Elford of Charleston, South Carolina, to adopt a more universal system of signaling.

Bruce also wrote to Parker, “I have thought upon a plan (which I offer, to you, for your consideration) which will save a great deal of time as well as trouble in spelling the names of vessells [sic].” Bruce suggested, “to get the names of all the merchant vessels which you wish to signalize & place numbers against their names.” Bruce’s plan was especially useful when “there are three or four vessells [sic] in the Light House Channel at the same time.” The speed of the vessels made it impossible to spell the name of all arriving ships when the telegraph agent had to signal multiple arrivals.⁵² Ultimately, Parker accepted the lighthouse keeper’s suggestion, but not because of Bruce. What Bruce did not know is that Elford had already patented a system of assigning numbers to ships and Parker was negotiating terms with Elford to adopt the system in Boston and the surrounding areas.⁵³

MECHANICAL INNOVATION

The Light-House Establishment offered engineers, entrepreneurs, and mechanics numerous opportunities to invent new apparatuses. Many of these mechanical devices were patented by their inventors and can be found among the various sources related to early United States patents. Several of the patents discussed here have been previously mentioned in Chapter 2 as they related to providing individuals with opportunities for commercial profit. Here those patents are used as examples supporting the argument that

⁵¹ Bruce to Parker, November 12, 1824, Box 2, Folder 42, JRPC.

⁵² Bruce to Parker, September 24, 1824, Box 2, Folder 42, JRPC.

⁵³ Elford to Parker, June 21, 1824, Box 3, Folder 97, JRPC.

the Light-House Establishment was one of the United States' premier scientific organizations before the Civil War.

One of the early patents under the United States Light-House Establishment was Winslow Lewis' lamp and reflector system discussed earlier. Lewis' patented his lamp in 1810 after he witnessed a lamp in a barber shop projecting a light out into the dark street. Lewis noticed the barber had put a lens in front of the lamp and Lewis felt this idea would be useful in the Light-House Establishment. Lewis' "discovery" convinced him to conduct experiments on "his" innovation at the Boston Lighthouse as discussed at the opening of this chapter. The scientific observations conducted at the Boston Lighthouse helped negotiate with the Treasury Department on adopting the patent throughout the Light-House Establishment.

Lewis also experimented with "double glais[ing]" the lantern and "leaving a space between the panes of 3-8ths inch" in order to "prevent the humid air from condensing on the glass in Cold weather, or what the keepers Call the glass sweating."⁵⁴ Glass sweating, as Lewis called it, diminished the effect of the light as it passed through the lantern glass. Unfortunately, it does not appear that Lewis ever patented his "double glais-ed" windows. Modern sources trace the double glazed window to the late 19th or early 20th

⁵⁴ Melville, 9.

century, indicating Lewis could have patented the concept and profited handsomely from it.⁵⁵

Others devised mechanical devices to solve the condensation problem. David Melville developed an improvement to the Argand lamp to eliminate condensation of humid air or the accumulation of frost. His improvement “consist[ed] in having a tight scuttle door to close at pleasure the communication with the lantern from the bay next below; and the lantern fitted with four or more air ports, under the windows fitted also, so as to be closed at pleasure; then by opening the air ports to admit the external air, and keeping the scuttle closed to exclude the vapor of the lower part of the Light House from the lantern, and both humidity and frost will be prevented from collecting on the windows at all seasons and in all states and temperatures of the atmosphere, and the frost may even be dislodged after it has accumulated.”⁵⁶

Keeping the winter oil from congealing was another concern for the Light-House Establishment, especially in north where the winters were the coldest. As Stephen Pleasonton informed his superior, Levi Woodbury, Secretary of the Treasury, “the best Spermaceti from head matter, pressed in Winter, will congeal and and become hard

⁵⁵ Thermotek Windows, “History of Double Glazing,” February 22, 2016 <http://thermotekwindows.com.au/2016/02/> (accessed February 12, 2017). Aroseal Solutions, “The History of Double Glazed Windows,” December 1, 2014 <http://www.arosealsolutions.ca/resources-page/?pg=1&pgtitle=the-history-of-double-glazed-windows> (accessed February 12, 2017). Abbie Clarke, “History of Double Glazing,” December 1, 2012 <http://www.doubleglazingprices.org.uk/history-of-double-glazing/> (accessed February 12, 2017). Sarah Clark, “A Brief History of Double Glazing,” February 7, 2012 <http://ezinearticles.com/?A-Brief-History-Of-Double-Glazing&id=6866863> (accessed February 12, 2017). Door and Window.com, “The Evolution of Your Double Pane Window Starts with Ancient History,” January 8, 2012 <http://www.doorandwindow.com/windows/types/double-pane/double-pane-windows-and-ancient-history.html> (accessed February 12, 2017).

⁵⁶ Melville, 10.

whenever the mercury in Fahrenheit's Thermometer descends as low as 24 degrees."⁵⁷ Several mechanics invented oil heaters that could be attached to the lighthouse lamps as a possible solution to the congealing problem. Captain Alexander Black, for instance, patented an improvement to Lewis' Argand lamp in 1817. Black's patent embraced "an improvement for trimming the lamps used in Light Houses, for heating the oil, for raising the wick, for snuffing the lamp." The Light-House Establishment, however, found Captain Black's improvement "does not answer" the purpose for which it was designed.⁵⁸ Luckily for Captain Black, his invention had many other uses outside the Light-House Establishment including "for keeping seaman's hands and feet warm while at helm, for warming the feet of persons while traveling on horseback or in carriages, and lighting the road, and for gas lights."⁵⁹

Lewis also took out a patent for a heating element designed "to obviate the difficulty of keeping the oil in a fluid state in the winter season." Lewis' design captured the heat rising from the flame via a "trumpet formed, or funnel mouth" metal tube positioned above the lamp and returned the heat to the bottom of the lamp where the heat was "communicated...to the oil in the fountain."⁶⁰ Lewis, however, obtained the patent illegally. David Melville had expressed the idea to Lewis a few years earlier and went so far as to draw a diagram of the idea. Melville claimed his mechanical solution could keep the oil in a fluid state "to such a degree that summer strained oil may be used in the winter season without difficulty."⁶¹ Burning summer strained oil in "the coldest weather

⁵⁷ Pleasonton to Woodbury, December 3, 1838.

⁵⁸ Melville, 8-9.

⁵⁹ Ibid., 11.

⁶⁰ Ibid., 5

⁶¹ Ibid.

without difficulty” would save the Establishment thousands of dollars annually because summer strained oil was cheaper than winter pressed oil.⁶² Lewis, of course, opposed the idea of burning summer strained oil in the winter because it directly impacted his government contract with the Treasury Department for supplying oil to the Light-House Establishment. If the Establishment choose to burn the cheaper summer oil in the wintertime, Lewis would lose money on the loss of the winter oil supply. This is perhaps the reason Lewis attempted to secure the oil heater patent for himself. Lewis recognized the need for the heater, but by utilizing it without Melville’s knowledge, Lewis could hide the fact that the heater allowed summer oil to be burned in the wintertime from Pleasonton and the Light-House Establishment.

Melville had “practised [sic] for more than ten years,” keeping the oil in a fluid state in Argand lamps. He challenged Lewis on the latter patenting the improvement illegally. Lewis did everything in his power to undermine Melville and keep the patent for himself. Lewis claimed he had received nothing from the Light-House Establishment in exchange for installing the apparatus on lamps in northern lighthouses. He also argued the savings to the Establishment would be inconsequential. As the exclusive supplier of spermaceti oil to the Light-House Establishment, Lewis’ claims were obviously intended to protect his own interests. Despite Lewis attempts, Melville successfully defended his right to the invention and Lewis vacated the patent in 1819.⁶³

The United States Patent Office fire of 1836 destroyed many patents related to the Light-House Establishment prior to that date, yet the frequency with which the patents for improvements in lighthouses were taken out after 1837 provides some evidence of the

⁶² Ibid., 5, 15-6.

⁶³ Ibid., 41-2.

Establishment being a center for innovation. In 1841, Benjamin Hemmenway of Roxbury, Massachusetts, patented a separate oil reservoir for the Argand lamp that allowed for the replenishing of oil in the lamp without having to remove the oil chamber. Hemmenway noted the removal of the oil chamber was not only inconvenient, but had a “tendency to cause a derangement of the connecting parts from wear incident thereto, is generally attended with the accident of an overflow or dropping of oil on the exterior of the lamp.”⁶⁴ Three years later the United States Patent Office granted Hemmenway and Winslow Lewis a shared patent for a lighthouse lamp.⁶⁵

The same year Hemmenway patented his improvement to the Argand lamp, Benjamin F. Greenough of Boston patented another improvement. Greenough’s improvement consisted in constructing the button of the lamp, that part “which serve to spread the flame of the wick,” out of platina and placing it atop a conical shoulder and adjusting rod so that the button is not destroyed by the light.⁶⁶ Greenough noted “the heat caused by the current of air passing over both sides of the flame is so intense as to often melt down, or soon burn out, or destroy the button, if the same is made of brass, iron, or copper, in the usual manner.”⁶⁷ Greenough also designed an adjustable air flow for the lamp. The adjustment mechanism not only facilitated the air flow to the flame, but also accommodated Greenough’s different fuel mixtures. Different fuels required a different ratio of fuel-to-air in order to achieve the brightest light and maximum burning

⁶⁴ Benjamin Hemmenway, “United States Patent No. 1,934 – Lamp,” January 20, 1841, 2.

⁶⁵ Winslow Lewis and Benjamin Hemmenway, “United States Patent No. 3,692,” August 7, 1844.

⁶⁶ Platina is an impure form of platinum.

⁶⁷ Greenough, “Patent No. 2,039 – Lamp.”

efficiency.⁶⁸ Other lighthouse lamp improvements were patented by Charles Wheeler in 1846 and Abraham Coates in 1856 and 1859.⁶⁹

Benjamin F. Coston of Washington “invented a new “for generating, condensing, and burning gas from oil, resin or coal, and in applying the gas in light-houses”⁷⁰ Coston’s improvement obviated “the disadvantages arising from the collection of sediment in the ordinary siphon,” which allowed the resin or oil to be “introduced into the hottest part of the retort without any portion coming in contact with the sides.” Coston’s innovation provided for a “jacket around the pipe,” which kept the pipe “cool and prevent[ed] the tar from baking onto said pipe.” Coston also desired a Letters Patent for his particular method of construction which he claimed heated the gas “to a high temperature before burning.”⁷¹ Unfortunately, for Coston, the United States Light-House Establishment did not see the benefit of gas in lighting the coast. They chose not to adopt Coston’s innovative catoptric gas burner.

Not all patented improvements for the Light-House Establishment related to the lamp. Alonza Farrar applied for a Letters Patent for an improvement he made to the construction of metallic reflectors.⁷² Winslow Lewis’ reflectors were known for their poor quality. Lewis added silver to his brass and copper reflectors to give them a greater reflecting power, but because Lewis only plated his reflectors with silver, the silver easily

⁶⁸ Greenough, 3.

⁶⁹ Charles Wheeler, “United States Patent No. 4,454 – Light-House Lamp,” April 11, 1846. Abraham Coates, “United States Patent Office No. 14,492 – Improvement in Regulating the Flow of Oil to the Wick in Carcel Lamps,” March 25, 1856, re-issue January 4, 1859.

⁷⁰ Benjamin F. Coston, “United States Patent No. 3,894 – Generating and Burning Gas for Light-Houses,” January 31, 1845.

⁷¹ Coston.

⁷² Alonza Farrar, “United States Patent No. 3,518 – Metallic Reflector,” April 4, 1844, 2.

rubbed off.⁷³ Smoke and dust accumulated on these reflectors causing them to tarnish. The repeated cleansing and re-polishing of the lens diminished the reflector's power and eventually destroyed the reflector altogether.⁷⁴ Farrar's improvement consisted in "applying a surface of flint glass, or what may in fact be termed a parabolic lens," to the reflector.⁷⁵ This improvement did not eliminate the accumulation of smoke and dust on the reflector, but it did provide for a more reflective surface and eliminated the diminishing of the reflective power due to the silver plating rubbing off.

In 1839, Benjamin F. Willard, patented an improvement on his father's, Simon Willard, clockwork mechanism.⁷⁶ The younger Willard's improvement "effected in the following manner: In addition to the ordinary clock-work heretofore used for imparting a regular rotary motion to the main or vertical shaft...there is arranged upon and secured to the frame of the clockwork in a horizontal position a circular rim or railway...of any required diameter." The addition of this circular railway reduced the friction of turning the lamps, thus allowing for a smoother rotation of the light. Willard's patented improvement also "cause the lights to appear and disappear" in a quicker "succession of sudden flashes."⁷⁷ According to Willard, this quicker "succession of sudden flashes" would "render the light clearly distinguishable from all others."⁷⁸ Willard's patent was successful enough that he continued to provide clockworks to the Light-House

⁷³ Pleasonton to Winslow Lewis and Messers C. Grinnell, Jr. and Co., February 15, 1830, RG 26, Entry 18, Vol. 8, 185, NARA. Pleasonton to Winslow Lewis, April 9, 1838, RG 26, Entry 18, Vol. 13, 153, NARA. Farrar, 2.

⁷⁴ Farrar, 2.

⁷⁵ Ibid.

⁷⁶ Thomas Tag, "Early American Lighthouse Illumination," *The Keeper's Log* 14, no. 1 (Autumn, 1998), 24.

⁷⁷ Benjamin F. Willard, "United States Patent No. 1,085 – Improvement in Revolving Lights for Light-Houses," February 20, 1839, 2.

⁷⁸ Ibid.

Establishment until 1850 when Congress reorganized the institution under a five member Light-House Board.⁷⁹

Not all mechanical innovations in the Light-House Establishment went through the United States Patent Office. In 1838, Army Corps Engineer Lieutenant. I. W. P. Lewis invented an oil lamp for use in lighthouses. Lewis offered his lamp to the Light-House Establishment for \$500, but he did not apply for a Letters Patent.⁸⁰ Ten years later, as noted in Chapter 3, Captain Howard Stansbury innovated an adaptation to Alexander Mitchell's screwpile foundation because the environment would not support the use of Mitchell's innovation without Stansbury's adaptation. No known patent exists for Stansbury's diskpile innovation. Similarly, Lieutenant George Gordon Meade invented a five wick hydraulic lighthouse lamp in 1852 while he waited for appropriations from Congress to finish lighthouse at Sand Key in Florida. Meade's lamp raised the oil "to the level of the burner by being discharged from the reservoir in the dome of the lantern" rather than by "pumping up the oil by clockwork." Meade demonstrated the lamp's simplicity and claimed its "uniform working afforded great relief to the keepers."⁸¹ The newly formed Light-House Board agreed with Meade's assessment and universally adopted the lamp to replace those installed by Winslow Lewis over the past 40 years. Meade did not apply for a Letters Patent for his hydraulic lamp.

⁷⁹ Tag, "Early American Lighthouse Illumination," 24.

⁸⁰ Pleasonton to I.W.P. Lewis, November 13, 1838, RG 26, Entry 18, Vol. 14, 31, NARA. Pleasonton to Winslow Lewis, November 27, 1838, RG 26, Entry 18, Vol. 14, 51, NARA.

⁸¹ George Gordon Meade qtd. in Elinor De Wire, "Meade and Lighthouses," The General Meade Society of Philadelphia, <http://generalmeadesociety.org/about-george-g-meade/meade-and-lighthouses/> (accessed March 16, 2016). Thomas Tag, "American Lighthouse Lamp Identification Document," 20, United States Lighthouse Society, <http://uslhs.org/american-lighthouse-lamp-identification-document> (accessed March, 16, 2016).

The reasons Lieutenant I. W. P. Lewis, Captain Howard Stansbury, and Lieutenant George Gordon Meade did not patent their inventions are not always clear. Lewis, Stansbury, and Meade all possessed a strong sense of civic duty, which may have influenced their decision not to apply for a Letters Patent. The cost of applying for a Letters Patent might also have been a factor. From 1793 to 1861, the fee to apply for a letters patent was \$30.⁸² These fees remained the responsibility of the individual even though their inventions were part of the innovator's government service. In Meade's case, the fees were not affordable. As Elinor De Wire acknowledges, Meade's financial problems were a driving force in his re-enlistment in the United States Army. Meade's father lost large sums of money in a loan to the United States government that was never repaid and private survey work did not provide enough financial security for Meade to support his wife and children.⁸³ For the others, the \$30 fee probably was probably not worth the time and trouble of going through the patent process.

SEAPORTS: SCIENTIFIC LABORATORIES AND MECHANICAL WORKSHOPS

The scientific experiments and mechanical innovations within the Light-House Establishment turned American ports into scientific laboratories and workshops for the practical arts. This is not a novel argument, yet it is an important one. Understanding American port cities as scientific spaces and centers of knowledge construction helps scholars move past the notion that ports were gateways of economic, social, and cultural exchange. It helps us see that ports were more than just end nodes on a global trade network and that they were more than just distribution centers. Port cities contributed

⁸² Christopher Beauchamp, *Invented by Law: Alexander Graham Bell and the Patent that Changed America*, (Cambridge, MA: Harvard University Press, 2015), 218 n7.

⁸³ De Wire, "Meade and Lighthouses."

significantly to the advancement of the arts and sciences in the United States, especially in the first half of the nineteenth century. Knowing this, and understanding how ports contributed to the construction of knowledge clarifies both our understanding of the role that ports played in history of the United States and the the advancement of science in this country in the early nineteenth century.

Because of their urban nature, ports were better positioned to provide the necessary resources for performing science and constructing knowledge than rural villages and farms. As centers of population, ports cities contained more human and labor resources with a greater diversity of ideas. According to Economic historian Jacob Price, all towns in the United States with a population of 4,000 people or more in 1790 were port cities.⁸⁴ Their coastal location and status as entrepôts, added to the ports' diversity over other urban spaces. Immigrants who arrived in American ports with their different ideas did not always migrate out of the city. As commercial centers, ports had more financial resources and expendable wealth that could be devoted to science and the arts. Cities had huge financial resources, but the could be concentrated around a single good or industry. Lowell, Massachusetts, for instance was tied to the textile industry. While port cities may have specialized in certain commodities, they offered access to a diverse set of goods, thus increasing their capital resources over non-port cities. As political centers, America's entrepôts had stronger channels for garnering state support than the hinterlands. From a political standpoint, it may be hard to differentiate the port from other urban centers.

⁸⁴ Jacob M. Price, "Economic Function and Growth of American Port Towns in the Eighteenth Century," *Perspectives in American History* 8 (1974): 126.

The engagement in mechanical arts was essential to the construction of knowledge. Here too, it may be difficult to separate the port city from other urban areas, however, the ports' coastal location made them ideal places for the Light-House Establishment to pursue the mechanical arts. Alexander's use of mechanical occultations in testing Babbage's mathematical theory for distinguishing lighthouses and the Boston Marine Society's observations regarding Winslow Lewis's lamp and reflector are just two examples illustrating the importance of ports to the Light-House Establishment's engagement in the arts. These men of science, and others like them, used port cities to construct knowledge as much as they used the ports to transfer and disseminate existing knowledge from other parts of the globe.

Although this chapter has focused on the United States Light-House Establishment as one of the nation's premier scientific enterprises, other institutions also used early republic seaports as scientific laboratories. For instance, the Army Corps of Engineers also used ports as centers of research and as spaces to construct engineering knowledge. In 1826 near Lewistown, Delaware (present day Lewes, Delaware) Corps Engineer Lieutenant Colonel Joseph Totten conducted research at the request of Philadelphia merchants regarding the construction of a breakwater. Philadelphians wanted a breakwater to create a secure harbor at the mouth of the Delaware River as a safe haven for their ships against ice floes, storms, and winds. Totten's research did not limit itself to engineering. Totten also studied elements of the natural world – the winds, the tides, and the even the marine life. This research led Totten to rule out the possibility of constructing a wooden pier. Totten noted a pier constructed of, or enveloped by, wood

was subject to “the ravages of the worm, in the lower part of the bay.” The worms, Totten claimed, “would soon destroy any wall, in which timber entered as an essential part.”⁸⁵

Scientific laboratories were uncommon in the early United States. Individuals engaging in the practice of science used a variety of spaces to conduct their research and construct knowledge. Seaports were no exception. Ports offered access to the natural world and the material resources needed for scientific practice. Seeing seaports as centers of knowledge construction rather than just centers of commerce and distribution not only opens a whole area of for studying seaports, it also creates a bridge between economic history, maritime history, urban history, and the history of science and technology. Studying seaports as scientific laboratories and mechanical workshops can help us integrate the history of science and technology into more mainstream history. Protecting commerce was the focus of the Light-House Establishment, thus America’s seaports were an integral part of making the Establishment one of the nation’s leading scientific enterprises.

SCIENTISTS AND MECHANICS

If the Light-House Establishment turned American seaports into scientific spaces and centers of knowledge construction, the experimenters, inventors, and mechanics engaging in science were a diverse lot. While elites such as John Henry Alexander, Alexander Dallas Bache, and Joseph Henry helped make a name for American science among Europeans near the middle of the nineteenth century, science in the early United States was practiced in a large part by commoners. Farmers, merchants, women, free and enslaved African Americans, and even children.

⁸⁵ William Jones, *Remarks on the Proposed Breakwater at Cape Henlopen*, (Philadelphia: William Fry, 1826), 16.

The population diversity in the seaports equated to a democratic stage in the development of science. As many historians, including Thomas S. Kuhn, George H. Daniels, and Andrew J. Lewis, argue, the democratic stage was a necessary step in the development of science.⁸⁶ This is true regardless of the geographic location of science. Jan Golinski, for instance, shows a similar scientific democracy in Great Britain with the sale of barometers and study of the weather in the seventeenth and eighteenth centuries.⁸⁷ Thus, the development of science and the arts in America were not exceptional. They followed a path similar to the development of science in other nations.

Andrew J. Lewis argues natural history in the early American republic was largely observational and classificatory.⁸⁸ The same cannot be said for science in the Light-House Establishment, where experimenters and mechanics performed science to gain new knowledge. Charles Beck, Winslow Lewis, and David Melville did more than observe and classify. Their experiments constructed knowledge in the fields of physics and chemistry. In genteel society, it was expected that new knowledge would be published for all, but few commoners had the connections to disseminate their findings and many probably did not see the need to publish their findings. As illustrated in the first two chapters, the men of the Light-House Establishment simply applied their findings to

⁸⁶ Thomas S. Kuhn, *The Structure of Scientific Revolutions*, (Chicago: UC Press, 1970), 15. George H. Daniels, "The Process of Professionalization in American Science: The Emergent Period, 1820-1860," in *The Scientific Enterprise: Readings from Isis*, eds. Ronald L. Numbers and Charles E. Rosenberg, (Chicago: UC Press, 1996), 25. Andrew J. Lewis, *A Democracy of Facts: Natural History in the Early Republic*, (Philadelphia: UPenn Press, 2011), 2-5,7.

⁸⁷ Jan Golinski, *British Weather and the Climate of Enlightenment*, (Chicago: UC Press, 2007), 108-11, 121.

⁸⁸ Andrew J. Lewis, 5.

solving practical everyday problems before carrying on.⁸⁹ This lack of records makes it difficult for the historian. Evidence of the Light-House Establishment experiments were recorded in the correspondence between peers, between the Treasury Department and the mechanics, and between the Establishment and other society men.

Aside from the engineers, such as Lieutenant I. W. P. Lewis, Lieutenant George Gordon Meade, and Captain Howard Stansbury, most of the individuals engaged in science and the mechanical arts for the Establishment did not consider themselves philosophers, scientists, engineers, or mechanics. Their writing lacks the scientific terminology and references found in the work of other scientists, such as Ferdinand R. Hassler and John Henry Alexander. David Melville, for instance, uses a common vernacular to describe his inventions and explain their workings.⁹⁰ This challenges Andrew J. Lewis' argument that men who engaged, even part-time, in the natural world of the early republic saw themselves as contributing to American philosophy and science.⁹¹ Rather, these men saw themselves as businessmen, inventors, and laborers. Winslow Lewis, for instance, ran a cordage shop and distributed oil for the Light-House Establishment in addition to his tinkering and lamp work for the Establishment.⁹² Lewis essentially had his hands in any prospect that presented an opportunity for his own profit. He employed other men whom he considered to be the real mechanics. Similarly, David Melville owned a hardware and stationary store, yet he promoted the use and expansion of gas lighting. The natural gas industry was still in its infancy in the 1810s/ The industry

⁸⁹ Ibid., 137. Lewis states that publication was expected and that negative assessments of science emerged if the results were not published.

⁹⁰ Melville, 7-9.

⁹¹ Andrew J. Lewis, 7-9.

⁹² Isaac P. Davis and Winslow Lewis, "Trade Card," MS0175 / --03, Bostonian Society, Boston, MA.

did not become more viable until the second half of the century. Melville's inventions were something he tinkered with on the side. He too saw it as an opportunity to advance his own financial interests. Melville also employed mechanics to assist him as he tinkered in the practical arts.⁹³

Additionally, both Lewis and Melville saw themselves as inventors. In a letter to Albert Gallatin dated March 10, 1812, Lewis stated, "I am confident that there never was a reflector made before my invention in any Optical principle."⁹⁴ Melville also saw himself as an inventor. In a letter to his friend John Boss, Melville claimed he could prove "myself to be the first inventor" of an improvement to the Argand oil lamp.⁹⁵ In separate notarized affidavits, Melville again acknowledged "himself to be the original Inventor" of two improvements to the Argand lamp.⁹⁶

Charles Beck, Frederick W. A. L. Brown, and Jonathan Bruce, however, saw themselves as laborers. All three were engaged at various times in what Bruce referred to as simply, "tending the telegraph" at Boston between 1823 and 1837.⁹⁷ In October 1824, Bruce complained of another agent offering for Bruce to do "two-thirds of the work," while the other agent got "two-thirds of the money." Bruce threatened, "I shall not tend the Telegraph any longer," but apparently recanted later. In their correspondence with the proprietor of the Boston marine telegraph, Beck and Brown spoke frequently of their toils

⁹³ Melville, 7.

⁹⁴ Winslow Lewis to Albert Gallatin, March 10, 1812, RG 26, Entry 17E, Box 1, NARA.

⁹⁵ Melville, 10.

⁹⁶ Ibid., 6, 10.

⁹⁷ Bruce to John Rowe Parker, September 13, 1823, Box 2, Folder 42, JRPC.

with menial tasks including painting, repairing the telegraph's ropes and chains, and replacing the telegraph's connector arms.⁹⁸

Although men like Winslow Lewis and David Melville did not see themselves as engineers, mechanics, philosophers, or scientists, the state on the other hand did view them as such. Stephen Pleasonton often referred to Winslow Lewis and the other lighthouse contractors as engineers when corresponding with them and others about the work Lewis and the other contractors performed.⁹⁹ In his report to Congress, Pleasonton claimed, "in building all the more important lights I have employed engineers, with as much science, united to practice, as any to be found in the country."¹⁰⁰ Some might argue Pleasonton did not know the difference, but in a letter dated October 3, 1838, he specifically called out those engineers formally trained in that field as inadequate compared to those who learned the trade through the hands on practical experience of building structures.¹⁰¹

The state also viewed lighthouse keepers as mechanics. A lighthouse keeper's duties included properly adjusting and repairing the lamps, lenses, and in revolving lights, the clockwork mechanisms. These adjustments required the keeper to possess a mechanical ability. Many of these adjustments were done through screws, but sometimes

⁹⁸ Brown to Parker, May 18, 1831, Box 2, Folder 38, JRPC. Beck to Parker, January 22, 1825, Box 1, Folder 24, JRPC.

⁹⁹ Pleasonton to Winslow Lewis, October 3, 1837, RG 26, Entry 18, Vol. 12, 340, NARA. Pleasonton to Levi Woodbury, October 3, 1838, RG 26, Entry 18, Vol. 13, 503, NARA. Pleasonton to Winslow Lewis, October 5, 1838, RG 26, Entry 18, Vol. 13, 514, NARA. Pleasonton to Winslow Lewis, October 24, 1838, RG 26, Entry 18, Vol. 14, 9, NARA.

¹⁰⁰ Pleasonton to Thomas Corwin, March 8, 1852, in United States Treasury Department, *Light-Houses: A Letter from the Secretary of the Treasury...in Reply to a Report Made to Congress by the Light-House Board*, by Thomas Corwin, 32nd Cong., 1st sess., 1852, H. Doc. 88, 4.

¹⁰¹ Pleasonton to Woodbury, October 3, 1838.

the adjustments meant precisely filing the lamp burner to ensure an even flame. As Winslow Lewis explained to Stephen Pleasonton in 1822, if the flame caused the lamp's air tube to "become uneven," the uneven part must be "taken off with a file."¹⁰² Filing the burner of an Argand lamp not only required a keeper to possess precise mechanical knowledge of the lighthouse lamps, but also an understanding of chemistry and physics. When filed correctly, Lewis claimed "the lamp then is the same as when new," but if the burners were filed too much, the lamp was rendered useless. This filing of the lamp burner may have resulted from the inferiority of Lewis' lamps.

Wicks were another aspect the required the lighthouse keeper to perform the duties of a mechanic. Lewis noted that if the wicks were not expertly trimmed and raised, the keeper will "fill the lantern with smoke in much less time than one hour."¹⁰³ Trimming and raising the wick required the keeper to possess a basic knowledge of chemistry and physics. They also required precision on the part of the keeper. The Argand lamp used a wide flat woven wick, usually made of cotton fibers. If the wick were trimmed too close to the burner, the flame would cause the wick to char, or "crust." Crusting prevented the lamp from burning properly and wicks were required to be trimmed every four hours through the night as a result.¹⁰⁴ Once the wick burnt down completely, the lighthouse keeper had to replace the wick. This task required the keeper to disassemble the burner before inserting the wick and reassembling it afterwards.

¹⁰² Winslow Lewis to Pleasonton, December 11, 1822, RG 26, Entry 17, Box 1, NARA.

¹⁰³ Winslow Lewis to Pleasonton, April 25, 1826, RG 26, Entry 17, Box 1, NARA.

¹⁰⁴ Pleasonton, *Instructions to Keepers of Lighthouses within the United States*, (Washington, DC: GPO, 1835). Lewis to Pleasonton, April 25, 1826. Patricia Majher, *Ladies of the Lights: Michigan Women in the U.S. Lighthouse Service*, (Ann Arbor, MI: University of Michigan Press, 2010), 13.

Cleaning the lamps, lenses, and reflectors also required a mechanic's hand. Cleaning could easily cause a misalignment that needed to be fixed. Often times keepers had to remove the lamp from the lantern in order to clean it properly. Removal from the lantern presented its own set of mechanical problems since each lamp required precise placement to ensure the light's maximum brightness and efficiency. Lewis' lamp and reflector system used screws to adjust the lamp's placement in front of the reflectors.¹⁰⁵ Keepers had to be careful in their removal and replacement of the lamps. Even a small adjustment could affect the quality of the light and impact mariners at sea.

Perhaps the most mechanically involved aspect of a keeper's duties was maintaining the clockworks mechanism for revolving lights. Revolving lights, that is those that appeared to "flash," helped mariners distinguish one lighthouse from another. The speed of the light's revolution determined how often the light "flashed" its signal. To create the effect of a "flashing" light, the lamp and reflector system rotated on a gear driven mechanism. The motor operated by a gravity-fed weight attached to a cable. The lighthouse keeper would raise the weight by hand cranking the mechanism and wrapping the cable around a barrel. Once the weight reached the top of the lighthouse, it would fall. The falling weight caused the barrel to rotate and this motion was transferred to the lens through a series of gears somewhat resembling the interior workings of a clock.¹⁰⁶ According to John T. Graham, because Winslow Lewis' Argand-style lamp and reflector

¹⁰⁵ Tag, "American Lighthouse Lamp Identification Document," 16.

¹⁰⁶ Pau Zielinski, "Lighthouse Technology: Clockwork Mechanism," December 16, 2015, *Keeper's Blog*, St. Augustine Lighthouse and Maritime Museum, <http://www.blogstauginelighthouse.org/lighthouse-technology-clockwork-mechanism/> (accessed March 23, 2016). Tag, "Early American Lighthouse Illumination," 24-5.

system was relatively light, the amount of weight needed to turn the clockwork mechanism was correspondingly very little.¹⁰⁷

This clockwork mechanism ran continuously from dusk until dawn each day. Keepers were responsible for maintaining the mechanism to ensure the gear-driven motor ran smoothly. The keeper inspected gears and weights daily making sure everything was properly aligned for an effortless rotation of the lens. If the gears jammed, became misaligned or worn, or for any other reason prevented the mechanism from rotating the lamp and reflector, the keeper was responsible for the repairing the mechanism. Sometimes repairs might require extensively mechanical work such as filing rough spots or adjusting the spacing between gears. Other times, simply keeping the gears properly oiled might prevent future problems.

If the state saw these men as mechanics, the keepers themselves did not necessarily see themselves in that same light. The keepers most likely saw themselves as laborers, rather than as mechanics. A poem written by Fred Morong, a lighthouse keeper in Maine, illustrates how much lighthouse keeper's self-identified with their labor.

excerpt from the poem "Brasswork"

by Fred Morong

"Oh, what is the bane of the lightkeeper's life,

That causes him worry, struggle, and strife,

That make him use cusswords and beat up his wife?

It's brasswork.

What makes him look ghastly consumptive and thin,

¹⁰⁷ John T. Graham, "Weights and Weightways at American Lighthouses," *The Keeper's Log* 32, no. 1 (Winter 2016): 36.

*What robs him of health, of vigor, and wim,
And causes despair and drives him to sin?*

It's brasswork.

*The devil himself could never invent
A material causing more worldwide lament,
And in Uncle Sam's service about ninety percent*

Is brasswork.

*The lamp in the tower, reflector and shade,
The tools and reflectors pass in parade
As a matter of fact, the whole outfit is made*

Of brasswork.

*The oil containers I polish until
My poor back is broken, aching, and still
Each gallon and quart, each pint and gill*

Is brasswork.

*I lay down to slumber all weary and sore,
I walk in my sleep, I awake with a snore
And I'm shining the knob on my bedchamber door*

That's brasswork.

*From pillar to post, rags and polish I tote
I am never without them, for you will please note
That even the buttons I wear on my coat*

Are brasswork.

*The machinery, clockwork, and fog signal bell,
The coal hods, the dustpans, the pump in the well,
Now I'll leave it to you mates, if this isn't, well
Brasswork.
I dig, scrub and polish, and work with a might,
And just when I get it all shining and bright,
In comes the fog like a thief in the night
Good-bye brasswork.”¹⁰⁸*

Although this poem was written several years after the period under study here, it is still relevant. Aside from the “buttons on the coat,” the life of the lighthouse keeper was much the same at the time the poem was written as it was in the first half of the nineteenth century. There were a few more modern conveniences, but the daily tasks were the same. The keepers’ lists of duties consisted chopping firewood, cleaning, painting, and other routine tasks that required much more labor than it did mechanical ability. The keeper at the Black Rock Light in Connecticut claimed they “never had much time to [even] get lonely” before listing all of their daily toils.¹⁰⁹ When the retiring keeper at Egg Rock Lighthouse in Massachusetts in 1850 welcomed the new keeper, the former warned the latter of the extensive labor required to maintain the light.¹¹⁰ In 1851, when the newly formed Light-House Board surveyed the various keepers, they listed many as having “no vocation.” Several, including James Hubbard, the keeper at Navesink Twin Lights in

¹⁰⁸ Qtd. in Elinor De Wire, *Guardians of the Lights: Stories of U.S. Lighthouse Keepers*, (Sarasota, FL: Pineapple Press, 1995), 279-80.

¹⁰⁹ Mary Louise Clifford and Candace Clifford, *Women Who Kept the Lights: An Illustrated History of Female Lighthouse Keepers*, (Alexandria, VA: Cypress Communications, 2000), 15.

¹¹⁰ De Wire, *Guardians of the Lights*, 24-5.

New Jersey (appointed 1851); Epraim L. Lockerman, keeper of the Reedy Island Lighthouse (1850); and William Vennard, keeper of the Portsmouth Harbor Light (1849) were farmers before their respective appointments as keepers.¹¹¹

Reading the correspondence between the lighthouse keepers in Boston and the marine telegraph shows lighthouse keepers to be primarily unskilled and untrained in the arts. Although the state considered Lighthouse keepers to be mechanics, Stephen Pleasonton acknowledged that many keepers possessed little training or experience in the arts when he was called before Congress to defend his administration of the Light-House Establishment. In a letter to John P. Kennedy, Chairman of the House Committee on Commerce, Pleasonton stated, “There is not a single keeper, out of about two hundred and forty, in charge of the reflector lights, so far as my knowledge extends, who is capable of taking charge of and conducting a lens light properly; and there are few in our country who are capable and would be willing to receive the inconsiderable sum for their services which we give Mr. Lopez, the present keeper at Navesink....It would, therefore, only be in the vicinity of large towns that we should have it in our power to obtain suitable keepers, and at the same time proper assistants, and materials with which to repair the machinery.”¹¹²

Natural philosophy and the mechanical arts were primarily practiced by white males in the early United States republic, but this democracy of science did not limit itself to the Anglo-American genteel society. Andrew J. Lewis argues, all classes

¹¹¹ Thornton A. Jenkins, *Report*, January 30, 1852 in United States Congress, *Report of the Officers Constituting the Light-House Board*, 32nd Cong., 1st sess., 1852, S. Doc. 28, 170, 179, 196.

¹¹² Pleasonton to Kennedy, December 28, 1841, New Jersey Lighthouse Society, <http://www.njlhs.org/njlight/firstfire.htm> (accessed April 5, 2013).

participated in natural philosophy during the first few decades of the nineteenth century and that scientific practice was a far more variegated enterprise than simply white men observing and classifying nature.”¹¹³ Lewis uses the example of South Carolina slaves assisting Dr. William Read, a rice plantation owner, with analyzing fossilized teeth of an unknown creature. But scientific practice was even more variegated than Lewis contends. African Americans, women, and even children engaged in the collection and construction of scientific knowledge.¹¹⁴ This was true even in the United States Light-House Establishment.

The records and examples of African Americans, women, and children participating in science are sparse due to the high degree of paternalism in the white male community towards these classes of individuals, yet there is evidence of their participation. In the south, the Light-House Establishment offered opportunities in science and the arts for a predominantly African-American labor force. Although their participation in science was forced upon them due to their bonded state, African Americans engaged in early American science in the construction of port infrastructure. In 1811, Thomas Walker and James Evans were awarded a contract to build a lighthouse for the port of Georgetown, South Carolina. With few other options for labor, Walker and

¹¹³ Andrew J. Lewis, 4-5.

¹¹⁴ See Londa Schiebinger, *Plants and Empire: Colonial Bioprospecting in the Atlantic World*, (Cambridge, MA: Harvard University Press, 2007). James Delbourgo, *A Most Amazing Scene of Wonders: Electricity and the Enlightenment in Early America*, (Cambridge, MA: Harvard University Press, 2006), 183-9. Nina Baym, *American Women of Letters and the Nineteenth Century Sciences: Styles of Affiliation*, (New Brunswick, NJ: Rutgers University Press, 2002). Schiebinger, Delbourgo, and Baym discuss African Americans and women. My study will introduce children as mechanics and experimenters.

Evans hired slaves from local plantations to haul and lay the bricks of the tower.¹¹⁵ Hauling bricks for the tower required manual labor, but laying the bricks required slaves to have knowledge beyond even basic schooling. The tapered brick tower stood 87 feet tall. Calculating the gradient of the walls was no easy task. It required a strong knowledge of mathematics and construction techniques. Local historian Robert MacAlister describes the beacon as having walls five and a half feet thick at the bottom and two feet thick at the base of the lantern room.¹¹⁶ While knowledge of brick construction and mathematics may have been available on the plantations, experience in building structures of the lighthouse's height was only available in the seaports, where imposing structures were a necessity for the safety of maritime commerce and navigation. African Americans thus participated in and were taught the art of practical engineering. They gained useful knowledge which they carried with them back to the plantation or on to other projects, such as the construction of the lighthouse at Cape Romain outside McClellanville, South Carolina.¹¹⁷

Women also served as mechanics in the Light-House Establishment. In 1826, the Establishment appointed Edward Shoemaker's widow keeper of the Old Field Point

¹¹⁵ Robert MacAlister, *Georgetown's North Island: A History*, (Charleston, SC: The History Press, 2015), 57. "The State Briefly: Georgetown: Group to Celebrate Lighthouse Day," *The State* (Columbia, SC), August 9, 2005, B3. Kraig Anderson, "Georgetown Lighthouse," *Lighthouse Friends.com* (August 27, 2015), <http://www.lighthousefriends.com/light.asp?ID=336>. Jason Lesley, "Drawn by the Light," *Coastal Observer* (Pawley's Island, SC), May 7, 2015.

¹¹⁶ MacAlister, 57.

¹¹⁷ Suzanne P. Wylie and David Chamberlain, "National Register of Historic Places Nomination for Cape Romain Lighthouses," September 4, 1981, 3. Bruce Roberts and Ray Jones, *Southeastern Lighthouses*, (Philadelphia: Chelsea House Publishers, 2000), 44.

lighthouse in New York.¹¹⁸ Although other women such as Catharine Moore had unofficially performed the duties of the lighthouse keeper at Black Rock Harbor, Connecticut as early as 1817, Shoemaker was the first woman officially hired by the federal government to serve in the position of a keeper. Appointing the lighthouse keeper's widow as the new keeper followed the long standing tradition of European craft guilds. As Londa Schiebinger notes, "guild regulations gave a widow the right to run the family business after the death of the husband."¹¹⁹ Elinor De Wire acknowledges, it "became an unofficial rule concerning the appointment of most women" as lighthouse keepers and the state "had few reservations about hiring women with several years of apprentice-type experience."¹²⁰

In many cases, the widow was already familiar with the duties of keeping the lighthouse, having assisted their husbands in an unofficial capacity. The state recognized this fact in appointing widows to their husbands' former post. De Wire notes, "lighthouse keeping was largely a family affair."¹²¹ The state preferred to appoint married men with families as lighthouse keepers knowing the family could assist them in tending the light. De Wire continues stating that "by 1851, 30 widows had succeeded their husbands at

¹¹⁸ Virginia Neal Thomas, "Women's Work: Women Lighthouse Keepers in the Early Republic, 1820-1859," (MA Thesis, Old Dominion University, Norfolk, VA), 95. USCG, "Women Lighthouse Keepers: Women Lighthouse Keepers & Other Female Employees of the U.S. Lighthouse Board/Service," http://www.uscg.mil/history/uscghist/Women_Keepers.asp (accessed September 1, 2015).

¹¹⁹ Londa Schiebinger, *The Mind has No Sex?: Women in the Origins of Modern Science*, (Cambridge, MA: Harvard University Press, 1989), 95.

¹²⁰ De Wire, *Guardians of the Lights*, 188.

¹²¹ *Ibid.*, 183.

American lighthouses.”¹²² In all, 53 women were officially employed by the United States Light-House Establishment as lighthouse keepers between 1820 and 1859.¹²³

Interest in female lighthouse keepers has increased substantially in the last three decades as several scholars have examined the role of women in the United States Light-House Establishment and later the Lighthouse Service. These include the mother-daughter team of Mary Louise and J. Candace Clifford, Patricia Majher, Elinor De Wire, Bethany Bromwell, and Virginia Neal Thomas among others.¹²⁴ Thomas and Majher acknowledge the duties of the keeper by including a transcription of Stephen Pleasonton’s instructions to lighthouse keepers, but unfortunately, none of these studies fully examine female keepers as mechanics or scientific experimenters. Most explore the social aspects of female lighthouse keepers and focus on women laboring in a man’s world without addressing their engagement in practical science. Thomas’ thesis comes the closest by comparing the work of the lighthouse keeper to the domestic work of a

¹²² Ibid., 188.

¹²³ Thomas, “Women’s Work,” 95. USCG, “Women Lighthouse Keepers.”

¹²⁴ Listed in the order of their dates of publication: Mary Louise Clifford and J. Candace Clifford, *Women Who Kept the Lights: An Illustrated History of Female Lighthouse Keepers*, (Alexandria, VA: Cypress Communications, 1993). Elinor De Wire, *Guardians of the Lights: The Men and Women of the U. S. Lighthouse Service*, (Sarasota, FL: Pineapple Press, 1995). Connie Scovill Small, *The Lighthouse Keeper’s Wife*, (Orono, ME: University of Maine Press, 1999). Lenore Skomal, *The Keeper of Lime Rock: The Remarkable True Story of Ida Lewis, America’s Most Celebrated Lighthouse Keeper*, (Philadelphia, PA: Running Press, 2002). Mary Louise Clifford and J. Candace Clifford, *Mind the Light Katie: The History of Thirty-Three Female Lighthouse Keepers*, (Alexandria, VA: Cypress Communications, 2006). Patricia Majher, *Ladies of the Lights: Michigan Women in the United States Lighthouse Service*, (Ann Arbor: University of Michigan Press, 2010). Bethany Bromwell, “Mothers of the Sea: Female Lighthouse Keepers and their Image and Role in Society,” (MA Thesis, UMBC, 2008). Virginia Neal Thomas, “Women’s Work: Women Lighthouse Keepers in the Early Republic, 1820-1859,” (MA Thesis, Old Dominion University, 2010). Skomal’s book was republished by Globe Pequot Press under the title *The Lighthouse Keeper’s Daughter: The Remarkable True Story of American Heroine Ida Lewis* in 2010.

homemaker. Majher surmises that this oversight into the science and mechanical arts may result from the “remarkably little detail about these women’s lives.”¹²⁵

Despite these studies overlooking the scientific and mechanical role of female keepers, it is possible to understand the extent that women lighthouse keepers were mechanics and experimenters by examining the primary sources relating to male keepers. Those sources can be applied to female keepers as well since they performed the same job. As previously discussed, serving as a lighthouse keeper required one to possess a mechanical ability. Keepers were responsible for properly adjusting and repairing the lamps, lenses, and the clockwork mechanisms used in revolving lights. While Thomas notes that women’s domestic work involved tending fires and lamps in the home, filing the burner of a lamp would not have been common practice for women in the nineteenth century.¹²⁶ Filing was considered a man’s work and in many cases the artisan craft of a metalworker. According to Catherine E. Beecher’s 1843 treatise on domestic housework, if a lamp burner in the home needed to be filed, it was to be done by the male in the household.¹²⁷ Londa Schiebinger, however, complicates this idea and the notion of gender roles. Schiebinger argues what went on in private homes outside the view of the public eye may or may not have followed the accepted gender conventions of the day.¹²⁸

¹²⁵ Patricia Majher, email to author, August 24, 2015.

¹²⁶ Thomas, 23-4.

¹²⁷ Catharine E. Beecher, *A Treatise on Domestic Economy for the use of Young Ladies at Home and at School*, (Boston: Thomas H. Webb & Co., 1843), 255. Jeanne Boydston, *Home and Work: Housework, Wages, and the Ideology of Labor in the Early Republic*, (New York: Oxford University Press, 1990), 142-3. Alice Kessler-Harris, *Out to Work: A History of Wage Earning Women in the United States*, (New York: Oxford University Press, 1982), 21-2, 47-50.

¹²⁸ Schiebinger, *The Mind has No Sex?*, 82-89. While Schiebinger does not make the argument explicitly, her examples of female astronomers demonstrate the complexity of conventional gender roles inside the home.

Within the Light-House Establishment, the tasks for tending the light were the same for men and women with the exception of painting the lighthouse. According to Dennis Noble, “Stations whose principle keepers were women were excused from this chore.”¹²⁹

Additionally, as previously noted, cleaning the lighthouse lamp required mechanical knowledge. The Argand oil lamps used in lighting the United States’ coastal beacons were nearly identical to the Argand lamps used in homes. Catharine Beecher’s domestic manual instructed women to “take the lamp to pieces and cleanse it.”¹³⁰ Disassembling the lamp to clean it not only required knowledge of the lamps mechanical construction, but again, also required the keepers to remove the lamp from its very precise placement between the lens and reflector. Some lighthouses had as many as thirty lamps; each with their own exact placement for providing the best light possible.¹³¹

Even children participated as mechanics and scientific experimenters within the Light-House Establishment. As early as 1813, David Melville employed Benjamin Marshall to assist him in “attending the gas apparatus.” The boy was only thirteen years old at the time. In a deposition supporting Melville’s patent infringement suit against Winslow Lewis, Marshall claimed he had worked for Melville off and on for at least the next five years.¹³² While neither Melville or Marshall specify the latter’s exact duties in assisting Melville, it is logical the Marshall’s duties included mechanical work. Melville would have instructed Marshall on how to perform that mechanical work until the boy

¹²⁹ Dennis L. Noble, *Lighthouses & Keepers: The U.S. Lighthouse Service and its Legacy*, (Annapolis, MD: Naval Institute Press, 1997), 92.

¹³⁰ Beecher, *A Treatise on Domestic Economy*, 282.

¹³¹ Stephen Pleasonton to John A. Dix, January 1847 in United States Congress, *Lighthouses: Letter from the Secretary of the Treasury...in Reply to a Report Made to Congress by the Light-House Board*, 32nd Cong., 1st sess., 1852, H. Doc. 88, March 23, 1852, 14.

¹³² Melville, 17.

became proficient enough to complete the tasks on his own. Because of the inconsistency of Marshall's off and on employment, it seems unlikely that the boy was any sort of apprentice to Melville. Rather it is more likely that Marshall was an assistant whom Melville hired when he needed an extra set of hands to help him with the mechanical duties tending to the gas apparatus.

Children were also employed in tending the light. In 1857, fifteen-year-old Idawalley (Ida) Zoradia Lewis took charge of the Lime Rock Lighthouse when her father, Hosea Lewis, the keeper of record, had a stroke.¹³³ Normally the task of keeping the light would have fallen to Hosea's wife, Zoradia Lewis. Zoradia, however, was pre-occupied with caring for her husband and Ida's younger sister who had also fallen ill.¹³⁴ Most historians have focused on Ida's daring and heroic rescues, but the fifteen-year-old girl also performed all the mechanical duties of keeping the light. She trimmed the wicks, polished the reflectors, filed the burners, maintained the clockworks mechanism and made all of the necessary adjustments for keeping the light lit every night. Ida's contributions went unpaid because she was tending the light while her father was incapacitated. As Elinor De Wire notes that it was not uncommon for children to assist in keeping the light. In many ways it was unofficially expected. According to De Wire, the Light-House Establishment preferred to hire married keepers with families because of the sheer amount of work that needed to be done at the lighthouse.¹³⁵ De Wire also notes

¹³³ In some sources Ida's middle name is spelled Zorada.

¹³⁴ Kraig Anderson, "Ida Lewis Rock, RI," *Lighthouse Friends.com*, <http://www.lighthousefriends.com/light.asp?ID=398> (accessed March 16, 2016). Clifford and Clifford, *Women Who Kept the Lights*, 90. Bromwell, "Mothers of the Sea," 76.

¹³⁵ De Wire, *Guardians of the Lights*, 39-40.

there were no age restrictions for lighthouse keepers in the first half of the nineteenth century.¹³⁶

What is at issue here is the question “What constituted science in the early United States?” Science can be defined simply as knowledge. Individuals performing science and engaging in the mechanical arts gained knowledge through empirical observation and testing. Although the Charles Becks, James Hubbards, Ida Lewises, and Benjamin Marshalls of the Light-House Establishment were simply doing what they had to do to get by in their day to day tasks, they were engaged in scientific activities. These individuals constructed knowledge through their daily tasks because their daily routine relied on empirical observation and testing. Many of these individuals did not even realize they were engaging in empirical observation and testing and even if they did, they were not necessarily interested in the knowledge the produced. Beck, Hubbard, Lewis, Marshall and the so many other average Americans in the Light-House Establishment may have constructed knowledge for their own gain, but their primary goal was doing their job and doing it to the best of their ability. As we will see in the following chapter, civic duty played an important role in early nineteenth century American science. The lack of interest in the knowledge produced by these individuals does not change the fact that they were engaged in science. Their work helped make the Light-House Establishment one of the leading scientific institutions in the United States in the early nineteenth century.

¹³⁶ Ibid., 39.

CONCLUSION

Similar to the Coast Survey's impact on surveying, the Army Corps of Engineers' influence on American engineering, and the marine telegraph's role in the advancement of communications, the United States Light-House Establishment played a major role in the creation of scientific knowledge in America. As this chapter has demonstrated, the Establishment conducted numerous experiments in the chemical analysis of fuels and the physical science of illumination to produce new knowledge about the natural world. This construction of knowledge and engagement in scientific experimentation made the Light-House Establishment one of the premier scientific organizations in the United States and placed the agency at the forefront of American science prior to the outbreak of the American Civil War.

The Establishment employed a diverse lot of workers including men, women, and children of all ages. The Establishment's men and women of science also included both the formally educated, such as the engineers of the Topographical Corps, and the tinkerers who learned through the successes and failures of their practical experiences. These mechanics and scientists did more than make observations and record their findings. They engaged in the construction of knowledge; knowledge that these scientifically-minded individuals used to find ways of improving the nation's coastal navigation. They invented dozens of lighthouse innovations including new lamps, lenses, reflectors, clockwork mechanisms, and other devices designed to provide a brighter, more consistent light. Some of these mechanics applied for Letters Patents and the United States Patent Office granted many patents for lighthouse innovations between 1789 and 1860. Men, such as Winslow Lewis and David Melville, sought to profit from

their ideas and secure their livelihood. Others, including including Winslow's nephew, Lieutenant I. W. P. Lewis, Lieut. George Gordon Meade, and Captain Henry Stansbury were content with knowing they had done their civic duty. Although it is possible that Lewis, Meade, and Stansbury did not wish to pay the fee to patent their inventions, they, and others like them, seem to have cared more about improving navigation than they did about any personal gain they might have received from their work. For this reason, many innovations went unpatented by their inventors. There are no known records of the Light-House Establishment's female mechanics inventing new apparatuses for the service.¹³⁷ Other historians have argued that women of the Light-House Establishment, such as Ida Lewis, seemed more concerned with performing their civil service faithfully, accurately, and to the best of their ability.¹³⁸ This may be true, but it may also be the easiest assessment given the lack of records within the Light-House Establishment highlighting the scientific and mechanical contributions of women. Ruth Oldenziel argues nineteenth-century women made all kinds of things, they simply were not the sort of thing one would patent.¹³⁹ Additionally, it is also possible the Establishment's women invented new devices and innovated new methods, but simply did not record their discoveries or share them with anyone else.

With the majority of the nation's lighthouses being placed in or near its harbors, the Light-House Establishment provide the perfect opportunity for men and women to engage in science. The environment of the harbor provided the perfect space to pursue

¹³⁷ Candace Clifford, email to author, September 29, 2014. Majher, email to author, August 24, 2015.

¹³⁸ De Wire, *Guardians of the Lights*, 199-203. Noble, 112-4. Clifford and Clifford, 90-4.

¹³⁹ Ruth Oldenziel, *Making Technology Masculine: Men, Women, and Modern Machines in America, 1870–1945*, (Amsterdam: Amsterdam University Press, 1999), 26-42.

experiments. These experiments turned early republic seaports in to scientific laboratories and workshops for the practical arts. Ports were more than gateways of exchange. They were more than end nodes on a global trading network. Early republic ports were centers for the exploring and obtaining knowledge. They were field schools for those who wished to learn about science, the arts, and the natural world.

CHAPTER 5

REPUBLICAN VALUES AND INNOVATION

If the environment necessitated the involvement of the state in science and the practical arts as discussed previously in Chapter 3, the government's entrance into these fields was heavily influenced by republican values. Specifically, the values of civic duty, prudence, honesty, and self-reliance shaped the manner in which the government engaged in scientific endeavors. These values were at the core of American republicanism. Values such as civic duty and self-reliance promoted the advancement of practical science and mechanical innovation, while prudent management of government expenses seemed, at least on the surface, to slow, or even oppose, scientific progress. Opinions over defining these republican values also developed into a long-standing debate over who was best qualified to manage the government's scientific endeavors.

In the late 1830s, complaints against the Fifth Auditor of the Treasury, Stephen Pleasonton, and his administration of the Light-House Establishment began to mount. By the mid-1840s, those complaints had reached the halls of the Capitol Building.¹ The complaints were of a scientific nature. Edmund Blunt, Assistant to the Coast Survey, and Lieutenant I. W. P. Lewis of the Topographical Engineers were the most critical of Pleasonton's administration, but even the Secretary of the Treasury, Walter Forward, chimed in on the need for a "competent scientific and practical engineer" to provide

¹ United States Congress, *Examination – Light-House Establishment*, 27th Cong., 3rd sess., 1843, H. Doc. 183.

guidance for the Establishment.² Of the three, Blunt was by far the loudest critic. He wrote to public officials, editors of important newspapers, and mariners involved in the transatlantic trade. Blunt argued the lights in the United States were “greatly inferior in brilliancy, in the distance they may be seen, and in good management” in comparison to those in Britain and France.³ Blunt continued, stating, “We have been for years behind other nations in taking advantage of other improvements.”⁴ Lewis confined his complaints to his official report, which was authorized by Congress and commissioned by the Secretary of the Treasury. Similar to Blunt, Lewis claimed the lights in France and Great Britain were far superior to those in the United States, Lewis argued, France and Great Britain had “called in the aid of their most eminent scientific men to improve the construction and illumination of their coastal lights,” but noted “the establishment of this country has languished under the rule of ignorant and avaricious contractors, unrestrained by law or other influences requisite to the proper government of so important a branch of public service.”⁵ Lewis went on to say, “everything like systemic arrangement is utterly unknown; obscure inland beacons have more lamps than exterior lights of the highest importance.”⁶ As an example, Lewis noted, “the beacon-light on the Penobscot river has

² Walter Forward to John White, February 24, 1843 in H. Doc. 183, 2.

³ E. and G. Blunt to Levi Woodbury, November 30, 1837, in United States Light-House Establishment, *Compilation of Public Documents and Extracts from Reports and Papers relating to Light-Houses, Light-Vessels, and Illuminating Apparatus, and to Beacons, Buoys, and Fog Signals, 1789 – 1871*, (Washington, DC: GPO, 1871), 94.

⁴ Ibid.

⁵ I. W. P. Lewis to Walter Forward, January 31, 1843, in H. Doc. 183, 4.

⁶ I. W. P. Lewis, *Report of I. W. P. Lewis, Civil Engineer*, 1842, in H. Doc. 183, 8.

as many lamps, and much larger and better reflectors than the great coast light of Petit Manan, where three wrecks have occurred since the period of this examination.”⁷

While Blunt and Lewis shared common views, it is difficult to say whether or not the latter came to his views independent of Blunt. The young Lewis was an up and coming engineer who undoubtedly sought to make a name for himself. Blunt on the other hand already held a great deal of influence through his association with the Coast Survey. Blunt was the first Assistant appointed to the Coast Survey under Ferdinand Rudolph Hassler.⁸ In a letter to Walter Forward, the Secretary of the Treasury, Lewis acknowledged his debt to Blunt, “who in the most liberal manner, supplied me, graciously, with a number of costly astronomical instruments that I could not have obtained from any other source.”⁹ Lewis needed these instruments to perform his survey of the coastal beacons. With Blunt’s views being previously known, it is plausible to believe Blunt had ulterior motives for supplying Lewis “in the most liberal manner” of such expensive equipment.¹⁰

Might Blunt not have been trying to influence the outcome of Lewis’ report? As an Assistant to the Coast Survey, Blunt was a man of formal science. He believed the Coast surveyors and the Army Corps engineers were the true keepers of science in the United States. Blunt wished to see the Survey and the Corps take charge of the Light-

⁷ I. W. P. Lewis, *Report of I. W. P. Lewis, Civil Engineer*, 1842. Petit Manan is a coastal isle in the Gulf of Maine located approximately 14 miles due east of Bar Harbor and Mount Desert Island. Historically, the light at Petit Manan provided assistance to navigation between the ports of Rockland, Camden, and Matinicus on the far south side of Mount Desert Island and Jonesport, Cutler, and Machias on the far north side.

⁸ NOAA, “Profiles in Time – C&GS Biographies: Edmund Blunt,” *NOAA History*, June 8, 2006, <http://www.history.noaa.gov/cgsbios/biob6.html> (accessed February 8, 2016).

⁹ Lewis to Forward, January 31, 1843.

¹⁰ *Ibid.*

House Establishment similar to how the Navy had taken control of the Coast Survey earlier. Additionally, Blunt invented a lighthouse lamp that he hoped would be adopted by the Establishment. By making formal charges of mismanagement against Pleasonton's administration, Blunt attempted to undermine Winslow's Lewis' exclusive lamp contract with the Establishment so that the former would get an opportunity to introduce his lamp into the agency.

As Secretary of the Treasury and Pleasonton's direct superior, Walter Forward also expressed his concerns about the possibility of mismanagement in the agency. In a letter to the Speaker of the House of Representatives, John White, Forward stated, "it has been found impossible to guard against all abuses," because the Establishment was "unaided by the science and skill now sought."¹¹ Despite the Secretary's belief that it was "impossible to guard against all abuses," he did not blame the Fifth Auditor's management of the system.¹² Forward stated the abuses "necessarily result from the existing defects in the system, and must not be readily imputed to mismanagement of the Department."¹³ The defects mentioned in Forward's letter resulted from the republican values that guided Pleasonton's administration of the Establishment. Those values included a strong sense of civic duty, prudent management, honesty, and a focus on self-reliance. Pleasonton was a staunch Jeffersonian republican. Jefferson appointed Pleasonton federal office in the state department as a reward for the Democrat-Republicans delivering Pleasonton's home state of Delaware to Jefferson in the election of 1800.

¹¹ Forward to White, February 24, 1843.

¹² Ibid.

¹³ Ibid.

For his part, Pleasonton defended his administration of the Light-House Establishment stressing the growth of the Establishment and his prudent fiscal management of the agency.¹⁴ Pleasonton claimed the Establishment was “maintained annually at about one-third the expense of the British lights of the same kind, upon an average, and for a somewhat less sum than the French light-houses cost for their maintenance.”¹⁵ Pleasonton also stressed his strong sense of civic duty noting that he did “all I can do, under a clause which has been inserted in each light-house law for some years past.”¹⁶ Pleasonton argued that he built up the Establishment “from the inconsiderable number of 54 to the number of 330 light-houses and 41 light-ships, with numerous buoys, beacons, &c., within the 32 years I have had charge of it.”¹⁷ Lastly, Pleasonton stressed the importance of eliminating corruption in government transactions. He cited the lighthouse at Parinet river as an example. Pleasonton argued, the “commander in the navy, of high standing,” who surveyed the site and recommended the establishment of the lighthouse, was irresponsible in his civic duty. According to Pleasonton, the river “was supposed to be a harbor for vessels in bad weather,” but it “was found to be only two feet deep.”¹⁸ Pleasonton stated, “for some years past” the navy had “recommended the establishment of lights where they have since been found useless or unnecessary.”¹⁹ Although Pleasonton did not explicitly state why the navy

¹⁴ Pleasonton to Thomas Corwin, March 8, 1852, in United States Treasury Department, *Light-Houses: Letter From the Secretary of the Treasury...in Reply to a Report Made to Congress by the Light-House Board*, by Thomas Corwin, 32nd Cong., 1st sess., 1852, H. Doc. 88, 6-7.

¹⁵ Ibid.

¹⁶ Ibid.

¹⁷ Ibid.

¹⁸ Ibid.

¹⁹ Ibid.

recommended useless sites, he implied either the naval officers were incompetent or they had a personal, corrupt interest in the establishment of the lights. The Fifth Auditor believed only, “a single officer attached to the Treasury Department” could provide for “the proper application of the moneys appropriated” for the navigational aids and “insure the best attention” the the Establishment with “the most economical expenditure of the public moneys.”²⁰ Pleasonton thus demonstrated that he not only believed in the core republican values of civic duty, prudence, honesty, and self-reliance, but that he also embodied those ideals with every effort.

Much has been said about republican values their relationship to innovation and commerce in the early nineteenth century United States. David Nye, for instance, claims the Jeffersonian idea of an agrarian republic was not about “preserving the wilderness or halting development,” but rather “the citizen who contemplated such public improvements became aware of the power of democracy” and saw it as his civic duty to be a vanguard for the republic.²¹ Nye’s mentor, Leo Marx, argues Americans failed to acknowledge the “root contradiction between industrial progress and the older, chaste image of a green republic.”²² Indeed, Joyce Appleby and Drew R. McCoy earlier noted, the idea of a truly agrarian republic devoid of any industrial development was a myth.²³ McCoy argues there was “an uneasy suspicion (and sometimes recognition) among the

²⁰ Ibid.

²¹ David E. Nye, *American Technological Sublime*, (Cambridge, MA: MIT Press, 1994), 36.

²² Leo Marx, *Machine in the Garden*, (1965; repr., New York: Oxford University Press, 2000), 220.

²³ Joyce Appleby, “Commercial Farming and the ‘Agrarian Myth’ in the Early Republic, *Journal of American History* 68, no. 4 (March 1982): 833-49. Drew R. McCoy, *The Elusive Republic: Political Economy in Jeffersonian America*, (1980; repr., Chapel Hill: UNC Press, 1996).

Revolutionaries” that America “was already a relatively advanced commercial society” and that an agrarian republic was unrealistic.²⁴ And as John F. Kasson argued, “the ideology of republicanism helped to provide a receptive climate for technological adaptation and innovation.”²⁵ More recently, Mehdi Achouche argues Jefferson did “not repudiate science when he laud[ed] the rural virtues, but he [did] express an extreme defiance towards science’s practical applications,” because he felt they “threaten[ed] the virtue underpinning the American republic.”²⁶

American republicanism and innovation were therefore not in direct opposition to one another. As Eda Kranakis demonstrates, rural communities, such as those in Fayette and Lancaster counties in western Pennsylvania, relied heavily on innovation for access to commercial markets.²⁷ Yet in the sphere of government there was a mixed reaction to innovation and scientific progress. The state embraced commercial expansion by providing for the Coast Survey, the Light-House Establishment, and the coastal defense system. According to Merritt Roe Smith the government also held an interest in exchangeable part manufacturing for supplying the nation’s military needs.²⁸

In terms of the specific values discussed in this chapter – civic duty, prudence, honesty and self-reliance - Hugh R. Slotten argues some viewed scientific practice as a

²⁴ McCoy, 70.

²⁵ John F. Kasson, *Civilizing the Machine: Technology and Republican Values in America, 1776 – 1900*, (New York: Hill & Wang, 1999), 50.

²⁶ Mehdi Achouche, “A ‘Republic of Science’?: The Role of Science in Thomas Jefferson’s Imperial Vision,” in Donna Spaulding Andreolle, et. als., eds., *Science and Empire in the Nineteenth Century: A Journey of Imperial Conquest and Scientific Progress*, (Newcastle upon Tyne, UK: Cambridge Scholars Publishing, 2010), 103.

²⁷ Eda Kranakis, *Constructing a Bridge: An Exploration of Engineering Culture, Design, and Research in Nineteenth-Century France and America*, (Cambridge, MA: MIT Press, 1996), Chapter 1.

²⁸ Merritt Roe Smith, *Harper’s Ferry Armory and the New Technology*, (Ithaca, NY: Cornell University Press, 1977).

civic duty. According to Slotten, Ferdinand R. Hassler, Superintendent of the Coast Survey, “argued it was the ‘duty’ of every government to ‘to promote as much as possible the general benefit of the nation, and especially its scientific improvement.’”²⁹ Yet, the state practiced prudence in its involvement with innovation and scientific enterprise because the state feared corruption. Slotten notes Congress was concerned about Hassler’s slow progress on the charting the coast because they worried “the longer the results were kept within the Coast Survey office, the more easily they might be manipulated or ‘cooked’ by some unscrupulous employee.”³⁰ Similar feelings of prudence were expressed toward the Army Corps of Engineers. According to Todd Shallat, Jefferson objected to the public financing of internal improvements because Jefferson “viewed as a source of boundless patronage” and “a bottomless abyss of public money.”³¹ Shallat goes on to say that “science, engineering, and internal improvements – the things Jefferson loved – might feed the dens of corruption.”³² Honesty and the prevention of corruption were key values in Jefferson’s republican ideology. Smith acknowledges that “Jefferson wanted to proceed with caution” and was pained with anxiousness over balancing progress with republican values.³³ Smith claims Jefferson “simply did not want to jump headlong into a frenzied program of national development at the expense of what mattered most – the preservation of values associated with a rural society” and a virtuous republic. John Lauritz Larson’s political study of public works

²⁹ Hugh R. Slotten, *Patronage, Practice, and the Culture of American Science: Alexander Dallas Bache and the U.S. Coast Survey*, (New York: Cambridge University Press, 1994), 56.

³⁰ *Ibid.*, 57.

³¹ Todd Shallat, *Structures in the Stream: Water, Science, and the Rise of the U.S. Army Corps of Engineers*, (Austin: University of Texas Press, 1994), 119.

³² *Ibid.*

³³ Smith, 26.

projects confirms the state's prudence with their tepid involvement in internal improvements.³⁴ Smith, however, claims innovation and scientific progress reinforced republican values rather than undermining them.³⁵

This chapter adds to the historiography of the history of science and technology in two significant ways. First, it examines science and technology in the early United States, a period that has often been wanting in the history of science and technology. Ann Johnson surmised this lack of science, technology, engineering and medicine (STEM) in the early American republic is because STEM played “a key, but unmentioned role” in negotiating the interaction between mankind, nature, and society.³⁶ This chapter confirms Johnson's theory showing the importance of science and innovation in the early United States while at the same time demonstrating why it remains mostly invisible. Second, this chapter examines the interaction of innovation and scientific progress and the American brand of republicanism. Whereas others have generically alluded to the republican values that influenced innovation and scientific progress, this chapter takes a deeper look at some of those republican values. Particularly, this chapter examines how civic duty, prudence, honesty, and self-reliance impacted science and innovation in the first half of the nineteenth century in the United States.

CIVIC DUTY

Civic duty was one of the most important republican values held by the state and those who served in government. Gordon S. Wood first equated republicanism with the

³⁴ John Lauritz Larson, *Internal Improvement: National Public Works and the Promise of Popular Government in the Early United States* (Chapel Hill: UNC Press, 2001).

³⁵ Smith, 65.

³⁶ Ann Johnson, “STEM in the EAR,” *Journal of the Early Republic* 36, no. 1 (Spring 2016): 2.

“public good” in his *The Creation of the American Republic* (1969).³⁷ Wood argues by definition, republicanism has “no other end than the welfare of the people,” and that civic duty, that is sacrifice, was seen as a public virtue.³⁸ Those individuals who engaged in, oversaw, and promoted practical science in the early American republic believed their scientific endeavors represented their civic duty. Learned men, such as Ferdinand R. Hassler, Alexander Dallas Bache, and George Gordon Meade saw their work in the sciences as their duty to their country; whether that country be their native home or their adopted one.

As previously noted, Ferdinand Rudolph Hassler, the first superintendent of the United States Coast Survey, believed it was the government’s duty to promote scientific advancement. In his “Report on the Works executed for the Survey of the Coast of the United States, upon the Law of 1832, and their junction with the Works made in 1817 by and under the direction of F. R. Hassler,” which he included in his 1834 publication of the *Principal Documents Relating to the Survey of the Coast of the United States since 1816*, Hassler argued it was the government’s responsibility to promote “scientific improvement, . . . upon a liberal scale.”³⁹ Hassler also believed that it was his civic duty to employ military officers in the Coast Survey’s scientific work because they were more economical than civilians and he valued the military’s obedience and discipline.⁴⁰

³⁷ Gordon S. Wood, *The Creation of the American Republic, 1776 – 1787*, (New York: W. W. Norton & Company, 1969), 53-65, especially 55.

³⁸ *Ibid.*, 55, 68.

³⁹ Ferdinand Rudolph Hassler, “Report on the Works executed for the Survey of the Coast of the United States upon the Law of 1832, and their junction with the Works made in 1817 by and under the direction of F. R. Hassler,” in Ferdinand Rudolph Hassler, *Principal Documents Relating to the Survey of the Coast of the United States since 1816*, (New York: William Van Norden, 1834), 151, qtd. in Slotten, 57.

⁴⁰ Slotten, 51.

Hassler, however, argued the “character of our Republican military” mandated their subservience to a civil power.⁴¹

Hassler saw himself as a man of science. He believed Americans were incapable of producing science and men of science in the same mold as European nations.⁴² As a civil servant of the United States government, Hassler saw the promotion of science as his personal civic duty. Hassler attempted, in his mind, with every effort to carry out that civic duty faithfully. Unfortunately, according to Slotten, Hassler did not understand the differences between American and European political cultures. Slotten argues Hassler, “ignorant of Washington politics” did not do “enough to educate Congress and cultivate influential friends and political supporters.”⁴³ Hassler tried to force the United States to accept European scientific standards, such as the French metric system, civilian oversight of government surveys, and the belief that scientists possessed superior moral qualities.⁴⁴

Hassler may have been one of the premier scientists in the United States at the time, but his mightier-than-thou attitude prevented him from seeing that everyday Americans were producing science. This was actually the case with many formally trained engineers, philosophers, and scientists. Interpreting Hassler’s actions and attitudes returns us to the question asked in Chapter Three – what constitutes science? Hassler did not believe the work of Americans constituted science because many had not be formally trained in the sciences. Hassler, however, failed to realize that science had less to do with training than it did with the methodology. Even though many Americans had not been formally trained in philosophy or science, they still engaged in a method of empirical

⁴¹ Hassler, 48, qtd. in Slotten, 52.

⁴² Slotten, 53, 59.

⁴³ Ibid., 49.

⁴⁴ Ibid., 50, 52.

observation and testing. Empirical observation and testing is what qualified the work of Americans as science.

Congress refuted Hassler on several occasions including the use of the French metric system. Congress' rebuttal of Hassler mainly resulted from the latter's arrogance, but the rebuttal nevertheless gives the appearance that the American brand of republicanism conflicted with science. This is clearly not the case. If one sees Hassler's point of view on the relationship of civic duty and the promotion of science, it becomes easy to reconcile republican values with innovation and science.

Similarly, Pleasonton understood it was his civic duty to promote science within the Light-House Establishment. Over the course of his 32-year tenure as Superintendent of the Light-House Establishment, Pleasonton authorized, monitored, and even suggested experiments and practical improvements conducted by local entrepreneurs and mechanics working for the agency. Some of those experiments and practical improvements were discussed in the previous. In 1823, for instance, Pleasonton authorized the installation of lamps and reflectors at Cape May, New Jersey "on the principle of a revolving triangle including the apparatus of Melville & Black's improvement for heating the oil."⁴⁵ David Melville ran experiments on his apparatus for heating oil in lighthouse lamps "for several years previous" to 1814 in order "to keep the oil in a fluid state" during cold winters.⁴⁶ Melville's experiments proved successful enough that Pleasonton authorized the

⁴⁵ Pleasonton to Winslow Lewis, April 22, 1823, RG 26, Entry 18, Vol. 6, 127, NARA. The apparatus referred to in Pleasonton's correspondence was that of David Melville and not of Melville and Black. Alexander Black's patent for heating oil was found unacceptable. Pleasonton's reference to Melville & Black's patent resulted from Winslow Lewis' account of the apparatus.

⁴⁶ David Melville, *An exposé of facts...relating to the conduct of Winslow Lewis...addressed to the Hon. The Secretary of the Treasury*, (Providence, RI: Miller & Hutchins, 1819), 4, PRHC, no. 470. HAG.

installation of the improvement in northern lighthouses. In other instances, Pleasonton monitored experiments involving lamps and lenses in Boston and New Jersey, a “ventilator” to eliminate frost and condensation on lenses and lantern windows in Newport, and fuel experiments in various locales.⁴⁷ In 1840, Pleasonton wrote to one of his contractors, “this is an age of improvement and we must keep up with it.”⁴⁸

One instance that Pleasonton monitored very closely was the manufacturing of the lamp and reflector system used by the Light-House Establishment. Throughout February 1840, Pleasonton advised Winslow Lewis to change his method of manufacturing lighthouse reflectors. Lewis hammered his reflectors while others manufactured theirs using molds.⁴⁹ Pleasonton noted that reflectors made on molds had a “true parabola form.”⁵⁰ Pleasonton continued saying, “I would advise you to also have your reflectors made in moulds, for without adopting that mode, it is impossible to have them of a true parabola, or the focus properly made.”⁵¹ When Lewis objected by explaining his method of manufacturing, Pleasonton replied that reflectors made in molds were, “so much superior to the hammered reflectors, that there can be no room for hesitation in employing them in preference to the those that are hammered....the moulds not only

⁴⁷ Pleasonton to Hon. F. Mallory, October 3, 1838, RG 26, Entry 18, Vol. 13, 505. NARA. Pleasonton to Samuel Swartwout, December 10, 1829, RG 26, Entry 18, Vol. 8, 152, NARA. Pleasonton to William R. King, June 4, 1838, RG 26, Entry 18, Vol. 13, 240-2, NARA. Pleasonton to George Bancroft, June 10, 1839, RG 26, Entry 18, Vol. 14, 383-4, NARA. Pleasonton to Winslow Lewis, October 24, 1838, RG 26, Entry 18, Vol. 14, 8, NARA.

⁴⁸ Pleasonton to Winslow Lewis, March 2, 1840, RG 26, Entry 18, Vol. 15, 303, NARA.

⁴⁹ Pleasonton’s correspondence with Lewis utilizes the British English spelling of “moulds.” Except where I use a direct quote, I use the American English spelling of “molds” for ease of reading.

⁵⁰ Pleasonton to Winslow Lewis, February 3, 1840, RG 26, Entry 18, Vol. 15, 246, NARA.

⁵¹ Ibid.

produce a smoother surface than can be obtained by hammering, they must necessarily all be alike, which is a matter of great consequence.”⁵² Still Lewis was reluctant. Perhaps Lewis felt his friendship with Pleasonton was stronger than reality.⁵³ Lewis did not interpret Pleasonton’s advice with much concern until Pleasonton took a more direct tone, stating,

As I understand your mode of making them [the reflectors] however, I am clearly of the opinion that it is not as good as that adopted by the British and as tried by Mr. Blake of Boston. You hammer yours upon a block, as I understand you, to give them the proper curve, whilst the British and Mr. Blake form theirs in a die of steel and pressure. Whilst yours therefore presents an uneven surface, theirs presents a surface as smooth as plate glass, and is capable of reflecting the light in a much greater degree. It was for this reason I recommended to you to employ moulds or dies of steel in making your

⁵² Pleasonton to Winslow Lewis, February 17, 1840, RG 26, Entry 18, Vol. 15, 270-1, NARA.

⁵³ Every historian of the USLHE has commented on the relationship between Pleasonton and Lewis as being friendly. Their relationship was in fact a business relationship. Pleasonton looked to Lewis in areas where the former had little expertise, such as maritime affairs, but numerous letters from Pleasonton take a very harsh tone with Lewis indicating they were not personal friends. In fact, Lewis only maintained his relationship with Pleasonton by forcing the Fifth Auditor to award him contracts based on his consistently low bids. Lewis’ low bids eventually led other contractors to stop bidding on lighthouse contracts. At that point, Pleasonton often went directly to Lewis for his lowest price to perform the work, but this was more out of expediency and efficiency in the absence of competing bids. It should not be construed as Pleasonton having anything more than a business relationship with Lewis.

reflectors...I am apprehensive that he [Mr. Blake] will obtain a preference over you in supplying the Lighthouses, unless you adopt the same mode, and I should very much regret that you should be cut out of this business after you have devoted so long a time to it.⁵⁴

Lewis had been in the “business” for thirty years and it was with Pleasonton’s response at the end of February indicating Lewis would be left out of government contracts, that the contractor finally understood the Fifth Auditor’s polite ultimatum. Thereafter, Lewis agreed to use molds for manufacturing his reflectors, and Pleasonton was “glad to learn” that Lewis would “not be superseded by new comers.”⁵⁵

Pleasanton took his civic duty seriously. In September of 1807, for instance, while serving as a clerk in the state department, Pleasanton refused to issue a commission signed by President Thomas Jefferson. Jefferson appointed Benajah Nicholls as the surveyor of the Port of Windsor, North Carolina. Pleasanton “discovered” a previously issued commission to “William H. Ruffin appointing him to the same office,” and therefore refused to execute the President’s orders.⁵⁶ In a letter to Pleasanton, Jefferson claimed he had “no recollection of the name of William H. Ruffin,” but found

⁵⁴ Pleasanton to Winslow Lewis, February 25, 1840, RG 26, Entry 18, Vol. 15, 283, NARA.

⁵⁵ Pleasanton to Lewis, March 2, 1840.

⁵⁶ Pleasanton to Jefferson., September 17, 1807, *Thomas Jefferson Papers*, Series 1, General Correspondence, 1698-1827, LOC, Washington D.C., <http://memory.loc.gov/master/mss/mtj/mtj1/039/0400/0430.jpg> (accessed March 3, 2013).

Pleasanton's actions "perfectly right."⁵⁷ Jefferson's lack of recall is surprising. Jefferson was well known for his meticulous note taking. Pleasanton, for his part, simply carried out his civic duty, without regard to Jefferson's higher authority. Another President might have viewed Pleasanton's actions as disrespectful and insubordinate. Jefferson's acquiescence, however, illustrates the importance of civic duty and the correctness of Pleasanton's action in adhering to his civic duty as a core republican value.

Pleasanton often performed his civic duty at great personal expense; neglecting his own family or risking his own life for the greater good of the nation. For instance, in 1821, Pleasanton remained at his post in the federal government despite his wife Matilda's "obstinate & distressing disease." In a letter to his cousin Caesar Augustus Rodney, Pleasanton acknowledged, "Mrs. P[.]'s health has been so bad for the last two or three weeks, and continues to get worse, that I have concluded to take her to the Shenandoah Springs in Virginia," but would "return myself immediately."⁵⁸ Another time, Pleasanton wrote to family and friends that "Mrs. P[.] is absent in Penns^a."⁵⁹

Pleasanton's most well-known civic duty came during the War of 1812 when he risked own life to save valuable State Department papers during the British attack on Washington in 1814. Pleasanton's boss, Secretary of State James Monroe, serving double duty as James Madison's Secretary of War, scouted British encampments on the Chesapeake, Patuxent, and Potomac and sent word back to Washington of the impending

⁵⁷ Jefferson to Pleasanton, September 20, 1807, *Thomas Jefferson Papers*, Series 1, General Correspondence, 1698-1827, LOC, Washington D.C., <http://memory.loc.gov/master/mss/mtj/mtj1/039/0400/0464.jpg> (accessed March 3, 2013).

⁵⁸ Pleasanton to Caesar Augustus Rodney, July 16, 1821. *H. Fletcher Brown Collection of Rodney Family Papers, 1676 – 1898*, Vault Box 25, Folder 9, DelHS.

⁵⁹ Pleasanton to Thomas M. Rodney, September 12, 1837. *H. Fletcher Brown Collection of Rodney Family Papers, 1676 – 1898*, Vault Box 25, Folder 10, DelHS.

attack. Pleasonton, with the help of First Lady Dolly Madison answered the call, taking the State Department papers and hiding them at Roxeby Plantation near Leesburg, Virginia until it was safe to return them to the city.⁶⁰ Among the papers Pleasonton gathered and couriered out of the city were the original copies of the Articles of Confederation, the Constitution of the United States, the Declaration of Independence, and Washington's Commission as General of the Continental Army. Several historians, beginning with John B. Ellis in 1869, have diminished the importance of Pleasonton's actions and relegated the incident to the status of mere trivia. Michael Farquhar calls the incident a "footnote" in the historical record.⁶¹

Years later, Brigadier General William H. Winder asked Pleasonton to explain why State Department books and records were moved during the attack on Washington. Pleasonton responded in a modest republican fashion stating he could not recall whether or not it was he or Mr. John Graham, the chief clerk of the office, who received Colonel Monroe's message. Pleasonton remembered only that "it was the part of prudence to preserve the valuable papers of the Revolutionary government."⁶² Not once in his recollection did Pleasonton portray himself as anything more than a civil servant doing

⁶⁰ Pleasonton to William H. Winder, August 7, 1848. Qtd. in Edward D. Ingraham, *A Sketch of the Events which Preceded the Capture of Washington by the British on the Twenty-Fourth of August 1814* (Philadelphia: Carey and Hart, 1849) <http://books.google.com/> (accessed April 19, 2013).

⁶¹ John B. Ellis, *The Sights and Secrets of the National Capital: A Work Descriptive of Washington City in All its Various Phases*, (New York: United States Publishing Co, 1869), 276-7, <http://books.google.com/> (accessed March 3, 2013). Michael Farquhar, *A Treasury of Foolishly Forgotten Americans: Pirates, Skinflints, Patriots, and Other Colorful Characters Stuck in the Footnotes of History*, (New York: Penguin Books, 2008), Chapter 10. Anderson Chenault Quisenberry, *Kentucky in the War of 1812*, (Frankfort, KY: Kentucky Historical Society, 1915), 219-21. Harrison Williams, *Legends of Loudoun: An Account of the History and Homes of a Border County in Virginia's Northern Neck*, (Berryville, VA: Virginia Book Company, 1976), 180.

⁶² Pleasonton to Winder, August 7, 1848.

his civic duty. He did not play the hero, nor did he so much as acknowledge the danger to his own personal life. The British torched Washington as Pleasonton crossed the Potomac into Virginia.⁶³

Such devotion to civic duty was not uncommon in the early American republic and Pleasonton extended his expectations of civic duty to his subordinates and contractors working for the Establishment. In 1830, Winslow Lewis requested partial payment for work already completed in order to meet his expenses, but Pleasonton was unable to make an exception for even his most favored contractor. Pleasonton explained that, “although the law of January 1823, allows a discretion to make payments for work done for the United States as it progresses,” he found it necessary “to lay down a rule to defer all payments until the entire work executed.” He further explained, “From this rule I have made no exceptions, and I regret that my duty now, will not permit me to make an exception in your favor.”⁶⁴ In another instance, Pleasonton denied a leave of absence for a subordinate stating, “it is considered inconsistent with the public service to grant leave for so long a period.”⁶⁵

Entrepreneurial mechanics, such as James Elford, David Melville, and Winslow Lewis also saw their work as part of their civic duty. Historian Robert E. Shalhope sees entrepreneurial work as a commercial brand of republicanism that allows “men to view themselves as committed to the harmony, order, and communal well-being of a republic while actively creating an aggressive, individualistic, liberal one,” based on their

⁶³ Ibid.

⁶⁴ Pleasonton to Winslow Lewis, August 27, 1830, RG 26, Entry 18, Vol. 8, 99, NARA.

⁶⁵ Pleasonton to Daniel P. Drown, September 30, 1834, RG 26, Entry 18, Vol. 10, 298, NARA.

capitalistic desires.⁶⁶ Elford, a resident of Charleston, South Carolina, patented a universal signal code for maritime communication. Elford and his Boston agent, John Rowe Parker, believed the advantages of early communication were important to local merchants, but that a universal system was advantageous to the state.⁶⁷ Elford's and Parker's civic duty was to see the national adoption of the universal code. Such widespread adoption of Elford's system would not only tie the nation together, it would help facilitate national economic growth by accelerating port operations and reducing the time in port.

Melville invented several apparatuses for the Light-House Establishment including an oil heater, a method of eliminating the accumulation of frost and humidity on lenses and lantern windows, and a method for burning natural gas in the lighthouse lamps instead of spermaceti oil. The entrepreneurial mechanic detailed these inventions in a report to the government in 1819. Although the purpose of the report was to expose the alleged abuses of his inventions by an agent of the Treasury Department, Melville provided a glimpse into his sense of civic duty regarding his scientific experiments and practical improvements.⁶⁸ Melville began conducting his experiments and perfecting his apparatuses five years before his report. Melville believed it was “a duty of every citizen” and a “*privilege* of the citizens to represent” the sanctity of their work to the government.”⁶⁹

⁶⁶ Robert E. Shalhope, *The Roots of Democracy: American Thought and Culture, 1760-1800*, (Boston: Twayne Publishers, 1990), 138.

⁶⁷ Parker to The Proprietors of Central Wharf, Boston, May 12, 1824, Box 2, Folder 54, Ms. Coll. 186, Parker, John R. (John Rowe), 1777-1844, Correspondence 1802-1840, KUPL. Hereafter cited as JRPC.

⁶⁸ Melville.

⁶⁹ Melville, 3.

Lastly, Lewis saw his entrepreneurial work on lamps and lenses as his civic duty. In a letter to Albert Gallatin, Lewis demonstrates his sense of civic duty noting his work for “Commodore Rogers [sic],” and the Light-House Establishment over the past four years inventing lamps, reflectors, and other lighting apparatuses.⁷⁰ In an earlier letter to Gallatin, Lewis’s sense of civic duty is also apparent when he offers to “reimburse the money paid for [his] patent as well as every Expense [the] government may have been at” should his improvements “be found not to answer the purpose now calculated & that the saving of oyl [sic] is not equal to one half of the quantity consumed in the present system.”⁷¹ Additionally, Lewis offered to repair “att [sic] my own expense all the apparatus that may be put into any lantern under my direction” if they failed to meet this standard.⁷²

Others also viewed Lewis’ improvements to the lighthouse lamp as part the general idea of civic duty. The editors of the *Boston Gazette* noted Lewis’ invention was part of the “ingenuity and public spirit” exhibited by Americans. The newspaper continued by saying Lewis’ invention, along with the inventions of other Americans, “exhibit to the world, the most unequivocal proofs” of their republican virtue.⁷³

As individuals and the state constructed knowledge and gained experience in innovation and practical science, they did so for the benefit of the nation as a whole. Civic duty was one of the most important characteristics of American republicanism. Civic duty was the responsibility of every citizen to look out for the public good. As

⁷⁰ Lewis to Gallatin, March 10, 1812, RG 26, Entry 17E, Box 1, NARA. Lewis was referring to Commodore John Rodgers.

⁷¹ Lewis to Gallatin, March 8, 1812.

⁷² Ibid.

⁷³ “Untitled,” *Boston Gazette* (Boston, MA), June 13, 1811, 2.

Chapter 2 highlighted, individuals engaged in science and the arts to solve commercial problems. While some participated for profit, many others produced scientific knowledge out of their sense of civic duty. Chapter 4 highlighted the many individuals who forewent patenting their inventions and improvements out of their sense of civic duty. Today, innovating technologies is much more a choice. Individuals are more inclined to participate because of profit because the nation's most absolute, most basic needs have already been met. In the young nation, innovation was a necessity to secure the future of the country. In seeking to solve commercial and environmental problems before profit, American engineers, mechanics, and tinkerers invoked their sense of civic duty. Civic duty, in turn, thus shaped the development of innovation and practical science in that it determined the sorts of inventions that were produced and the type science that was performed.

PRUDENCE (cautious and responsible management)

Prudence was also a core republican value and those who demonstrated prudent management of government affairs were rewarded with long tenures in office. Of the republican values discussed here, the virtue of prudence might be the one most opposed to science. Noah Webster's 1828 and 1844 dictionaries claimed prudence was "wisdom applied to practice." The dictionary noted that, "prudence implies caution in deliberating and consulting on the most suitable means to accomplish valuable purposes." Webster's dictionary continued stating, "prudence differs from wisdom in this, that prudence implies more caution and reserve than wisdom, or is exercised more in foreseeing and

avoiding evil, than in devising and executing that which is good.”⁷⁴ These definitions of prudence were well articulated by Alexander Hamilton, James Madison, and John Jay in their essays on the Federalist system which have since been collected under the title *The Federalist Papers*. Madison championed, “shrewdness in management of affairs” and “good judgment in the use of resources,” in the 43rd essay of *The Federalist Papers*.⁷⁵ “Shrewdness in management of affairs” and “good judgement in the use of resources” was synonymous with “caution in deliberating...the most suitable means to accomplish valuable purposes.” Madison then argued “theoretical reasoning...must be qualified by the lessons in practice,” and that “the existence of a right to interpose will generally prevent the necessity of exerting it.”⁷⁶ Although Madison’s language is speaking to explicit powers of government, Madison is advocating moderation and accommodation, or “caution and reserve.” Madison also championed “caution” as a republican value in the 38th essay of *The Federalist Papers*. Madison argued, “whence could it have proceeded that a people, jealous as the Greeks were of their liberty, should so far abandon the rules of caution as to place their destiny in the hands of a single citizen.”⁷⁷ Madison went on to say the lessons learned from the American improvement of the ancient system exposed

⁷⁴ “Prudence,” in Noah Webster, *American Dictionary of the English Language*, (Springfield, MA: G & C. Merriam, 1828), <https://www.1828.mshaffer.com/d/word/prudence> (accessed February 14, 2017).

⁷⁵ Publius (James Madison), “No. 43: The Same Subject Continued,” in Clinton Rossiter, ed. *The Federalist Papers* (New York: Signet Classic, 2003), 272-3.

⁷⁶ Publius (James Madison), “No. 43,” 272-3.

⁷⁷ Publius (James Madison), “No. 38: The Same Subject Continued, and the Incoherence of the Objections to the New Plan Exposed,” in Clinton Rossiter, ed. *The Federalist Papers* (New York: Signet Classic, 2003), 228.

the “great imprudence” of multiplying the hazards, difficulties, and objections “to such experiments.”⁷⁸

Any one of the above referenced definitions, and in some cases all of them, defined the federal government’s involvement in innovation and practical science in the early United States. Science was, and still is for that matter, an expensive endeavor. The federal government, however, had limited experience and resources with which to engage in the scientific practice. In terms of management of affairs, Congress forced the superintendents of the Coast Survey, Corps of Engineers, and Light-House Establishment to pursue shrewd fiscal policies by repeatedly underfunding those agencies and their scientific endeavors. Pleasonton proved a most able administrator in this respect, but others, particularly Ferdinand Rudolph Hassler of the Coast Survey, often drew the fury of Congress for their lack of fiscal accountability.

Although Hassler garnered the indignation of Congress, his administration of the Survey actually embodied the republican value of prudence. To begin with, Hassler was a shrewd administrator. He insisted on doing things properly, which meant conducting the survey with accuracy and precision. In fact, Hassler felt so strongly about the accuracy and precision of the survey that he refused to allow his assistants to perform any of the calculations associated with completing the survey.⁷⁹ This display of caution slowed the progress of the work, but Hassler remained unconcerned. He understood the importance of the survey and the dangers associated with even the smallest inaccuracy, or what Hassler perceived as evil. Miscalculations on charting the coast and underwater hazards put the lives of mariners and passengers at risk; not to mention the dangers to commerce.

⁷⁸ Publius (James Madison), “No. 38,” 229

⁷⁹ Slotten, 56-7.

Hassler felt his assistants were unqualified. He felt they would make mistakes in their computations. Hassler, therefore, chose to prevent his assistants from performing the essential functions of the survey and handled all of the mathematical calculations himself.⁸⁰ In preventing his assistants from performing the core of the survey work, Hassler attempted to avoid what he perceived as the evil of unqualified assistants computing the triangulation.

Drawing on European precedents, Hassler requested military officers to assist him in the triangulation of the Survey. According to Slotten, Hassler believed the use of military personnel was compatible with Jefferson's brand of republicanism because it reduced expenses and waste. Military salaries were already accounted for under the Army and Navy. As the survey was conducted primarily during times of peace, the use of military officers provided an efficient use for soldiers who would otherwise be under- or un- employed. Prudence thus came from the shrewd frugality of shared expenses. There was no need to pay out expenses twice when there were a number of highly skilled military officers available. Additionally, the Coast Survey trained military officers in practical science, which Hassler believed aided the officers in performing an essential part of their civic duty.⁸¹

Congress, however, did not see the Superintendent of the Coast Survey as fiscally responsible. In 1841, Congressman Caleb Cushing, for instance, claimed Hassler was spending millions of dollars of taxpayers' money with little to show for the expenses.⁸² According to Slotten, Congress claimed the work on the Survey was "too expensive" and

⁸⁰ Ibid.

⁸¹ Ibid., 49.

⁸² Ibid., 56.

progressing at “too slow” a pace.⁸³ Congress shut Hassler out of the Survey in 1818 and shifted responsibility for the work to the military in part because of the slow progress being made.⁸⁴ Hassler was reappointed as head of the Survey in 1832, but Congress moved control back to the military between 1834 and 1836 on account of what they deemed was Hassler’s lack of prudence and adherence to republican values of responsible fiscal management.⁸⁵ As a result of Cushing’s attack on the Survey, Congress forced Hassler to be more accountable for the Survey’s finances in the final years of his employment with the agency.⁸⁶

The state’s republican value of prudence did not limit itself to the Coast Survey. Nearly every government agency was affected by the state’s prudent fiscal policies. Similar to the Coast Survey and the Light-House Establishment, appropriations for the Army Corps of Engineers were often insufficient for their purpose.⁸⁷ Additionally, economic historian Mark R. Wilson illustrates how the republican virtue of prudence

⁸³ Ibid., 49.

⁸⁴ Hassler’s foreignness and uncompromising management of the Survey also played a role in his ousting. In the 1810s, the Army Corps of Engineers waged a political battle against Hassler because of his contempt for the engineers and surveyors who worked underneath him and his contempt for the American way of performing science. Hassler’s lack of political connections in Washington allowed those who opposed Hassler to gain the upper hand and take control of the Survey.

⁸⁵ Slotten, 49-56.

⁸⁶ Ibid., 56.

⁸⁷ Todd Shallat, *Structures in the Stream: Water, Science, and the Rise of the U.S. Army Corps of Engineers*, (Austin: University of Texas Press, 1994), 118. Henry E. Barber and Allen R. Gann, *A History of the Savannah District U.S. Army Corps of Engineers*, (Savannah, GA: Savannah District USACE, 1989), 47-51. Frank N. Schubert, ed., *The Nation Builders: A Sesquicentennial History of the Corps of Topographical Engineers, 1838-1863*, (Fort Belvoir, VA: USACE, 1988), 10, 43. Aubrey Parkman, *Army Engineers in New England: The Military and Civil Work of the Corps of Engineers in New England, 1775-1975*, (Waltham, MA: USACE New England Division, 1978), 14, 22, 43. Harold Kanarek, *The Mid-Atlantic Engineers: A History of the Baltimore District U.S. Army Corps of Engineers, 1774-1974*, (Washington: Superintendent of Documents GPO, 1975), 3, 16-7, 37.

influenced the actions of the United States Army's Quartermaster Corps throughout the American Civil War.⁸⁸ According to Sally Kenney and James F. Nagle, the state's frugal fiscal policies originate in the republican values of the early nineteenth century.⁸⁹ Shortly after Congress authorized the Coast Survey in 1807, the legislative body passed laws regulating government contracts, which codified the bidding process and payment procedures.⁹⁰

In the early nineteenth century, as they often are today, government appointments were politically motivated. Many of these appointees possessed little experience in financial management beyond their own personal finances. Others did not see fiscal accounting as a high priority. Hassler, for instance, even believed accounting was beneath him. In a letter to President Andrew Jackson, Hassler is noted as saying anyone could be a "Woodbury [sic]" (referring to Levi Woodbury, secretary of the Treasury and meaning anyone could be a treasurer or accountant), but there could only be one Hassler.⁹¹

Similar to Hassler, and perhaps even more so, Stephen Pleasonton was a shrewd administrator who took his civic duty for prudent fiscal management seriously. Throughout his tenure, Pleasonton ensured that government contracts were executed in the most cautious manner. When bids were too high for the Congressional appropriations, he either returned the money to the surplus fund for the next fiscal year or he got contractors to lower their bids. For instance in 1835, Pleasonton asked Winslow Lewis to

⁸⁸ Mark R. Wilson, *The Business of Civil War: Military Mobilization and the State, 1861 – 1865*, (Baltimore, MD: JHU Press, 2006), 3, 32.

⁸⁹ Ibid., 109. Sandy Kenney, "The Foundations of Government Contracting," *Journal of Contract Management* (Summer 2007 supplement), 13. James F. Nagle, *A History of Government Contracting*, 2nd Edition, (Washington, DC: GPO, 1999), 7, 53, 71.

⁹⁰ Kenney, 13.

⁹¹ Slotten, 53.

“reconsider the subject” and inform him if he could refit the lighthouse at Mobile Point for \$500 less than Lewis’ original bid.⁹²

At least one historian of the Light-House Establishment has argued that Pleasonton took pride in returning funds to the Treasury, but this claim shows a general lack of understanding about government spending policies.⁹³ By law, any unspent appropriations must be returned to the Treasury.⁹⁴ Much of the money Pleasonton returned to the surplus fund resulted from insufficient congressional appropriations. Pleasonton could not move forward on projects that were not adequately funded by Congress. Fifth Auditor returned the money to the Treasury, not because he was a penny-pinching bureaucrat, but because he was forced to return it by law and Pleasonton saw it as his civic duty to follow the letter of the law.

If Pleasonton is to be viewed as a shrewd penny-pinching bureaucrat, it is because Congress consistently failed to provide adequate appropriations for the Establishment. Pleasonton, however, repeatedly informed Congress of the need for additional appropriations. On December 19, 1823, for instance, Pleasonton noted that he could not accept Winslow Lewis’ proposal for the Fort Gratiot Lighthouse because the appropriations were “but \$3,500.” Pleasonton went on to say, “An additional sum has been asked for, and when the appropriation shall be made, proposals will again be

⁹² Pleasonton to Winslow Lewis, May 14, 1835, RG 26, Entry 18, Vol. 10, 449-50, NARA.

⁹³ Dennis L. Noble, *Lighthouses & Keepers: The United States Lighthouse Service and Its Legacy*, (Annapolis, MD: Naval Institute Press, 1997), 12.

⁹⁴ Constitutional Convention, *United States Constitution*, Article 1, Section 9, 1787, http://www.archives.gov/exhibits/charters/constitution_transcript.html (accessed February 16, 2016).

invited.”⁹⁵ In December 1835, Pleasonton wrote to Joel B. Sutherland, Chairman of the Committee of Commerce, noting “an appropriation was made at the last session of Congress of one thousand and fifty dollars, for placing buoys in Nanticoke, Wicomoco, and other rivers on Eastern Shore of Maryland,” but “that the sum of three thousand dollars more is desirable for the purpose of procuring additional buoys for the rivers; and a further sum of one thousand dollars to employ persons to take care of them.”⁹⁶

Furthermore, as mentioned in Chapter 1, Pleasonton had to ask Congress for additional appropriations for the construction of the Carysfort Reef lighthouse in 1838.⁹⁷

The lack of sufficient funding for the Light-House Establishment did not limit itself to Pleasonton’s administration. Even before Pleasonton’s administration, Albert Gallatin, Secretary of the Treasury, was known to ask Congress for additional funding. On December 11, 1811, Gallatin informed Thomas Newton, Chairman of the Committee on Commerce, that extending an improvement recently adopted in the Boston area “to all the light houses... would however exceed the ordinary appropriations.” Gallatin continued, “Should it be thought proper to authorize the expense, nothing more will be necessary than to introduce an item to that effect in the general appropriation law.”⁹⁸ In September 1819, the Treasury Department acknowledged the possibility of insufficient appropriations for a lighthouse at Long Island Head, but the Treasury Secretary declined “making any application to Congress for any deficiency in the appropriation.”⁹⁹

⁹⁵ Pleasonton to Winslow Lewis, December 19, 1823, RG 26, Entry 18, Vol. 6, 206, NARA.

⁹⁶ Pleasonton to Sutherland, December 26, 1835, RG 26, Entry 18, Vol. 11, 165, NARA.

⁹⁷ Pleasonton to Winslow Lewis, July 2, 1838, RG 26, Entry 18, Vol. 13, 288-9, NARA.

⁹⁸ Gallatin to Newton, December 4, 1811, RG 26, Entry 18, Vol. 4, 140, NARA.

⁹⁹ S. H. Smith to Henry A. S. Dearborn, September 7, 1819, RG 26, Entry 18, Vol. 5, NARA.

In reality, any money Pleasonton saved because of his prudence was likely spent on unexpected expenses. It was impossible to predict when a beacon or pier might be destroyed by a storm and need to be replaced. These unexpected expenses had to come from the Light-House Establishment's general appropriations and similar to the appropriations for specific projects, they were often inadequate. If Pleasonton's prudence in managing his accounts is to be interpreted as pride, it is because Pleasonton prided himself on being a good civil servant, doing his civic duty and possibly on being able to cover these unexpected expenses without having to ask Congress for more money, not because he took pride in returning money to the Treasury.

Although Pleasonton's prudence is most evident in his frugal management of the Light-House Establishment, the Fifth Auditor was prudent in other aspects of his administration. For instance, Pleasonton was cautious about wasting resources and supplies. In November 1819, Pleasonton was cautious about letting Lewis reduce the number of lamps in certain lighthouses, even though Lewis' reduction provided a better light. In a letter to the then Secretary of the Treasury, Pleasonton wrote that "I am of the opinion that a deduction should be made of the oil allowed Mr. Lewis of at least 5,000 gallons; that he should be required to replace all the lamps originally fitted up, unless otherwise directed by the [local] Superintendent of the Light House."¹⁰⁰ In another instance, Pleasonton allowed Winslow Lewis to reuse some of the bricks from Benjamin

¹⁰⁰ Pleasonton to William H. Crawford, November 13, 1819, RG 26, Entry 18, Vol. 5, 213, NARA.

Henry Latrobe's lighthouse on Frank's Island when Lewis contracted to rebuild the beacon after Latrobe's collapsed.¹⁰¹

HONESTY (elimination of corruption)

Closely related to prudence and civic duty is the republican value of honesty. American republicanism sought honest men to serve in and watch over government. One of the chief concerns was the elimination of corruption that naturally came with the power of governing. As the United States continued to industrialize, the vices of greed, power, and wealth began challenging the Jeffersonian value of honesty. In the early republic period, land speculators were among the most corrupt. They often lied to prospective landowners about the quality of the land and future amenities to sell the land a values higher than its real worth. According to Drew McCoy, Jefferson expressed some concern with the problem of land and the challenges the land speculators created for an ideal republic even though Jefferson's vision for a virtuous republic was grounded in landownership.¹⁰² After the Civil War, corruption ran rampant in reconstructing the South and the expansion of the railroads. For instance, in a stock-for-votes exchange, the railroad industry's Crédit Mobilier scandal reached to the highest levels of government implicating the Vice President of the United States along with several Senators and

¹⁰¹ Michael W. Fazio, "Benjamin Latrobe's Designs for a Lighthouse at the Mouth of the Mississippi River," *Journal of the Society of Architectural Historians* 48, no. 3 (September 1989), 246.

¹⁰² McCoy, 189.

Congressmen.¹⁰³ Rampant corruption during reconstruction and the Gilded Age following the American Civil War finally buried the Jeffersonian ideal of a virtuous republic.¹⁰⁴

In 1828, Noah Webster defined corruption as “Depravity; wickedness; perversion or deterioration of moral principles; loss of purity or integrity.”¹⁰⁵ At least one modern historian adds intent and purpose to Webster’s definition arguing corruption can be defined as an intentional act of dishonesty, usually with the purpose of achieving some sort of personal gain for the perpetrators.¹⁰⁶ Aside from land speculation, corruption in the early United States usually resulted from large scale public investment in infrastructure projects.¹⁰⁷ These large-scale infrastructure projects could range from canals and turnpikes to coastal defenses, lighthouses, public piers, and surveys; projects which involved commerce, engineering, innovation and the state through the government’s institutions of science.

Throughout the first half of the nineteenth century, government officials feared corruption. They made it their civic duty to prevent corruption whenever possible. When fraud occurred, government officials sought to immediately remove the source of the

¹⁰³ Richard White, *Railroaded: The Transcontinentals and the Making of Modern America*, (New York: W. W. Norton and Company, 2011), 64. Stephen Ambrose, *Nothing Like it in the World: The Men Who Built the Transcontinental Railroad, 1863-1869*, (New York: Simon & Schuster, 2001), 374.

¹⁰⁴ Richard White, “Information, Markets, and Corruption: Transcontinental Railroads and the Gilded Age,” *Journal of American History* 90, no. 1 (Jun 2003), 19, 21, 23.

¹⁰⁵ “Corruption,” in Noah Webster, *American Dictionary of the English Language*, (Springfield, MA: G & C. Merriam, 1828), <https://www.1828.mshaffer.com/d/word/corruption> (accessed February 16, 2017).

¹⁰⁶ This definition of corruption is based on the introductory paragraph of Richard White, “Information, Markets, and Corruption: Transcontinental Railroads and the Gilded Age,” *Journal of American History* 90, no. 1 (Jun 2003), 19.

¹⁰⁷ John Joseph Wallis, “Constitutions, Corporations, and Corruption: American States and Constitutional Change, 1842 – 1852,” *The Journal of Economic History* 65, no. 1, (Mar. 2005), 219.

dishonest actions. The elimination of corruption was thus a chief factor in the state's funding of practical science. As previously mentioned, Congressman Cushing accused the Coast Survey of spending millions of taxpayers' dollars, without anything to show for it.¹⁰⁸ Where were all the appropriations going? Congress initiated an investigation into the Coast Survey for possible fraudulent activity before it would authorize the coming year's appropriations.¹⁰⁹

In his position as Fifth Auditor of the Treasury, Stephen Pleasonton spent his entire career combating corruption. Early in his tenure with the Treasury Department, Pleasonton refused to pay for work on a Grand River pier. In a letter to Thomas Foster, the regional customs agent for the Sandusky, Ohio area, Pleasonton noted his suspicions of fraud. The Grand River Harbor Company offered to sell one of its piers to the federal government. In anticipation of the purchase the Grand River Harbor Company hired Abraham Skinner to make repairs to the pier. The company sought to increase the value of its property so the company could ask a higher price for the structure. Skinner sought payment from the United States before the repairs were completed rather than from the Grand River Harbor Company. Pleasonton saw through the scheme informing Foster that the Grand River Harbor Company "expect[ed] the United States to buy it [the pier], probably at a high rate. This could not have been the intention of the law, and I cannot undertake to authorize any such measures."¹¹⁰

In another instance, Pleasonton reprimanded Winslow Lewis, one of the primary building contractors for the Light-House Establishment for poor workmanship at two

¹⁰⁸ Slotten, 56.

¹⁰⁹ Ibid.

¹¹⁰ Pleasonton to Foster, May 26, 1825. RG 26, Entry 18, Vol. 6, 416, NARA.

Florida lighthouses. Lewis won the contract to build the beacons at St. John's River and St. Mark's Island by underbidding all other contractors. In turn, Lewis subcontracted the job to a local builder who "committed so great a fraud," in the workmanship of the buildings.¹¹¹ In the original contract, Lewis had the "option to build the house either of brick or stone, but none to erect the walls of both materials."¹¹² Lewis' subcontractor built both lighthouses of brick and stone against the protests of the regional superintendent. Pleasonton stated that in deviating from the specifications of the contract, Lewis "exonerated the United States from all obligations to receive the work [finished lighthouse] or to pay you one dollar for it." Pleasonton was "determined in all cases where contractors make arbitrary alterations in executing work for the United States, under contracts, they shall be the sufferers."¹¹³ After a lengthy correspondence on the subject, Lewis rebuilt both lighthouses at his own expense.¹¹⁴ In fact, Pleasonton closely watched all of Lewis' contracts and corresponded regularly with Lewis on issues of fraudulent work performed by the contractor or his workers.¹¹⁵

In January of 1842, Pleasonton questioned the unexpected increase in oil consumption at the two Erie, Pennsylvania lighthouses. In a letter to Charles W. Kelso, the regional superintendent of the lighthouses, Pleasonton demanded an explanation for the excessive oil usage,

¹¹¹ Pleasonton to Lewis, June 14, 1830. RG 26, Entry 18, Vol. 8, 262, NARA.

¹¹² Pleasonton to Lewis, April 13, 1830, RG 26, Entry 18, Vol. 8, 224, NARA.

¹¹³ Pleasonton to Lewis, April 13, 1830.

¹¹⁴ Pleasonton to Lewis, June 14, 1830.

¹¹⁵ Pleasonton to Lewis, November 2, 1822, RG 26, Entry 18, Vol. 6, 64, NARA.

Pleasonton to Lewis, October 8, 1829, RG 26, Entry 18, Vol. 8, 116, NARA. Pleasonton to Lewis, September 18, 1837, RG 26, Entry 18, Vol. 12, 318, NARA. Pleasonton to Lewis, May 18, 1838, RG 26, Entry 18, Vol. 13, 208, NARA. Pleasonton to Lewis, September 22, 1838, RG 26, Entry 18, Vol. 13, 483, NARA. Pleasonton to Lewis, August 16, 1841, RG 26, Entry 18, Vol. 17, 39, NARA.

Now on referring to your return for the year 1840, I find there was consumed at both the light houses and beacon, in that year, 364 gallons of oil, making it not quite 23 gallons per lamp. How has such a difference arisen? Your letter affords no explanation,....It seems to me incredible that there should be a difference of eight gallons per lamp between the two years, or that 31 gallons per lamp could have been consumed, if the keepers had done their duty.¹¹⁶

But that was not all. Pleasonton continued,

And what appears to be equally strange, is that although you inform me you had suspended both lights, one on the 18th and the other on the 25th December, neither of which can be relit before April, yet you inform me you had been under the necessity of purchasing forty-four gallons of oil for the present quarter and insert a sum of 73 06/100 dollars in your estimate, to enable you to pay for it.¹¹⁷

Clearly, Pleasonton had uncovered a fraud which most likely stemmed from Kelso or the keeper's selling the oil to supplement their income. A similar instance occurred in 1829 in Portsmouth, New Hampshire. Pleasonton wrote to John P. Decatur, a recently appointed customs collector, telling Decatur not to hire a man named Godfrey as an

¹¹⁶ Pleasonton to Kelso, January 19, 1842, RG 26, Entry 18, Vol. 17, 247, NARA.

¹¹⁷ Ibid.

assistant keeper. According to Pleasonton, Godfrey had “embezzled oil and iron from one of the lighthouses.”¹¹⁸

Pleasanton’s strong commitment to the eradication of corruption in the Light-House Establishment is best demonstrated by the importation of the Fresnel lighthouse lens. In 1838, Congress responded to Lieutenant I.W. P. Lewis’s report on the Light-House Establishment by authorizing the purchase of two French made Fresnel lighthouse lenses to be used on an experimental basis. If the lenses proved to be an improvement over the current system, Congress would authorize the purchase of additional lenses. To facilitate the purchase of the lenses, the Treasury Department commissioned Captain Matthew Calbraith Perry of the United States Navy to meet with Monsieur Lepaute, the French manufacturer of the Fresnel lens, and Léonor Fresnel.¹¹⁹ Perry was also to visit Britain and report on the state of the lighthouses there. Pleasanton authorized Perry’s expenses to be paid for by the Treasury through its agent General Lewis Cass.

Perry completed his commission, yet he encountered difficulties in paying for the lenses. In a letter to his friend Eugene A. Vail a year after his assignment, Captain Perry complained of “General Cass communicating his determination not to comply with the request of Mr. Pleasanton in reference to the payments for the lenses manufactured by Mr. Lepaute.” Perry believed “Mr. Pleasanton has purposely thrown these difficulties in the way.”¹²⁰ Scholars have cited this letter as evidence condemning Pleasanton, however,

¹¹⁸ Pleasanton to Decatur, October 8, 1829, RG 26, Entry 18, Vol. 8, 116, NARA.

¹¹⁹ Augustin Fresnel died of tuberculosis in 1827. Augustin’s brother, Léonor Fresnel, took over the research and management of the lens’ manufacturing process after Augustin passed away.

¹²⁰ Perry to Vail, New York, June 15, 1839, RG 45, Entry 464. “Office of Naval Records & Library: Subject File U.S. Navy 1775 – 1910 KL – Lighthouse and other navigational aids,” NARA.

the Fifth Auditor had nothing to do with General Cass' refusal to pay Perry's bills.¹²¹

Perry did not submit his bills in accordance with the agreed upon contractual installment plan; a plan designed to prevent corruption in government transactions. As Pleasonton noted in his September 27, 1838 correspondence with Perry, "Although we do not make advances for work done at home, yet, in the case of these lenses, which are made by artists employed by the French Government, you will make such advances, from time to time, as may be necessary to secure a prompt and faithful execution of the work."¹²²

General Cass followed protocol, a fact Perry acknowledged in his letter to Vail. "General Cass was undoubtedly right in declining a responsibility that might at some future time involve him in trouble." Pleasonton, however, had no hand in the matter until later when he criticized Perry for "neglecting or declining" to fulfill the agreed upon arrangement.¹²³

Pleasanton admonished Perry, "Had you drawn bills for the different instalments [sic], stipulated to be paid Mr. Lepaute, agreeably to the arrangement made with this Office,...every difficulty and inconvenience would have been obviated."¹²⁴ In fact, Pleasonton hoped Perry would be able to speed up the purchase by procuring "the lens and apparatus already made for the French Government, paying them for it whatever sum the one you have contracted for will cost." Pleasonton wanted to have the lenses sent over "in time to try it before the meeting of Congress, as their next session will be a short one, and I should be very glad to have something definite done in regard to our lighthouse

¹²¹ John H. Schroeder, *Matthew Calbraith Perry: Antebellum Sailor and Diplomat*, (Annapolis: Naval Institute Press, 2001), 85. Levitt, 142.

¹²² Pleasonton to Perry, September 27, 1838, RG 45, Entry 464, "Office of Naval Records & Library: Subject File U.S. Navy 1775 – 1910 KL – Lighthouse and other navigational aids," NARA.

¹²³ Perry to Vail, June 15, 1839. Pleasonton to Perry, May 16, 1839, RG 26, Entry 18, Vol. 14, 340-1, NARA.

¹²⁴ Pleasonton to Perry, May 16, 1839.

establishment before they adjourn.”¹²⁵ Pleasonton remained faithful to his republican values of civic duty and the elimination of corruption.

When Pleasonton learned of the difficulties created by Captain Perry, he wrote to General Cass and requested that Cass pay Monsieur Lepaute for the lenses. In making his request of Cass, Pleasonton stated very plainly the reasons for the difficulties. Perry,

entered into a contract with Mr. Lepaute at Paris for the manufacture and delivery by him, at Havre, of two sets of Dioptic and Lenticular apparatus, with a lantern for Lighthouses, for which Mr. Lepaute was to be paid by installments in the manner described in the contract....Capt. Perry, on leaving Paris, made no provisions for paying these several installments to Mr. Lepaute, as they became due.¹²⁶

Perry was apparently too consumed with his naval duties in testing the new steam frigate *Fulton* to concern himself with properly securing the two Fresnel lenses. Perry admitted as much in a April 10, 1840 report to Congress when he claimed he was “deeply occupied with other official engagements.”¹²⁷ Pleasonton’s tight-fisted and prudent fiscal policies, thus, must be viewed in the light of Jeffersonian values as the Fifth Auditor’s most effective weapon against greed and corruption, or the possibility thereof. Despite Pleasonton’s attempts to prevent corruption in the Light-House Establishment, his

¹²⁵ Pleasonton to Perry, September 27, 1838.

¹²⁶ Pleasonton to Cass, March 2, 1839, RG 26, Entry 18, Vol. 14, 201, NARA.

¹²⁷ Office of the President of the United States. *Communication from the President of the United States*, by Martin Van Buren, 26th Cong., 1st sess., S. Doc. 619 (Washington, DC, 1840).

Jeffersonian values were an obstacle to the individuals working with the Fifth Auditor. Pleasonton's efforts at preventing corruption were greatly appreciated by his superiors and others concerned with the Light-House Establishment. For instance, in 1852, the Light-House Board noted, "great credit is due to the zeal and faithfulness of the present general superintendent, and to the spirit of economy which he has shown."¹²⁸ Walter Forward, the Secretary of the Treasury, found not fault in Pleasonton's management of the Light-House Establishment. Forward wrote the Speaker of the House of Representatives that "defects in the system" and not the "mismanagement of the department," were the root cause of any complaints against the Establishment.¹²⁹

Other historians have noted Perry's mission, but have sided with Perry when he stated, "Mr. Pleasonton has purposely thrown these difficulties in the way."¹³⁰ These historians have ignored Pleasonton's explanation that Perry failed to follow the proper procedures for procuring the lens. Pleasonton was simply doing his civic duty to prevent any possible corruption from occurring by making sure Captain Perry followed the Treasury's protocol.

SELF-RELIANCE (small domestic production)

In addition to civic duty, prudence, and honesty, self-reliance played a significant role in technical labor and commercial products in the early United States. To Jeffersonians, the core value of self-reliance translated to domestic production by small artisan shops in the fields of innovation and practical science. As Jefferson noted in 1821,

¹²⁸ USLHB, *Report of the Officers Constituting the Light-House Board*, 32nd Cong., 1st sess., 1852, S. Doc. 28, 42.

¹²⁹ Forward to White, February 24, 1843.

¹³⁰ Perry to Vail, June 15, 1839.

the value of science to a republican people, the security it gives to liberty by enlightening the minds of citizens, the protection it affords against foreign power, the virtue it inculcates, the just emulation of the distinction it confers on nations foremost in it; in short, its identification with power, morals, order and happiness...these considerations are always present and bearing with their just weight.¹³¹

Hugo A. Meier argues Jefferson and his followers understood the United States would have to rely heavily on foreign science until the nation could establish its own scientific institutions and programs.¹³² According to Terry S. Reynolds, many of the engineering instructors were French.¹³³ Ferdinand Hassler, Superintendent of the Coast Survey, was a Swiss mathematician. However, the state also expected that the reliance on foreign science would be brief and that America would be producing its own science and scientific identity before long. According to Merritt Roe Smith, by the 1850s, “the young republic had relinquished its abject dependency on European technology and no longer stood in awe of the Old World’s industrial prowess.”¹³⁴

Self-reliance also meant domestic production of the equipment used by the state’s scientific endeavors. Early in the Coast Survey’s history, Hassler travelled to Europe to

¹³¹ Thomas Jefferson, *Memorial on the Book Duty*, November 30, 1821, <http://lachlan.bluehaze.com.au/lit/jeff16a.htm> (accessed December 12, 2016).

¹³² Hugo A. Meier, “Thomas Jefferson and a Democratic Technology,” in Carroll W. Pursell, Jr., ed., *Technology in America: A History of Individuals and Ideas*, (Cambridge, MA: MIT Press, 1990), 20.

¹³³ Reynolds, 16.

¹³⁴ Smith, 18.

purchase all of the equipment used by the Survey. Hassler could not find high quality scientific instruments manufactured in the United States. When Hassler regained control of the Coast Survey in the early 1830s, he continued the practice of procuring the Survey's scientific equipment abroad. Hassler also shipped the Coast Survey work abroad to be engraved for printing. Eventually, the Secretary of the Treasury, Levi Woodbury, informed Hassler on the necessity of using domestic producers and suppliers for the Survey's needs.

In reply to your letter of the 27th ultimo, asking permission to send abroad for Engravers to execute the Coast Survey Charts, I would observe, that it is deemed preferable by the President & myself, that you should make inquiry and employ engravers in this Country, for the Coast Survey work, if suitable ones can be obtained, And it should be only in the event of a failure to obtain such ones here, after a full inquiry, that persons should be obtained elsewhere.¹³⁵

The republican value of self-reliance was one of the primary concerns early in the history of the Light-House Establishment that prompted Congress to approve the purchase of Winslow Lewis' patent lighthouse lamp and reflector system. As the editors of the *Boston Gazette* noted, "such inventions raise the character of a nation and essentially contribute to its real dignity and importance."¹³⁶ Lewis' business was that of a mariner turned small artisan mechanic. Lewis was an entrepreneur, but in his nearly forty

¹³⁵ Woodbury to Hassler, February 2, 1841, RG 23, Entry 2, Vol. 1, 173, NARA-II.

¹³⁶ "Untitled," *Boston Gazette* (Boston, MA), June 13, 1811, 2.

years of supplying the Light-House Establishment with his patent lamps, he never employed more than a few workmen. His lamps and reflectors were handmade one at a time as needed by the establishment. Lewis, thus was the embodiment of small artisan manufacturer desired by early republican values.¹³⁷

Self-reliance proved essential for ensuring prudence in the Light-House Establishment. Throughout his tenure as Superintendent of the Light-House Establishment, Pleasonton maintained Lewis' domestically produced lamps and reflectors were both cheaper and superior to the apparatuses used in Britain and France.¹³⁸ Furthermore, Pleasonton argued the United States' reliance on domestically produced spermaceti oil also realized the state a savings over colza oil used by France.¹³⁹

Yet there were some items the United States was simply unable to produce of high enough quality to protect the lives of mariners and the safety of commerce. Glass was one of those items. Although glass manufacturing was one of America's first industries, production and quality were limited prior to the mid-nineteenth century. In 1798 when Lewis first "discovered" the effect of placing a lens in front of a lamp, he "found that the Lenses Could Not be made in this Country."¹⁴⁰

There are several reasons for the limited production and quality of American glass. First, as Steve W. Martin argues, American glass manufacturers, such as the

¹³⁷ Gallatin to Newton, December 4, 1811. Melville, 43. United States Treasury Department, *Report from the Secretary of the Treasury...Relative to the Light-Houses of the United States by the Messrs. Blunt, of New York &c.*, January 26, 1838, 25th Cong., 2nd sess., S. Doc. 138, 1838, 28. Pleasonton to Lewis, February 3, 1840. Pleasonton to Lewis, February 17, 1840. Pleasonton to Lewis, February 25, 1840.

¹³⁸ S. Doc. 138, 30-2. H. Doc. 183, 9. H. Doc. 88, 2.

¹³⁹ H. Doc. 183, 56. H. Doc. 88, 14. Pleasonton to Woodbury, December 3, 1838, RG 26, Entry 18, Vol. 14, 58-62, NARA.

¹⁴⁰ Lewis to Gallatin, March 10, 1812.

Boston & Sandwich Glass Company, used wood as their primary fuel for manufacturing glass until the second half of the nineteenth century when coal came into more common use.¹⁴¹ Wood does not burn as hot as coal. The lower intensity of heat from wood creates imperfections in the glass. The most common imperfections are bubbles.¹⁴² The French glass manufactories at Saint-Gobain experienced similar issues in the late eighteenth century according to industrial revolution historian John Raymond Harris.¹⁴³

The low heat from wood fired furnaces also caused American glass manufacturers to produce a thicker glass. For the lenses used in lighthouses, the thickness of American glass was a major concern. As Francis Ross Holland, Jr. points out, when Lewis used domestically produced glass, the glass had a greenish tint which diminished the brilliancy of the light.¹⁴⁴ Presumably, the green tint of Lewis' glass resulted from the iron oxides present in soda-lime. These oxides become more apparent with thicker glass made from soda-lime.

The production and quality of American glass was also limited by the lack of skilled gaffers. A gaffer was a skilled master artisan who oversaw a team of glassmaking laborers. According to Brooke Hindle, most gaffers in the United States had to be brought over from Europe, while Arlene Palmer contends the most prominent gaffers in the eighteenth century United States were from Germany, including Caspar Wistar, John

¹⁴¹ Steve D. Martin, "Glass Facts: History of Glass," *Historical Facts About Glass*, http://www.texasglass.com/glass_facts/history_of_Glass.htm (accessed March 7, 2016).

¹⁴² J. R. Harris, *Industrial Espionage and Technology Transfer: Britain and France in the Eighteenth Century*, (Surrey, UK: Ashgate Publishing, 1998), 332-4.

¹⁴³ *Ibid.*

¹⁴⁴ Francis Ross Holland, Jr., *America's Lighthouses: An Illustrated History*, (1972; repr., Brattleboro, VT: Stephen Greene Press, 1988), 15.

Frederick Amelung, and Henry William Stiegel.¹⁴⁵ Joan E. Kaiser notes English gaffers staffed the many Boston glassworks factories, but they too, experienced labor issues with high turnover and a lack of experienced gaffers.¹⁴⁶

Finally, glassmaking was an expensive venture. Many early American glass manufacturers fell victim to poor fiscal management. As one historian notes, prior to Deming Jarves' acquisition of the New England Glass Company of East Cambridge in 1817, "the company continually suffered from management problems and changed hands several times until it was ready to go under."¹⁴⁷

For the reasons stated above, Lewis limited his use of American glass to inner and outer wick tubes.¹⁴⁸ These tubes were responsible for providing the proper draft (air flow) to the wick to ensure the wick burned at an acceptable and uniform rate. Elsewhere, such as the plate glass windows in the lantern room, Lewis used "the best French plate glass."¹⁴⁹ Although the French experienced problems at Saint-Gobain in the late eighteenth century similar to the Americans, the French produced a higher quality glass than the Americans. The quality of French glass came from their longer duration of

¹⁴⁵ Brooke Hindle, "The Exhilaration of Early American Technology," in Judith A. McGaw, ed., *Early American Technology: Making and Doing Things from the Colonial Era to 1850*, (Chapel Hill: UNC Press, 1994), 63. Arlene Palmer, *Glass in Early America*, (Winterthur, DE: The Henry Francis du Pont Winterthur Museum, 1993), 9-10.

¹⁴⁶ Joan E. Kaiser, *The Glass Industry in South Boston*, (Lebanon, NH: University Press of New England, 2009), 10.

¹⁴⁷ Wicked Yankee, "The Boston & Sandwich Glass Company," March 10, 2013, <http://wickedyankee.blogspot.com/2013/03/the-boston-sandwich-glass-company.html> accessed March 7, 2016.

¹⁴⁸ Pleasonton to Winslow Lewis, October 21, 1841, RG 26, Entry 18, Vol. 17, 129, NARA.

¹⁴⁹ Pleasonton to Winslow Lewis, February 21, 1842, RG 26, Entry 18, Vol. 17, 286, NARA.

experience in manufacturing glass at lower heat and their industrial espionage of the British glass manufacturing processes.¹⁵⁰

CONCLUSION

Clearly, a political battle was brewing over the control of the Light-House Establishment and science was at the heart of the arguments. Military officers, such as Blunt, Lewis, and later Lieutenants Richard Bache and Thornton A. Jenkins, used science to support their claims that the Light-House Establishment could be better managed by the military and the scientifically trained men who made up the military's officer ranks. Although Pleasonton's main defense was grounded in his republican beliefs, he too used science to support some of his arguments. For instance, according to Edmund Blunt, Pleasonton noted "the distance that each French light is visible," and compared them to the distance at which each American light can be seen.¹⁵¹ Yet, the Blunt brothers argued that Pleasonton's distances at which the American light could be seen were unrealistic. The Blunts noted, "the distance at which any object may be seen, or the limits of extreme visibility, is determined by the figure [sic] of the earth; and it is demonstrably impossible for an observer at sea, at any attainable height, to discover lights at the distances he pretends."¹⁵²

A similar battle had raged over the control of the Coast Survey since mid 1810s. Civilian and military leaders clashed over the who was best suited to manage the survey and science was at the forefront of the political conflict. Civilian science eventually won

¹⁵⁰ Harris, chapter 14, 323-60.

¹⁵¹ Edmund and George Blunt to Woodbury, February 22, 1838, in United States Senate, *Documents in Relation to the Light-House Establishment*, 25th Cong., 2nd sess., 1838, S. Doc. 258, 1.

¹⁵² *Ibid.*

out over the military in 1836. Diplomatic efforts of the Survey's second superintendent in the 1840s smoothed the relationship between the Survey and the military.

The republican values of civic duty, prudence, honesty and self-reliance did not exist in isolation from one another. They provided the foundation of American republicanism and created a sense of completeness for the citizen striving to help build the young nation. One could not be self-reliant without being prudent. One could not claim a sense of civic duty without honesty. One could not thrive in the new nation without the passion of holding these values as part of their being. Thus, these core republican values worked together as men of science sought to solve commercial and environmental problems while using practical science and the mechanical arts to secure the future of the republic.

CHAPTER 6

STATE INVOLVEMENT IN INNOVATION AND KNOWLEDGE CONSTRUCTION

The previous chapters have shown how commercial problems facilitated Americans' engagement in practical science and innovation, how the environment necessitated the government's interaction, the solutions that resulted from both the government and its citizens, and how the values of a republican society impacted the development of science and shaped the government's involvement in the field. This chapter explores the government's involvement in America's early scientific ventures. What follows is an examination of government's uneven acquiescence of its role in practical science and innovation.

On October 23, 1770 the *HMS Carysford* ran aground a previously uncharted reef on the outer reaches of the Florida Keys.¹ The *HMS Carysford*'s "discovery" of the shoal prompted the British Admiralty to add the underwater hazard to their nautical charts over the next five years.² Despite the barrier's inclusion on British maps, Carysfort Reef, as it was mistakenly named, remained physically unmarked for more than 50 years.³ It was only after the United States Light-House Establishment placed a floating lightship, the

¹ "On this Day," *The Citizen* (Key West, FL), October 23, 2013, <http://keysnews.com/node/50799> (accessed January 8, 2016). Love Dean, "Carysfort Reef Lighthouse," in Thomas W. Taylor, ed., *Florida Lighthouse Trail*, (Sarasota, FL: Pineapple Press, 2001), 68.

² Dean, 68.

³ Dean, 68, Tom Taylor, "Lightships of the Florida Keys, *The Keeper's Log* 20, no. 1 (Fall 2004), 18, 20-22. According to Dean, at some point the name Carysford was misspelled as Carysfort and the name has remained the latter ever since.

Caesar, on the reef in 1826 that the shoal's location become physically and visually marked for the first time.⁴

The lightship, however, proved ineffective. A year after the Light-House Establishment stationed *Caesar* at the reef, the coral barrier claimed both the Spanish slave ship *Guerrero* and the British anti-slaver *HBM Nimble*. According to historian Gail Swanson, the signal from the lightship “had been too weak to warn where the dangerous reef was.”⁵ Additionally, hurricanes frequently blew *Caesar* off its moorings.⁶ As a result, the Light-House Establishment commissioned a second lightship, *Florida*, to replace *Caesar* in 1830. Although the lightship *Florida* fared better than *Caesar* in terms of longevity, it too proved inadequate for the intended purpose. In 1851, Thomas Budd, Captain of the U.S. Mail packet steamship *Union* noted the lightship at Carysfort Reef “shows two miserable lights, and does more harm than good.”⁷ That same year, Lieutenant David Dixon Porter remarked, “On the reef near Cape Largo, the floating lightship, showing two lights, intended to be seen twelve miles, but they are scarcely discernable from the outer ledge of Carysfort reef, which is from four to five miles distant. On two occasions, I have passed it at night, when the lights were either very dim

⁴ Taylor, “Lightships,” 18, 20-22.

⁵ Gail Swanson, *Slave Ship Guerrero* (West Conshohocken, PA: Infinity Publishing, 2005), 14-16. Quote on 16. Brad Bertelli, “The Story of Lightship Captain John Walton from Key West,” *Keynoter* (Tavernier, FL), March 6, 2015, http://www.keysnet.com/2015/03/06/501577_the-story-of-lightship-captain.html?rh=1 (accessed January 8, 2016).

⁶ Dean, 68. Taylor, “Lightships,” 20-1.

⁷ Budd to Lt. Thornton A. Jenkins, July 24, 1851, in United States Congress, *Report of the Officers Constituting the Light-House Board*, 32d Cong., 1st sess., 1852, Ex. Doc. 28, 214.

or not lighted.”⁸ Porter went on to acknowledge, “Five vessels have gone ashore on and about Carysfort reef since I have been running this route, all of them a total loss, and no doubt all of them deceived by the lightboat.”⁹ Historian Kraig Anderson claims 63 vessels ran aground at Carysfort between 1833 and 1841 while the lightship *Florida* was stationed at the reef.¹⁰

In 1837 Congress appropriated \$20,000 for a more permanent light station at Carysfort Reef. The Light-House Establishment in turn commissioned Lieutenant I. W. P. Lewis of the Army Corps of Engineers to survey the reef, a practice that gradually became more common after the late 1830s.¹¹ Lewis’ survey suggested three possible sites for the Carysfort beacon, but more importantly indicated the Congressional appropriation would be insufficient for the work that needed to be done. Stephen Pleasonton, the Fifth Auditor of the Treasury and Superintendent of the Light-House Establishment responded to the survey noting, “a further appropriation of 80,000 dollars,” was needed, but “doubted whether anything more will be appropriated this year.”¹²

Congress made further appropriations for Carysfort in July 1838, but as Pleasonton remarked to one of his contractors, it was only “forty thousand instead of

⁸ Porter to Lt. Thornton A. Jenkins, May 1851, in Ex. Doc. 28, 211. Porter is the grandson of Captain David Porter, Sr. of Baltimore who established the first marine telegraph station in the United States mentioned in Chapter 2.

⁹ Ibid.

¹⁰ Kraig Anderson, “Carysfort Reef, FL,” Lighthousefriends.com, <http://lighthousefriends.com/light.asp?ID=703> (accessed January 8, 2016).

¹¹ Lt. I.W.P. Lewis was first commissioned by the USLHE in 1838 to report on the condition of the nation’s lighthouses. His report to Congress showed many of the lighthouses were in deplorable condition and suggested the USLHE was being mismanaged by the the Treasury Department. The report was highly praised by transatlantic mariners who claimed the lights in the U.S. were inferior to those in Europe. The report also made a name for Lewis and started a decade and a half long political battle over charges of corruption by the Fifth Auditor and the USLHE.

¹² Pleasonton to Winslow Lewis, June 2, 1838, RG 26, Vol. 13, 239, NARA.

eighty thousand dollars.”¹³ With the funds for the lighthouse still lacking, the Fifth Auditor was unable “to commence the work this season.”¹⁴ In 1847, ten years after Congress originally authorized the construction of the Carysfort Reef lighthouse, the legislative body finally appropriated sufficient funds to build the beacon.¹⁵ According to Michael J. Rhein, the federal government eventually spent \$105,069.00 building the Carysfort light.¹⁶

While awaiting further appropriations, Pleasonton solicited proposals for the construction of the Carysfort light. He settled on the design submitted by Lieutenant I.W.P. Lewis. Lewis’ plans incorporated a new construction technique known as a screwpile foundation. Alexander Mitchell, a blind Irish engineer, pioneered the screwpile technique in England earlier that year when he superintended the construction of the Maplin Sands lighthouse in the mudflats of the Thames Estuary. Prior to Mitchell’s innovation, most contractors constructed offshore foundations by driving piles into the ground. Mitchell premised his technique on the principles of a screw; attaching a coiled flange to the end of his piles and twisting them into the seafloor until they were securely anchored in the earth. Mitchell reasoned the spiral blades would hold more securely in the soft ocean bed than driven piles.¹⁷

The iron piles used in constructing the Carysfort Reef Lighthouse represented the latest knowledge in innovation and practical science. They were manufactured in an iron

¹³ Pleasonton to Winslow Lewis, July 14, 1838, RG 26, Vol. 13, 316, NARA.

¹⁴ Ibid.

¹⁵ Anderson, “Carysfort Reef, FL.”

¹⁶ Michael J. Rhein, *Anatomy of the Lighthouse*, (Glasgow, Scotland: Saraband, 2001), 120.

¹⁷ Ibid., 115. Howard A. Perko, *Helical Piles: A Guide to Design and Installation*, (New York: Wiley, 2009), 6-9.

foundry at Philadelphia with such precision and exactness that any one section of the piles could be interchanged with any other section. The piles were then assembled in Philadelphia to ensure their universality before being shipped to the engineers and contractors building the lighthouse at Carysfort. Merritt Roe Smith, a historian of science and technology, argues the government's involvement in interchangeable parts manufacturing began with assembling weapons for the Ordnance Department in 1823.¹⁸ Thus, by the late 1840s, the government had more than twenty years of experience producing interchangeable parts. This experience represented the most advanced knowledge and innovation available at the time.

In addition to the screwpile foundation, Lieutenant Lewis' plan also called for the installation of a Fresnel lens, an optical apparatus invented by French civil engineer Augustin Jean Fresnel discussed in Chapter 4. Unfortunately for Lewis, the Fresnel lens purchased for the Carysfort Lighthouse was misplaced when it arrived in New York. The lens arrived in several crates that were not clearly marked. The customs agent in New York sold the crates at auction, only to find out later that it was the lens intended for Carysfort. By the time the government recovered the lens, it was too late. The Carysfort Reef lighthouse was already complete and operating with a different set of lenses.¹⁹ Physically marking the shoal with a navigational beacon may have helped mariners visualize the boundaries of the coral reef, but charts and maps also needed to be updated with more accurate information. Numerous shipwrecks over the previous two decades at the site highlighted the necessity of having an accurate map of the area. (Anderson holds

¹⁸ Merritt Roe Smith, *Harper's Ferry Armory and the New Technology: The Challenge of Change*, (Ithaca, NY: Cornell University Press, 1980), 110.

¹⁹ Eric Jay Dolin, *Brilliant Beacons: A History of the American Lighthouse*, (New York: Liveright Publishing Company, 2016), 121-3.

the Carysfort Reef responsible for 20 percent of all Florida Keys shipwrecks in the 1830s.)²⁰ The federal government recognized physically marking the underwater hazard was not enough and ordered a survey of the site. Under the direction of Alexander Dallas Bache, Army Lieutenant James Totten completed the triangulation portion of the survey while civilian cartographer Isaac Hull Adams carried out the topographic survey at Carysfort.²¹ Totten and Adams completed their charting of the shoal in 1855.

Marking the Carysfort Reef represented two things for the state. First, the Carysfort Reef Lighthouse was the culmination of the state's expertise in innovation prior to the Civil War. The lighthouse showcased the latest innovations in engineering and the most current knowledge of practical science. Second, Carysfort also represented the collaborative efforts of the government's most prolific scientific institutions in the first half of the nineteenth century – the Army Corps of Engineers, the Coast Survey, and the Light-House Establishment. While these institutions worked together previously on other projects prior to Carysfort, marking the Carysfort Reef was the one of the first infrastructure projects in which all three organizations came together for the common goal of protecting commerce and navigation. The triumvirate achieved this aim through innovation and scientific practice.

This chapter chronicles the story of how the aforementioned government agencies interacted and constructed knowledge. These institutions were the United States' leading scientific centers and at the forefront of the federal government's involvement in

²⁰ Anderson, "Carysfort Reef, FL."

²¹ Survey of the Coast of the United States, *Annual Report 1855. No. 29 (F No. 4) Preliminary Chart of Florida Reefs from Key Biscayne to Carysfort Reef*, 1855, Item 3311, Image ID cgs05880, Historic Coast & Geodetic Survey Collection, NOAA, <http://www.photolib.noaa.gov/htmls/cgs05880.htm> (accessed January 8, 2016). The source lists the authors of the survey as Lieut. Jas Totten and I. H. Adams.

constructing knowledge in the first half of the nineteenth century. The Corps of Engineers, Coast Survey, and Light-House Establishment actively constructed, learned, and transmitted knowledge through their interactions with each other and their individual engagement in practical science and mechanical innovation along the nation's coasts.

HISTORIOGRAPHY

The story of the triumvirate begins with institutional histories of government agencies. In 1889, Arnold Burges Johnson chronicled the history of the United States Lighthouse Service in *The Modern Light-House Service*. Johnson became Chief Clerk of the United States Light-House Board in 1869.²² Johnson completed the history of the Light-House Service in his spare time at the request of the International American Congress.²³ His narrative is a broadly encompassing work that not only chronicles the administration and growth of the United States Light-House Establishment and Light-House Board, but also provides a comparison with the lighthouses of other nations. Johnson includes the technical specifications for the construction of lighthouses and lightships and provides information on customs duties, tonnage, and other commercial statistics. It is the first comprehensive history of the Light-House Establishment and succeeding Light-House Board presented in a straightforward, unbiased, factual manner. In 1910, President William Howard Taft transferred the responsibilities of the Light-House Board to a newly created civilian managed Lighthouse Bureau. He appointed George Rockwell Putnam the first Commissioner of the Bureau. Seven years after his

²² Kenrick A. Claflin and Son, Item # 1063. "(envelope from) Arnold Burges Johnson, Chief Clerk, U. S. Light House Board, Washington DC, c.1895," <http://www.lighthouseantiques.net/Charts/charts.html> (accessed October 8, 2016).

²³ Arnold Burges Johnson, *The Modern Light-House Service*, (Washington DC: GPO, 1889), iii-v.

appointment, Putnam wrote the most comprehensive history of the Lighthouse Service (to that date) with *Lighthouses and Lightships of the United States*.²⁴ Putnam's narrative places American lighthouses in the realm of humanitarian work and provides an overly "general and rather non-technical" examination of the history and administration of the Service. Putnam's study is divided geographically, which became a common trend in future histories of the Lighthouse Service. Despite its age, it remains one of the most cited references on American lighthouses.²⁵ Putnam served as the Commissioner of the United States Lighthouse Bureau for 25 years from 1910 to 1935.²⁶

Government sanctioned histories of the Army Corps of Engineers began appearing in the 1970s. These narratives were based on the activities of the individual Corps districts and while they were written by government employees, each narrative is as unique as the work of each district. There is an attempt at standardization among these narratives. They present a factual history of the Corps with very little interpretation.

Notable editions used in this study include Harold Kanarek's *Mid-Atlantic Engineers: A*

²⁴ George R. Putnam, *Lighthouses and Lightships of the United States*, (Boston: Houghton Mifflin Company, 1917). A brief note on the naming convention of the lighthouse agency in the United States. References to the Light-House Establishment usually refer to the period from 1789 to 1851 as this was the name officially referred to in correspondence by Stephen Pleasanton, the Fifth Auditor and Superintendent of Lighthouses. The Light-House Board refers to the period from 1851 to 1910. This is the official name given by Congress in the act that established the Board. The Lighthouse Service generally refers to the period from 1910 until 1939 when the agency was known as the Bureau of Lighthouses. Because Putnam's narrative was written during this period, scholars often refer to the Lighthouse Service, however, Putnam's study encompasses the entire history of the agency from its establishment under the Treasury Department in 1789. After 1939, lighthouse came under the jurisdiction of the United States Coast Guard Service. Occasionally, scholars will use the Lighthouse Service to also refer to this period.

²⁵ Putnam.

²⁶ Judi Kearney, "George Rockwell Putnam, Commissioner, Bureau of Lighthouses," *Lighthouse Digest* 20, no. 4 (Jul/Aug 2011), 42.

History of the Baltimore District U.S. Army Corps of Engineers, 1774-1974 (1975), Aubrey Parkman's *Army Engineers in New England: The Military and Civil Work of the Corps of Engineers* (1978), and Henry E. Barber and Allen R. Gann's *A History of the Savannah District U.S. Army Corps of Engineers* (1989). Frank N. Schubert's *The Nation Builders: A Sesquicentennial History of the Corps Topographical Engineers* (1988) provides a brief, but informative history of the Corps' short-lived topographical survey division.²⁷ These government-sanctioned histories tended to look inward at the activities of the institutions under review rather than placing them in the context of social, political, and cultural events.

About the same time the government began sanctioning the histories of the Army Corps of Engineers, mainstream historians began writing histories of government institutions. Francis Ross Holland, Jr's *America's Lighthouses: Their Illustrated History since 1716* (1972) provided a much needed update to Putnam's 1917 history of the United States Lighthouse Service. Todd Shallat's *Structures in the Stream* (1994) examines the work of the Army Corps of Engineers in building breakwaters and clearing obstacles from the nation's rivers and harbors. Hugh R. Slotten's *Patronage, Practice, and Culture of American Science* (1994) explores the interrelationship of patronage,

²⁷ Henry E. Barber and Allen R. Gann, *A History of the Savannah District U.S. Army Corps of Engineers*, (Savannah, GA: Savannah District USACE, 1989). Frank N. Schubert, ed., *The Nation Builders: A Sesquicentennial History of the Corps of Topographical Engineers, 1838-1863*, (Fort Belvoir, VA: USACE, 1988). Aubrey Parkman, *Army Engineers in New England: The Military and Civil Work of the Corps of Engineers in New England, 1775-1975*, (Waltham, MA: USACE New England Division, 1978). Harold Kanarek, *The Mid-Atlantic Engineers: A History of the Baltimore District U.S. Army Corps of Engineers, 1774-1974*, (Washington: Superintendent of Documents GPO, 1975).

politics, and science in nineteenth century government institutions.²⁸ Newer studies of the United States Lighthouse Service, such as Elinor De Wire's *Guardians of the Lights* (1995) and Dennis L. Noble's *Lighthouses and Keepers* (1997) tend to focus more on individual lighthouses and their keepers rather than the institution.²⁹ One of the most recent histories of a government agency is Mark R. Wilson's study of the United States Quartermasters Corps during the American Civil War. *The Business of Civil War: Military Mobilization and the State 1861- 1865* (2010) argues the North won the war between the states because the officers in charge of procuring the Army's war supplies pieced together a system of highly functioning relationships between the government, suppliers, and labor production in a holdover of ideals based on Jeffersonian republicanism.³⁰

The issue with these institutional studies is the they examine the institutional structures in isolation of the other agencies. Thomas G. Manning's *U. S. Coast Survey vs. Navy Hydrographic Office* (1988) is one exception. Manning looks at the long running political battle between the two government agencies regarding the role of civilians and

²⁸ Francis Ross Holland, Jr., *America's Lighthouses: Their Illustrated History Since 1716*, (Brattleboro, VT: Stephen Greene Press, 1972). Holland's work was reprinted in 1988 by Dover Publications as *America's Lighthouses: An Illustrated History*. Todd Shallat, *Structures in the Stream: Water, Science, and the Rise of the U.S. Army Corps of Engineers*, (Austin: University of Texas Press, 1994). Hugh Richard Sloten, *Patronage, Practice, and the Culture of American Science: Alexander Dallas Bache and the U.S. Coast Survey*, (New York: Cambridge University Press, 1994).

²⁹ Elinor De Wire, *Guardians of the Lights: Stories of U.S. Lighthouse Keepers*, (Sarasota, FL: Pineapple Press, 1995). Dennis L. Noble, *Lighthouses and Keepers: The United States Lighthouse Service and Its Legacy*, (Annapolis, MD: Naval Institute Press, 1999).

³⁰ Mark R. Wilson, *The Business of Civil War: Military Mobilization and the State, 1861 – 1865*, (Baltimore, MD: JHU Press, 2010).

the military in state science.³¹ Unlike the existing narratives, this chapter seeks to highlight the interaction of the Army Corps of Engineers, Coast Survey, and the Light-House Establishment rather than examining them in isolation.

In addition to the institutional histories, this chapter engages the literature of knowledge construction. How knowledge was constructed in the United States in the first half of the nineteenth century has been a topic of interest for historians of science and technology since at least 1976 when Alexandra Oleson and Sanborn C. Brown published an edited volume of essays on *The Pursuit of Knowledge in the Early American Republic*. *The Pursuit of Knowledge* examined the influence of regional learned societies regarding the construction of knowledge in the United States prior to the American Civil War.

Oleson argues these learned societies, “fostered the development of science and scholarship and provided invaluable communication links between the far-flung members of the young republic’s intellectual community.”³² Andrew J. Lewis’s more recent monograph, *A Democracy of Facts* (2011), contradicts Oleson’s claims arguing Americans generally mistrusted the knowledge constructed by learned men. In Lewis’ study of naturalists in the early American Republic, Lewis found natural philosophers did not achieve credibility with the general populace until after it became involved with the state.³³ In between these two narratives, Eda Kranakis’ *Constructing a Bridge* and Ann Johnson’s essay “Material Experiments: Environment and Engineering Institutions in the

³¹ Thomas G. Manning, *U.S. Coast Survey vs. Naval Hydrographic Office: A 19th Century Rivalry in Science and Politics*, (Tuscaloosa, AL: University of Alabama Press, 1988).

³² Alexandra Oleson and Sanborn C. Brown, eds., *The Pursuit of Knowledge in the Early American Republic: American Scientific and Learned Societies from Colonial Times to the Civil War*, (Baltimore, MD: JHU Press, 1976), viii.

³³ Andrew J. Lewis, *A Democracy of Facts: Natural History in the Early Republic*, (Philadelphia: UPenn Press, 2011).

Early Republic,” focus more on the individuals constructing knowledge and the methods they used. Kranakis’s study of James Finley’s suspension bridge argues the construction of knowledge was shaped by both class and society. According to Kranakis, early Americans constructed knowledge through their experiences, but later adopted a hybrid method of experience and mathematical theory after the French attempted to build a version of Finley’s bridge across the River Seine.³⁴ Johnson’s essay examines the work of Army Engineer Joseph G. Totten in constructing coastal defenses for the young nation. Johnson argues engineers constructed knowledge on the strength of materials using a “cookbook formula” of empirical research that led engineers to predicting how construction materials would react once they were part of a built infrastructure.³⁵ This study compliments the aforementioned works by examining government institutions as centers of knowledge construction.

DEFINING THE STATE

While my research studies the work of individuals, I consider individuals employed by the state to be a part of the state. I define “the state” as the agent of government. My definition of the state includes the federal, state, local municipalities, and the individuals in the employment of these entities. The actions and decisions of individuals employed by the state were not necessarily seen as being the work of the individual. Rather, these actions and decision, especially those by individuals in positions of authority, often became viewed by society as the actions, decisions, and policies of the

³⁴ Eda Kranakis, *Constructing a Bridge: An Exploration of Engineering Culture, Design, and Research in Nineteenth-Century France and America*, (Cambridge, MA: MIT Press, 1996).

³⁵ Ann Johnson, “Material Experiments: Environment and Engineering Institutions in the Early American Republic,” in Carol Harrison and Ann Johnson, eds., *National Identity: The Role of Science and Technology (Osiris 24)*, (Chicago, IL: UC Press, 2009).

the government. Henry A. S. Dearborn's and Samuel Harrison Smith's decision not to adopt natural gas for use in the Light-House Establishment discussed later in this chapter provides an excellent of how individual actions become government policies. Dearborn was the Collector for the Port of New York and Smith was the Commissioner of Revenue. At the time of their decision to forego the adoption of natural gas lighting, the two individuals were in charge of managing the lighthouses in the region surrounding New York.

TRIALS AND TRIBULATIONS

The government's involvement in innovation and knowledge construction went through many trials and tribulations. Their involvement began with the new constitutional government. In just the ninth official act of Congress, passed on August 7, 1789, the federal government assumed responsibility for the safety of the nation's commerce and navigation. The act provided for the:

...support, maintenance and repairs of all lighthouses, beacons, buoys, and public piers erected, placed or sunk, before the passing of this act, at the entrance of, or within any bay, inlet, harbor or port of the United States, for rendering the navigation thereof easy and safe...³⁶

The passage of the act thrust the government into the realm of practical science for which it was ill-prepared. The federal government not only acquired the 12 lighthouses then in

³⁶ United States Congress, *An Act to Provide for the Establishment and Support of Light-Houses, Beacons, and Buoys*, 1789, 1st Cong., 1st sess., ch. 9, sec. I, 1789.

existence, but also two beacons under construction; one in Massachusetts and one in Virginia.³⁷

Assuming responsibility for the nation's navigational aids immediately invested the government with a need for practical knowledge of engineering and mechanical arts if it were to properly oversee the construction, maintenance and repairs of the aids as required by the new law. Although a few of the engineers who served in the Continental Army continued to serve the new government in various positions, as a whole, government employees and contractors lacked the practical knowledge and expertise needed for managing coastal navigation as the nation entered the nineteenth century. Europe earlier experienced a similar problem identifying proper expertise. As Eric H. Ash notes, "The rise of the expert and the development of the early modern state are parallel stories."³⁸ In his *Power, Knowledge, and Expertise in Elizabethan England*, Ash argues the the meanings of the word "expert" was undergoing a transformation from meaning experience to also include skill. Ash claims it was this transformation that gave rise to expert mediators as the state sought expertise in the various areas of knowledge. Ash's expert mediators were the go-betweens between the royal administrators and those who were experts in their fields of knowledge and scientific practice.³⁹ Deborah Harkness makes a similar claim for Elizabethan London arguing it was the city of London that nurtured the development of the expert through its "minor vernacular figures and their

³⁷ The two lighthouses were the Portland Head Light in what is now Maine and the Cape Henry Light at the mouth of the Chesapeake Bay in Virginia.

³⁸ Eric H. Ash, "Introduction," in Eric H. Ash, ed. *Expertise: Practical Knowledge and the Early Modern State*, (Chicago: UC Press, 2010), 11.

³⁹ Eric H. Ash, *Power, Knowledge, and Expertise in Elizabethan England*, (Baltimore, MD: JHU Press, 2004), 10.

small successes, trial-and-error progresses, and mundane aspirations.”⁴⁰ The author surmises these minor figures embraced the emerging empirical and print cultures available to them. In the fourth case study of her narrative, *The Jewel House*, Harkness examines “Big Science” in Elizabethan London and how the municipality sought out and vetted expertise knowledge.⁴¹ Across the English Channel, the French were equally seeking out expert knowledge. Chandra Mukerji’s *Impossible Engineering* examines the search for engineering expertise in building the Canal du Midi in the late seventeenth century. Mukerji argues the learned men and so-called engineering experts were unable to solve the problem of getting water to flow up the mountains without the expertise of local female peasants who lived and worked with the water on a daily basis.⁴²

INITIAL INVOLVEMENT

Between 1789 and the turn of the century, the federal government finished the Portland Head and Cape Henry lights. In Portland, the government contracted with stone masons Jonathan Bryant and John Nichols. Bryant and Nichols used local rubblestone to build the Portland Head Light, employing teams of oxen to haul the rubblestone more than six miles overland to the construction site near Cape Elizabeth. Initially, the government contracted with Bryant and Nichols for a fifty-eight-foot tower. As the tower neared the expected height, however, everyone involved with the project realized the light’s focal plane would not be tall enough to provide an adequate aid to navigation. The area’s frequent heavy fogs diminished visibility as the clouds lifted off the ocean along

⁴⁰ Deborah E. Harkness, *The Jewel House: Elizabethan London and the Scientific Revolution*, (New Haven, CT: Yale University Press, 2007), 6.

⁴¹ *Ibid.*, chapter 4, 142-80.

⁴² Chandra Mukerji, *Impossible Engineering: Technology and Territoriality on the Canal du Midi*, (Princeton, NJ: Princeton University Press, 2009).

Cape Elizabeth's rocky coast. Public officials worked with the contractors on altering the original plans for the lighthouse. They increased the height of the Portland Head Light to 72 feet with a focal plane of 101 feet above sea level.⁴³

Construction on the Cape Henry lighthouse at the mouth of the Chesapeake Bay also experienced problems which public officials and contractors failed to anticipate. The federal government contracted with John McComb, Jr., a bricklayer from New York, to complete the lighthouse started by the Virginia Commonwealth at Cape Henry.

McComb's contract called for a foundation 13 feet deep, but the instability of the cape's sandy ground forced McComb to alter the plans. At one point, after McComb had cleared the area for the foundation, the wind whipped up the sand and deposited fifty cartloads of the coastal ground cover over McComb's work. In the end, McComb added seven feet to the depth of the foundation to compensate for the instability of the sandy shore.⁴⁴

Although the government contractors ran into unforeseen problems when building the Portland Head and Cape Henry lights, the projects were ultimately successes. Not only did both structures provide protection for the safety of commerce and navigation for many decades, those involved with the projects also gained valuable knowledge in the fields of engineering and natural philosophy. The successful completion of the Portland Head and Cape Henry lights gave ship owners, merchants, and mariners something to feel good about with regards to the new national government.

⁴³ Kraig Anderson, "Portland Head, ME," Lighthousefriends.com, <http://lighthousefriends.com/light.asp?ID=546> (accessed October 13, 2016).

⁴⁴ Kraig Anderson, "Cape Henry (Old), VA," Lighthousefriends.com, <http://lighthousefriends.com/light.asp?ID=448> (accessed October 13, 2016).

FAILURE AT FRANK'S ISLAND

The issues at the Portland Head and Cape Henry, however, were minor in comparison to the problems the government experienced in the first decade of the nineteenth century at the Frank's Island lighthouse near the mouth of the Mississippi River. Within three years of securing the Louisiana Purchase from France, Congress authorized the construction of a lighted beacon to mark the entrance of the Mississippi River.⁴⁵ Gallatin initially inquired of Barthelemy Lafon, a local architect and surveyor, to draw up plans for the Frank's Island light. Gallatin, however, found Lafon's plan unacceptable and commissioned Benjamin Latrobe, the Surveyor of the Public Buildings, for a proposal. Latrobe was the United States' leading architect and engineer at the time. Latrobe studied engineering and architecture in England under the famed John Smeaton and Samuel Pepys Cockrell, respectively.

From the outset, the proposal for a lighthouse at the mouth of the Mississippi River was fraught with problems. To begin with, the government took 12 years to adopt a plan for the lighthouse. According to architectural historian Michael W. Fazio, Latrobe submitted four proposals between 1805 and 1817. Latrobe's first design was very utilitarian. The plan called for a simple octagonal stone tower similar to the beacon at Sandy Hook New Jersey.⁴⁶ Latrobe's estimate for the building was \$20,000.⁴⁷

Latrobe's first proposal also incorporated engineering methods he had previously used in constructing the Bank of Philadelphia, which "spread the weight over the whole

⁴⁵ Michael W. Fazio, "Benjamin Latrobe's Designs for a Lighthouse at the Mouth of the Mississippi River," *Journal of the Society of Architectural Historians* 48, no. 3 (Sept 1989), 232.

⁴⁶ *Ibid.*, 233.

⁴⁷ *Ibid.*, 235.

surface covered equally.”⁴⁸ Gallatin, however, questioned Latrobe’s expertise, fearing the “the top of the pyramid would bend, in heavy storms.”⁴⁹ The Treasury Secretary asked Latrobe to “dispel [his] fear of the bending,” before he solicited construction bids “in conformity with [the] plan.”⁵⁰ Latrobe dispelled Gallatin’s fears by engineering a structural innovation that allowed the tower to act monolithically. Fazio explains Latrobe’s method as a reinterpretation of “Smeaton’s achievement [interlocking stone joints] at Eddystone,” by “bond[ing]the courses of stone at intervals by means of the individual units of the spiral staircase extended ‘thro’ the wall from inside to outside.” According to Fazio, Latrobe’s innovation significantly reduced the structure’s mass, “allowed the masonry cross-sections to act monolithically,” and integrated “internal spaces and structure into a single system.”⁵¹

Second, while the potential bending of the tower was a concern for the Gallatin, congressional leaders, and other government officials, it proved minor in comparison to the ground upon which the lighthouse was built. The mouth of the Mississippi was (and still is) an alluvial delta. The soft, muddy ground made the weight of the structure much more important than its height. Concern over the alluvial soil’s suitability slowed the process of erecting a beacon at the mouth of the Mississippi River. Gallatin commissioned Latrobe’s assistant, Lewis De Mun to survey the mouth of the Mississippi

⁴⁸ Latrobe to Thomas Vickers, July 24, 1805 qtd. in Fazio, 235.

⁴⁹ Gallatin to Latrobe, September 16, 1805, RG 26, Vol. 3, Page 328, NARA.

⁵⁰ Ibid.

⁵¹ Fazio, 235.

River.⁵² De Mun took soil samples of three possible sites and visually analyzed them for their content and suitability. De Mun's survey determined the alluvial soil was mostly made up of clay. He then issued his report to Latrobe and the Treasury Department with his recommendation for building the lighthouse on Royal Island to the west of the Southwest Pass of the Mississippi River.⁵³ Latrobe seconded the recommendation solely on De Mun's report, telling Gallatin "the deeper you dig, the harder it [the soil] becomes." Latrobe also claimed the clay soil "is perfectly watertight."⁵⁴ Latrobe, however, never personally inspected any of De Mun's three sites in making his recommendation. Years later, Latrobe noted in his journal, "these old islands consist of a hard blue Clay from the surface to a depth of 45 feet."⁵⁵

In the interim, Latrobe's redesigned the lighthouse. According to Fazio, the new design incorporated several architectural innovations that surpassed the brilliance of

⁵² Gallatin to Lewis Dumain, June 23, 1805, RG 26, Entry 18, Vol. 3, 329, NARA. There are many discrepancies throughout the sources regarding Dumain's name. Gallatin addressed his letter to Lewis Dumain and a "Report on the Survey of the Coast of Louisiana" in the *American State Papers Volume 1* is signed by a Lewis Dumain. In Edward C. Carter II, John C. Van Horne, and Lee W. Formwalt's compilation of Benjamin Henry Latrobe Journals, Latrobe referred to his assistant at times as both Louis de Mun and Mr. De Mun. Edward C. Carter II, John C. Van Horne, and Lee W. Formwalt, compilers and editors of the Benjamin Henry Latrobe Papers refer to Latrobe's aide as Lewis De Mun. Fazio, using Carter et al's compilation and Talbot Hamlin's 1955 biography of Latrobe uses the name Louis De Mun. John Morrill Bryan, biographer of Robert Mills, also uses the name De Mun. John Morrill Bryan, *Robert Mills: America's First Architect*, (New York: Princeton Architectural Press, 2001), 59. Blog historian Jay Riedl spells Latrobe's assistants last name De Munn. Jay Riedl, "More on the Planning for the Original Lighthouse," Frank's Island Lighthouse, October 23, 2007, <http://www.franksislandlight.blogspot.com> (accessed January 13, 2016). As the consensus among historians is that Lewis' last name was De Mun, this paper will follow their lead, despite the primary government documents reading Dumain.

⁵³ Fazio, 235.

⁵⁴ Latrobe to Gallatin, December 24, 1806, qtd. in Fazio, 236.

⁵⁵ Benjamin Henry Latrobe, "Journal Entry," February 27, 1819, in *The Papers of Benjamin Henry Latrobe: Journals, 1799 – 1820*, Edward C. Carter II, John C. Van Horne, and Lee W. Formwalt, eds., (New Haven, CT: Yale University Press, 1980), 223.

Smeaton's work and transcended anything yet seen in European engineering, practice or theory.⁵⁶ Yet, the final design also abandoned the simplicity and frugality of Latrobe's original proposal. Recognizing the future importance of New Orleans as an entrepôt to the world, Latrobe's last proposal intended to showcase the grandeur of the new nation. Latrobe's latest vision included arches, columns, an elegant piazza, and marble stairs imitating the style of the ancient Greeks.⁵⁷

Although Latrobe found the the alluvial soil suitable for his design few others agreed. Over the next several years, the Treasury Department advertised for bids to construct the beacon according to Latrobe's plans, but it received no offers. Fazio claims this was mostly Latrobe's fault. Latrobe wanted to circumvent the federal government's bidding process and hand-pick his own contractor. In soliciting bids, Latrobe wrote a very technical and complex advertisement which he knew few contractors would be willing to undertake. An excerpt of Latrobe's advertisement read:

...The buttress walls (which must be founded upon sprayed arches (sic) turned on a brick wall erected on the rim of a smaller inversed Cupola turned within the larger one) to be united with each revolution of the stairs, by brick splayed arches forming the well of the staircase and extending to the external wall of the tower; and on the crown of those splayed arches, reverse arches must be turned, the reverse feet of which support the buttresses

⁵⁶ Fazio, 236.

⁵⁷ "Proposals," *National Intelligencer and Washington Advertiser* (Washington, DC), June 8, 1807, 4.

above. These arches forming a succession of recesses rising with the spiral line of the steps will continue to the elevation of fifty feet;...⁵⁸

Carter et als., believe the lack of interest in contracting for the lighthouse lie in the unfamiliar environment of the Gulf coast.⁵⁹ In either case, contracting issues stalled the government's progress for seven years before the War of 1812 delayed the construction further.

After the War of 1812 ended, the Treasury Department commissioned another survey of the mouth of the Mississippi River under the direction of United States Navy Commodore Daniel Patterson, Benjamin Henry Latrobe's eldest son Henry Sellon Boneval Latrobe, and the customs collector for the state of Louisiana, Pierre LeBarbier Duplessis, Jr. Similar to De Mun's earlier survey, the 1816 survey found the clay soil got harder the deeper they surveyors dug. After digging to a depth of fifty feet at several sites, Patterson, Latrobe, and Duplessis found the soil on Frank's Island "the most solid of all those in the neighborhood, and even more so than that selected by Mr. De Munn [sic]."⁶⁰

At the conclusion of the survey, the Treasury prodded Winslow Lewis, into bidding on the project. As previously mentioned in earlier chapters, Lewis contracted with the Light-House Establishment to fit up all the lighthouses with his patented lamp and reflector system. He also contracted with the government to deliver the annual supply of spermaceti oil to each lighthouse. While fitting up the navigational aids with his

⁵⁸ "Proposals."

⁵⁹ Carter, 284-5n11.

⁶⁰ Riedl, "More on the Planning."

patented lamp and reflector system, Lewis made minor repairs to the lighthouses. Lewis, however, had never built a complete lighthouse. Similar to the others who refused to bid on the project, Lewis recognized the inherent problems with Latrobe's design and adamantly refused to be held accountable for the foundation's failure if he undertook the contract.

Despite the federal government's careful approach to the construction of the Frank's Island lighthouse by commissioning two surveys, building the lighthouse at Frank's Island proved to be one of the young republic's biggest failures regarding coastal navigation. Government officials made two fatal decisions. First, on the advice of Patterson, the younger Latrobe, and Duplessis, the government selected Frank's Island on the Northeast Pass, for the lighthouse's construction.⁶¹ De Mun originally recommended Royal Island, but noted that all three sites he surveyed, including Frank's Island, were suitable for building the elder Latrobe's simplistic tower. Over the course of planning for the lighthouse, the design changed several times. With each new design, the architecture of the lighthouse grew more elaborate and the weight of the structure increased significantly. De Mun could not have anticipated the new design and therefore his survey provided no assurances of the soil's suitability beyond the original plan for a simple tower. The survey by Patterson, Latrobe, and Duplessis took the revised plans into consideration when recommending Frank's Island. As noted in a letter to Samuel H. Smith, the Commissioner of the Revenue, Patterson, Latrobe and Duplessis stated, "it is our opinion that a building may be erected of the heaviest materials." The three surveyors understood the government's "decided preference would be given to a stone or brick

⁶¹ Fazio, 240.

building.” They included their own plan, presumably drawn by Henry Latrobe, “to be built principally of the latter materials.”⁶²

This brings up the second, more fatal decision made by the Treasury. Treasury officials accepted the design submitted by Henry Latrobe. Similar to the senior Latrobe’s last proposal, Henry’s design was quite elaborate. The younger Latrobe incorporated several of his father’s features into the design including the integration of the tower resting atop the keeper’s house and a wraparound cast-iron column supported piazza. The elder Latrobe praised his son’s work as doing him “infinite credit,” and noting that “Smeaton himself could have designed nothing of better construction.”⁶³

Unfortunately, Henry Latrobe succumbed to yellow fever in 1817 a year after he submitted his design for the Frank’s Island light and a year before Winslow Lewis and his contractors began construction on the lighthouse. Henry’s father became the point of contact for any questions relating to the plans for the lighthouse. The elder Latrobe was already in New Orleans simultaneously working on the city’s water supply with his other son, Benjamin Henry Latrobe II during the lighthouse’s early construction. The senior Latrobe inspected the lighthouse in 1819 while it was still under construction and claimed the work was “faithfully executed & of good materials.”⁶⁴ Fazio, however, argues the

⁶² Daniel J. Patterson, H. S. Bonneval Latrobe, and P. L. B. Duplessis to Samuel H. Smith, November 12, 1816, in United States Congress, *Commerce and Navigation, 1789-1823*, vol. 2, (Washington: Gale & Seaton, 1834), 45, <http://books.google.com> (accessed January 13, 2016).

⁶³ Benjamin Henry Latrobe to Henry Latrobe, June 4, 1817 qtd. in Fazio, 241.

⁶⁴ Benjamin Henry Latrobe, “Report on the Lighthouse at Frank’s Island & on the Balize,” May 8, 1819 qtd. in Fazio, 244.

senior Latrobe never inspected the piles underneath the lighthouse. If he had, the elder Latrobe would have known the piles were improperly constructed and not watertight.⁶⁵

Even before construction was finished, the beacon's foundation settled sixteen inches. Latrobe found this settling harmless because the foundation had not cracked and the settling was uniform.⁶⁶ Eventually, however, the foundation did crack under the massive weight of the structure. As the foundation gave way, the lighthouse sunk into the soft alluvial soil and collapsed entirely. The Treasury Department commissioned an inspection of the wreckage to determine its salvageability. Various inspections between April 1820 and March 1821 gave conflicting reports. The first expressed optimism of rebuilding the tower with guidance from Latrobe. This option ultimately proved unattainable. Similar to his son Henry, Benjamin Latrobe succumbed to yellow fever in September 1820 while inspectors were continuing their assessment of the collapse. The second inspection, conducted by Major Joseph Jenkins deemed the repairs too costly, having already spent 15 years and \$85,000 constructing the light.⁶⁷

Mr. Ruddock, a civil engineer from Carolina who happened to be in New Orleans at the time, unofficially conducted a third inspection. What possessed Ruddock to inspect the lighthouse remains a mystery. The government did not commission his opinion, having already received two reports from other qualified engineers. Fazio says, Ruddock claimed, "had I not have seen the necessity of interfering in this business, never should I have run myself into the trouble, expense, and hazards, that I on this account have

⁶⁵ Fazio, 244.

⁶⁶ Carter, 287n.

⁶⁷ Fazio, 232, 245.

done.”⁶⁸ Fazio claims Ruddock was the only engineer to inspect the pile foundation and takes soil samples from below the lighthouse.

Patterson, Latrobe, and Duplessis took soil samples “to the depth of fifty feet” and similar to De Mun’s survey, found the clay “grew gradually harder as we descended.”⁶⁹ Ruddock’s inspection noted the clay “weighed 95 lbs. to the cubic foot,” but also that the island was being inundated by water from below; a fact that seems to be confirmed by the elder Latrobe’s visit in April 1819 when he acknowledged the erosion on the island.⁷⁰ When Ruddock “thrust a pole two inches in diameter, down among the pilings, ten feet deep...and drew the same out again...the water, immediately rose within two inches, of the top of the ground, being 4 feet above high water.”⁷¹ According to Ruddock, the contractors had failed to fill the piled timbers with “shells or solid materials” as called for by the contract which would have prevented the water from undermining the structure. Ruddock also claimed the workmen “removed the scaffold poles too soon, before the work had got properly dry, and consolidated together.” Ruddock further noted, “the arches were not sprung, in a proper manner” and the “walls were carried up too high.”⁷² The consequence of this poor workmanship, according to Ruddock, was the weight of the structure proved too heavy for the foundation and the supports.

Ruddock and others were quick to blame Lewis and his subcontractors for the failure at Frank’s Island. Given some of Lewis’ other shady dealings with the Light-

⁶⁸ Qtd. in Fazio, 245.

⁶⁹ Patterson, Latrobe, and Duplessis to Smith, November 12, 1816. Riedl, “More on the Planning.”

⁷⁰ Fazio, 245. Carter 286n16.

⁷¹ Fazio, 245.

⁷² Beverly Chew to Pleasonton, May 26, 1821, RG 26, Entry 17C, Box 23, NARA.

House Establishment, historians have been too eager to follow suit.⁷³ While criticism of Lewis' workmanship is certainly warranted, pointing fingers and placing blame does not address the more important question of why the government proceeded to carry out the project over the concerns of qualified contractors. The fact the Treasury commissioned two separate surveys eleven years apart before attempting to build the lighthouse at the mouth of the Mississippi River demonstrates the extent to which government officials learned from the experience constructing the Cape Henry light at the mouth of the Chesapeake Bay. Building the light at Cape Henry informed government officials of the environment's impact on construction. From that point forward, surveys would be a regular aspect of constructing aids to navigation. On the other hand, that the Treasury proceeded to carry out Latrobe's plan over the objections of the contractors shows the government still had much to learn and that it was still somewhat unprepared for its role in practical science. That no contractor was willing to undertake Latrobe's project should have raised concern with the Treasury Department, but it did not. Additionally, Lewis' refusal to be held accountable if the foundation failed should have held sway with government officials, but the government likewise passed on its obligation to consider the knowledge presented.

Two important questions arise out of the failure at Frank's Island. First, why did the Treasury reject the plan by Barthelemy Lafon? Lafon was a former United States Army Engineer, architect, cartographer, local city planner, and surveyor.⁷⁴ Presumably, Lafon knew the area much better than the federal government's surveyors, engineers, and

⁷³ Fazio, 243.

⁷⁴ Fazio, 233. Jim Frasier, *The Garden District of New Orleans*, (Jackson, MS: University Press of Mississippi, 2012), 19.

contractors. As Fazio notes, Lafon's 1806 and 1813 maps of Louisiana and the Mississippi delta were the primary sources of information on the area prior to the 1838 chart made by Andrew Tabott.⁷⁵ Second, why did the government proceed with the construction of the Frank's Island light when no contractor, including Winslow Lewis, was willing to stake their name on the project's foundation? The first question can easily be addressed. The second requires a deeper analysis.

ANALYZING THE GOVERNMENT'S DECISION

Lafon's plan provided for a square wooden tower built on a truncated pyramid base. Lafon recommended building the structure of local cypress timbers for their strength and resistance to decay.⁷⁶ Frank's Island Lighthouse historian Jay Riedl implies the government rejected Lafon's plan because it was not monumental enough.⁷⁷ This implication is problematic. While Lafon's plan may not have met requirements of being a monument, neither did Latrobe's first design.⁷⁸ Rather it seems the Treasury rejected Lafon's plan for a variety of cultural reasons. First, Lafon was a Creole with a French heritage.⁷⁹ Given the prevailing attitudes about race in the early nineteenth century, it seems likely Treasury officials dismissed Lafon's plan as unsuitable because of Lafon's status as a Creole. Although there is no direct evidence that race played a factor in the Treasury's decision, Creoles were often considered inferior because of their non-European heritage. Creoles were therefore believed to be less capable of producing tracts of a knowledgeable character.

⁷⁵ Fazio, 240 n41.

⁷⁶ Ibid., 233.

⁷⁷ Riedl, "Planning for the Original Lighthouse," September 26, 2007, <http://www.franksislandlight.blogspot.com> (accessed January 13, 2016).

⁷⁸ Fazio, 234-5.

⁷⁹ Frazier, 19.

The Treasury Department may also have rejected Lafon's design because of his French heritage and education. Fazio also implies the government wanted to announce the elimination of the French from the Mississippi Valley. With the United States having recently acquired the Louisiana Purchase from the French, constructing a monument designed by a French Creole ran counter to the federal government's vision for the area.⁸⁰ Additionally, Lafon used French theoretical methods in engineering his cypress tower.⁸¹ In the early nineteenth century, engineering in the United States tended to follow the British method of tried and true practical experience rather than using mathematical theory.⁸²

Lastly, and perhaps equally probable, the Treasury Department may not have trusted Lafon's design based on the engineer's personal character. As early as 1802, Lafon engaged in illicit privateering and was a close associate of the pirate Jean Lafitte.⁸³ By late 1814, a grand jury indicted Lafon for his illicit acts of piracy against the Spanish. While this indictment came almost a decade after Treasury officials dismissed Lafon's plan for the lighthouse, historian William C. Davis indicates the government was aware of Lafon's illegal activities much earlier.⁸⁴ Compounding the issue of Lafon's personal character was the fact that Lafon's son, Thomy Lafon, was a mulatto.⁸⁵ If Barthelemy's status as a Creole was not enough to concern the government, his intimacy with a negro

⁸⁰ Fazio, 232.

⁸¹ Ibid., 233 n10.

⁸² Kranakis, 1-5.

⁸³ William C. Davis, *The Pirates Lafitte: The Treacherous World of the Corsairs of the Gulf*, (Orlando, FL: Harcourt Books, 2005), 7, 32, 61, 233.

⁸⁴ Ibid., 7, 32.

⁸⁵ Russell Guerin, "Notes on Barthelemy Lafon," January 4, 2010, <http://www.russguerin.com/history/notes-on-barthelemy-lafon/> (accessed October 28, 2016).

woman most certainly flew in the face of what was publicly acceptable in the early decades of the nineteenth century.

Despite Lafon's status as a Creole and his personal character, Lafon's knowledge and design for a lighthouse at the mouth of the Mississippi River should not be disputed. As Jim Frasier notes, Lafon constructed several buildings in New Orleans including the Pedesclaux-Le Monnier House. Originally designed as a one residence, later architects have added three additional stories to the Pedesclaux-Le Monnier House attesting to the quality of Lafon's knowledge and original plan.⁸⁶

This leads to the second question. Why did the government proceed with executing Henry Latrobe's plan for the Frank's Island lighthouse against the objections of qualified contractors? This question requires a deeper analysis of the government's values. Economics undoubtedly played a major factor in the decision to proceed with the project. Since colonial times, the mouth of the Mississippi River had been known as an important point of entry into the interior of the continent. The federal government envisioned New Orleans as a major entrepôt that could aid in the nation's westward expansion and economic growth.⁸⁷ The government wished to provide safety for vessels sailing through the various passages of the Mississippi delta and the surrounding islands. The interest in commerce appears to have trumped all other concerns. As Patterson, Latrobe, and Duplessis noted, "vessels can stand close in with the land without any danger, and the distance between that and the northeast pass being small, the light would

⁸⁶ Frasier, 8.

⁸⁷ Scott P. Marler, *The Merchants Capital: New Orleans and the Political Economy of the Nineteenth Century South*, (New York: Cambridge University Press, 2013), 39-40. Douglass C. North, *The Economic Growth of the United States, 1790 – 1860*, (New York: W. W. Norton & Company, 1966), 64.

be very perceptible, and enable them to run in with confidence to a good anchorage off the bar.”⁸⁸ Additionally, the mouth of the Mississippi frequently experienced heavy fogs, which mandated the presence of a light for the safety of vessels.⁸⁹ Frank’s Island, thus “unite[d] all the advantages that can be obtained here.”⁹⁰

Aside from the commercial interests, however, it appears the Treasury Department also highly valued the knowledge of professional engineers and men of science. In the mid-1810s when the surveys were conducted, the federal government remained in want of knowledge of the natural world. They turned to those who were well respected for their knowledge in similar areas of natural philosophy and the mechanical arts. Evidence extracted from the second state-sponsored survey seemed to confirm the findings of the first survey completed 11 years earlier and validate Latrobe’s claims. Furthermore, Latrobe’s track record with the Virginia State Penitentiary, Bank of Philadelphia, and United States Capital Building undoubtedly held great sway with Treasury officials in accepting Latrobe’s opinions being the best available. Thus, in the eyes of the government, the opinions of Latrobe, De Mun and Patterson were more informed than those of Lafon and Lewis. The Treasury Department had little reason to doubt the opinions of their most trusted scientific minds.

THE DEBATE OVER NATURAL GAS LIGHTING

If Winslow Lewis’ opinion did not hold promise with the government in regards to the Frank’s Island Light, the contractor held great sway with the Treasury Department and the regional lighthouse superintendents in terms of lighting the coastal beacons. In

⁸⁸ Patterson, Latrobe, and Duplessis to Smith, November 12, 1816.

⁸⁹ Ibid.

⁹⁰ Ibid.

1816, David Melville of Rhode Island, approached the Light-House Establishment about using natural gas as a source for lighting the nation's lighthouses. Melville spoke with Lewis about introducing natural gas lighting into coastal beacons one evening and Lewis promised to raise the issue with Pleasonton the next time he was in Washington. Lewis, however, failed to follow through on his promise. Being the primary contractor for supplying the Light-House Establishment with its annual supply of spermaceti oil, Lewis was adamantly opposed to Melville's assertion that natural gas provided a brighter light because it was a direct financial threat to his own contracts with the government.⁹¹

Melville had to attend business in Washington as a designated representative of the electorate for Rhode Island in that year's presidential election. While in the District of Columbia, Melville argued natural gas would eliminate many of the problems associated with the illumination in American lighthouses such as the condensation of humid air, the high cost of oil, and the need to warm winter pressed oil to a liquid state for continuous burning.⁹² Additionally, Melville claimed natural gas produced an "increased and more certain light," than the best spermaceti oil then in use by the Establishment.⁹³ Melville secured permission to conduct an experiment with natural gas for one year at the Newport, Rhode Island Lighthouse.⁹⁴ Lewis was forced to rescind his contract for

⁹¹ David Melville, *An exposé of facts...relating to the conduct of Winslow Lewis...addressed to the Hon. The Secretary of the Treasury*, (Providence, RI: Miller & Hutchins, 1819), 7, PRHC, no. 470. HAG.

⁹² *Ibid.*, 7.

⁹³ *Ibid.*, 7.

⁹⁴ *Ibid.*, 5. S. H. Smith to Winslow Lewis, October 19, 1818, RG 26, Entry 18, Vol. 5, 94, NARA.

supplying oil to the Newport Light, under the auspices that failure to do so would look badly upon him.⁹⁵

Despite giving up the Newport light for a year, Lewis continued his fight against Melville's experiment. Lewis suggested to Melville that he might profit more handsomely if the Newport native produced a failure in the experiment. Lewis believed the Nantucket oil manufacturers would compensate Melville to the tune of \$10,000 if Melville's experiment failed.⁹⁶ Melville, however, refused to be a part of Lewis' underhanded scheme. Lewis then took a different route. Lewis wrote to Samuel H. Smith, the Commissioner of Revenue and Henry A. S. Dearborn, the regional superintendent who oversaw the Newport Light, that natural gas was unpredictable and dangerous. As representatives of the state, Smith and Dearborn accepted Lewis' opinion as more knowledgeable than Melville's and when the year on Melville's experiment expired, the government chose not to adopt natural gas for wider use throughout the Establishment.

WAXING AND WANING STATE INVOLVEMENT

Although navigation was one of the principle sciences in the early nineteenth century United States, it was not the only area in which the government engaged in scientific practice. The federal government also engaged in innovation and practical science in the areas of communication, defense, infrastructure, and surveying. As the government learned from its early trials and tribulations, its involvement in innovation and scientific practice began to improve. By the late 1830s, Army Engineers such as Colonel Joseph G. Totten, Brevet Lieutenant Colonel James Kearney, Major William Turnbull, Lieutenant Robert E. Lee, and Lieutenant Joseph Mansfield had made a name

⁹⁵ Melville, 46.

⁹⁶ Ibid., 47.

for themselves constructing coastal defenses and canals and assisting with other national public works projects.⁹⁷ The Coast Survey produced its first chart of Bridgeport Harbor.⁹⁸ The Light-House Establishment had experimented with numerous lamps, lenses, fuels, and other apparatuses for use in coastal navigation.⁹⁹ And Congress had established the Bureau of Weights and Measures for regulating the nation's standards of measurement.¹⁰⁰ Historian Hugh Slotten argues with the establishment of the Bureau of Weights and Measures, Congress recognized the scientific connection between the standardization of weights and measures and the Coast Survey. This realization led Congress to reappoint Ferdinand Rudolph Hassler as the Superintendent of the Coast Survey.¹⁰¹ In 1818, Congress removed the Coast Survey from Hassler's oversight arguing the work was "too expensive and too slow" under civilian management. Congress felt the Navy could do the work more efficiently, but this proved incorrect.¹⁰²

Despite these advances, the federal government still failed to fully embrace existing innovations that could benefit the public good. For instance, on March 10, 1837, at the request of Congress, Levi Woodbury, Secretary of the United States Treasury

⁹⁷ William Turnbull, *Reports on the Construction of the Piers of the Aqueduct of the Alexandria Canal across the Potomac River at Georgetown, District of Columbia*, (1838; repr., Washington DC: GPO, 1873). Johnson, "Material Experiments," 61-65. Schubert, 24. Barber and Gann, 37-51. Parkman, 17-18. Kanarek, 15, 23.

⁹⁸ NOAA, OCS, "Important Dates in History," <http://www.nauticalcharts.noaa.gov/staff/important-dates.html>, (accessed July 24, 2015). Aaron L. Shalowitz, *Shore and Sea Boundaries* Vol. 2, (Washington, DC: GPO, 1964), 13, 89, 276 n13, 552, 564.

⁹⁹ Melville, 7-11. S. H. Smith to Winslow Lewis, October 19, 1818, RG 26, Entry 18, Vol. 5, 94, NARA.

¹⁰⁰ Hugh Richard Slotten, *Patronage, Practice, and the Culture of American Science: Alexander Dallas Bache and the U.S. Coast Survey*, (New York: Cambridge University Press, 1994), 50.

¹⁰¹ *Ibid.*, 50.

¹⁰² *Ibid.*, 49-50.

Department, sent a “circular to certain Collectors of Customs, Commanders of Revenue Cutters, and other persons” possessing knowledge of telegraphic science “with the view of procuring from the most intelligent sources such information as would enable Congress, as well as the Department, to decide on the propriety of establishing a system of telegraphs for the United States.”¹⁰³ The telegraph in which Woodbury inquired was a visual telegraph that required a line of site between the signalers and receivers. Messages were transmitted, or “telegraphed,” through a series of flags, banners, and colored balls. Once the signal was received by a station, the message was then retransmitted to the next station down the line. Some historians have called this the “pre-telegraph” to distinguish it from Samuel F. B. Morse’s electromagnetic telegraph, but this designation is ahistorical.¹⁰⁴ In the nineteenth century, the telegraph simply referred to any system relaying messages, with or without electricity. Although a few of the respondents to Woodbury’s inquiry mentioned the electromagnetic telegraph being tested by Samuel F. B. Morse, the predominant systems then in operation were those employing a semaphoric code.

DEBATING THE TELEGRAPH

Captain David Porter, Sr. proved the utility of the semaphoric telegraph in America several decades earlier when he erected a flagstaff on Baltimore’s Federal Hill

¹⁰³ Levi Woodbury, “Circular to certain Collectors of the Customs, Commanders of Revenue Cutters, and other persons,” March 10, 1837 in United States Treasury, *Telegraphs for the United States: Letter of the Secretary of the Treasury Transmitting a Report upon the subject of a System of Telegraphs for the United States*, 25th Cong., 2d sess., 1837, H. Doc. 15. Levi Woodbury to the Honorable J. K. Polk, December 6, 1837 in H. Doc. 15.

¹⁰⁴ Richard A. Schwarzlose, *The Nation’s Newsbrokers Volume 1: The Formative Years: From Pretelegraph to 1865*, (Evanston, IL, Northwestern University Press, 1989).

in 1796 to communicate the arrival of ships into port.¹⁰⁵ Local merchants subscribed to Porter's telegraph service for \$2.50 per annum and in return received a private signal flag assigned to their specific ship.¹⁰⁶ As a ship approached the port, the ship's crew raised the merchant's private colors for Porter's observatory to see. Porter, or his observer, would then fly the private flag from the observatory to communicate the ship's arrival to the docks. These private signals kept the system local. Unless the merchant purchased extra flags and subscribed to the telegraph service in other ports, the private signal was only relevant to the merchant's home port.

In addition to the private signal flags, Porter's system also utilized a series of generic flags, banners and balls.¹⁰⁷ Porter reported the arrival of foreign vessels, non-subscribing ships, and news from the sea using these non-descript symbols. For example, Porter raised a "pendant" when a brig approached and a burgee, a short wide swallow-tailed triangle triangle, signal the arrival of a topsail schooner.¹⁰⁸ Porter's signals were likely based on telegraphic systems he encountered in his 20-plus years at sea. After the American Revolution Porter captained the United States Revenue Cutter *Active*, where he frequently interacted with French and British naval officers.¹⁰⁹ Additionally, Porter frequently sailed as a private shipmaster to the Caribbean, where marine observatories

¹⁰⁵ M. V. Brewington, "The Observatory," *Maryland Historical Magazine* 44, no. 2 (1949): 101-10.

¹⁰⁶ David Porter, "Proposal," *Federal Gazette and Baltimore Daily Advertiser* (Baltimore, MD), March 16, 1797, 4. Brewington, 105.

¹⁰⁷ David Porter, "To the Merchants of Baltimore & Fells Point and Citizens in General," *Federal Gazette & Baltimore Daily Advertiser* (Baltimore, MD), August 15, 1797, 4.

¹⁰⁸ Brewington, 104.

¹⁰⁹ *Ibid.*, 102.

had existed since at least the mid 1500s.¹¹⁰ A marine observatory was a land based station that communicated with ships either passing at sea or arriving in port. The structure of the marine observatory station could range from a single flagstaff from which the signals were flown to lookout tower with many of the observatories sitting under a cupola atop a port's merchant exchange building.

Eleven years after Porter established his marine observatory, merchants and city officials in Portland, Maine authorized Captain Lemuel Moody to erect a similar system to benefit commerce and spur economic growth of the local community. Moody used Porter's system as a basis for his own, but he added colored balls to the flags and banners used to communicate non-subscribing ships and other news. This addition continued the "Americanization" of the marine telegraph. Other ports followed. Savannah established a signal line running from the Tybee Island lighthouse to the city docks by 1812.¹¹¹ New York adopted the optical telegraphic system of Captain Samuel C. Reid in 1821 and Key West began announcing port arrivals in 1829.¹¹² By the 1830s, marine telegraphs were

¹¹⁰ Alejandro de la Fuente, *Havana and the Atlantic World in the Sixteenth Century*, (Chapel Hill: UNC Press, 2011), 1.

¹¹¹ "Lamentable," *City Gazette and Commercial Daily Advertiser* (Charleston, SC), October 5, 1812, 3.

¹¹² Samuel Reid to Levi Woodbury, April 1837 in H. Doc. 15. "New Telegraph," *New York Spectator* (June 29, 1821), 2. Robert Greenhalgh Albion, *The Rise of New York Port*, (New York: Charles Scribner's Sons, 1939), 217. "From the Key West Register," *Eastern Argus* (Portland, ME), February 24, 1829, 2. "Shipping Intelligence," *Eastern Argus* (Portland, ME), April 13, 1830, 3.

present in nearly every major American seaport.¹¹³

Many of the respondents to Woodbury's inquiry acknowledged the utility of the telegraph with a "national point of view."¹¹⁴ As Captain Andrew Mather, commander of the United States Revenue Cutter *Wolcott* stated in his reply, "As to the utility of a telegraph from the seat of Government to the principal seaports and commercial cities, I believe there is but one opinion. There is no doubt of its great importance to the commercial interests, and its importance in time of war is incalculable."¹¹⁵ Moody believed a concise message could be sent more than 100 miles between Portland and Boston in less than 20 minutes.¹¹⁶ Mather opined the rate of conveyance would be even faster at "six to eight miles per minute, and in urgent cases eight to ten miles per minute."¹¹⁷ Mather's viewpoint was seconded by Signor Penistri, an Italian living in New Orleans at the time. Penistri's experience with the Italian telegraph during its war against Austria in 1830 noted telegraphic messages ran "one hundred miles in about 11 minutes, more or less, according to the communication."¹¹⁸ In England, the Holyhead telegraph was so efficient, it could transmit a message 128 miles to Liverpool in five minutes; a

¹¹³ According to various advertisements for the marine telegraph by John Rowe Parker in numerous New England newspapers, by 1830 marine telegraph stations existed in Alexandria (VA), Baltimore (MD), Boston (MA), Charleston (SC), Key West (FL), Nantucket (MA), New Haven (CT), New London (CT), New Orleans (LA), Newburyport (MA), Newport (RI), Norfolk (VA), Portland (ME), Portsmouth (NH), Providence (RI), Salem (MA), Savannah (GA), and the Vineyard (MA) with relay stations at important points in between ports such as Montauk Point (NY), Point Judith (RI), and Sandy Hook (NJ). It is conceivable that the telegraph was adopted in other ports such as Lewes (DE), Cape May (NJ), St. Augustine (FL), and Wilmington (NC).

¹¹⁴ John R. Parker to Woodbury, September 1, 1837 in H. Doc. 15.

¹¹⁵ Mather to Woodbury, September 20, 1837 in H. Doc. 15.

¹¹⁶ Moody to John Anderson, August 4, 1837 in H. Doc. 15.

¹¹⁷ Mather to Woodbury, September 20, 1837.

¹¹⁸ S. Penistri to Martin Van Buren, April 28, 1837 in H. Doc. 15.

rate of almost 26 miles per minute.¹¹⁹ The Holyhead line was the most renowned among mariners in the late eighteenth and early nineteenth centuries; however, despite its remarkable efficiency, the Holyhead telegraph was not the fastest. On January 5, 1805, the *Providence Patriot* (Rhode Island) reported M. Vloers, a Belgian physician, could “transmit communications from Antwerp to Rome, in eighteen minutes;” by telegraph.¹²⁰ If Vloers’ claims were correct, his message travelled more 940 miles in less than one-third an hour; a rate eclipsing 52 miles per minute and more than double that of Holyhead.

Woodbury also sent the circular to the Franklin Institute, one of the leading centers for the promotion of mechanical arts in the early nineteenth century. The Institute recommended, “the propriety of causing two telegraphs to be erected, in which careful experiments may be made on all the points that bear upon the general question submitted to him by the House of Representatives.”¹²¹ One of these two telegraphs would be erected along the coast connecting seaports with one another, such as the line contemplated by John Rowe Parker, “from the [Boston] Observatory to Point-Judith” in Narragansett, RI via Cape Cod, Nantucket, and the Vineyard.¹²² The other line proposed by the Institute would be established for overland communication.

Some individuals responded negatively to Woodbury’s request. William W. Polk of New Haven Connecticut, for instance, “doubt[ed] whether many advantages would be derived from such an institution in a time of peace by either the public or the

¹¹⁹ “Telegraphic Signals,” *The Eastern Argus* (Portland, ME), December 18, 1827.

¹²⁰ “Untitled,” *Providence Phoenix* (Providence, RI), January 5, 1805, 4.

¹²¹ R. M. Patterson to Woodbury, April 18, 1837 in H. Doc. 15.

¹²² “Marine Telegraph,” *Providence Patriot and Columbian Phoenix* (Providence, RI), November 10, 1827, 2.

government,” and that if any benefit did exist, it would “by no means commensurate with the expense.”¹²³ Messrs. Servel and Gonon argued the system would be inexpedient noting that in Russia it “often require[d] five or six hours to communicate thirty or forty words” over “a distance of only seven leagues.”¹²⁴

Despite the overwhelming support for the telegraph, the United States government did not invest in the system. Woodbury laid the information before Congress, but Congress failed to act upon the inquiry it had initially requested. Congress’ inaction may have resulted from its recognition of the advances in telegraphic science. Morse lobbied for his recently invented electromagnetic telegraph arguing, “telegraphs constructed on the ordinary principles” were “*useless the greater part of the time.*”¹²⁵ Morse noted, “in foggy weather, and ordinarily during the night, no intelligence can be transmitted.”¹²⁶ He also claimed, “even when they can transmit, much time is consumed in communicating but little, and that little not always precise.”¹²⁷ Morse then went on to discuss the advantages of his “entirely new mode of telegraphic communication.”¹²⁸

In a follow up letter of November 28, 1837, Morse wrote Woodbury relaying the results of his experiment. Morse and his associates had sent a message over ten miles with “perfect” results and Morse claimed, “our success has, thus far, been complete.”¹²⁹ Morse had “no doubt of its effecting a *similar result at any distance.*”¹³⁰ Consequently,

¹²³ Polk to Woodbury, October 1, 1837 in H. Doc. 15.

¹²⁴ “A brief explanation of the advantages offered by the system of unilversal [sic] and perpetual telegraphs: the invention of Messrs. Servel and Gonon,” in H. Doc. 15.

¹²⁵ Morse to Woodbury, September 27, 1837, in H. Doc. 15. Emphasis in original.

¹²⁶ Ibid.

¹²⁷ Ibid.

¹²⁸ Ibid.

¹²⁹ Ibid.

¹³⁰ Morse to Woodbury, November 28, 1837, in H. Doc. 15. Emphasis in original.

Morse requested an audience with Congress to demonstrate his electromagnetic telegraph, asking Woodbury, “*How late in the session can I delay my visit, and yet still be in season to meet the subject of telegraphs when it shall be presented by your report?*”¹³¹

RENEWED INTEREST IN INNOVATION AND SCIENCE

If Congress did not follow through on the telegraph, it did show interest in other areas of innovation and practical science. A year after Woodbury’s inquiry into the telegraph, Congress passed two very important pieces of legislation regarding the state’s involvement in science. The first was a resolution to purchase a French made lenticular apparatuses for trial in American lighthouses. The Secretary of the Treasury commissioned United States Navy Captain Matthew Calbraith Perry for the task. Due to ongoing manufacturing problems in France’s glass industry, the lenses were not shipped to the United States for another two years.¹³² The Treasury contracted with the French to install the lenses, as they were more complicated than anything currently in use in the United States Light-House Establishment. The installation was completed in the winter of 1840-1.

The second piece of legislation was the Army Reorganization Act of 1838. The Act established the Corps of Topographical Engineers separate from the Army Corps of Engineers and repealed the General Survey Act of 1824.¹³³ The Topographical Engineers had existed within the larger Corps of Engineers for decades surveying the nation’s rivers, harbors, and other sites for public works. Until the passage of the Army Reorganization Act, however, one-third of the Topographical Engineers were civilians.

¹³¹ Ibid.

¹³² Thomas A. Tag, “Fresnel Lens Makers Part II: The Sautter Lens Works Producers of the Fresnel Lens,” *The Keeper’s Log* 21, no. 3 (Summer 2005), 26-9.

¹³³ Schubert, 24.

The Act ended the Topographical Corps' reliance on civilian engineers by prohibiting the Corps' hiring of civilians for surveys. The Act achieved this measure by increasing the number of Topographical Engineers, all drawn from the officer ranks, within the Corps.¹³⁴

With the repeal of the General Survey Act of 1824, the Topographical Corps' focused changed from surveying the nation's rivers and harbors to surveying and constructing sites of public works. This included proposed sites for lighthouses and other navigational aids. The Topographical Engineers had previously interacted with the Light-House Establishment conducting site surveys for potential lighthouses, the first of which came in 1834 with survey of the Brandywine Shoals in Delaware under Captain Hartman Bache.¹³⁵

Additionally, in 1842, the Corps was given the responsibility of assessing the Light-House Establishment and the condition of the nation's aids to navigation. This task was assigned to Lieutenant I.W.P. Lewis, the engineer who surveyed the Carysfort Reef and later designed the lighthouse placed at the reef.¹³⁶ The new duty of assessing the Light-House Establishment increased the interaction between the Establishment and the Corps of Engineers, but the relationship was contentious. At issue were concerns over the management, or mismanagement, of the Establishment and how the state might improve

¹³⁴ Ibid.

¹³⁵ Ibid., 28.

¹³⁶ I. W. P. Lewis to Walter Forward, January 31, 1843, in United States Congress, *Examination – Light-House Establishment: Letter from the Secretary of the Treasury*, by Walter Forward, 27th Cong., 3rd sess., 1843, H. Doc. 183, 4. Pleasonton to Winslow Lewis, March 21, 1842, RG 26, Entry 18, Vol. 17, 348, NARA. Pleasonton to Winslow Lewis, July 2, 1838, RG 26, Entry 18, Vol. 13, 288-9, NARA.

coastal navigation. Lewis' report was very critical of Pleasonton and the Fifth Auditor's management of the Light-House Establishment.

MORE WAXING AND WANING

As evidence of the state's waxing and waning involvement in innovation and practical science, Congress failed to act on either the Fresnel lens or Lewis' report. Stephen Pleasonton, the aforementioned Superintendent of the Light-House Establishment, stood ready to purchase more Fresnel lenses after the initial installation and experiments were conducted, "if it be thought proper by Congress to authorize any more."¹³⁷ Pleasonton even suggested purchasing more lenses for additional experiments on Long Island.¹³⁸ Yet, as Pleasonton acknowledged years later, Congress "determined to take no action upon it, and none as far as I can learn, has ever been taken on it since."¹³⁹

Lewis' report met a similar fate from Congress. Lewis condemned Pleasonton's management of the Establishment, but Congress did little to rectify the situation. Congress sent a commission, Lieutenants Thornton Alexander Jenkins and Richard Meade Bache, to Europe to study how Britain and France managed their lighthouses, but Pleasonton remained in his role as Superintendent of the Light-House Establishment and Congress continued to underfund lighthouse appropriations. The previously mentioned Carysfort Reef Lighthouse provides an excellent example. Congress originally

¹³⁷ Pleasonton to the Honorable John P. Kennedy, December 28, 1841, New Jersey Lighthouse Society, <http://www.njlhs.org/njlight/firstfre.htm> (accessed April 5, 2013).

¹³⁸ United States Light-House Board Establishment, "Progress of Improvement in American Lights," in United States Light-House Board Establishment, *Compilation of Public Documents, and Extracts from Reports and Papers Relating to Light-Houses, Light-Vessels, and Illuminating Apparatus, and to Beacons, Buoys, and Fog Signals, 1789 to 1871*, (Washington: GPO, 1871), 325.

¹³⁹ United States Treasury Department, *Light-Houses: Letter from the Secretary of the Treasury...in Reply to a Report Made to Congress by the Light-House Board*, by Thomas Corwin, 32nd Cong., 1st sess., 1852, H. Doc. 88, 3.

appropriated only \$20,000 for the Carysfort Reef Lighthouse. Pleasonton requested further appropriations noting the lighthouse would cost four times the Congressional authorizations.¹⁴⁰ Congress appropriated an additional \$40,000 the following year, but it was still insufficient. In all the state spent over \$105,000 on the lighthouse.¹⁴¹ Congress' continual underfunding of the Light-House Establishment not only prevented Pleasonton from purchasing additional Fresnel lenses on his own, it also maintained the status quo management of the Establishment.

Congress' response to the Lewis report, however, was not immediate. The process of authorizing the commission fell victim to the bureaucracy of the government. Congress appeared content with inaction, much as it had after it procured the two experimental Fresnel lenses. Because of the federal government's slow bureaucratic process, three years lapsed between I.W.P. Lewis' report and Congress' reluctant authorization of the commission. In the interim, mariners continued their complaints against the Light-House Establishment. Edmund Blunt, an Assistant Superintendent of the Coast Survey, and his brother George Blunt, publisher of *The American Coast Pilot*, spearheaded the mariners' efforts and became the face of the political opposition to Pleasonton's administration of the Establishment.¹⁴²

¹⁴⁰ Pleasonton to Winslow Lewis, July 14, 1838, RG 26, Vol. 13, 316, NARA.

¹⁴¹ Rhein, 120.

¹⁴² United States Congress, *Documents in Relation to the Light-House Establishment*, March 3, 1838, by E. & G. W. Blunt, 25th Cong., 3rd sess., 1838, S. Doc. 258. Pleasonton to Ingoldsby W. Crawford, December 12, 1837, "Drafts of Pleasonton Correspondence," RG 26, Entry 17H, NARA-II. Pleasonton to Winslow Lewis., December 14, 1837, RG 26, Entry 18, Vol. 12, 471-2, NARA. Pleasonton to Messrs Charles Morgan & Co., December 14, 1837, "Drafts of Pleasonton Correspondence," RG 26, Entry 17H, NARA-II

Lieutenants Jenkins and Bache were skilled surveyors and senior officers in the Coast Survey. Jenkins graduated at the head of his class at West Point in 1834, and as a result, was commissioned to the Coast Survey that same year.¹⁴³ Bache joined the Coast Survey four years later, while it was still under the superintendency of Ferdinand Rudolph Hassler. Bache was the brother of Alexander Dallas Bache, who took charge of the Coast Survey when Hassler passed away. Jenkins and Richard Bache spent a year abroad conducting their investigation of the British and French lighthouses. In Great Britain, Jenkins and Bache paid particular attention to the lighthouses in Ireland and Scotland, where the climate and geography played a more significant role. Both men recommended wide scale adoption of the Fresnel lens and the creation of a lighthouse board made up of military officers and scientifically minded men to oversee the Light-House Establishment.¹⁴⁴ Additionally, Jenkins and Bache confirmed the opinions of Lt. I. W. P. Lewis and the Blunt brothers; expressing the lighthouses in the United States were “inferior to all they had seen in Europe.”¹⁴⁵

Congress acted on Jenkins and Bache’s recommendations, but once again the bureaucratic pace of change slowed the process. The state’s first action transferred the responsibility for lighthouse construction to the Corps of Engineers.¹⁴⁶ No longer would the Treasury Department be responsible for soliciting, accepting, and overseeing the

¹⁴³ “Rear Admiral Thornton A. Jenkins, U.S.N.,” *The Virginia Magazine of History and Biography* 1, no. 3 (January 1894), 338.

¹⁴⁴ Pleasonton to Thomas Corwin, March 8, 1852 in United States Treasury, *Light-Houses: Letter from the Secretary of the Treasury...in Reply to a Report Made to Congress by the Light-House Board*, by Thomas Corwin, 32nd Cong., 1st sess., 1852, H. Doc. 88, 3.

¹⁴⁵ Pleasonton to Corwin, March 8, 1852.

¹⁴⁶ Amy K. Marshall, *Frequently Close to Peril: A History of Buoys and Tenders in U.S. Coastal Waters, 1789 – 1939*, (MA thesis, East Carolina University, 1997), 12.

contracts for new lighthouses. That task was now in the hands of a group with expertise in engineering and practical science. This transfer of responsibility limited the Treasury Department's role to the administration of Congressional appropriations.

The Corps of Engineers had been created for similar concerns in constructing coastal defenses and surveying the nation's waterways had proven its worth in these areas, as well as in advising on privately built internal improvement projects. In the eyes of learned men, the transfer of this responsibility represented new possibilities for practical science and innovation as many of the agencies created by Congress and the federal government created scientific agendas for resolving problems of commerce and navigation.

While Congress removed the responsibility for lighthouse construction from oversight by the Treasury Department, the rest of the Light-House Establishment remained under the superintendency of the Fifth Auditor. Congress took another four years before finally authorizing the establishment of a lighthouse board made up of scientifically-minded men as originally recommended by Jenkins and Bache's report. In authorizing the Light-House Board, Congress specifically mentioned the scientific nature of the enterprise and the qualifications expected of the board's members in stating, "a board...to be comprised of two officer of the Navy of high rank, two officers of Engineers of the Army, and such civil officers of scientific attainments..." The Light-House Board assembled the best scientific minds in the United States including, Alexander Dallas Bache, Superintendent of the Coast Survey, and Joseph Henry, Superintendent of the Smithsonian Institution. Other members, such as Commander Samuel F. Du Pont of the United States Navy, Lieutenant Colonel James Kearney of the

Topographical Engineers, and Lieutenant Thornton A. Jenkins of the Coast Survey all had extensive education and practical training in mathematics, surveying, and other sciences. The creation of the Light-House Board ended the Treasury Department's tenure as superintendent of the Light-House Establishment.

One of the first changes made by the newly established Light-House Board was the importation of the French made Fresnel lighthouse lens. Jenkins and Bache had been impressed with the lens' performance in both England and France and testimony by mariners in the United States indicated the experimental lens installed at Navesink Highlands in New Jersey was the best light in the United States. Lieutenant David Dixon Porter commented the twin lights at Navesink were the "only perfect lights on our coast, not only as regards regularity in lighting, but in the brilliancy of the light."¹⁴⁷ Captain George Barker of Boston considered the French lens at Navesink to be "among the best lights on our sea-coast."¹⁴⁸ Packet ship captain William H. Russell noted, "with the exception of the lights on the Highlands of Navesink, near the entrance to New York, I do not know of any light along the entire line of our coast, which will bear any comparison with those of England."¹⁴⁹ By 1860, the Light-House Board had installed Fresnel lenses in all of the lighthouses in the United States including the lighthouse at Carysfort completed in 1852.

¹⁴⁷ Porter to Jenkins, May 1851.

¹⁴⁸ Barker to The Light-House Board, August 29, 1851, in United States Congress, *Report of the Officers Constituting the Light-House Board*, 32d Cong., 1st sess., 1852, Ex. Doc. 28, 219.

¹⁴⁹ Russell to Lt. Thornton A. Jenkins, August 27, 1851, in Ex. Doc. 28, 220.

CONCLUSION

The Carysfort Reef was the recipient of the state's innovation and knowledge leading up to the American Civil War. The marking of the Carysfort Reef, both physically and visually, represented the best the federal government had to offer. More than one hundred and sixty years after its construction, the Carysfort Reef Lighthouse remains as a testament to the government's achievements in innovation and its construction of scientific knowledge. Yet, while Carysfort is a testament to the government's accomplishments before 1860, the state's involvement in innovation and scientific practice went through many trials and tribulations. The federal government followed an inconsistent, often waxing and waning path of engagement similar to their involvement in building infrastructure, internal improvements, and public works.¹⁵⁰

The trials and tribulations of the government's venture into innovation and science proved to be a great learning experience. Many of these trials resulted from the government's unpreparedness for entering scientific practice so soon after the nation gained its freedom from Britain and established a strong centralized government. At other times, defining expertise, identifying the experts, and constructing knowledge created political situations that shaped the federal government's involvement in science. By the time Carysfort Reef was marked and the lighthouse at the reef built, the federal government was fully immersed in innovation and scientific practice.

The state established government agencies, including the Army Corps of Engineers, the Coast Survey, and the Light-House Establishment to deal with the

¹⁵⁰ For more on the state's waxing and waning involvement in internal improvements and public works, please see John Lauritz Larson, *Internal Improvement: National Public Works and the Promise of Popular Government in the Early United States*, (Chapel Hill, NC: UNC Press, 2001).

commercial and navigational problems that plagued the nation. While the state only specified the objectives of these institutions, those in charge of the agencies adopted agendas that either engaged in or promoted the use of practical science and innovation to resolve those problems. These individuals, however, represented the government and their decisions often became policy, or at the very least were viewed by others as the policies of the government.

The government's involvement in innovation and the construction of knowledge was also inconsistent; waxing and waning as the state's priorities changed. Those priorities were sometimes dictated by need, as was the case in constructing the Frank's Island Lighthouse. Other times, the priorities were determined by financial and political concerns. The Treasury Department approved David Melville's request to experiment with natural gas lighting in coastal navigation because Melville argued natural gas was cheaper and more efficient. Politics, however, prevented natural gas from being adopted, despite its advantages. Still at other times, the government's priorities reacted to public outcry, such as the mariners complaints against the Light-House Establishment. Regardless of what influenced the state's priorities in innovation and science, men such as Benjamin Henry Latrobe, Lewis De Mun, Winslow Lewis, David Melville, Levi Woodbury, and Lieutenants Thornton A. Jenkins and I. W. P. Lewis made the federal government a major factor in the construction of knowledge in the early American nineteenth century. The longevity of the Carysfort Reef Lighthouse stands as evidence of that fact.

CHAPTER 7

CONCLUSION

The intersection of science, technology, commerce, and the state is an important relationship in the history of the United States, especially in the late eighteenth and early nineteenth centuries when the fledgling nation was still developing. The nation's need for a strong economy pushed the federal government into accepting responsibility for preserving and protecting commerce. Despite the nation's westward expansion to the Pacific in the first half of the nineteenth century, maritime shipping remained the principle means of commerce. Shipping acted as a gateway, providing access to the global network of exchange. Protecting commerce, therefore, meant protecting maritime shipping and the state assumed that responsibility with the advent of the Light-House Establishment, the Coast Survey, and the Army Corps of Engineers. These agencies in turn pursued scientific agendas to meet their obligations.

The path to scientific expertise, however, was not an easy one. The government's involvement with science and innovation was filled with many challenges. The unexpected difficulties at Portland Head and Cape Henry and the failure at Frank's Island highlighted the government's unpreparedness for its new responsibilities. The War of 1812 delayed the Coast Survey and temporarily interrupted the installation of Winslow Lewis' patented lamp and reflector system, but it illustrated the expertise of the Army Corps of Engineers work in coastal defenses. These trials and tribulations proved to be a great learning experience as witnessed by the longevity of the Carysfort Reef Lighthouse.

Additionally, the government's involvement often waxed or waned with the nation's immediate priorities. Congress authorized the agencies that undertook building the nation's infrastructure, but then often failed to appropriate enough funds for their successful operation. Congress also left these agencies to determine their own agendas until it became necessary for the legislative body to intervene. Hassler's removal as Superintendent of the Coast Survey in 1816 and his later reappointment in 1832 as well as Congress' dealing with the Army Corps of Engineers and Light-House Establishment between 1837 and 1850 help illustrate the government's waxing and waning involvement in science and innovation.

The government's involvement in innovation and practical science was also shaped by the republican ideology of the early United States. Republican values influenced how Superintendents managed their agencies. Most attempted to adhere to principles of prudent management, honesty, civic duty, and promoted the idea of a self-reliant nation. Superintendents, such as the Light-House Establishment's Stephen Pleasonton, worked diligently to weed out corruption. They did their best to practice prudence in their management through caution and thrift. The superintendents, and many of the individuals who worked for them, also felt it was their civic duty to promote the nation's self-reliance in innovation and science. The Treasury, for instance, admonished Hassler in the 1830s for continuing to use foreign equipment and suppliers for the Coast Survey. This idea of self-reliance generated many new inventions including Captain Stansbury's diskpile foundation for offshore structures and improved methods for coastal illumination. When Army Corps Engineers I. W. P. Lewis and George Gordon Meade invented new apparatuses for illuminating the coast, they chose not to patent their

inventions, but instead gave them to the government without profiting because their civic duty was greater than their desire for fame or wealth.

The United States Light-House Establishment played an important role in the creation of scientific knowledge, particularly in the areas of illumination and chemical analysis of various fuels. These scientific endeavors produced new knowledge about the natural world. Additionally, the engineering and surveying needs of the Establishment resulting in the agency contributing to those fields through their interactions with the Corps of Engineers and Coast Survey. The dual role of lighthouse keepers as telegraph agents also put the Establishment in position to contribute to the advancement of communications. The Establishment's engagement in constructing knowledge and performing science, thus placed the agency at the forefront of American science prior to the outbreak of the Civil War. As such, the Light-House Establishment deserves to be recognized as one of the leading scientific enterprises in the United States alongside the Army Corps of Engineers and Coast Survey.

The Light-House Establishment employed a diverse lot of laborers. The men, women and children who performed science for the Establishment included both the formally educated and the everyday tinkerers. These individuals did more than make observations and record their findings. They engaged in the construction of scientific knowledge. The Light-House Establishment was responsible for dozens of innovations, including clockwork mechanisms, new engineering methods, improved lamps and reflectors, and many other devices designed to improve coastal navigation.

The Light-House Establishment provide the perfect opportunity for men and women to engage in science. The coastal and harbor environments provided the perfect

space to pursue experiments and learn about the natural world. These experiments turned early American seaports in to scientific laboratories and workshops for the practical arts. Ports were more than gateways of exchange or end nodes on a global trading network. Early American ports were centers for creating, exploring and obtaining knowledge. They were field schools for those who wished to learn about science, the arts, and the natural world.

The environment also played a role in shaping both the government's involvement in innovation and practical science and science's interaction with commerce. Government officials, inventors, and other individuals interested in advancing science and the arts viewed the environment as an adversary. These individuals sought to tame the environment and thus approached the natural world with an antagonist attitude. The landscape was sort of a manifest destiny; something that must be conquered to prove Americans' dominance in nature. The romantic literarists attempted to change society's perception of nature and, but those engaged in scientific practice remained steadfast in their hostility towards the environment.

The natural world also provided American with the means for overcoming environmental challenges. The extracted natural resources from the land to solve everyday problems. In the process, these individuals gained valuable knowledge that not only advanced their understanding of the natural world, but also of science and the arts.

The environment was an unrelenting challenge and often combating the constantly changing natural world was beyond the capital ability of individuals. The federal government necessarily had to intervene. The state possessed both the knowledge and resources for taking on projects concerning the environment. This expertise was then

passed on to individuals and local communities through the construction of infrastructure. Internal improvements became a responsibility of the federal government as a result of its expertise as much as it did for the government's ability to commandeer the necessary resources. Additionally, as the government expanded its role in dealing with the environment, they sought to simplify nature. One landscape was treated the same as another indicating the lessons learned at Cape Henry, Frank's Island, and Portland Head may not have been learned after all. The government chose Republican values over best practices, which often led to complications and failures.

As the nation's economic interests increased, so did the challenges that needed to be addressed. Despite the westward expansion, eastern seaports remained the anchor of American commerce. Commercial problems were shipping problems. These problems included the British impressment of American sailors, reefs, shoals, and other underwater hazards, and the loss of income from ships sitting idly in port with no place to sail and no cargo to load. Those concerned with commerce and the economy used science and the practical arts to solve everyday commercial problems. Many of these problems were seen as matters "of serious importance."¹

Protecting the lives of mariners was one of the most important issues for American commercial interests. The loss of life had a great impact on local communities from the personal tragedy felt by those affected to the economic loss associated with a reduced labor pool for working the ships, docks, and other commercial interests. The loss of cargo was also important as the loss of goods had a more direct impact on the economy. Cargoes lost as a result of shipwrecks correlated to losses in profits, customs

¹ United States Congress, *Breakwater – Crow Shoal – Pier and Light-House*, 25th Cong., 2nd sess., 1838, H. Doc. 433, June 18, 1838, 1.

duties, and wages. These financial losses were necessary to keep the economy churning and the loss of a single ship, such as *The Union* could bankrupt a local merchant or ship owner.

Practical science and mechanical arts were necessary to protect commerce and provide safe passage into and out of the nation's harbors. Early on this task was taken up by individuals who had an interest in commerce. Men, such as Lewis Brantz and Lemuel Moody charted the coasts and local harbors. Others, including Winslow Lewis and David Melville, innovated improvements to navigation through better illumination or invented entirely new devices, all for the purposes of advancing the nation's economy. The government relied heavily on individual citizens to produce this kind of science, however, by mid-century, the government began relying more heavily on its own scientific enterprises. The Coast Survey began providing charts and maps for selecting lighthouse sites and the Corps of Engineers were constructing breakwaters, lighthouses, and public piers.

This shift required the government agencies to collaborate with each other. In order to build the breakwaters, lighthouses, and public piers used to protect and facilitate the nation's commerce, the Corps of Engineers needed to understand the various elements of the natural world. The Corps turned to the Coast survey for information on tides, currents, winds, and the makeup of the ocean floor which the Survey had gained through their scientific studies of the harbors and coastal inlets. The Corps of Engineers also learned through their own work as they built the infrastructure of the ports. Commerce served as the underlying and unifying principle.

In the private sector, entrepreneurs sought to improve port efficiencies and they turned to science and the arts to advance their goals. The advanced reporting of ship arrivals through the marine telegraph, for instance, made it possible for merchants and ship owners to pre-arrange unloading of cargoes, sell the incoming goods, and identify cargos for the next voyage. The advanced notification reduced the amount of time ships lay idle in port resulting in a faster return to the sea where ships and crews made their money. An idle ship makes no money. The reduction in port idle time could average as much as two weeks.

This study has provided just one way to examine the intersection of science, technology, commerce, and the state in the early nineteenth century United States. I have focused on the period between the ratification of the United States Constitution and the American Civil War because science, technology, and commerce changed dramatically in the face of railroad expansion after the war and because the federal government held little power prior to the Constitution. Before the Constitution, each state pursued individual economic and scientific agendas most likely resulting in an incoherent narrative.

Additionally, my examination centers around the Army Corps of Engineers, the Coast Survey, and the Light-House Establishment. These were the first agencies established by the federal government to work towards the betterment of commerce and the economy. In an age when maritime commerce still dominated the economy, it should not be a surprise that these agencies focused their energies on improving navigation. Navigation in itself was a science, however, these agencies turned to the natural world, the mechanical arts, and the practical sciences of engineering and surveying to

accomplish their objectives. Those objectives primarily consisted of providing safe passage for ships sailing into and out of America's commercial ports.

Lastly, I have focused almost exclusively on the Atlantic states. Gulf states and the Midwest receive some attention, but the majority of the study is on the eastern seaboard's commercial centers. This is not intended to discount the contributions of the Pacific west, but rather to recognize the West was just beginning its development in the decade immediately preceding the American Civil War. The West therefore offered a very different narrative.

There are other ways to examine the intersection of science, technology, and commerce in the early United States. While this study has examined the intersection through maritime interests because of the dominance of maritime trade on commerce and the economy, one might also choose to look at the intersection of science, technology, and commerce through agriculture as Joyce E. Chaplin does in *An Anxious Pursuit*. Chaplin's study looks at how agricultural innovations impacted commercial growth in colonial America and the early United States republic.² Similar to how maritime interests dominated trade, agricultural products and food stuffs were the dominant products in commercial markets.

In terms of the science and arts studied here, it might be more helpful to organize the study based on the different sciences, such as engineering, illumination, surveying, and chemical experimentation. This would allow a more detailed examination of the fields that could be brought together in a final chapter at the end rather than the arching narrative of the current study that begins and ends with a discussion of the various

² Joyce E. Chaplin, *An Anxious Pursuit: Agricultural Innovation and Modernity in the Lower South, 1730 – 1815*, (Chapel Hill: UNC Press, 1996).

agencies, but narrows in the middle to almost solely focus on the Light-House Establishment.

A second option is to re-frame the study as an examination of the science and innovation in the Light-House Establishment prior to 1850. Framing the study as an examination of science and innovation in the Light-House Establishment prior to 1850 would serve two purposes. First, it would fill the void in historiography of American lighthouses which tends to privilege the politics of Stephen Pleasonton's administration and the romanticized stories of lighthouse keepers. Thomas A. Tag's series of articles on lighthouse illumination in *The Keeper's Log* is not enough.³ More needs to be said about the innovation and science in the Light-House Establishment. Second, such a study would answer the critics of Pleasonton's administration who claim the Light-House Establishment was unscientific before the advent of the Light-House Board in 1852. What these critics overlook is the question, "what was considered science?" during the first half of nineteenth century. Chapter 3 of this study is a first step and could be used as the foundation for revising the dissertation into a monograph. In contrast the the currently held beliefs about the Light-House Establishment, answering the question "What was considered science?" will demonstrate the Establishment was one of the most scientific organizations in the early United States. The Establishment served as an outlet for inventors and tinkerers to test their innovations and a place to promote science and the

³ For more on Thomas A. Tag's articles on technology in the Light-House Establishment, please see *The Keeper's Log* volumes 13-14 (1997-8) and 21-22 (2005-6).

practical arts. Such a study might resemble Hugh Richard Slotten's examination of the Coast Survey or Todd Shallat's narrative of the Army Corps of Engineers.⁴

⁴ Hugh Richard Slotten, *Patronage, Practice, and the Culture of American Science: Alexander Dallas Bache and the United States Coast Survey*, (New York: Cambridge University Press, 1994). Todd Shallat, *Structures in the Stream: Water, Science, and the Rise of the U.S. Army Corps of Engineers*, (Austin: University of Texas, 1994).

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APPENDIX A – PERMISSION TO PRINT

The following is the Smithsonian National Museum of American History's permission to print figure 2.1 Winslow Lewis' Lamp and Reflector Patent #1305.



James Risk <james.r.risk@gmail.com>

Publication Permission Request

Johnston, Paul F. <johnstonpf@si.edu>
To: James Risk <james.r.risk@gmail.com>

Mon, Dec 7, 2015 at 2:09 PM

—VIA EMAIL—

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Sincerely,

PFJ

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From: James Risk <james.r.risk@gmail.com>
Date: Monday, December 7, 2015 at 11:36 AM
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