The Cannon's Place in the Rise of the British Empire

An Essay

Submitted to

The Faculty of the

United States Naval War College

In Partial Fulfillment

of the Requirements for the

Graduate Certificate in Maritime History

---

by
LTC Aaron D. Bright, USA

May 21, 2021

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
06/01/2021	Certificate Essay	August 2020 - June 2021

4. TITLE AND SUBTITLE
The Cannon's Place in the Rise of the British Empire

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Aaron D. Bright

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
John B. Hattendorf Center for Maritime Historical Research
U.S. Naval War College
688 Cushing Rd
Newport, RI 02841

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The role of the cannon is absolutely essential to understanding maritime Britain and serves as an excellent performance indicator for its sea-minded culture. This single innovation tells us about more than just Britain's prowess in naval combat. By understanding the symbiotic relationship between it and Britain's national culture, we gain access to clues into why this culture, of all those that had similar opportunities, possessed such an immense capacity for innovation and Empire.

15. SUBJECT TERMS
Cannon; age of sail; innovation; British culture

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			J. Ross Dancy
UNCLASS	UNCLASS	UNCLASS	UU	44	19b. TELEPHONE NUMBER *(Include area code)* 401-841-4805

The Cannon's Place in the Rise of the British Empire

by
LTC Aaron D. Bright, USA

APPROVED:

_____	Geoffrey Till, PhD Committee Director
_____	John Maurer, PhD Committee Member
_____	Evan Wilson, DPhil Committee Member
_____	Coordinator Graduate Certificate in Maritime History

HMS *Victory*'s (100) first shot of the day on October 21st, 1805, was a raking shot from its forecastle carronade into the stern of the *Bucentaure* (80).[1] It came at the culmination of enduring 40 minutes of unrelenting fire from the van of the 39 allied Spanish and French ships. The outnumbered British force of 33 ships advanced perpendicularly in two columns.[2] Such a dangerous and atypical attack direction was a calculated risk. Vice-Admiral Lord Nelson accepted that the initial punishment on his ships was worth the position in which it placed his fleet to return the favor. Leading both columns were his first-rate ships and his most aggressive commanders; Nelson front-loaded firepower to do the most damage from the start and protect his smaller ships.[3] On the approach, *Victory*'s gun crews loaded all cannons double-shotted for the initial engagement, including the carronades. Every gun carrying twice its intended payload increased each shot's smashing effect from the reduced muzzle velocity of firing two at once. What mattered more was the close range in which the fight would take place. The slower-moving, double-shotted payloads created jagged holes and a shower of splinters inside the enemy hulls, while the higher velocity ones carved out a cleaner tunnel through it. They would essentially use the defenses of the enemy ship against itself.

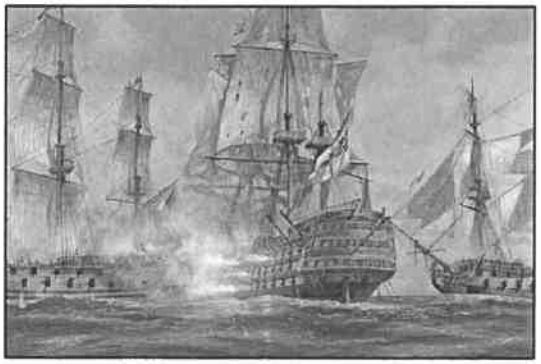

Figure 1: Victory's opening raking shots into the Bucentaure's stern. "Crossing the Line: The Battle of Trafalgar." by Patrick O'Brien.

When the distance closed to nil, with the *Victory* at the head of the windward British line of battle, it nearly collided with the French *Bucentaure*.

[1] The *Victory* at Trafalgar was actually carrying 105 guns on the day. A single 18 pdr carronade was part of its launch for use on any potential amphibious assaults, but not for the battle that day.
[2] Gregory Fremont-Barnes, *Trafalgar 1805: Nelson's Crowning Victory* (New York: Osprey Publishing Ltd., 2005), 53.
[3] Adam Nicolson, *Seize the Fire: Heroism, Duty and Nelson's Battle of Trafalgar* (New York: Harper Perennial, 2006), 240.

As the *Victory's* bow "crossed the allied T" it came to within 5-10 meters of the French ship's stern.

The shotgun-like blast from the stubby barreled British 68 pounder (pdr) carronade erupted, sending one large round shot and 500 musket balls and a cloud of thick gray smoke into the intricate woodwork of the *Bucentaure's* stern.[4] Inside the French flagship, the chaos of the smoke, noise, carnage, and shock of that first blast is near impossible to imagine. As the *Victory's* broadside guns bore past the *Bucentaure's* stern, Nelson's gun crews sequentially fired *Victory's* 51 port-side guns into the stern as well. Each pull of the lanyard from three separate gun decks was expertly aimed and timed thanks to well-trained, disciplined crews firing Blomefield cannons fitted with gunlocks. Each gun delivered its double-shotted payload at short range as it bore past. 102 Cannonballs, a total of 2,280 lbs. of solid iron, moving somewhere shy of 1500 fps[5] in magnitudes of 12, 24, and 36 lbs. each, penetrated the *Bucentaure*.[6] These raking shots, as the name implies, entered the rear and traveled along the internal length of the French 2nd rate in a split second. Each shot caused its own sequence of chaos in the opposing gun decks, traveling from rear to front. Searing hot iron cannonballs took lives and limbs, splintered wood and bone; some ricocheted, while others penetrated, but all cut a demoralizing and deafening path of carnage. By the end of that first salvo, the *Buentaure* had 20 of its guns knocked out of action along with 325 Frenchmen.[7] As the *Victory* turned to come alongside, it drifted into and locked with the French ship *Redoubtable* (74). British gun crews now had to fight on both sides of *Victory* and so shifted half the men to their larboard guns as trained, and fired a rippling broadside into it.[8] Marine Second Lieutenant Lewis Rotely wrote of his experience as a bystander from

---

[4] Nicolson, *Seize the Fire*, 244.
[5] Peter Goodwin, *HMS Victory Pocket Manual 1805: Admiral Nelson's Flagship at Trafalgar.* (Oxford: Bloomsbury Publishing Plc, 2018), 105
[6] For comparison purposes, a heavy modern-day bowling ball weighs 15 lbs.
[7] Goodwin, *HMS Victory*, 124.
[8] Ibid., 103.

the middle gun deck, "We were engaging on both sides; every gun was going off. A man should witness a battle in a three-decker from the middle deck, for it beggers all description…I fancied myself in the infernal regions."[9]

As fierce fighting took place across the upper decks of these two ships, the guns of the lower decks kept up the fire against both the *Redoutable* and the *Buentaure.* The *Victory*'s crew and marines fought off multiple attempts by the *Redoutable* to board it while gun crews fought below, muzzle to muzzle. *Redoutable* gave as good as it received for a time until there was an odd silence onboard both ships as each thought the other was giving up. 200 French boarders came out and prepared to swing across to the *Victory* just as a second formidable British man-of-war appeared. The *Téméraire* (98), a peer of the *Victory*, came to its aid. The odd silence came to an abrupt end, and the crossfire of British iron from these two ships shredded the *Redoutable*. *Victory*'s lieutenants ordered their gun decks to switch to treble-shotting the cannons, reduced the powder, and aim low so as not to hit the *Téméraire* through the *Redoutable* on the other side.[10] Multiple broadsides and the macabre result of a carronade shot from the *Victory* to the upper deck now full of French sailors and marines, along with a raking broadside from the *Téméraire,* put an end the last of the *Redoutable's* efforts.[11]

The account of the *Redoutable's* Captain, Jean-Jacques-Etienne Lucas, confirmed that they were forced to strike their colors after all their guns and crews were out of action. Napoléon would later convey to Captain Lucas, "Had all my ships behaved like yours, victory would not have been doubtful," and personally awarded him the Legion of Honor, France's highest order of merit. Lucas related in

Figure 2: Captain Lucas of the French Redoutable.

[9] Nicholas Tracy, *Nelson's Battles: The Art of Victory in the Age of Sail* (London: Caxton Publishing Group, 2001), 195.
[10] Nicolson, *Seize the Fire,* 260.
[11] Fremont-Barnes, *Trafalgar 1805*, 56-58. This source covers aspects of the whole paragraph, not just since the previous footnote.

his report that "out of a crew consisting of 643 men, 522 were no longer in a situation to continue the fight, 300 had been killed, and 222 were badly wounded. Among the latter were the whole of the *Etat Major,* [commissioned officers] 10 junior officers."[12] He later lamented watching his ship sink from the British *Swiftsure* (74) the next day after combined French/British attempts to save it. The *Swiftsure* crew was able to save him and 119 others of his crew but unable to remove many of the wounded from below decks before the *Redoutable* took them down with it.[13]

By the end of the four-hour battle, *Victory*'s gun crews expended 2,669 rounds, or roughly 27 tons of solid shot ammunition.[14] It was scarred and battered, but still afloat and in British hands. Though Britain lost its national hero in Nelson that day from a musket ball fired from the *Redoutable*, he won the Battle of Trafalgar. Two months before the battle, Nelson reconstituted the fleet after Napoléon halted his cumbersome plan for invading England. With Trafalgar, and the near destruction of Britain's principal maritime competitors, its command of the sea was now virtually unchallenged. Napoléon adopted the Continental System partially from the financial sting and loss of mobility he felt from losing his navy, and partially from trying to rebuild it.[15] That led to his invasion of Russia, and the eventual destruction of his land force. This paper is not a discussion on Trafalgar determinism, as it would be flawed to claim Napoléon's demise was inevitable following Trafalgar. However, this follow-on sequence helps frame the battle for the pivotal moment it was in history. Trafalgar and the

Figure 3: Vice-Admiral Lord Nelson.

---

[12] Before translation: "*Sur 645 hommes d'équipage, nous en avions 522 hors de combat, dont 300 de tués et 222 blessés, parmi lesquels se trouvait la presque totalité de l'état-major.*"

[13] Captain Lucas, Jean-Jacques-Etienne. *Le rapport ci-dessous fut écrit par Lucas juste après la bataille, dans le cadre de son rapport général au ministre de la marine, Decrès*. October 23, 1805. http://www.histoire-de-fregates.com/trafalgar/32-trafalgar/105-trafalgar-redoutable.

[14] *Victory* still had 93 tons of shot left after the battle. Goodwin, *HMS Victory,* 98.

[15] N.A.M. Rodger, *The Command of the Ocean: A Naval History of Britain, 1694-1815* (New York: W.W. Norton & Company, 2005), 543.

British Empire taking its place as the premier force on the seas at the beginning of the 19th century came at the result of thousands of factors. This paper focuses in on arguably the most crucial to British success, the cannon.

The Purpose.

The role of the cannon is absolutely essential to understanding maritime Britain and serves as an excellent performance indicator for its sea-minded culture. This single innovation tells us about more than just Britain's prowess in naval combat. By understanding the symbiotic relationship between it and Britain's national culture, we gain access to clues into why this culture, of all those that had similar opportunities, possessed such an immense capacity for Empire.

Declaring that the cannon is the sole item responsible for Britain's command of the sea neglects numerous other elements. The best gun in the world, crewed by men expertly trained in gunnery, was useless without functionally designed ships and the seamanship required to maneuver them in peace, combat, and bad weather. Conversely, the cannon was more dangerous than useful in the hands of untrained gun crews or undisciplined officers who lacked the experience and training to give proper guidance. Without the work, coordination, drive, and bickering between that of the Admiralty, the Ordnance Board, Parliament, and occasionally the Sovereign, little in the navy could have been possible. This paper does not discount these things in the slightest; in fact, it demonstrates the opposite. In pointing out how this one aspect had such a far-reaching ripple effect, it reasons that there is no such thing as a singular answer to a complicated question. What this paper does claim is just how vital mastery of the cannon was to the rise of the British Empire and its national culture.

While its value in battle is unquestionable, its two-way effect from and on British society, culture, government, its economy, and leadership are of paramount, if less obvious,

importance. Cannons were made by neither the navy nor the army but by contracted civilian manufactures. The miners who dug up the metals, the engineers who designed them, the loggers who cut the trees for fuel, and the foundry workers who gave them their form, encapsulate a part of the civilian and military landscape of the empire. Cannons sat in carriages made of Wealden elm to exact specifications, specific to each gun. They were restrained and maneuvered with pre-stretched ropes made from the highest quality portions of Russian hemp.[16] The government decided, procured, tested, and approved the numbers of guns and their disposition. Finally, it came to the gun crews and officers responsible for their training and actions in combat which would decide if it was all worth it.

In this regard, historians have overlooked providing this kind of contextual focus on the cannon and its part in opening sea lanes, protecting the commons, and creating a Britain at the epicenter of a connected world. This idea came from a mixture of personal experiences in technical and tactical work as a United States Army artillery officer for the past 21 years, a student at the U.S. Naval War College, and, most notably, a book review of Adrian Caruana's *The History of English Sea Ordnance 1523-1875 Vol. II,* by N.A.M. Rodger. In this, Rodger notes that "On the evidence here the ordnance world and the historical world do not meet at all. This is a work of loving antiquarianism, studying material objects virtually without reference to the context in which they were designed and used." The last line of his review helped form the reason for this paper and the current gap in the historiography: "It may and should be an inspiration to others to integrate the history of naval ordnance with naval and national history, where it belongs."[17] This is the purpose of this paper, claiming the cannon as one of the most representative elements of British cultural sea-mindedness. To support this

---

[16] Adrian Caruana, *The History of English Sea Ordnance 1523-1875, Vol. II: 1715-1815* (Rotherfield, UK: Jean Boudriot Publications, 1997), 358-359, 385; Rodger, *Command of the Ocean*, 558-559.
[17] N.A.M. Rodger, Review of *The History of English Sea Ordnance 1523-1875, Vol. II*, by Adrian B. Caruana. *The International Journal of Nautical Archaeology* 27, no. 2, (May 1998) 172-173. https://doi.org/10.1016/S1057-2414(98)80076-9.

claim, an in-depth examination analyzes the cannon's role in the rise of the British Empire through the culture that made it happen. It draws a direct line connecting the ubiquitous, all-encompassing efforts of the British people to putting cannonballs through French and Spanish ships at Trafalgar.

The Timeline.

The purpose of naval guns in the 16th century had more to do with "softening up the target before boarding." English pirates and privateers like Sir Francis Drake were more accustomed to using their cannons in a defensive role in the Caribbean against the Spanish than as their ships' primary weapon. That honor more than likely went to the cutlass. This embryonic Royal Navy was more concerned with keeping the ship and the loot inside it intact than they were with sinking it. The 17th century saw a progression toward cannons serving a much more substantial role. Captains realized they could significantly disable ships and occasionally get them to strike their colors before boarding, taking prizes with "less" effort.[18] Then, gun technology advancements in the 18th century had a dynamic consequence on warfare at sea, one that remains today.

Over that century, the ratio of ships taken to ships destroyed began to move in the opposite direction from where it had been. By the turn of the 19th century, British guns and gunnery increasingly brought devastating effects on those they faced despite efforts to increase structural resistance to such immense firepower.[19] The work of men like Thomas Bloomfield, William Congreve, and Charles Douglas, turned the British man-of-war from a ship taker to a ship killer.[20] This paper weaves these stories and others through the fabric of

---

[18] N.A.M. Rodger, "The Development of Broadside Gunnery, 1450-1650," *The Mariner's Mirror* 82, no. 3. (August 1996): 301-324. 308.

[19] Ian W. Toll, *Six Frigates: The Epic History of the Founding of the U.S. Navy* (New York: W.W. Norton & Company, 2006), 350. The exception here is the American Frigates built from *Quercus virens,* a live oak variant found only in the southeastern U.S., and the densest wood available for ship making. The stories of 18 pder cannon balls bounding off the hull of *USS Constitution* gave her the nickname *"Old Ironsides."*

[20] Caruana, *Sea Ordnance, Vol. II,* 25.

British culture. It reveals a society that prized function over form, foresight over immediate gains, and improvement over stagnation. The cannon is the needle weaving the overall story together. Its introduction to the sea induced monumental alterations in ships, tactics, trade, culture, government, religion, and most significantly, empire.

Getting the Ship Right, or Rather, the Right Ship.

Prior to (and well into) the 15th century, when Italian city-states fought for preeminence, the galley was the dominant force on water. Since it relied on banks of rowers, its movement was independent of the wind, allowing it to outmaneuver sailing ships that either contested them or tried to evade in the waters of the Mediterranean. Unfortunately for the galley, that same century, the cannon took hold on sailing vessels in force. No longer did the advantage of maneuverability hold primacy after cannon firepower moved out of being strictly land-based. Sailing ships became "mobile castles" and eventually could only be bested by peer ships.[21]

The French invention of the gun port on a sailing ship in 1501 added the ability to create decks of guns, eventually creating two walls of stacked protruding gun barrels.[22] This added to its firepower without affecting its method of propulsion. For the galley, replacing a few oarsmen with a one-ton cannon was not a recipe for mobility. Unlike the galley, a sailing ship's propulsion was clear of the ship, above it and out of the way. There was no sacrifice of speed for firepower, just additional sails and masts. A galley also never had the endurance at sea of a masted ship, and now it lost the one advantage it had in maneuverability.

Proponents of the galley attempted to hold on to their tried-and-true weapon during a 50-year evolution of experimentation. Galleys were still dangerous during this time of transition for the gunned sailing ship. They added bow-chasers and stern-chasers, but these

---

[21] Peter Padfield, *Maritime Supremacy and the Opening of the Western Mind: Naval Campaigns that Shaped the Modern World* (Woodstock and New York: The Overlook Press, 1999), 7.
[22] Fredrick Leslie Robertson, *The Evolution of Naval Armament* (London: Constable & Co. Ltd., 1921), 7.

were fixed and so aimed by orchestrating all the oarsman at once.[23] They attempted to meld the best of both worlds and developed the galleass. It had sails and a deck of guns over a lower deck of rowers, but it was not to be. What in theory was meant to mate the best attributes of sailing ship and galley, in practice combined the worst. Other than the obvious risk to the exposed rowers staring down the barrels of opposing rows of guns, the galleass was sluggish, unseaworthy, and less capable of carrying heavy ordnance. Since its cannons were up high, it made it crank and "unmanageable in even a moderate breeze."[24] This was the reason the largest guns went to the lowest decks of a ship-of-the-line. Later, adding the weight of protection for the oarsman to the weight of the cannons engineered out any advantage from human propulsion.[25] Though there were instances in the coastal waters of the Baltic where galleys prevailed, it was not to be in the long run. The gunned sailing ship eventually became a porcupine too dangerous to approach for either the galley or the galleass.

Figure 4: The Galleass. The attempt at combining sails, guns and rowers.

While this shift was more gradual than immediate, sailing ships armed with cannons made the galley and galleass less practical fighting vessels. With this changing of the guard at sea and the new ocean-going gunned warship, Western Europe expanded around the globe rapidly.[26] The introduction of the maritime cannon married endurance with lethality and set the stage for a sea-minded nation to take advantage. What they needed now were better guns and opportunities to use them. In the shift from galley to ship-of-the-line, Carlo Cipolla, in his work *Guns, Sails, and Empires,* concluded that "Within Europe herself, supremacy was gained by those nations which shifted more completely to guns and sails. The era of human

---

[23] John Francis Guilmartin, Jr., *Galleons and Galleys* (London: Cassell & Co, 2002), 66, 68.
[24] Robertson, *Evolution of Naval Armament,* 7-8.
[25] Peter Padfield, *Guns at Sea*, (New York: St. Martin's Press, 1974), 43.
[26] Peter Padfield, *Maritime Supremacy and the Opening of the Western Mind: Naval Campaigns that Shaped the Modern World* (Woodstock and New York: The Overlook Press, 1999), 7.

energy was over, and the era of the machine was beginning to open up."[27] Machines in England and the people who built this new infrastructure mark the next phase of the cannon story.

Getting the Right Gun, or Rather, Getting the Gun Right.

Before the middle of the 16th century, England lacked the skill or equipment to cast its own guns in iron and relied on importing what it needed. Prior to that, the first cannons were made the same way a cooper would make a wooden barrel since they did not yet know how to make a strong metal pipe. Instead of strips of wood, they used strips of iron called staves to form the tube and surrounded them with metal hoops.[28] Still to this day, we refer to this part of any cannon or howitzer as the barrel for that reason. Subsequent ones were cast in bronze or brass. Though bronze is made from combining copper and tin, while brass renders from the mixture of copper and zinc, cannon history treats the two terms interchangeably.

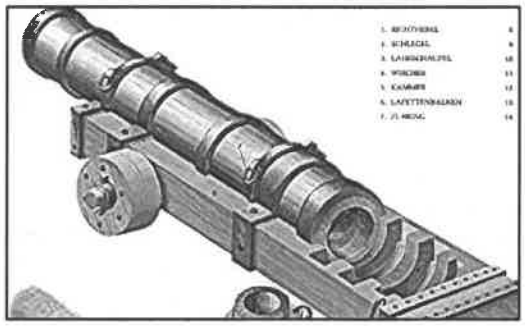

Figure 5: Early breech-loading cannon made from strips of iron and hoops like a wooden barrel.

Making a bronze gun was a lengthy and expensive process, but they were exceptional pieces of equipment. There were founders in England that possessed the skills to make them from knowledge acquired through the ancient art of bell making. The amount of copper needed made England dependent on importing it from other nations or reappropriating it from local or foreign church belfries. They later found copper deposits in Elizabethan England but only in small quantities.[29] Relying on other nations that could be potential enemies was, and remains, not an ideal way to outfit your military.

---

[27] Cipolla, *Guns, Sails and Empires,* 88-89.
[28] Adrian Caruana, *The History of English Sea Ordnance, 1523-1875, Vol. I* (Rotherfield, UK: Jean Boudriot, 1994), 6-7.
[29] Rodger, *Safeguard of the Sea,* 213.

The case for arming a man-of-war with bronze ordnance over iron was substantial. Iron is twenty percent heavier than bronze. It loses much of its original strength after melting and casting. It is prone to rust at sea and corrosion from firing. In comparison to bronze, an iron gun was considered ugly. Iron is more brittle than bronze and so had to be cast much thicker and thus heavier. Iron guns' relative enormous size made them best suited to emplacements like fixed fortifications and ships where its maneuverability was not a key factor for tactical survival. When a bronze gun failed, it buckled, bubbled, or cracked from the overpressure. When an iron gun failed, it had a bad habit of exploding—killing or seriously maiming its crew and anyone unlucky enough to be within its blast radius.[30] Two such occurrences accounted for several deaths onboard the gun decks of the French *Redoutable* at Trafalgar. Though the arguments against iron were many, they still failed to outweigh two significantly practical factors: iron was cheap, and England had lots of it.

Henry VIII and The English Iron Industry.

In 1543, with another French war imminent, Henry VIII was nearly bankrupt.[31] French and Scottish campaigning and massive projects like artillery fortifications for the south coast of England overextended the Crown. Taxes increased, and the pound's value decreased. Henry needed masses of guns at an affordable price, now. Iron guns were the practical answer.[32] With his decision to start producing English-iron cannons, he removed two significant hurdles, lack of funds and supply. In doing so, he also introduced a new obstacle in a lack of skilled labor. The answer here came from an unlikely source for a 16th century English King: Frenchmen.

---

[30] Rodger, *Command of the Ocean*, 224-5.
[31] Cipolla, *Guns, Sails and Empires,* 38.
[32] Henry Cleere and David Crossley. *The Iron Industry in the Weald* (Cardiff, UK, Merton Priority Press: 1995), https://www.wealdeniron.org.uk/Pubs/The%20Iron%20Industry%20of%20the%20Weald%20-%20C+C.pdf, 118.

English expertise in iron gun manufacturing originally came from experienced French iron smelters unhappy with their situation east of the Channel. These men came from the Pays de Bray, France's iron founding region. King Francis' interest in their profession declined. The costs of living rose from poor harvests in Normandy and Picardy back in the 1520s, and these men branched out to seek a better life for themselves and their families. They found it in Southern England.[33] In a perfectly timed alignment of needs, two unlikely problems collided to produce what would be an industry that changed naval warfare and England forever. England no longer had a skilled labor problem.

To make an iron cannon in the 1500s, you needed two distinct pieces of infrastructure. The first was the furnace. It received the ore extracted from the ground by miners, melted it down, and purified it to varying degrees of usable iron. The other is the foundry. It turned the iron rendered from the furnace into any number of finished products. An object like a skillet needed little skill to cast. Cannons required the most technical knowledge and, except for some anchors, typically the most metal. In southeastern England is an area called the Weald, a strip of land crossing through present-day Hampshire, Surrey, Sussex, and Kent. Iron mining operations existed here since the Romans extracted ore from it during their occupation. Before Henry decided to start casting iron guns, only a single active blast furnace operated in the Weald in 1520. By 1548 there were 53 furnaces and 53 foundries. A single strategic royal decision about a cannon problem produced an entire industrial complex. It had far-reaching effects, and in another 25 years, these numbers would double.[34]

---

[33] Cleere, *Iron Industry,* 120.
[34] Cleere, *Iron Industry,* 117, 130.

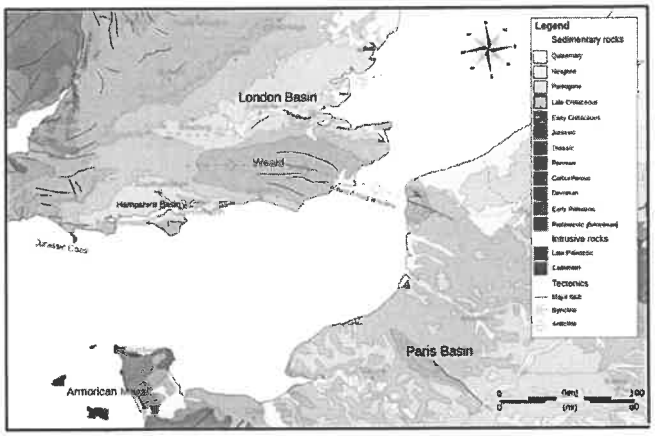

Figure 6: The Weald, shown in dark green.

English gun founders took what they learned from their French counterparts and perfected the processes in short order; the students became the masters. The Weald was heavily wooded with few roads but near enough to London to make trips to the armory possible. Iron making became an attractive investment for the land-owning gentry of the area. Some made fortunes while others lost them. The area and the industry offered endless possibilities. Because horrible roads were worse in the cold, it cost more to move guns to London overland in winter than in summer. This was good news for transporters but bad for foundries that mainly operated in winter. It was part of the cost of doing business and added to the growth of another industry (transport) to working Englishmen. To feed the furnaces, logging cleared thousands of acres of forest. There was controversy in this, but not the ecological one there would be today. Since the textile industry that existed in the Weald previously also required wood for fuel to heat their dye vats, the sudden influx of gun founders made the woods' resources contested.[35] Deforestation became a problem later on in the 1630s.[36] A century of cutting down timber for shipbuilding and burning in furnaces will do that.

Economically, it was a coming together of wealthy landowners in the area who knew a financial opportunity when they saw one, with professional iron craftsmen who could turn their investment into profit. Only a few of this latter group had the capital or the business savvy to develop their own furnaces and foundries. Those that tried frequently failed. The

---

[35] Zell, Michael. *Industry in the Countryside: Wealden Society in the Sixteenth Century.* (Cambridge, UK, Cambridge University Press: 2004), 127-9.
[36] Cipolla, *Guns, Sails and Empires,* 62.

vast amount of upfront capital required made borrowing risky, something only gentlemen with either money or lender contacts were capable of seeing to fruition.[37]

For the foundries that burned coal, there was a profession called colliers. Their job was to prepare coal for use in the blast furnaces. Metalworkers, blacksmiths, and whitesmiths in the area built the tools foundry workers used in their craft. More horses and stables were required to move the timber and completed guns. The list of professions born from nothing that profited directly or indirectly was enormous, spanning far and wide across British society. Foundries made more than just cannons, and other inventions came into being. In 1774, the cannon-lathe created by John Wilkinson perfected boring out a cannon by spinning the gun while the bit remained fixed. It was so perfect of a system that an acquaintance of his, James Watt, used it to bore the first perfectly cylindrical walls he needed for his invention, the steam engine.[38]

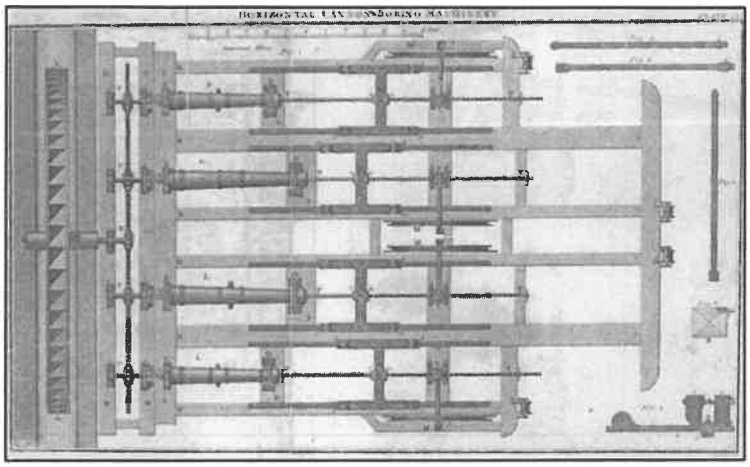

Figure 7: The Cannon, itself, spins attached to a gear, chain, and hydro wheel, while the non-spinning drill is pushed into it, creating the bore.

English iron guns were known for their simplicity, much like English armor before them. They were built to be functional, not beautiful, a deep contrast to nations like Italy. Italian founders knowingly compromised the strength of many of their guns and even the accuracy of their shot for the sake of form. This alone illuminates a striking difference in attitude between English and some European societies.[39] Practicality versus extravagance at this time was a cultural theme that placed England in a commanding position over its European counterparts in the coming centuries.

---

[37] Zell, *Industry in the Countryside,* 129-30.
[38] Clive Trebilcock, ""Spin-off" in British Economic History: Armaments and Industry, 1760-1914," *The Economic History Review* 22, no. 3 (December 1969): 474-490, https://www.jstor.org/stable/2594122, 477.
[39] Cipolla, *Guns, Sails and Empires,* 43.

By 1550, England imported few bronze guns.[40] England now possessed the knowledge and ability to make what would, over the next 200+ years, come to be known as the ship-of-the-line. These were categorized by their level of firepower in how many cannons they donned. At the battle of Trafalgar, the *Victory,* and ships like it, were the most sophisticated, technologically advanced weapon systems of their time. It alone possessed 35% more firepower than all of Wellington's artillery at Waterloo.[41] Britain's naval cannons were manned by arguably the best equipped, trained, led, and disciplined crews a nation could then assemble.

The Men Onboard.

Command of the Sea depended on success in battle, and gunnery held a position of primacy in making that a reality. Mastery of sailing was a crucial element to getting into a favorable position for attack or retreat. Once there, however, gunnery proficiency typically became the determinate between failure or success in action. No matter the crew's sailing skill, nor how well-fed or healthy they were, it all counted for naught if they failed at gunnery. It was the ultimate purpose of a British man-of-war. Together, gunnery and sailing were two of the most effective performance indicators of a competent captain. At the heart of this floating weapon system were the well-trained crew and their gun.

Though it was arguably the most critical piece of equipment of combat action for the ship, the cannon's role was admittedly a distinctive one. A ship's cannons had two primary tasks, to kill people and break the other ship. They could be used for other ancillary jobs such as signaling, salutes, intimidation, firing ashore, or as a prop for an admiral's portrait, but their real purpose was in action. Their role as instruments of training and discipline when the ship was not in contact was just as important.

---

[40] Rodger, *Safeguard of the Sea,* 213.
[41] Goodwin, *HMS Victory*, 105.

The most glaring piece of evidence of its fundamental importance was in the ship rating system. The type and number of guns dictated everything about a ship. They were "rated" by a system that divided them into six classes.[42] A rating of 1-6 decided the ship's scale, its displacement tonnage, victualing, sails, and crew size. The definitions varied by year, but the basis remained the same. A first-rate ship was the highest at 100+ guns.

Like the rating system, crew sizes carried through the ages as all nations came to understand the requirements of fighting a ship. "Third rate ships-of-the-line to first rates, armed with 64 to over 100 guns, were manned with between 491 and over 850 men."[43] The remainder ran the other ancillary aspects (cooks, quartermasters, etc.) of the ship. A full gun crew was determined by the weight of the gun (plus carriage) divided by 500 lbs, to the closest even number. The navy chose 500 because it was determined to be the "estimated weight a single man could haul." Where a 32 pdr on the lower deck required 14 crew members, a 12 pdr on the upper deck needed only 10.[44] Like guns today, a full crew is ideal for speed and ease of operation but not completely necessary. The numbers of men allotted to a gun only allowed for one broadside of the ship to be fully manned, but the even number meant they could man two guns each if necessary.

While fully manning half the guns seems strange on the surface, it made sense for two reasons. First, a ship of the line typically only fought on one side at a time and always so in one-on-one fights. Second, to have full crews on all guns would be impractical for victualing and living space.[45] To fully crew all the guns would create an engineering conundrum. Housing more sailors meant building a bigger ship. A bigger ship meant creating a bigger target without the added benefit of more guns. Adding guns would just create the need for

---

[42] N.A.M. Rodger, *The Command of the Ocean: A Naval History of Britain, 1694-1815,* New York: W.W. Norton & Company, 2005. 762.
[43] Ross J. Dancy, *The Myth of the Press Gang*, (Woodbridge, UK: Boydell Press, 2015) 5.
[44] Goodwin, *HMS Victory,* 102.
[45] Peter Goodwin, "The Practice and Power of Firing Broadsides in British Men of War During the Age of Fighting Sail," *Arms & Armour,* 13, no. 1 (2016): 48-61. https://doi.org/10.1080/17416124.2016.1191750, 58.

more sailors, creating an endless engineering loop. A gun could be crewed by much fewer men and frequently was when the situation dictated. Reload times increased, but the guns kept firing, and a gun firing every two to three minutes was better than one not firing at all. The heavy attrition that gun crews faced in action meant that they had to have creative backup plans to keep as many firing as possible.

Supporting Cast.

There was a cast of characters on a ship-of-the-line that made the gun crews' job possible. There was only one Gunner per ship, and he was one of the standing Warrant Officers. This meant he was essentially a part of the ship, whatever state it was in. He was typically the most experienced with ship ordnance, in direct consult with the Captain, but with the gruff exterior of a gundeck upbringing. The combination typically made him a more diverse mentor. He oversaw everything to do with the guns, including their loading on and off the ship, their maintenance, storage of the shot and powder, and much more.[46] Within the 1730 *Regulations and Instructions Relating to His Majesty's Service at Sea*, the Gunner abided by 40 "articles" that provided him specific guidance on his duties. They ranged from ordering everything the ship needed to be lethal before the crew arrived, to inspecting small arms before turning them back in and everything in between.[47] His place during combat was below the water line in the powder magazine, "supervising the filling and issuing of cartridges to the guns." The crews and

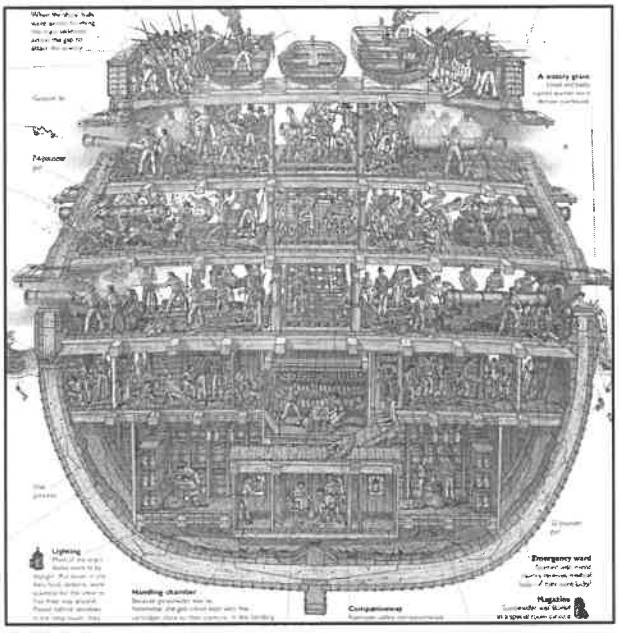

Figure 8: Drawing depicts gun decks in action and operations in the gunpowder rooms below the water line.

[46] The Historical Maritime Society, "The Gunner and His Crew in Aubrey's Royal Navy." *The Dear Surprise.* https://thedearsurprise.com/the-gunner-and-his-crew-in-aubreys-royal-navy/.
[47] *Regulations and Instructions Relating to His Majesty's Service at Sea* (Admiralty, 1st ed. 1730), 99-110.

officers may change out, but he was a part of the ship and its continuity for how gun operations worked.[48] The *Victory*'s master gunner, William Rivers, was its longest-serving member, having worked in that position from 1793 to 1811.[49]

The yeoman of the powder room was a petty officer but paid at the rate of a warrant due to the delicate and dangerous nature of his job. He assisted the Gunner inside the magazine, wearing no buckles but leather or felt slippers to keep from making sparks.

Gunner's mates were the senior petty officers who saw to the guns themselves. Each one had his own deck, and he carried the implements needed to repair problems with guns during action.

Quarter-gunners were junior petty officers that assisted their respective gunner's mate. Each one was responsible for four guns.

The gun captain held neither rank nor a place on the crew. He was responsible for overseeing its actions and training. When it came time to aim and pull the lanyard, that was his job.

As for junior officers (midshipmen and lieutenants) in action, command of the divisions of guns fell to the most junior. It was an essential part of their training as future captains and first lieutenants.

---

[48] The Historical Maritime Society, "The Gunner and His Crew."
[49] Goodwin, *HMS Victory*, 39.

Finally, those who had necessary day-to-day jobs, which were unnecessary during combat, created the log train along predetermined routes through the ship to move powder and ammunition to the gun crews. This train too had to be a well-oiled, practiced, and disciplined machine. On a first-rate, this was anywhere from 80-100 men, and occasionally women. It was usually the boys of the ship that had the job of "powder monkey" that ran the final length of the deck to deliver the powder to the gun itself. *Victory* had 31 onboard at Trafalgar.[50]

Figure 9: Upper left, junior officers; center, gun captain; lower right, powder monkey.

This cast of characters held the collective responsibility for improving the level of gunnery proficiency according to the guidance of the Captain. "Gun drill was stressed by almost all admirals," usually done as dry fire—that is without powder and shot loaded.[51] In 1731 the *Regulations and Instructions Relating to His Majesty's Service at Sea,* set in writing that Captains will "discipline the ship's company frequently in the exercise of the great guns…to render them more expert in time of battle."[52] Across the officer corps, there was disagreement on the correct tactic on which to train, speed or accuracy. Nelson and those who agreed with him found confirmation of the advantage being in speed at Trafalgar. Technology was not yet ready for the proponents of accuracy, though their day was not far away.

Gun Drill. Speed and Accuracy.

Gun drill practice was the only way to get a crew up to standard. No amount of *showing* could replace *doing*. Officers timed the crews they were in charge of, attempting to get them as fast as possible. A full round of firing and reloading generally took a minute and

---

[50] Goodwin, *HMS Victory*, 98, 129.
[51] Rodger, *Command of the Ocean,* 405.
[52] *Regulations and Instructions,* 30.

a half. A well-trained, proficient crew could do so safely in under a minute.[53] The recoil from a fired cannon pushed it back to clear the gun ports, allowing the crew to reload internal to the ship. The rope employed to stop it, the breeching rope, was three times the length of the barrel and reduced a 32 pdr to 11 feet of recoil. This allowed crew members 18 inches of room for reloading and shortened the length needed to re-emplace it. If left unrestrained, the 32 pdr traveled rearward 50 feet.[54] Pulleys, ropes, and tackles made the effort possible but still not as quick and easy as it would be with a lighter brass piece. The strain these heavier iron pieces placed on a ship's hull through the breaching rope attached to the ringbolts stopping their recoil was immense, eight imperial tons per ring bolt. The idea of a ripple of fire replaced a full broadside of guns firing all at once. This new practice saved the fibers of the hull from the concentrated shock of all guns jolting it at once. This both lengthened the life of the ship and kept it sturdy where it arguably counted most.[55]

At the opening contest of Trafalgar, the British *Royal Sovereign* (100) at the head of the leeward column was the first to trade shots with the enemy. It fired around 80 broadsides to the Spanish *Santa Ana's* (112) 25-30 throughout their two-hour battle before the latter struck its colors.[56] Gunnery speed to Nelson was of the utmost importance for just this reason. More shots per engagement meant more casualties on the enemy ship and fewer shots coming back. Proponents of accuracy were unfortunately ahead of their time and the technology available. Nelson had clearly validated the closer and quicker mindset at Trafalgar. Getting in close, holding one's fire until ordered, and doing so while the enemy cannonballs streak past you (and through your friends) takes a high level of discipline and

---

[53] Goodwin, "Practice and Power," 57; Goodwin, *HMS Victory*, 103. The gun crews trained for the film *Master and Commander* used the accurate sequence of events. Martin Bibbings drilled the actors and by the time of shooting they could regularly achieve times of less than a minute.
[54] Goodwin, *HMS Victory,* 106. This figure comes from when author and former Royal Artilleryman Adrian Caruana performed this test personally for his book published in 1994.
[55] Caruana, *Sea Ordnance Vol. I*, xviii; Goodwin, *HMS Victory,* 96, 106-7.
[56] Nicolson, *Seize the Fire,* 225.

nerve. The *Victory* suffered 20 dead and 30 wounded in its run up to the allied line. Nelson himself remarked, "This is too warm work, Hardy, to last long," after a French cannonball hit the launch and bounced off the deck, sending a large splinter of wood that took the buckle off Captain Hardy's shoe. Both of them assumed the other was hit, but neither was harmed.[57]

For this reason, as well as for maintaining good order and discipline, leadership and punishment could be draconian by today's standards. Poor discipline within a gun crew could be the difference between life and death, victory or defeat, as could cutting corners during battle. A well-practiced and proficient crew member knew his individual role and the roles of his mates. They could anticipate each other's actions and could work almost unconsciously. If one of them fell, another could take his place and keep the gun in action. That was the goal, keep shooting.

The Carronade and the Innovative Spirit.

Though the carronade only existed for a half-century on Royal Navy ships, it has a story spanning a critical 50 years, which bears telling. Its inventor is disputed between four individuals, and oddly enough, not as essential to the story here as what happened afterward. At Woolwich, the carronade went through its first trials in March of 1779. Its performance was underwhelming, and the Board of Ordnance sent its producers, the Carron Company, back to the drawing board. In a second trial, five months later, pitted against a long gun; it got a very different result with members of the Admiralty in attendance. This time the redesigned carronade was in its element, firing three different kinds of grape shot. The first consisted of 9x 1-lb balls, the second case contained 23x 8-oz balls, and a third case called langridge described as "15 pieces of iron one-inch square and three inches long."[58] It was a piece of langridge that peeled away a three-by-one-inch piece of Nelson's face from his skull at the

---

[57] Nicolson, *Seize the Fire,*203

[58] Caruana, *Sea Ordnance, Vol. II,* 164-5. This test is the only known reference that gives the explanation of what "langridge" case shot actually is.

Battle of the Nile.[59] The carronade's performance was obviously different from its long-gun competitor and gave the admiralty a glimpse of what it really was, a deck sweeper.[60] In modern terms, this test was similar to comparing a regular shotgun to a sawed-off shotgun. With the longer barrel, you get more range and a tighter spread of the projectiles. For the stubby-barreled "sawed-off" carronade, a single blast of grape lacked range depth but made up for it in coverage width. The carronade's grape shots killed or maimed anyone unlucky enough to be topside while simultaneously tearing apart sails and rigging. It would be a devastating piece of weaponry in a close naval fight, and the Admiralty knew it. Others needed convincing.[61]

That very next week, July 13th, 1779, the Admiralty produced a table for arming all its rates with carronades on the forecastles and quarterdecks to the objections of the Ordnance Board who had to find funding for it. They still saw it as vastly inferior to the cannon, which it was at longer ranges. For the Admiralty, the Ordnance Board's objections were akin to asking a fish to climb a tree. The carronade and cannon would not serve the same role and never should have been tested against each other. Over the next three months, the Ordnance Board ordered them, the Carron Company cast them, and the first ones arrived on His Majesty's ships.[62] New weapons seldom get that quick of a response, but the demands of war helped.

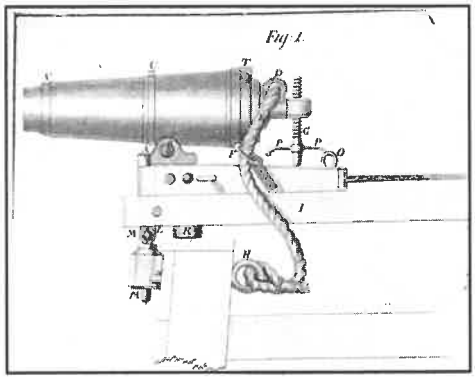

Figure 10: Anonymous drawing of a carronade from the 1790s. (Caruana, Vol. II, 199)

[59] Nicholson, *Seize the Fire,* 247.
[60] Martin Bibbings, "'An Awkward Engine': Captain Philip Broke's Troublesome Relationship with the Carronade," *The Mariner's Mirror* 102, no. 3 (2016): 303-324. DOI: 10.1080/00253359.2016.1202486, 305.
[61] John E. Talbott, "The Rise and Fall of the Carronade." *History Today* 39, no. 8 (1989): 24-30. http://web.b.ebscohost.com.usnwc.idm.oclc.org/ehost/pdfviewer/pdfviewer?vid=1&sid=a94c4b3f-6dd5-4cb8-8d95-4b71087769d5%40sessionmgr101. 26-28.
[62] Caruana, *Sea Ordnance, Vol. II,* 12, 164-5.

For its payload, the carronade's initial intent was firing a hollow shot. It was to be a 30% reduction in shot weight. Since Carron reduced the windage of its solid shot, they believed they could counter the increased recoil with the reduced shot weight. The Navy did not favor the risk of filling the empty cavity with explosive.[63] Solid shot and different types of grape would be all they required. This, however, added to its biggest drawback.

Recoil.

N.A.M. Rodger, in referring to the carronade in *Command of the Sea*, made the unfortunate conclusion that "the small charge meant low recoil forces and allowed a simple swivel mounting." While he is correct in saying it had a smaller charge, evidence within naval correspondence, and physics in general, suggest the contrary to the rest of his statement.[64] Recoil, in this case, has less to do with the amount of powder and more to do with Newton's third law of motion: to every action, there is an opposite and equal reaction. The ratio of projectile to piece and linear momentum calculations decide the recoil.[65] Its foremost complaints, and the vast amount of tinkering over several years, were due to its extremely violent recoil breaking its rather complex slide carriage, especially when firing solid shot.

A quick delve into science is necessary here to fully appreciate the greater point. Momentum is equal to weight times velocity. Think of momentum as measuring how unpleasant it would be to be hit by an object: more momentum = more unpleasant. A 32 pdr carronade with carriage weighs about the same as a 9 pdr long gun with its carriage. Their similar weight but different roles make them an ideal comparison for describing the physics at work. A 9 lb. cannonball moving at 1,500 fps from a long gun has its momentum calculated at 13,500. The slower moving but heavier 32 lb. ball from a carronade traveling at

---

[63] Ibid., 162, 166.
[64] Rodger, *Command of the Ocean,* 420.
[65] Barry Parker, *The Physics of War: From Arrows to Atoms* (Amherst, NY: Prometheus Books, 2014), 151-155.

750 fps has a calculated momentum of 24,000: a 10,500 more momenta punch, at half the speed.[66] Since these two pieces weigh roughly the same, but their shots have very different linear momentums, Newton's third law of motion informs us that the recoil in the opposite direction of the shot's path is also much higher for the carronade. Think about the difference you feel between firing a small-caliber handgun versus a large caliber one.

Iron cannons were typically built to a shot-weight to gun-weight ratio of about 1:100. The recoil was still high but manageable on a ship via a breeching rope bolted to the hull and around the cannon's cascabel. Carronades, by contrast, have a ratio of around 1:60.[67] Simply put, the lower the second number, the more significant the recoil effect. Other than its atrocious accuracy at longer ranges, the carronade's incredible recoil breaking carriages was the biggest problem to overcome. Though it used less powder, it still had a more significant recoil than a long gun or any gun the British Navy possessed in the age of sail. This is where the British innovative spirit proved its mettle.

The French acquired a carronade not long after the British but failed to appreciate it for what it was. When the French frigate *La Precieuse* (32) captured the British brig *Finkastre* in December of 1779, the French acquired their first carronade. Their initial reactions were that it was ineffective. Three years later, when the French frigate *Hébé* (40) capitulated after just a single broadside at close range from the all-carronade equipped *Rainbow* (46), their opinion began to waver.[68] In 1786, the

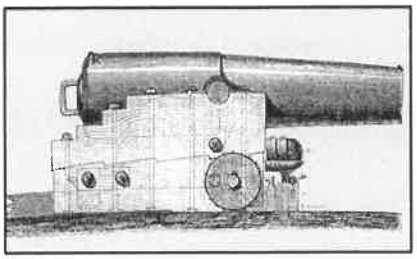

Figure 11: French obusier.

[66] Edward Simpson, *A Treatise on Ordnance and Naval Gunnery* Ed. 2, (New York: D. Van Nostrand, 1862), 30-31.
[67] Peter Padfield, *Guns at Sea,* (New York: St. Martin's Press, 1974), 102. Figures for the math completed here came from the gunner's rule of the time pictured within this source. Carronade shot:piece rations were: 32 pdr-1:60, 24 pdr-1:60, 18 pdr-1:62, 12 pdr-1:58.
[68] Syed Ramsey, *Tools of War: History of Weapons in Early Modern Times.* (Alpha Editions, 2016) https://books.google.com/books?id=jkk5DAAAQBAJ&pg=PT149&lpg=PT149&dq=finkastre+british+ship&source=bl&ots=LHFGdB2UBm&sig=ACfU3U3lfD51vWGUc4oilcvMmvSH0Mc6Kg&hl=en&sa=X&ved=2ahUKEwjX5ryQv8fwAhWPmOAKHSGkBAAQ6AEwA3oECAIQAw#v=onepage&q=finkastre%20british%20ship&f=false.

French attempted to make their own version called the *obusier*, but could not deliver an operational one until 1795. The big question here is why? In the case of the carronade, it seems likely that the defiance the French felt towards anything English would play a part. They certainly felt they were superior in such ways. But even then, the English version outperformed it. In 1804 Napoléon decided with his minister, Decrès, to adopt the British carronade for the French Navy.[69] Though some were present on French ships at Trafalgar in small numbers, the decision was too late to have any real effect before October 21st, 1805.

This is more of a story of British success than of French failure. The captain of the *La Precieuse,* de Vialis, actually did install some of the captured British carronades on his frigate. He found them as frustrating to use as many British captains did early on. We can infer that he most likely made an effort towards making them work since he took the time to have them installed on his ship, but the comparison ends there. There was no drive from the top to *make* them work and little competition among other captains to be novel. He eventually found the English carronades inefficient, and this is when the French decided they would attempt to make their own.[70] We can analyze this British success through what Mahan called a culture's "National Character," the fifth of his six elements of a seapower.[71]

What is most impressive about the carronade is not the carronade itself, but the effort and ingenuity that went into making it work properly where men like de Vialis stopped. One such Briton was Captain Roddam Home. He reported to the Admiralty on the adjustments he made to the carriage, attempting to make it a more effective part of his ship, the *Romney* (50). The recoil kept breaking his modified carriage designs, but he persevered through trial and error. The changes he made indicate he lacked the specialist knowledge onboard to create the

---

[69] Nicolas M., "Napoléon et l'évolution de l'artillerie des vaisseaux," *Trois-Ponts!,* December 10, 2013, https://troisponts.net/2013/12/10/napoleon-et-levolution-de-lartillerie-des-vaisseaux/.
[70] Ibid.
[71] Mahan, *Mahan on Strategy*, 53.

effective weapon he desired.[72] Though he failed through several attempts, it demonstrates the greater point of the desire to try and try again, especially when your Admiralty asks it of you.

Another such individual was Captain Philip Broke, at the time commander of the *Shannon* (38). Broke and the *Shannon* became infamous in American history as the crew that coaxed out and then soundly routed the glory-hungry Captain Lawrence and his *Chesapeake* (38). He did so in under 15 minutes of fighting in 1813 just outside Boston harbor.[73]

To understand the type of man Broke was, it helps to know a few things about the gunnery of his ship. From his personal expenses, Broke purchased upgraded sights for his cannons, paid for additional live-fire training and targets, and had special carriages made for some of the 9 pdrs to fire *en barbette*.[74] His training program was intense, and his sailors were highly skilled in cannons, small arms, swords, knives, and hand-to-hand combat. His gun crews could reload faster than most and hit moving targets at longer ranges. He trained them on how to "catch the roll" of the ship when they fired and drilled them consistently on it. He was a captain comfortable with the science and function of gunnery who expected the same of his crew.[75] A colleague of his, Captain Pechell, said of him, "The *Shannon's* men were better trained, and understood gunnery better, than any men I ever saw." If a captain and crew were going to figure out the carronade, it would be Broke and the *Shannon*.[76]

Figure 12: Captain Philp Broke.

He made several changes, including ones to the carriage, slide bed, trunnion loop, how it elevated, depressed, recoiled, and the doctrine of how to use it in various weather

---

[72] Caruana, *Sea Ordnance, Vol. II,* 168. Home was trying to reduce the resistance along the slide by smoothing out both parts more than they already were. The point of the slide is to provide more resistance, not less, along its length so as to gradually stop the recoil, not let it slide smoothly all the way.
[73] George C. Daughan, *1812: The Navy's War.* (New York: Basic Books, 2013), 190-4; Bibbings, "Awkward Engine," 321-2.
[74] Bibbings, "Awkward Engine," 323 n59. *"En barbette"* at this time was similar to a turret for a long cannon. His creation could swivel a 9 pdr back and forth and had 33 degrees of elevation.
[75] Robertson, *Evolution of Naval Armament,* 154-6.
[76] Bibbings, "Awkward Engine," 322-3.

conditions. During the War of 1812, he perfected it and published his work to the Admiralty.[77] He was the kind of innovative spirit that British national character embodied and encouraged to have free reign to "figure it out." And so he did.

The carronade fit well in the British tactic of close-in fighting. The doctrine developed over time and experience of fighting at sea with the tools at hand. A smoothbore cannon lacked the accuracy at distances beyond 200 yards that came later with rifling. Add to this, the physical toll reloading takes on gun crews, the effectiveness of its new Blomefield guns, and an Admiralty that rewards aggression while punishing cowardice, and you have a doctrine that favors a high volume of fire at close range to decide battles as quick as possible. The French may not have fully adopted the carronade since their doctrine was in opposition to this. In the French Navy, conservatism held the higher regard over aggression, and they sought battle at greater ranges where the carronade was much less effective.[78] It was a relatively short-lived life at sea for the carronade. During that half-century with the Royal Navy, it was formidable. Though the Admiralty experimented by arming ships like the *Rainbow* with nothing but carronades, this was the exception. It was never meant to replace the cannon, only supplement the ship-of-the-line with another club in its golf bag. The conclusion was to find the proper mix of long guns to carronades. Today's doctrine calls this echelonment of fire, switching to, and/or adding, a more effective weapon system as one draws closer to their enemy.[79]

Something must also be said for the seemingly vast differences in the training regimen of Captains like Broke and those of French, Spanish, Dutch, and American crews. During his time, engagements with the former routinely ended in the French taking three

---

[77] Ibid., 312-21.
[78] Padfield, *Guns at Sea,* 109; Rodger, *Command of the Ocean*, 222.
[79] H.C.B. Rogers, *Artillery Through the Ages.* (London: The Military Book Society, 1971), 88. Contemporary echelonment of fire also uses blast radius as a calculation in determining when to switch weapons in closing with an enemy so as to avoid fratricide. As Lt. Henry Shrapnel R.A. did not have his invention approved for service until 1804, this would not be a consideration for some time.

times the casualties as the British. Broke once lamented, "that our success was entirely owing to the deprivation of our enemies' crews in all professional skill, our seamen fought bravely as they had always done, and our equipment was greatly improved, but looking back…European navies had much degenerated." He also tells a story of French naval gunnery being so bad in one particular engagement that only twice did a French cannonball pierce his ship. After investigation, they found both shots came from the same 9 pdr fired by a French artilleryman they happened to have on board who took control of that gun.[80] Had Napoléon paid more attention to the training of his naval artillery as much as he did his land artillery, perhaps this might not have been the case. This is the difference between a land-minded and sea-minded national outlook. An important point here is not to assume that these examples speak for every captain and crew of the British and French Royal Navies. One can certainly find examples where performances varied, especially at Trafalgar, but the British fighting style when executed properly was the more effective of the time.

Other Innovations and Farsightedness.

Obviously dabbling in 19th-century hyperbole, Broke knew well that his training and equipment paid an equal part in his victories. To say British and French officers rarely missed an opportunity to disparage the other is an understatement. Gunnery technology and the way cannons evolved were just as critical to Britain's success. Spanish and French reluctance in this area aided the British, who more continually sought to improve their own and others' systems. The French methods in the 18th century stayed with what worked for longer than most, which had its advantages. It helped them build ships, weapons, and muscle memory in training. It provided focus to a known functional system. Adhering to a "best practice" allowed those being trained a better chance of mastery of that piece of equipment or way of using it. This all would have worked well for them if the British had the same outlook. It was

[80] Nicolson, *Seize the Fire,* 120-1.

also an outlook that blinded them to what was possible, keeping them away from adopting things like the carronade formally for another 20 years after the British. We cannot say that none were present with the French since we know a 32 pdr carronade burst onboard the *Redoutable*, "killing and wounding a great many men."[81]

The Blomefield-Pattern Gun.

The carronade is just one of several British innovations that, taken together, help illustrate the reason for success at Trafalgar and beyond. The British kept their sights on what could be, rather than what was. Three other innovations, more specifically the men behind them and their contributions, help this claim of British primacy in innovation. They continue the story of a nation constantly seeking improvement of the tools it has: Sir William Congreve's investigation and improvement of gun powder, Charles Douglas insistence on the gunlock, and, to start, Thomas Blomefield's cannon designs that took, and saved, the lives it was meant to.

To understand the Blomefield pattern guns, you first have to understand the problems of its predecessor, the Anderson-Fredrich pattern of 1760. Guns were killing crews in increasing numbers just before and during the American Revolution. The culprit turned out to be the unfortunate combination of a lack of metallurgical understanding, complacency, the proofing test they used, the boring process, and an imperfect gun design at critical points. The navy found itself stuck. It needed its cannons for the current war, but they were increasingly dangerous to use. Not only would they be killing British sailors, but most assuredly, they created increasing timidity in battle. Just getting rid of all its cannons was not an option, so they had to make do. For the arming of British ships, one could argue the American

[81] Edward Fraser, *The Enemy at Trafalgar: An Account of the Battle From Eye-Witnesses' Narratives and Letters and Despatches From the French and Spanish Fleets* (New York: E.P. Dutton & Co., 1906), 165.

Revolution as the rehearsal for its major European wars to come.[82] At the end of the war in 1783, a single man and his two teams retested all the guns with appalling results.

The British cannon industry accelerated exponentially after the American Revolution with two crucial episodes in English gun founding history. The first was the calamity of the increasing numbers of exploding guns as they aged. The second came in 1780 when an army captain from the Royal Artillery named Thomas Blomefield became Britain's new Inspector of Artillery and then the Superintendent of the Royal Brass Foundry.[83] He had extensive experience. Blomefield started his military career at 11 as a midshipman on the *Cambridge* (80). At 14, he attended the Royal Military Academy at Woolwich and received an Army commission. He served as an artillery officer onboard bomb vessels and rose through the ranks. He was an aide-de-camp to two generals, where he was closely involved in establishing the Royal Arsenal and gunnery experimentation.[84] He fought in the American Revolution until he was severely wounded at the Battle of Freeman's Farm on September 19, 1777, and evacuated to England. After his two-year recovery, he took up the post of Inspector of Artillery, where he pushed cannons to and beyond their maximum capacities.[85] With his exclusive knowledge and experience, which spanned naval combat, land combat, deep study of internal ballistics, and destroying thousands of cannons over seven years, he developed an incredible, standardized cannon design in 1787. It replaced the problematic Anderson pattern that killed so many gun crew members during the American Revolution. Because they were made from a very specific combination of British iron and melted-down Armstrong guns (at a very specific temperature and with specific fuel), only Britain could feasibly make them by

---

[82] Caruana, *Sea Ordnance, Vol. II,* 216-21.
[83] Bill Crews, "The Blomefield Pattern Cannon," *Age of Sail, Word Press*, (March 20, 2009) https://ageofsail.wordpress.com/2009/03/20/the-blomefield-pattern-cannon/
[84] Jonathan Spain, "Blomefield, Sir Thomas, first baronet (1744–1822), Army Officer," *Oxford Dictionary of National Biography.* September 23, 2004, accessed May 16, 2021. https://doi-org.usnwc.idm.oclc.org/10.1093/ref:odnb/2666.
[85] Robertson, *Evolution of Naval Armament,* 85-86 n3; Caruana, *Sea Ordnance, Vol. II,* 10.

his recipe because only Britain had the proper ingredients.[86] The most endearing aspect was their safety record. Instances of Blomefield's rupturing were exceedingly rare. It made gun crews more efficient by taking away the fear of firing that existed with the Armstrongs.

To go into all the changes Blomefield made and why he made them is unnecessary here. It would also be an extreme amount of technical writing and vocabulary that would mostly frustrate rather than bring clarity to most readers. Since it would also stray outside the purpose here, concentrating on the personalities involved and passing moments of technical aspects is more efficient. Apart from the carronades on *Victory*, all of its guns came from the same Blomefield pattern design at Trafalgar. The pattern is easily identifiable today when you visit the ship in Portsmouth, by the loop on top of the cascabel through which runs the breeching rope. This particular feature allowed gun crews to pivot the gun more easily left and right and kept the short end from snapping off the wall when firing at an angle other than 90 degrees.[87] This alone added to accuracy, rate of fire, and confidence. He started with naval guns. They undoubtedly called loudest for new cannons since gun explosions on ships had occasionally meant the end of the entire ship and/or the contest.

What he did was truly extraordinary. Guns are strongest when they are cold. After they have a few rounds through them, they warm up, which changes the properties of the metal. One of Blomefield's earliest changes as inspector of artillery was to the proofing method, which only judged a new gun at its cold state. Guns now underwent a proof of 30 rounds, double-shotted from the previous two-round proof. It was a dramatic change, which foundries did not appreciate, but more closely replicated the conditions on a British ship in action. Over the years, he and his team personally

Figure 13: Blomefield gun with breechrope and gunlock installed.

[86] Caruana, *Sea Ordnance, Vol. II,* 12.
[87] Brian Lavery, "Carronades and Blomefield Guns: Developments in Naval Ordnance, 1778-1805," In *British Naval Armaments*, edited by Robert D. Smith, 15-27. (London: Trustees of the Royal Armories, 1989), 24.

burst or found deficient somewhere around 2,500 guns that would have exploded onboard a ship during combat.[88] He had everyone's attention. He had figured out what was making them explode, why, and most importantly how to fix it.

The blame started with parliamentary penny-pinching that expected the Ordnance Board to award contracts to lower bidding foundries. Foundries worked with the metal they had near them, which was only of a cannon-making quality in the Weald and Yorkshire. He changed the metal content and how the furnaces and foundries melted it, adding the newest British invention, the steam engine, to operate the bellows to create a hotter fire. He maintained the new high standard of proof for new guns and designed his own cannon pattern based on where the preponderance of the Anderson models ruptured. His design was complete and put into production in 1787. By 1808 there were hardly any Andersons left in Naval service. According to the Chatham Survey Book, it would take until 1810 to have the Navy completely kitted with Blomefield guns.[89] By Trafalgar, five years later, they were ready and experienced with them.

Corned Gun Powder.

Cylinder, or corned, gun powder was another innovation that helped the cannon and British warfare on the sea evolve. It was designed to be safer, more reliable, consistent, faster burning, and easier to use than its predecessor. It was an answer to the difficult question of how to keep powder dry at sea. The new powder was more powerful than its forerunner, and because of that, gun crews had to relearn how to use it. There were accidents, and cannons ruptured, making such mistakes lethal. Everyone along the chain had to be taught not to use the same amount of charge or pack it as tightly as before. The old propellent was called serpentine powder, and there were several differences between the old and new. The critical

---

[88] Caruana, *Sea Ordnance, Vol. II,* 11.
[89] Lavery, "Carronades and Blomefield Guns," 27; Caruana, *Sea Ordnance, Vol. II,* 11-13.

distinction to understand is corned powder's faster burn rate. A faster burn rate meant a faster expansion of gasses. After ignition, gunpowder expands to take up three times the volume. If the expanding gasses produced more pressure than the gun could withstand before the shot left, the pressure found a way out through the metal, blowing apart the breech. During this time, the late 18th century, the previously mentioned Anderson guns started failing in this way; the combination of aging weak guns with new powder was deadly. The main problem with serpentine powder, though, was the opposite. It was weak and prone to turning unserviceable after extended periods at sea.

Figure 15: Vertical éprouvette mortar.

The personality that brought about this revolution in British gunpowder was William Congreve, the elder.[90] In 1783, the Board of Ordnance placed Congreve in charge of the Royal Laboratory, tasking him with investigating what was going wrong with the Crown's gunpowder industry. He was a thorough investigator. He found first that the method for testing it, called vertical *éprouvette*, was invalid.[91] Second, he gathered every type of gunpowder available he could find, including some foreign powder, and put them on the 4th rate *Grampus* (50) going to the Caribbean and back. All the powder left England serviceable, and all the British powder that came back had spoiled. To add insult to injury, the Dutch, Swedish, and Russian powders all came back serviceable. It was an exceptional test, if an embarrassing one for Britain.

Figure 14: William Congreve, the elder.

He uncovered crooked dealings among powder makers, both governmental and merchant. Manufacturers made their powder strong, so it could excel in proof. Engineering it so had the unfortunate side effect of

[90] Not to be confused with William Congreve *the younger*, responsible for the Congreve rocket; immortalized by Francis Scott Key as "the rockets' red glare" as he watched the British attack on Ft. McHenry.
[91] A vertical *eprouvette* is a type of fixed-elevation mortar that fired the same sized shot for every test. The only thing that changed was the powder. The strength of the powder was measured by distance the shot traveled.

significantly weakening its properties of preservation. Over time, this type of testing that relied only on performance at delivery day drew in less than honest practices from self-interested gunpowder producers. Eventually, they came to realize that passing proof was all they needed to get paid. What happened after money and powder exchanged hands was of little concern to them. Congreve also found nefarious dealings within the East India Company. They were cutting corners on their saltpeter refinement procedures and saving money by doing so. They delivered it below purity standards, but no one was checking until Congreve did.[92]

After concluding and publishing his investigation, he went on to invent his own system of refining saltpeter, adopted the single method for making cylinder charcoal, established a system of different sized grains for various weapons, exposed criminal activities and testing shortcomings, became Inspector of Gunpowder Manufactures in 1787, and was knighted in 1812. His new powder was more stable, sustainable, powerful, moisture tolerant, and cheaper to make. He and his team flushed the system of bad apples and perfected British gunpowder.[93] This example underscores that no culture is flawless, nor should anyone expect their own to be. Allowing any system to go unchecked, where human nature has input, people tend to get away with what they can until someone comes along to investigate. The Ordnance Board placed the right man for the right task in charge of investigating a complex problem that was vital to the Royal Navy. By stepping in to address the problem and taking the advice of the man they enlisted, the government here played an understated but critical role in cannon development, safety, and the RN's future dominance on the sea.

---

[92] Caruana, *Sea Ordnance, Vol. II,* 7-8
[93] Caruana, *Sea Ordnance, Vol. II,* 252-256.

The Gunlock.

The gunlock's introduction solved two significant problems. Relegating the linstock to the backup method of firing meant losing dependance on a smoldering piece rope for combat on water.[94] The second had to do with the linstock as well. They were relatively short. The gun captain had to either stand to the side of his cannon to fire it or announce to his #2 man to do so, making aiming during firing next to impossible. With the gunlock and its lanyard, he could now stand behind it just after the point where the breech rope stopped its recoil. This allowed him to look down the sights at his target at the moment of firing. Lastly, where the linstock started the explosive train at an unknown split second, the gunlock's detonation was completely predictable. Guns now fired at the precise moment the gun captain wanted.[95] This gave British ships an enormous advantage in accuracy and timing. Hitting a moving target with a gun emplaced on a ship moving in six degrees of freedom[96] with an inconsistent explosive train made all previous naval accuracy a thing of luck. The Spanish found this out the hard way at Trafalgar when Collingwood's *Royal Sovereign* should have been crippled through the gauntlet of its last 300 yards of approach. Instead, it made it through the

Figure 17: Mounted gunlock with lanyard.

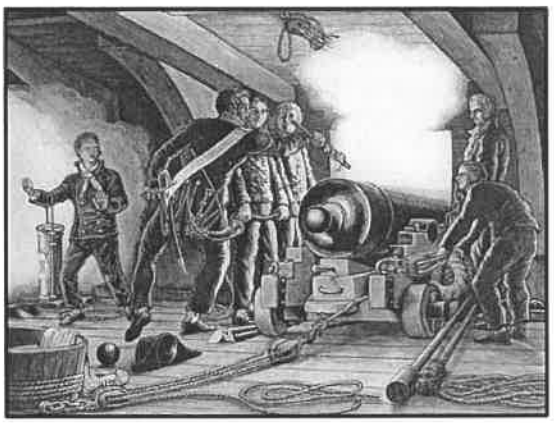

Figure 16: Firing from the side with a linstock.

---

[94] Gun crews kept them around, however, as a backup if their gunlock broke or failed in some way.
[95] J.M. Bingman, "Gunlocks: Their Introduction to the Navy," In *British Naval Armaments*, edited by Robert D. Smith, 41-44. (London: Trustees of the Royal Armories, 1989), 43.
[96] Rodger, *Command of the Ocean,* 541, 739 n47; https://www.usna.edu/NAOE/_files/documents/Courses/EN455/EN455_Chapter1.pdf. The "six degrees of freedom" are roll, pitch, heave, surge, sway, and yaw. Though these six are found in the index of *Command of the Sea,* Rodger incorrectly refers to them on page 739 as the "six dimensions" of ship movement. A ship still only exists and moves in three "dimensions," x, y, and z, like everything else. The United States Naval Academy teaches the six degrees of freedom as part of their seakeeping class..

broadsides of four ships, damaged but not disabled.[97] Had the roles been reversed, a different outcome is probable.

It is best to refer to the gunlock as an experimental piece of equipment from 1727-1790, with interest in it growing through the years. The first one appears to be of French origin in 1718 by Monsieur Deschamps, Master Armourer at Toulon. After John Anderson (designer of the Anderson-pattern guns) visited Paris in 1727, he came back to England and altered his cannon design to accept a gunlock in the future. From 1727 to 1779, the records become inconsistent as "locks" disappear and reappear, but always in small numbers. In 1780 Sir Charles Douglas (father to Howard Douglas) took command of the *Duke* (98) and was issued eight gunlocks, twice as many as was typical. He then purchased 28 more out of pocket. He must have been sold on them because the very next year, he took command of the *Formidable* (98) and, on December 11th, 1781, ordered that *all* its guns be fitted for locks.[98] From this point, and after attributing them to his resounding success at the battle of Saintes, gunlock fever took hold, and there was a flurry of new designs and improvements submitted for consideration.[99] Henry Knock's design won out and was the lock of choice that made it to Trafalgar. All this occurred while the French design stagnated and remained far from common use in 1805.[100]

Figure 18: Sir Charles Douglas, with left hand on a gunlock.

These three innovations taken together: corned gunpowder, the Blomefield-patterned guns, and gunlocks show the foresight and diligence that made this the culture of a sea-minded nation. The corned gunpowder was too powerful for the Andersons, and the gunlocks

---

[97] Peter Padfield, *Maritime Power: And the Struggle for Freedom: The Naval Campaigns that Shaped the Modern World, 1788-1851,* (Woodstock: Overlook Press, 2005), 238.
[98] Caruana, *Sea Ordnance, Vol. II,* 389-92.
[99] Padfield, *Guns at Sea,* 111-2.
[100] Caruana, *Sea Ordnance, Vol. II,* 392-3.

would make the Blomefield crews more lethal. The Blomefield-pattern guns solved several problems, but the British Royal Navy could not simply swap out all its guns at one stop in port. An extensive network of budgets and plans had to be scheduled over years to bring about the complete change. It had to marry the new functional gunpowder, with gunlocks, with Blomefield-patterned guns and carronades, all while ensuring they systemically phased out everything's old versions. It would have included re-training every gun crew on three significant changes that most likely did not come to everyone in the same order. New cannons had to be cast and bored of varying sizes and to exact specifications, which all the gun founders had to understand completely and execute flawlessly. Gunpowder had to be tested and retested to ensure the new recipe stood the test of time. All the new powder had to replace all the older powder stationed around the globe without missing a barrel. It must have been a massive undertaking that involved nearly every member of the Navy, the Admiralty, the Ordnance Board, gun founders, and every other citizen that had anything to do with making sure the old was out, and the new was in. Foresight and diligence saw them through.

Increasing British power by winning battles and gaining command of the sea would be the fruits of their labor. Mahan had reservations for the future of the United States Navy for this reason. He questioned whether the U.S. had the requisite capacity for sustained preparation for war in peace. In the first chapter of *The Influence of Sea Power Upon History*, he warned that a "peaceful, gain-loving nation is not far-sighted, and far-sightedness is needed for adequate military preparation."[101] When Mahan wrote this, the idea of farsightedness was in doubt for both England and the United States in a time of peace. His concern was their "willingness to ensure [their] prosperity" for the future.[102] He wondered if they could achieve a high level of naval preparedness. When men like Philip Broke, William

[101] Mahan, *Mahan on Strategy*, 29.
[102] Ibid., 72.

Congreve, Thomas Blomefield, and Charles Douglas knew what needed to happen, their government encouraged them, had their back, and there was a cultural understanding of what was necessary. It was the hallmark of a seapower. If such a thing could be repeated remains in question today.

Conclusion.

When you combine all this extraordinary, individual effort bred from the proper amount of governmental carrot and stick, a clear picture emerges. It permeates through more than just cannons, but nearly every aspect of life. Europeans had different struggles to worry about, mainly concerning how they felt about one another. Ancient Europeans were certainly not lacking in frontier lands as Britons were. If Britons wanted a "frontier" like Europe, it would have to be the sea. Though cultures like the Danes, French, and Spanish also went to the sea and found wealth there, they did not do it out of necessity as Britons did.

Geographically, the British Isles lent themselves to creating a culture that must subscribe to the idea that attack is the best method of defense. Early experiences with the Romans and Danes taught them that and carried on into Royal Navy doctrine. Just ask Admiral Byng. By the nature of their location, the British had to be aggressive.[103] This applies to both intellectual and physical aggression. It even made them a competitive people among themselves, challenging one another and growing from it. On the other side of that coin is the security that the English Channel provided them. Such secure borders allowed them to establish a system of governance much more democratic in nature, well ahead of its European neighbors.[104] That security privileged them a certain amount of experimentation in life, or trial and error, that those on the continent could not afford to chance. Essentially, geography helped create offensively-minded Britons and defensively-minded Europeans.

---

[103] Caruana, *Sea Ordnance, Vol. II,* 6.
[104] Robert D. Kaplan, *The Revenge of Geography* (New York: Random House, 2012). 31.

Between the two sides of this coin, and somewhere along the way, Britons had the choice between isolationism or interventionism. When they chose the latter, offensive-mindedness, sea-mindedness, and innovative-mindedness followed.

Society and geography in Britain were, and remain, hopelessly intertwined. It was a society born and bred on an island with bad roads caused by worse weather but with navigable waterways within and around it. It was a culture that, unlike the European continent, was utterly dependent on sea trade for foreign goods.[105] Its very livelihood found its link with the sea and that livelihood's protection in the navy from the start.

There is indeed such thing as a military culture, but each nation has its own based on the culture of the people that make it up. British citizens, soldiers, marines, and sailors alike saw the ocean for its possibilities, and less as an obstacle. It was a place to live, and less a place to merely transit. They did not see land and water as two different worlds, just one. Sir Walter Raleigh called the English cannon "a jewel of great value," but it was more than that. This essay reasons that this "jewel" was something that gave England not just a tactical advantage on the sea, but an economic, governmental, diplomatic, doctrinal, and cultural one as well.[106]

Word Count: 13,382.

---

[105] Mahan, *Mahan on Strategy*, 27-28.
[106] Cipolla, *Guns, Sails and Empires,* 44.

Aaron Bright

Bibliography

Barr, Nicholas, et al. "Ancient Britain." Encyclopedia Britannica. Accessed May 19, 2021. https://www.britannica.com/place/United-Kingdom/Ancient-Britain.

Bibbings, Martin. "'An Awkward Engine': Captain Philip Broke's Troublesome Relationship with the Carronade." *The Mariner's Mirror* 102, no. 3 (2016): 303-324. DOI: 10.1080/00253359.2016.1202486.

Bingman, J.M. "Gunlocks: Their Introduction to the Navy." In *British Naval Armaments*, edited by Robert D. Smith, 41-44. London: Trustees of the Royal Armories, 1989.

Caruana, Adrian. *The History of English Sea Ordnance, 1523-1875, Vol. I.* Rotherfield, UK: Jean Boudriot Publications, 1994.

Caruana, Adrian. *The History of English Sea Ordnance 1523-1875, Vol. II.* Rotherfield, UK: Jean Boudriot Publications, 1997.

Cipolla, Carlo M. *Guns, Sails and Empires: Technological Innovation in the Early Phases of European Expansion 1400-1700.* New York: Barnes and Nobles Books, 1996.

Clausewitz, Carl von. *On War: Indexed Edition.* ed. and trans. Michael Howard and Peter Paret. Princeton, NJ, Princeton University Press: 1989.

Cleere, Henry and David Crossley. *The Iron Industry in the Weald.* Cardiff, UK: Merton Priority Press, 1995.

Crews, Bill. "The Blomefield Pattern Cannon," Age of Sail, *Word Press,* (March 20, 2009) https://ageofsail.wordpress.com/2009/03/20/the-blomefield-pattern-cannon/.

Dancy, J. Ross. *The Myth of the Press Gang.* Woodbridge, UK: Boydell Press, 2015.

Daughan, George C. *1812: The Navy's War.* New York: Basic Books, 2013.

Fraser, Edward. *The Enemy at Trafalgar: An Account of the Battle From Eye-Witnesses' Narratives and Letters and Dispatches From the French and Spanish Fleets.* New York; E.P. Dutton & Co., 1906. https://babel.hathitrust.org/cgi/pt?id=mdp.39015074830707&view=1up&seq=10.

Fremont-Barnes, Gregory. *Trafalgar 1805: Nelson's Crowning Victory.* New York: Osprey Publishing Ltd., 2005.

Goodwin, Peter. *HMS Victory Pocket Manual 1805: Admiral Nelson's Flagship at Trafalgar.* Oxford: Osprey Publishing, 2017.

Goodwin, Peter. "The Practice and Power of Firing Broadsides in British Men of War During the Age of Fighting Sail." *Arms & Armour* 13, no. 1 (2016), 48-61. https://doi.org/10.1080/17416124.2016.1191750.

Guilmartin, John Francis Jr. *Galleons and Galleys.* London: Cassell & Co, 2002.

Handel, Michael. *Masters of War: Classical Strategic Thought. 3rd Ed.* London: Frank Cass, 2001.

The Historical Maritime Society, "The Gunner and His Crew in Aubrey's Royal Navy." The Dear Surprise. https://thedearsurprise.com/the-gunner-and-his-crew-in-aubreys-royal-navy/.

Kaplan, Robert D. *The Revenge of Geography.* New York: Random House, 2012.

Lavery, Brian, "Carronades and Blomefield Guns: Developments in Naval Ordnance, 1778-1805," In *British Naval Armaments*, edited by Robert D. Smith, 15-27. London: Trustees of the Royal Armories, 1989.

Lucas, Jean-Jacques-Etienne. *Le rapport ci-dessous fut écrit par Lucas juste après la bataille, dans le cadre de son rapport général au ministre de la marine, Decrès*. October 23, 1805. http://www.histoire-de-fregates.com/trafalgar/32-trafalgar/105-trafalgar-redoutable.

Mahan, Alfred T. *Mahan on Strategy: Selections from the Writings of Rear Admiral Alfred Thayer Mahan.* ed. John Hattendorf. Annapolis, MD: Naval Institute Press, 2015.

Nicolas M. "Napoléon et l'évolution de l'artillerie des vaisseaux," Trois-Ponts!. December 10, 2013. https://troisponts.net/2013/12/10/napoleon-et-levolution-de-lartillerie-des-vaisseaux/.

Nicolson, Adam. *Seize the Fire: Heroism, Duty and Nelson's Battle of Trafalgar.* New York: Harper Perennial, 2006.

Padfield, Peter. *Guns at Sea,* New York: St. Martin's Press, 1974.

Padfield, Peter. *Maritime Supremacy and the Opening of the Western Mind: Naval Campaigns that Shaped the Modern World.* New York: The Overlook Press, 1999.

Parker, Barry. *The Physics of War: From Arrows to Atoms.* Amherst, NY: Prometheus Books, 2014.

Ramsey, Syed. *Tools of War: History of Weapons in Early Modern Times.* (Alpha Editions, 2016) https://books.google.com/books?id=jkk5DAAAQBAJ&pg=PT149&lpg=PT149&dq=finkastre+british+ship&source=bl&ots=LHFGdB2UBm&sig=ACfU3U3lfD51vWGUc4oilcvMmvSH0Mc6Kg&hl=en&sa=X&ved=2ahUKEwjX5ryQv8fwAhWPmOAKHSGkBAAQ6AEwA3oECAIQAw#v=onepage&q=finkastre%20british%20ship&f=false.

Regulations and Instructions Relating to His Majesty's Service at Sea. Admiralty, 1st ed. 1731.

Robertson, Fredrick Leslie. *The Evolution of Naval Armament.* London: Constable & Co. Ltd., 1921.

Rodger, N.A.M. *The Command of the Ocean: A Naval History of Britain, 1694-1815.* New York: W.W. Norton & Company, 2005.

Rodger, N.A.M. The Development of Broadside Gunnery, 1450-1650, *The Mariner's Mirror* 82, no. 3. (August 1996), 301-324.

Rodger, N.A.M. Review of *The History of English Sea ordnance 1523-1875, Vol. II*, by Adrian B. Caruana. *The International Journal of Nautical Archaeology* 27, no. 2, (May 1998) 172-173. https://doi.org/10.1016/S1057-2414(98)80076-9.

Rodger, N.A.M. *The Safeguard of the Sea: A Naval History of Britain 660-1649.* New York: W.W. Norton & Company, 1998.

Rogers, H.C.B. *Artillery Through the Ages.* London: The Military Book Society, 1971.

Simpson, Edward, *A Treatise on Ordnance and Naval Gunnery, 2nd Edition.* New York: D. Van Nostrand, 1862.

Jonathan Spain, "Blomefield, Sir Thomas, first baronet (1744–1822), Army Officer," Oxford Dictionary of National Biography. September 23, 2004, accessed May 16, 2021. https://doi-org.usnwc.idm.oclc.org/10.1093/ref:odnb/2666.

Talbott, John E. "The Rise and Fall of the Carronade." *History Today* 39, no. 8 (1989): 24-30. http://web.b.ebscohost.com.usnwc.idm.oclc.org/ehost/pdfviewer/pdfviewer?vid=1&sid=a94c4b3f-6dd5-4cb8-8d95-4b71087769d5%40sessionmgr101.

Toll, Ian W. *Six Frigates: The Epic History of the Founding of the U.S. Navy.* New York: W.W. Norton & Company, 2006.

Tracy, Nicholas. *Nelson's Battles: The Art of Victory in the Age of Sail.* London: Caxton Publishing Group, 2001.

Trebilcock, Clive. ""Spin-off" in British Economic History: Armaments and Industry, 1760-1914." *The Economic History Review* 22, no. 3 (December 1969): 474-490. https://www.jstor.org/stable/2594122.

Zell, Michael. *Industry in the Countryside: Wealden Society in the Sixteenth Century.* Cambridge, UK, Cambridge University Press: 2004. https://www.wealdeniron.org.uk/Pubs/The%20Iron%20Industry%20of%20the%20Weald%20-%20C+C.pdf.