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**GREAT BRITAIN IN THE AGE OF SAIL: SCARCE
RESOURCES, RUTHLESS ACTIONS AND CONSEQUENCES**

by

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ABSTRACT

Materials to build ships in the Age of Sail were vast quantities of wood, masts, iron, canvas, hemp, pitch and tar. In the late 1700s, the British began using copper plating on the bottom of their ships. Attaining these materials was essential to the national security for Great Britain so they employed some shrewd methods to procure them. This led to negative consequences for Britain. The background of these key shipbuilding resources, to include where Britain obtained its naval stores, as well as Britain's ruthless actions and their consequences will be explored through historical data. The key shipbuilding resources had a direct impact on Britain's national strategy and policy decisions.



The materials to build and outfit ships during the Age of Sail were vast quantities of wood, masts, iron, hemp, gunpowder, pitch and tar, with the addition of copper in the late 1700s when the British began copper plating the bottom of their ships. With the Royal Navy serving as Britain's first line of defense, the resources for shipbuilding in the Age of Sail were critical to its national security. Unable to produce many of these key shipbuilding resources domestically for sustained periods of time, they had to be sourced from other countries or colonies. This dependence on foreign materials exposed Britain to disagreements with other countries and economic sanctions. Therefore, Britain took ruthless action in order to secure these key naval stores because they were vitally important to the state's survival, often with negative consequences for Britain.

Timber

Ship construction required different varieties of wood for its different parts and most types of trees did not provide wood that was suitable for ships. To complicate the matter, the life of wood varied as different kinds of wood rotted at different rates. The rugged sea and the harsh use of ships deteriorated the wood. By the later stages of its life, ships often had to be renovated piece by piece of wood that it was scarcely the original. Apart from the pest shipworm, decay, and the violence of the sea, battle caused its own havoc on wooden ships. To keep a ship in service, repair and replacement were constant. One way or another, a ship of the late eighteenth century was in permanent reconstruction.¹

Throughout the Age of Sail, shortages in timber were a major concern for the British Admiralty and heads of state.² In fact, complaints about the deforestation of the English countryside had been frequent since at least Elizabethan days.³ The woodlands of England had become less able to supply sufficient quantities of oak for the hulls of the Royal Navy's ships,

with a severe mast crisis which lasted throughout the Dutch Wars and was soon followed by a shortage of oak.⁴ By the mid-1700s, the English had nearly exhausted the supplies of large logs within a distance from the sea that made transport to the dockyards by road or water economical.⁵ Acute shortages in timber, reminiscent of the Dutch Wars, were prevalent between 1775 and 1815. The timber supply was inseparably connected with sea power as control of the sea allowed England to search the world for new sources of timber. Conversely, the Royal Navy feared the possibility of losing access to these foreign resources for the repair of the old fleet or the construction of a new one.⁶

Long before any work commenced at the shipyard, years were needed to prepare suitable timbers of oak and elm. Trees had to be planted, grown in the right manner, selected, cut, seasoned, and again selected. The British deliberately deformed certain trees so that they grew in a curve; these timbers were of great value. A mature tree might require sixty years to grow and seasoning the cut wood would take two to three more years. The shipbuilding industry of the nineteenth century was a long-term, deliberate, and fairly inflexible operation. While great care was taken to maintain forests of the right trees, Britain was not able to grow all the oak and elm needed for shipbuilding. It therefore had to import large quantities from the Baltic region.⁷

The use of unseasoned or green timber in times of desperation was one of the main causes of a sea vessel becoming unseaworthy. Throughout the eighteenth century, England spent quite a number of years at war which lead to constant demands on naval construction. This meant the forests were rapidly disappearing. The shortages led to malpractices in construction, the major one being that ships were often built with green wood due to the urgency of the naval situation. This resulted in many vessels beginning to rot before they were even launched.⁸

A great amount of wood was required to build and repair ships during the Age of Sail. The unit of timber measurement was the “load” which was fifty cubic feet. Roughly, the average oak of timber size contained about one load of timber and made up nearly a ton of shipping weight.⁹ The construction of an average 74-gun ship of the line required approximately 3000 loads of timber and needed re-equipping and some repair every two to three years, with major repairs every ten years, but was accelerated to eight years after 1806.¹ Approximately 3000 loads of timber equaled 2000 oak trees and represented the produce of 57 acres of land.¹⁰ In 1803, the British fleet numbered approximately 608 ships of all sizes, including eighty-one 74-gun ships. By 1813, there were a total of 920 ships, including one hundred forty-three 74s. In 1801, the annual consumption of timber in the royal dockyards was 36,000 loads annually, after 1803 it rose to 53,000 loads, and from 1810 to 72,000 loads. Though the annual consumption of timber fell after 1815, it fell only to the level of 1803.¹¹ The Royal Navy’s annual consumption of timber for building and repairs of 72,000 loads in 1810 required 48,000 full grown trees, and nature needed a century for oak to reach maturity.¹²

Great Britain could not supply all the required oak, which was the main material for the ‘great timbers’ of a ship and for the knees that linked together keel, ribs, beams, and carlines.¹³ The British Navy Board had considered foreign oak inferior to English oak and more liable to decay, though it had long imported it and other timber from the Baltic to supplement native supplies. Scarcity reluctantly changed these views. British naval administrators were aware of the dangers of reliance on supplies of naval stores from foreign sources, which could be cut off by enemy action, hostile diplomacy, bad weather, or a price of which was out of their control. But inadequate timber supplies forced them to enter new, untried markets and acquire large

¹ To build the 90 gun ship *Blenheim* in 1761, it took 188,668 cubic feet of timber or 3773 loads; to build the 100 gun ship *Royal George* in 1756, it took 288,025 cubic feet of timber or 5760 loads. Goodwin, *Construction and Fitting*, 239.

amounts of foreign timber, at first for repairs only, but increasingly for ship construction as well.¹⁴ By the late eighteenth century, the Baltic had become Britain's north European wood supply region. This region consisted of all the lands whose rivers flow into the Baltic Sea and the seas of adjacent regions of northern Europe such as Norway and Arctic coasts of Russia. On the south coast of the Baltic Sea, timber came down the Oder and the Vistula Rivers to Stettin and Danzig. On the east coast, the Neman and the Dvina Rivers reached back into the Russian hinterland before flowing into Memel and Riga. On the west or Swedish side of the Gulf of Bothnia, innumerable rivers brought timber from Norway and Sweden. Timber was also supplied from the Arctic watershed of Archangel, Russia.¹⁵

Britain relied heavily upon Norway for timber in the eighteenth century. Four-fifths of all imports into England of all Danish-Norwegian commodities from 1755-1764 were timber coming from the Norwegian forests. The eastern Baltic (east of the Oder River) furnished great masts, oak and shipbuilding spruce, and fir. Shipments from the American colonies of oak and pine remained small and of little consequence until later in the eighteenth century. Britain also obtained fir timber in small quantities from the White Sea area, and oak from Germany and Holland. But the supplies from all these sources hardly affected the Norway trade through which England obtained most of her sawn timber and smaller masts. Norway, favored by proximity to England, remained the largest supplier of the most commonly used woods in the mid-eighteenth century. Imports of timber or fir timber accounted for about one-sixth at real value of total imports from 1755 to 1763.¹⁶ Norway's forests became overexploited in the early nineteenth century however due to its easy access to England.¹⁷

One result of Napoleon's victory and Jena in 1806 and the Treaty of Tilsit in 1807 for the British was reduced access to the Baltic ports. Napoleon's Continental System created a timber

crisis for the British in 1807 to 1812. Before this crisis, timber shipments from British America (Canada) remained a fraction of the total timber imports. The success of the British in meeting the crisis of 1808-09 was speedy and remarkable. Import of timber from British America jumped from 27,000 loads in 1807 to 57,000 loads in 1808. They nearly doubled to 90,000 loads in 1809. Fir timber imports from the Baltic had fallen from 200,000 loads in 1807 to 25,000 loads in 1808; oak and masts fared even worse. The largest amount of square timber normally came from Prussia, but the year of Jena reduced imports to a fifth of the usual amount. They recovered a little in 1807 but dwindled to next to nothing in 1808. Wood continued to come from Sweden and in increasing quantities, for her adhesion to the Continental System was nominal. Sweden's ports also worked up an entrepôt trade between forbidden areas and the British. The most critical period lasted two years from 1808-9.¹⁸

In the late 1700s and early 1800s, new sources of timber were sought around the world with some success. Great Britain also explored acquiring timber from southern Europe and southern Russia. In the Mediterranean, good supplies of oak could be found in Albania, Tuscany, Provence and Languedoc but political instability and lack of control over the local forests made it difficult to get the wood to the ports.¹⁹ On the shores of the eastern Mediterranean and Black Sea, large sums of public money were invested with considerable time and labor expended. Although some excellent timber was forthcoming, primarily for the newly-acquired Malta dockyard which provided repair and refitting facilities for the Mediterranean fleet, the Navy Board ultimately failed to tap this source. Britain found promising timber suitable for all aspects of ship construction in the eastern Adriatic in present day Croatia. Grand schemes to build roads linking the forests to rivers that lead to sea ports were destroyed by Napoleon's campaign against Austria. France's victory at Austerlitz forced Austria to surrender

Dalmatia, including part of the Adriatic coast to Napoleon. French troops occupied and controlled this area halting abruptly the newfound British timber trade in Croatia. The Navy Board considered Albania as another possible source of ship timber, but the area also fell under French influence in 1805. Despite early optimistic reports of the availability of large amounts of good quality timber, plans to use the southern Russian provinces as a cheap source of supply were unsuccessful. The timber was neither so readily available nor so cheap and easy to transport as had been expected. The source could not be controlled, the shipping route was long and hazardous, and the Straits in Turkey always at risk to closure. Economically, strategically, and diplomatically, southern Europe and southern Russia were not viable timber sources for Britain.²⁰

Britain not only searched Europe and Canada for timber supplies but the entire world during the Napoleonic Age. Britain investigated the forests of Brazil when the Portuguese royal family offered timber in their gratitude for Britain's evacuation of them to Brazil. However, the felling and transportation of timber from the Brazilian interior were undeveloped and proved too expensive and time consuming to materialize as a timber source.²¹ In Central America, there is evidence that Britain used coercive diplomacy to maintain timber supplies, specifically in Honduras, Belize, and Panama. Mahogany was used in warships during the Napoleonic wars, but the best was expensive and the cheaper varieties so porous as to be worthless. Britain also imported mahogany and other tropical woods for ship building from the western Caribbean. During the timber crisis of 1808-12, the southern states of the United States supplied pitch pine and oak to build frigates, but this supply was very small and intermittent. There was also smuggling that developed through Canada which contained large amounts of Vermont oak exported to England through Quebec. The Cape of Good Hope provided another possible timber

source, but difficulties of felling and transporting timber in the undeveloped country made it expensive and the timber itself was not wholly suitable. Australian timber was very hard and durable and was seriously explored during the Napoleonic wars, but freights from the Pacific were too high to be economic unless such timber could return in empty convict transports and it never became an extensive trade. It was India which provided the most successful source of imperial timber to the navy. Teak was tough and durable and had an established reputation as an excellent ship timber. The British East India Company built teak warships in the Bombay dockyard and the Navy Board hoped that returning Company ships would bring home teak as part of their cargoes, but it was on the journeys back to Britain where profits were made and teak ship frames and timbers took up too much valuable cargo space. Thus, very little teak timber was imported into Britain.²²

Great Britain imported a significant amount of timber during the Age of Sail. In 1801, Britain imported 682,000£ of timber, accounting for 2.14% of the total official value of all imports in that year; in 1810, Britain imported 808,000£ of timber, which is 2.06% of the total official value of all imports in that year. Timber was such a significant import that it is one of the top 17 imported items of Great Britain listed in the *Abstract of British Historical Statistics* Overseas Trade section.²³

During the Age of Sail, provision for the supply of wood became a matter of strategic survival of state for Britain. First, native wood was utilized and the supply was exhausted.²⁴ England turned to the Baltic, but from 1807 to 1812, England was deprived of a normal store of timber and masts. Timber was smuggled out of the hostile ports, but was hardly enough to keep a frigate squadron in repair. With practically every foreign European port barred to her ships, England was able to maintain her Navy with timber and masts from her own colonial empire and

former colonies entailing a massive commitment of resources. When Europe closed her ports, British possessions and allies on every other continent contributed their trees to maintain the Royal Navy.²⁵

Masts/Spars

Another critical shipbuilding resource in the Age of Sail was masts which are sometimes called spars. In all of Britain there grew no trees suitable for the best masts, so dependence on foreign lands for masts had been ongoing since 1652 and lasted throughout the age of sail.²⁶ Devoid of large coniferous trees that could provide masts, England had obtained masts from the Baltic, principally from its eastern shores below the Gulf of Finland. Dependence on the Baltic for these vital items had led seventeenth-century Britain into many naval measures to protect her supplies. English fleets had often been in the Baltic, and the connection between economic, war, and policy had been direct.²⁷ The best timber for great and medium sized masts came from Russia, Prussia, Finland, and Sweden.²⁸ Substantial amounts of masts were obtained from Norway. Few 'great' masts, that is, masts of a diameter above 12 inches, came from the Norwegian forest, but 'middle' and 'small' masts of respectively 8 to 12, and 6 to 8 inches diameter, were obtained in larger quantities than from any other source to be used in naval construction. The numbers imported remained steady between 1750 and 1770 at 2,000-3,000 each of middle and small masts annually. These figures compared with a few hundred up to a thousand from the East Country and Russia annually.²⁹ Masts were available from southern France and northern Spain, but they were poor quality compared to those from Scandinavia so were not used.³⁰ The Baltic trade continued to grow powerfully from the American Revolutionary War until the imposition of the Continental Decrees by Napoleon in 1808. When the Treaty of Tilsit in 1807 closed Prussian ports to Britain and forced Prussia to hand over to

France territory west of the Elbe and in Poland. This reduced the number of masts Britain imported from there from 17,000 to 4,600 in 1808. After the Baltic was no longer restricted by the Continental System, it returned to being Britain's main source of masts.³¹

Geopolitical disturbances in Europe caused the American colonies to become an alternative to the Baltic for the supply of masts and the need for displays of naval power in the Baltic became less pressing. There were some timber imports from North America in the seventeenth century, and in the eighteenth century the quantity increased markedly to a few hundred annually.³² Every effort was made through legislation to encourage this alternative supply. The two natural difficulties were distance and the bulky nature of timber. Ships from the Baltic ports could make several voyages a year compared with one of two from America. Consequently, the pre-Revolution timber trade between Great Britain and her American colonies never exceeded modest dimensions. The Revolutionary War had a profound effect. When Great Britain lost her mast supplies from New Hampshire and Maine, she had much difficulty maintaining her fleets at sea. Some authorities go so far as to claim that Great Britain lost the War of the Revolution because of defective masts, which could not be replaced and led to her temporarily losing control of the sea.³³ When colonial mast supplies were cut off in 1775 due to the American Revolution, Britain filled the gap effortlessly via the Baltic.³⁴

As a result of the Continental Decrees, the Canadian timber trade started its boom years.³⁵ Britain opened up new sources for mast pines in New Brunswick and the St. Lawrence, but these new sources took time to develop. Consequently, Britain continued to be heavily dependent on the Baltic for its masts and great timbers. As the years went on, North American supplies increased and alleviated dependence on the Baltic.³⁶ With the navy's increasingly urgent needs since 1803, Canada now saw a rapid expansion and development of a trade in masts and in hull

timber based on Quebec and drawing on the inferior but necessary white oak of Upper Canada and the New England states. After the Baltic was restricted in 1807, Canada compensated by increasing mast exports from 4,422 to 16,729 in 1808 and reaching a maximum in 1811 with 23,053 vice 3,319 masts imported to Britain from Prussia and Russia in that year.³⁷

Tar and Pitch

Tar and Pitch are two more essential materials required to build and repair sailing ships. Sweden, Finland, and Russian forests provided not only wood but pitch and tar³⁸ which were used in caulking and in the preparation of ship's cordage. Ropes of the standing rigging were well tarred with "Swedes" or Stockholm tar.³⁹

The application of "white stuff" was one of the oldest methods of covering the hull. White stuff was very common during most of the seventeenth century, but toward the end of the century "black stuff," which cost half as much, came into use. White stuff consisted of train oil (from whales, seals or fish), rosin from pine trees, and brimstone (sulphur). Black stuff was a mixture of tar and pitch. Tar was obtained from pine trees and was boiled to produce pitch. Black stuff was a mixture of two parts of pitch to one of tar.⁴⁰ Because Britain was deficient on trees that were used to make pitch and tar, it once again was forced to rely on other nations to meet this need just as it did for timber and mast supply.

Swedish pitch and tar were of such a high quality that even heavily subsidized imports from America could not drive them out of the English market. Sweden had in the past been practically the sole foreign supplier of these essential naval stores. There was much agitation against the Swedish monopoly, and proposals were made to import pitch and tar from the American colonies where the pine forests of North Carolina in particular showed promise of an inexhaustible source of supply. The cost of shipment was great from North Carolina as

compared to Sweden. In 1703, a naval squadron which was to be fitted out against France could not be made ready for sea as there was insufficient pitch and tar available and the Stockholm Tar Company refused to ship any. The danger to British preparedness was obvious. An Act was passed giving substantial bounties to importers of colonial pitch and tar which encouraged American production to such an extent that within a few years the English market was glutted and quantities of pitch and tar were re-exported to the Mediterranean, Spain, Portugal, Holland, Hamburg, and Bremen. American pitch and tar, however, could not wholly replace Swedish. The American quality was poor, and the various Acts extending the bounties for further periods became more stringent on the pitch and tar product conforming to the prescribed standard of purity. Despite these regulations, improvement appears to have been very slight or nonexistent, and the bounty on pitch was eventually lowered. It is unlikely that after that time much colonial pitch was imported to Britain as its price came to be about on par with the preferred Swedish pitch, although it could have been used in British naval bases in America. Like Sweden, Norway had never ceased to supply England with some pitch and tar, but the quantities were much smaller. The East Country, Russia and Holland were other sources of supply, but again the quantities were small and by mid-1700s, negligible. This pattern of imports stayed unchanged until the American Revolution temporarily cut England off from some of her colonial supplies forcing her to draw more heavily on Scandinavia. By that time, however, Canada had become the principal supply of pitch and tar from the colonies and British dependence on Swedish supplies was therefore never again as acute as it had been in the 1700s.⁴¹

An example of the dominant position of Swedish pitch and tar emerges from a study of Navy Board contracts during the period 1694-1704 when £84,681 was paid for their purchase. The only other tar and pitch contract in this period was in the amount of £260 in 1702 for

‘English pitch’, which probably was produced from colonial tar. Risks were taken to keep the Baltic trade open, as in 1709 when quarantine restrictions were waived on ships bringing pitch and tar from Sweden, even as the plague raged throughout the Baltic region.⁴²

Hemp

Hemp is needed to make rope and is another critical resource required in shipbuilding and ship repair. Russia, Poland and Germany grew hemp for England,⁴³ but the quality of Russian hemp was unmatched.⁴⁴ Russian hemp imports outweighed East Country by two or three times throughout the eighteenth century and these two sources dominated the trade. In 1706, Russia and the East Country supplied over 90 percent of England’s hemp supply.⁴⁵ In 1801, 86 percent of British imported hemp came from Russia and six percent from Prussia.⁴⁶

The British explored many other areas of the world to reduce their reliance on Russia and the Baltic hemp. Attempts to provide adequate domestic supplies of hemp in Spain, France and Britain generally failed⁴⁷ and cultivation of hemp in North America had been unsuccessful in the eighteenth century.⁴⁸ Efforts were made to develop other supplies of hemp from Canada and India in 1790-2, and from Ireland, Spain, New South Wales, Italy, and the Adriatic in 1800-9. But none of these new sources could provide the quantities of the quality supplied by Russia.⁴⁹

Due to the almost sole reliance on Russia and Prussia, the supply of hemp was particularly affected by the Treaty of Tilsit in 1807. Hemp imports to Britain in 1807 were worth £639,507 and in 1808 they were one-third of that. Neutral vessels helped alleviate the shortage of hemp from Russia and were escorted by Royal Navy convoys in the Baltic.⁵⁰ By 1810 British hemp stocks were high enough that imports were forbidden except against matching Russian purchases of British goods.⁵¹

Very similar to timber, Britain imported a great amount of hemp in the days of sailing ships. In 1801, Britain imported 636,000£ of hemp, which is 2.00% of the total official value of all imports in that year; in 1810, Britain imported 752,000£ of hemp, which is 1.91% of the total official value of all imports in that year. Hemp imports also were significant enough to be one of 17 principal imports of Great Britain listed in the *Abstract of British Historical Statistics*.⁵²

Gunpowder

Gunpowder is another critical resource required by the Royal Navy to outfit their ship's cannons for battle. Gunpowder is combination of saltpetre, charcoal, and sulphur, most commonly in the proportions of seventy-five, fifteen, and ten percent respectively. Saltpetre (potassium nitrate) was mainly imported from India and sulphur mainly from Italy. Wood for charcoal was from the woodlands of England and was produced by the controlled burning of carefully selected wood. Making the charcoal was difficult in England's rainy climate and the shortage of timber added significantly to the difficulties in gunpowder production in the 1760s.⁵³

Most of the saltpetre required for domestic manufacture was from the European Continent after being imported from India and Persia, although, for a limited period in 1570s, some was purchased by England directly from Morocco.⁵⁴ But by the 18th century, there was a regular supply of natural saltpetre directly from India via the East India Company.⁵⁴ In India, saltpetre was described in 1793 as being 'very abundant and very cheap at Bengal, indeed in no other part of the world so cheap'; it was to become a significant commodity of the empire. The establishment of British control of this material of war gave them advantage as other western nations struggled to have such an accessible supply. Thus, Britain was able to continue to

⁵² Under Henry VIII and Elizabeth, there was an effort to gain independence from the Continent. This was achieved in 1560 by producing saltpetre artificially between the mid-sixteenth and mid-seventeenth centuries by mixing vegetable and animal refuse containing nitrogen with lime, earth and ashes. However, this resulted in inadequate and poor quality saltpetre.

achieve its territorial goals and command the sea with its ability to make gunpowder. India became a vital part of the functioning of the British Empire.⁵⁵

Iron

Iron is another key material required in shipbuilding and ship repair. The Navy Board bought bar iron mainly from Sweden, with a little from Spain, America and Russia, which it then passed to British contractors to work up into iron fittings for shipbuilding. The different qualities of iron depended on the ores from which it was made, and iron from British ores did not have the right qualities for shipbuilding. This allowed the Swedish government monopoly, the *Jernkontoret*, to maintain a high price on iron.⁵⁶ Iron Imports to England (in tons) were 244,000 in 1806 and 455,000 in 1823.⁵⁷ Total iron imports in 1801 were 331,000£ or 1.04% of the value of all imports that year; in 1810, iron imports were 197,000£, or 0.50% of the value of all imports into Britain that year. Iron was a significant enough imported resource that statistical data was kept on it.⁵⁸

Swedish exports to Britain were during the 1750s and 1760s mainly bar-iron. The Swedish mines and forges continued to supply the greater part of the total amount of bar-iron shipped to British ports from Europe even after Sweden in 1757 had joined her old ally France instead of Britain. Sweden could not afford to break with England, which was by far her most important customer, consuming well over half of her bar-iron exports which in themselves accounted for three-quarters of her total export trade. The England metal industries depended for at least half of their bar-iron requirements from Sweden. Hopes had been raised that the American colonies might produce more iron for shipment to Britain, but American exports stayed disappointingly small despite every inducement by the government in London. Spain, which had in the past been prominent in the iron-trade with England, had long since become of

little consequence as the growing demand outstripped her ability to ship more than the 1,000 to 2,000 tons annually that were by mid-1700 a small fraction of English iron imports. Russia iron exports had grown into the thousands of tons to be second to Sweden. Swedish dominance in the iron export trade was unassailable both for the quantity shipped and for the quality of her iron. Supplies from Sweden accounted never for less than one-half, and in some years for as much as three-quarters of foreign bar-iron imports which were generally in the vicinity of 30,000 tons annually during the 1750s and 1760s. Even the “second grade” of Swedish iron equaled in quality the best grades of any other bar-iron on the English market.⁵⁹

Since there was already a serious problem regarding a shortage of timber, iron was considered to be used in wood’s place as wooden knees and securing wooden beams. Iron fittings soon influenced current building trends, especially with the ever increasing problem of procuring good timber for knees and riders towards the end of the eighteenth century. This problem was expounded during the French Revolutionary and Napoleonic Wars when it was necessary to expand warship construction. So the use of iron in ship construction and fittings increased because the scarcity of timber had become such an acute problem. Attempts were made to use alternate woods such as fir and beech but these did not prove overly successful, but the introduction of iron fittings did alleviate matters somewhat. Iron bracketing was used to support the stern timbers and iron was also being used for deck hooks, breast hooks, and crutches, thus giving greater support to the fore and aft ends of ships beginning in the early 1800s. Their introduction eliminated the necessity to employ large pieces of oak previously used, the size of which had always been difficult to procure.⁶⁰ This shifted the timber acquisition problem to the iron monopoly of Sweden, but Sweden remained closely allied with Britain

during the Napoleonic Wars and iron remained available to Britain even through Napoleon's Continental System.

Copper

The pressure put on Britain's dockyards during war to keep the maximum number of vessels fit for service, as well as the greatly increased number of vessels stationed in warm waters where the shipworm thrived, led the Royal Navy to investigate the feasibility and effectiveness of any measure promising to extend the service life of their ships and decrease the need for frequent docking for periodic maintenance. Among these measures were the sheathing of ship's bottoms with copper, lead, brass, as well as renewed interest in traditional wooden sheathing. The *teredo*, or shipworm, is a bivalve mollusk which can wreak terrible destruction on unprotected timber. The shipworm's ideal habitat is in waters between 60° F and 80° F. It was a problem not encountered by the Royal Navy, on any scale, until English fleets began to venture into the Mediterranean in the second half of the seventeenth century. Since the ships returned each winter to colder English waters, the problem was repairable and containable. As the eighteenth century progressed and increasing numbers of British ships were sent to the West and East Indies, infestation with shipworm became universal. By 1775, the Navy Board saw that copper had been successful on the *Hawke* making it more durable and less prone to decay. From that time renewed attention was given to copper sheathing, finally recognized as the only viable defense against shipworm. In 1779, the decision was made to copper the British fleet.⁶¹

The advantage of coppering ships was lightness and durability; the disadvantage was cost and a serious problem of corrosion in the underwater ironwork of the hull, including the rudder irons and the heavy bolts which fastened together keel, stem and sternpost. By establishing a watertight seal between the hull and the copper by coating the hull with lacquered brown paper

before coppering, this prevented the electrolysis that caused the corrosion to the ironwork, thus coppering ships started joining the fleet in 1780. Coppering transformed tactical as well as strategic possibilities, for copper turned out not only to keep out the worm, but to repel fouling. Fouling was a constant problem and more so in the Caribbean where the weed grew twice as fast on the bottom of ships and there were no docks to perform maintenance to remove it. Copper remained naturally clean and bright, and coppered ships were thought to be at least a knot faster as a result—a huge tactical asset in ships whose best speed under fighting sail was only five or six knots. Ships which had been the slowest could now outpace the entire un-coppered fleet. Coppering extended the need to dock for cleaning and minor refits from every four months or so to about once every two years, though many lasted for much longer and the Royal Navy leadership estimated that it effectively increased the available fleet by one-third.⁶² Coppering ships gave rise to the expression ‘copper-bottomed’ as being synonymous with excellence.⁶³

In the middle of the eighteenth century, shipments of copper from Norway had ceased after an English company working mines near Bergen went out of operation, but an occasional cargo was still obtained from Sweden which had earlier sent large quantities of copper to England.⁶⁴ One great advantage of copper sheathing was that it did not have to be imported. As the American Colonies were lost and the Baltic proved as unreliable as ever, the old materials of pitch and tar that were used to seal ship’s bottoms became more expensive and difficult to obtain. Copper was expensive too, but its supply could be guaranteed.⁶⁵ Both Sweden and Norway had in the past supplied England with much copper while her own mines in North Wales and Cornwall remained neglected. At the end of the seventeenth century, copper mining was resumed and British imports dwindled to negligible amounts.⁶⁶ So while coppering was expensive, it was a local product with guaranteed supply that reduced the need for the imported

products of pitch, tar, and ultimately wood while requiring significantly less maintenance and increased ship availability.

Ruthless British Operations and Their Consequences

For Britain, the Baltic trade was strategically important. The area was the source of essential naval stores of wood, masts, tar and pitch, hemp, iron, and copper to sustain the sailing ship. Access was an additional problem for the English. The narrow straits providing access from the North Sea to the Baltic were vulnerable, especially because Denmark and Sweden could dominate that access.⁶⁷

England's policy of depriving her enemies of needed Baltic naval stores 'never bore such fruit as it did in the twelve years preceding Trafalgar'. Complete command of the sea, ruthlessly exerted, did its job, and the enemy fleets Nelson and others defeated were already half-beaten before battle due to lack of essential naval stores. England countered Tilsit with Orders in Council issued November 11, 1807—the severest of these declared Napoleon's coasts in a state of blockade and practically required all neutrals to trade through British ports.⁶⁸ But arrogant use of sea power had negative side effects such as hindering American relationships with Great Britain and other countries which in peacetime more or less lived on their exports of naval stores. Hence, after Trafalgar, Napoleon's military successes, his diplomatic skill, and British unpopularity paradoxically ensured that as British sea power strengthened, its ability to secure one of its chief necessities—wood—weakened. The essential Baltic ports could not be kept out of Napoleon's dominance. As a result, Great Britain had a very narrow margin of safety. The struggle over masts and spars, oak and pine plank, and the closing and opening of Baltic ports, was as decisive in determining the fate of the world as the battlefields.⁶⁹

In 1801, a sea crisis between Britain and Denmark emerged that involved the rights of neutrals. The Russian ruler, Paul I, wanted to become involved and Napoleon eagerly offered the island of Malta to Paul I to assist against the British. Paul I formed an alliance with the Scandinavian kingdoms and Prussia to seize all British ships in Russian ports and imprison their crews. Britain assembled an expedition under the command of Sir Hyde Parker with Heratio Nelson as his second in command. Britain was to defeat the northern alliance speedily, at any cost, and would begin with Denmark, the state which held one entrance to the Baltic. When the Foreign Office emissary returned from Copenhagen to the British fleet with news that the Danes would not surrender their fleet and were preparing to defend their city, Nelson was given charge of the force designed to shatter their defenses. On 2 April 1801, Nelson sustained for five hours the fire of the Danish fleet and the great Trekroner battery. He defeated the Danes and secured his own terms for an armistice. Ironically, this battle was unnecessary as Paul I had been murdered on 24 March in a palace conspiracy and his northern league dissolved. The news did not reach Denmark until after the action had been fought. Nelson did not leave the Baltic before he was certain that the merchant ships seized by Russia would be released. The speed and effect of the whole operation had shown that Britain could act unpredictably and ruthlessly when her maritime interests were threatened.⁷⁰ Although temporarily threatened by the Northern confederation of 1800-1, the trade was not interrupted.⁷¹

As a result of the treaty at Tilsit in 1807, the British government had early intelligence of secret clauses which supposedly called for the coercion of Denmark and Sweden and the exclusion of Britain from the Baltic. In the face of this grave threat the new government determined to act fast. A British envoy was sent ask Denmark to accept an alliance with Britain and voluntarily 'deposit' her fleet for safe-keeping, otherwise her fleet would be seized. On 25

July 1807, Admiral Gambier sailed with seventeen ships of the line and forty frigates, sloops, bomb vessels and gun brigs with 25,000 troops. In anticipation of the Crown Prince of Denmark's refusal to surrender his fleet, the expedition's orders were to cut off the island of Zealand and seal off the Danish capital from reinforcements by the main Danish army. The defense of Copenhagen had been entrusted to General Peyman. Cathcart commanded the British land forces. On 1 September, Cathcart and Gambier again offered Peyman terms to 'deposit' the Danish fleet into British hands and were again rejected. The next day, a merciless bombardment began from artillery emplacements but also with some shells thrown into the city from the bomb vessels,⁷² much of it with a new weapon, rockets. The city was now gradually set on fire and on the evening the 5 September. The barrage continued for three days before the Danes surrendered. Copenhagen was devastated with at least one-quarter of the city flattened, the first evidence of the destructive power of the rockets.⁷³ Peyman agreed that the British should take possession of the citadel, dockyard, the ships of war and their stores. The Danish casualties among combatants amounted to about 250, but some 2000 civilians were killed and many more rendered homeless.⁷⁴ This apparently unprovoked British attack on an inoffensive neutral aroused widespread disgust in Europe. Britain prevented Napoleon from getting the Danish fleet and made it impossible for France to seal the mouth of the Baltic.⁷⁵

A consequence of the 1801 attack of Copenhagen was mistrust of the British by the Danes that may have caused the Danes to reject the British "peacefully" removing the Danish fleet and naval stores in 1807. Another consequence of the 1801 attack was the Danish shores were more heavily defended in 1807 than before.⁷⁶

A consequence of the 1807 firebombing of Copenhagen was the hostility of Denmark and the cessation of the timber supply from Norway, a Danish possession.⁷⁷ Britain turned a neutral

into an enemy.⁷⁸ From 1807-1812, a ceaseless battle was fought to keep the Baltic open to British commerce and to subject the Baltic trade to principles of the British maritime code.⁷⁹ While the expedition against Copenhagen deprived Napoleon of ships, it caused guerrilla sea warfare in what the Danes call 'The English War'. War with Denmark was defensive, using cruisers for the incessant demands of convoy protection, especially exports of naval stores.⁸⁰

Copenhagen would be remembered for the savagery of the slaughter between two peoples without deep historic antagonism and who saw one another in blood and shared values as closely alike. As seagoing peoples, they shared the endurance and hardihood of an oceanic background.⁸¹ The word 'Copenhagen' meant more than the name of the Danish capital. It represented a past and present fear that some peaceful afternoon such as in the autumn of 1807, a British fleet would suddenly appear off one's coast and without warning attack. Completely surprised and unable to defend itself, a country's navy would be pounded into smoking ruins. The seizure of the Danish fleet in 1801 and the bombardment of Copenhagen in 1807 had uncovered the true features of British power, its utter ruthlessness. This ruthlessness played a part in foreign policy toward the British.⁸²

Strategy and Policy Decisions

Naval stores drove British strategy and policy decisions in regard to her interests in the Baltic region in the early 1800s. Henry Dundas, Secretary of War, in a letter outlining the importance of the Baltic to Britain to Evan Nepean, the first Secretary to the Admiralty, in January 1801, stating "we must all agree that we have now the greatest stake to contend for that ever called forth the exertions of this country." Following the Treaty of Tilsit in 1807, Britain faced the renewed threat of the removal of its sources of naval stores in the Baltic. Lord Castlereagh, Minister of War, wrote to the Admiralty on 18 July 1807 outlining the nation's

interest “to secure against all annoyance the large mass of British property which is now afloat in the Baltic and to preserve to this country an uninterrupted intercourse and supply of Naval Stores from the Baltic.”⁸³ Access to the naval stores in the Baltic directly affected the strategy and policy of the British War Department during the crises of 1801 and 1807 and the British leadership acted swiftly and ruthlessly in Copenhagen on both occasions to keep the Baltic open.

Naval stores were the most important resource to Britain in Age of Sail. Even the national reliance on imported grain was overshadowed by the need to secure supplies of shipbuilding materials. In the late eighteenth and early nineteenth century, Britain’s major procurement concern was the supply of naval stores from the Baltic region. It proved impossible to guarantee these naval resources through diplomatic and peaceful market-based solutions, and Britain was forced to send a fleet to the Baltic region to enforce her interests in 1801, 1807, and 1808-12.⁸⁴ The logistics of naval stores was a means to a strategic end and changed the course of the Napoleonic War. The Baltic Fleet fulfilled its strategic obligations by protecting the vast trade in northern Europe and thus ruining the Continental System.⁸⁵

The Cape of Good Hope had significant strategic value to securing naval stores. The importance of the Cape for the French was that if it was not in their possession, their position in the Indian Ocean would be seriously, if not irreparably, weakened. The British trade-route to the East to include India, appeared vulnerable due to its reliance on a port owned by the Dutch. Both Britain and France believed that whoever possessed the Cape would govern India.⁸⁶ Napoleon realized this fact and on 23 Feb 1798 advised the French Directory that instead of invading England he would “deal England the death blow by seizing Egypt and then driving Britain from India.”⁸⁷ In 1793 when the French were threatening to take Holland, Lord Grenville, Britain’s Foreign Secretary, responded to this challenge by offering the Dutch a garrison for the Cape as a

means of cutting off supplies from Mauritius (main French port in the Indian Ocean) to prevent a French invasion of India. Later that year, Henry Dundas wrote to Grenville that the preservation of the Cape was “an object of such importance that it was impossible for Britain to view with indifference any circumstance endangering its safety.” The Dutch refused, but in 1795, Britain quickly occupied the Cape after France overran Holland.⁸⁸ Britain occupied the Cape in 1795 because of its strategic value to the security of India, but returned it to the Dutch at the Peace of Amiens because it was expensive and they did not want the Cape as a colony. Napoleon’s strategy in the Trafalgar campaign had the indirect effect of drawing attention to the strategic importance of the Cape as Britain incorrectly thought the French fleet was heading to India. After these events in 1805, no British government could possibly consent to the return of the Cape to the Dutch at the end of the war. In 1806, Britain re-occupied the Cape and did not return it to the Dutch after Napoleon was defeated.⁸⁹ Britain also worked to prevent France from gaining allies on the overland route to India by creating diplomatic alliances with Baghdad and Persia.⁹⁰ The naval resources of wood and Britain’s sole reliance upon India for saltpetre were a part of the strategic value of the Cape to protect India. British policymakers acted strategically, repeatedly, and ruthlessly in order to secure these key naval materials that came from India.

The British need to secure naval resources deeply worried the naval administration. Charles Middleton, the comptroller of the Navy Board, wrote in 1786 that “when the variety of services that are to be provided is considered and how much the exertion of the fleet depends on punctual and proper supplies of stores, it must be allowed that no branch of the service is of more importance than this to the public.” This concern would go on to impact successive British government’s foreign and colonial policy. The British put significant organizational effort into controlling the market for naval stores.⁹¹

British leadership understood the strategic criticality of shipbuilding resources and based policy decisions not just on acquiring these materials but denying her enemies of them. William Pitt outlined the economic rationale of British policy to remove naval stores from the Baltic while stopping the France from doing the same in a speech given to Parliament asking, “Shall we allow entire freedom of the trade of France...shall we allow her to receive naval stores undisturbed and to rebuild and refit that Navy which the valour of our seamen has destroyed?”⁹² Henry Dundas also set policy upon the desire to destroy the existing naval power of Britain’s enemies while depriving them of the naval stores trade required to rebuild their navies. One by one the navies of Europe were smashed or confiscated during the Napoleonic Wars. British naval victories over the French, Spanish, and Dutch, the removal the Danish fleet, the Portuguese fleet, and a Russian squadron in Lisbon, as well as the deterioration of enemy existing fleets without the material means to maintain or replace them led to a situation in 1815 where the Royal Navy was equal in size to all other navies combined.⁹³

Of the scarce naval stores, timber, masts, and pitch and tar were the most acutely short in supply for the Royal Navy. Great Britain went to great lengths to ensure she had enough wood during the Age of Sail by literally using supplies from all over the Earth. Britain was so short on wood that at times, untreated and uncured wood was rushed into ship production and was then already beginning to rot prior to it being in service. It took a couple of years before wood was ready to be used in shipbuilding and this long lead time made wood even more scarce. Because of its great size and limited shelf life, wood was difficult to stockpile. Even though iron came almost exclusively from Sweden and hemp from Russia, Britain focused on keeping the Baltic open to ensure it had these two supplies as well as wood, masts, pitch, and tar. Iron and hemp did not have the long lead times and severe shelf life issues that wood did and thus, easier to

stockpile. Britain was generally on good terms with Sweden and even during Napoleon's Continental System, Sweden did not really participate and even acted as an entrepôt at critical times to alleviate shortages of naval stores. Iron was used as a substitute for wood in an attempt to alleviate the extreme shortage of timber and coppering the bottom of ships reduced the amount of timber needed for repairs. But Britain still searched and utilized the entire Earth in order to meet its critical requirement for wood.

Scarce resources from abroad caused national security crisis similar to the importance of oil today; Great Britain at times took ruthless action that led to negative consequences. Britain took decisive and drastic action to secure the survival of the state by keeping the Baltic Sea open as well as securing the sea and overland routes to India. British politician's decisions and policies were determined by their focus on logistics. Naval stores were the most important resource to Britain in Age of Sail. The logistics of acquiring naval stores while denying enemy access to them was a means to a strategic end. Despite the adverse consequences of their actions, Britain was always able to maintain naval dominance throughout the Age of Sail, keep the Baltic Sea open for trade, prevent a French invasion of England and India, defeat Napoleon, and maintain its world-wide colonies.

Notes

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- ¹ Noel Mostert, *The Line Upon a Wind: The Great War at Sea, 1793-1815* (New York: W.W. Norton & Company, 2007), 63.
- ² Robert G. Albion, *Forests and Sea Power: The Timber Problem of the Royal Navy 1652-1862* (Cambridge, MA: Harvard University Press, 1926), vii-viii.
- ³ H.S.K. Kent, *War and Trade in Northern Seas: Anglo-Scandinavian Economic Relations in the mid-Eighteenth Century* (Cambridge, UK: Cambridge University Press, 1973), 44-45.
- ⁴ Albion, *Forests and Sea Power*, vii-viii.
- ⁵ Kent, *War and Trade*, 44-45.
- ⁶ Albion, *Forests and Sea Power*, vii-viii.
- ⁷ Otto von Pivka, *Navies of the Napoleonic Era* (New York: Hippocrene Books Inc., 1980), 13.
- ⁸ Peter G. Goodwin, *The Construction and Fitting of the English Man of War, 1650-1850* (Annapolis, MD: Naval Institute Press, 1987), 238-239.
- ⁹ Albion, *Forests and Sea Power*, 9.
- ¹⁰ Mostert, *Line Upon a Wind*, 64.
- ¹¹ Patricia K. Crimmin, "Searching for British Naval Stores: Sources and Strategy c. 1802-1860," *Journal of the Australian Association for Maritime History* 19, no. 2 (1996): 114.
- ¹² Mostert, *Line Upon a Wind*, 64.
- ¹³ Arthur R.M. Lower, *Great Britain's Woodyard: British America and the Timber Trade, 1763-1867* (Montreal: McGill-Queen's University Press, 1973), 6-9.
- ¹⁴ Crimmin, "Searching for British Naval Stores," 115.
- ¹⁵ Lower, *Great Britain's Woodyard*, 13-16.
- ¹⁶ Kent, *War and Trade*, 39-41.
- ¹⁷ Lower, *Great Britain's Woodyard*, 13-16.
- ¹⁸ *Ibid.*, 48-54.
- ¹⁹ Richard Harding, *Seapower and Naval Warfare 1650-1830* (London: University College Press, 1999), 43-44.
- ²⁰ Patricia K. Crimmin, "A Great Object with Us to Procure This Timber: The Royal Navy's Search for Ship Timber in the Eastern Mediterranean and Southern Russia, 1803-1815," *International Journal of Maritime History* 4 (December 1992): 84-112.
- ²¹ Albion, *Forests and Sea Power*, 362.
- ²² Crimmin, "Searching for British Naval Stores," 117-120.
- ²³ B.R. Mitchell, *Abstract of British Historical Statistics* (Cambridge, UK: Cambridge University Press, 1962), 282-290.
- ²⁴ Eugene L. Rasor, *English/British Naval History to 1815: A Guide to Literature* (Westport, CT: Praeger Publishers, 2004), 4.
- ²⁵ Albion, *Forests and Sea Power*, 344-345.
- ²⁶ *Ibid.*, vii-viii.
- ²⁷ Lower, *Great Britain's Woodyard*, 9-10.
- ²⁸ Anthony N. Ryan, "Defence of British Trade with the Baltic, 1808-13," *English Historical Review* 74 (July 1959): 443-444.
- ²⁹ Kent, *War and Trade*, 43-44.
- ³⁰ Harding, *Seapower and Naval Warfare*, 43-44.
- ³¹ Crimmin, "Searching for British Naval Stores," 118.

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- ³² Kent, *War and Trade*, 43-44.
- ³³ Lower, *Great Britain's Woodyard*, 10-11.
- ³⁴ Knight, "New England Forests and British Seapower, 227-229.
- ³⁵ *Ibid.*, 227.
- ³⁶ Lower, *Great Britain's Woodyard*, 46.
- ³⁷ Crimmin, "Searching for British Naval Stores," 118.
- ³⁸ Lower, *Great Britain's Woodyard*, 17-18.
- ³⁹ Brian Lavery, *Nelson's Navy: The Ships, Men, and Organization, 1793-1815* (Annapolis, MD: Naval Institute Press, 1989), 157.
- ⁴⁰ Brian Lavery, *The Arming and Fitting of English Ships of War 1600-1815* (Annapolis, MD: Naval Institute Press, 1987), 57.
- ⁴¹ Kent, *War and Trade*, 80-85; Lavery, *Arming and Fitting of English Ships*, 62.
- ⁴² Joseph J. Malone, "England and the Baltic Naval Stores Trade in the Seventeenth and Eighteenth Centuries," *Mariner's Mirror* 58 (November 1972): 384-385.
- ⁴³ Lower, *Great Britain's Woodyard*, 18.
- ⁴⁴ Oliver Warner, *The Sea and the Sword: The Baltic 1630-1945* (New York: William Morrow & Company, 1965), 97.
- ⁴⁵ Malone, "England and the Baltic," 385-386.
- ⁴⁶ Roger Morriss, *The Foundations of British Maritime Ascendancy: Resources, Logistics, and the State, 1755-1815* (Cambridge, UK: Cambridge University Press, 2011), 178-179.
- ⁴⁷ Harding, *Seapower and Naval Warfare*, 133.
- ⁴⁸ Ryan, "Defence of British Trade," 444.
- ⁴⁹ Morriss, *The Foundations of British Maritime Ascendancy*, 178-179.
- ⁵⁰ *Ibid.*, 178-179.
- ⁵¹ N.A.M. Rodger, *The Command of the Ocean: A Naval History of Britain, 1649-1815* (New York: W.W. Norton & Company, 2004), 558-559.
- ⁵² Mitchell, *Abstract of British Historical Statistics*, 282-290.
- ⁵³ Jenny W. West, *Royal Historical Society Studies in History*, issue 63, *Gunpowder, Government and War in the Mid-Eighteenth Century* (Woodbridge, UK: Boydell, 1991), 7, 174-175.
- ⁵⁴ *Ibid.*, 2-11.
- ⁵⁵ Brenda J. Buchanan, *Gunpowder, Explosives and the State: A Technological History* (Burlington, VT: Ashgate Publishing Company, 2006), 67-87.
- ⁵⁶ Rodger, *Command of the Ocean*, 302.
- ⁵⁷ Lower, *Great Britain's Woodyard*, 6.
- ⁵⁸ Mitchell, *Abstract of British Historical Statistics*, 282-290.
- ⁵⁹ Kent, *War and Trade*, 14, 59-68.
- ⁶⁰ Peter G. Goodwin, "The Influence of Iron in Ship Construction: 1660-1830," *Mariner's Mirror*, 84 (February 1998): 26-38.
- ⁶¹ Randolph Cock, "'The Finest Invention in the World': The Royal Navy's Early Trials of Copper Sheathing, 1708-1770," *Mariner's Mirror*, 87 (November 2001): 446-456.
- ⁶² Rodger, *Command of the Ocean*, 344-45; Lavery, *Nelson's Navy: Ships, Men, and Organization*, 222.
- ⁶³ Von Pivka, *Navies of the Napoleonic Era*, 21.
- ⁶⁴ Kent, *War and Trade*, 14.

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- ⁶⁵ Lavery, *Arming and Fitting*, 65.
- ⁶⁶ Kent, *War and Trade*, 87.
- ⁶⁷ Rasor, *English/British Naval History*, 82; Warner, *Sea and the Sword*, 4.
- ⁶⁸ Albion, *Forests and Sea Power*, 198, 336.
- ⁶⁹ Lower, *Great Britain's Woodyard*, 47.
- ⁷⁰ Warner, *Sea and the Sword*, 99-101; Goodwin, "Influence of Iron in Ship Construction," 32.
- ⁷¹ Ryan, "Defence of British Trade," 445.
- ⁷² Richard Woodman, *The Victory of Seapower* (London: Chatham Publishing, 1998): 115-118.
- ⁷³ Mostert, *Line Upon a Wind*, 527.
- ⁷⁴ Woodman, *Victory of Seapower*, 117-118.
- ⁷⁵ Rodger, *Command of the Ocean*, 549.
- ⁷⁶ Mostert, *Line Upon a Wind*, 527.
- ⁷⁷ Lower, *Great Britain's Woodyard*, 48-50.
- ⁷⁸ Anthony N. Ryan, "The Causes of the British Attack upon Copenhagen in 1807," *English History Review*, 68 (January 1953): 54-55.
- ⁷⁹ Ryan, "Defence of British Trade," 466.
- ⁸⁰ Woodman, *Victory of Seapower*, 124-129.
- ⁸¹ Mostert, *Line Upon a Wind*, 396.
- ⁸² Jonathan Steinberg, "The Copenhagen Complex," *Journal of Contemporary History*, 1 (July 1966): 23-46.
- ⁸³ James Davey, *The Transformation of British Naval Strategy, Seapower and Supply in Northern Europe, 1808-12* (Woodbridge, UK: The Boydell Press, 2012), 29-31.
- ⁸⁴ *Ibid.*, 19-24.
- ⁸⁵ *Ibid.*, 192.
- ⁸⁶ Vincent T. Harlow, *The Founding of the Second British Empire 1763-1793*, vol. 1, (London: Longmans, Green and Co., 1952), 107-108.
- ⁸⁷ J. Holland Rose, A.P. Newton, and E.A. Benians, eds., *The Cambridge History of the British Empire*, vol. 2, *The Growth of the New Empire* (Cambridge UK: Cambridge University Press, 1940), 71.
- ⁸⁸ Harlow, *Founding of the Second British Empire*, 134-125.
- ⁸⁹ L.C.F. Turner, "The Cape of Good Hope and the Anglo-French Conflict, 1797-1806," *Historical Studies: Australia and New Zealand*, vol. 9, no. 36 (1961): 368-378.
- ⁹⁰ Michael Duffy, "World-wide War and British Expansion, 1793-1815, Trade, Economy, State," in *The Oxford History of the British Empire: The Eighteenth Century*, vol. 2, ed. William Roger Louis, et al. (Oxford UK: Oxford University Press, 1998), 200.
- ⁹¹ Davey, *Transformation of British Naval Strategy*, 21.
- ⁹² *Ibid.*, 28.
- ⁹³ Duffy, "World-wide War and British Expansion," 203-204.

BIBLIOGRAPHY

- Albion, Robert G. *Forests and Sea Power: The Timber Problem of the Royal Navy 1652-1862*. Cambridge, MA: Harvard University Press, 1926.
- Bovill, E.W. "Queen Elizabeth's Gunpowder." *Mariner's Mirror*, 33 (July 1947): 179-186.
- Buchanan, Brenda J. *Gunpowder, Explosives and the State: A Technological History*. Burlington, VT: Ashgate Publishing Company, 2006.
- Cock, Randolph. "'The Finest Invention in the World': The Royal Navy's Early Trials of Copper Sheathing, 1708-1770." *Mariner's Mirror*, 87 (November 2001): 446-459.
- Crimmin, Patricia K. "A Great Object with Us to Procure This Timber: The Royal Navy's Search for Ship Timber in the Eastern Mediterranean and Southern Russia, 1803-1815." *International Journal of Maritime History*, 4 (December 1992): 83-115.
- Crimmin, Patricia K. "Searching for British Naval Stores: Sources and Strategy c. 1802-1860." *Journal of the Australian Association for Maritime History*, Vol. 19, No. 2, (1996): 113-124.
- Duffy, Michael. *World-wide War and British Expansion, 1793-1815*. Vol. 2, in *The Oxford History of the British Empire: The Eighteenth Century*, edited by William Roger Louis et al., 184-201. Oxford: Oxford University Press, 1998.
- Gardiner, Robert. *Warships of the Napoleonic Era*. Annapolis, MD: Naval Institute Press, 2003.
- Goodwin, Peter G. *The Construction and Fitting of the English Man of War, 1650-1850*. Annapolis, MD: Naval Institute Press, 1987.
- Goodwin, Peter G. "The Influence of Iron in Ship Construction: 1660-1830." *Mariner's Mirror*, 84 (February 1998): 26-40.
- Harding, Richard. *Seapower and Naval Warfare 1650-1830*. London: University College London Press, 1999.
- . *The Evolution of the Sailing Navy, 1509-1815*. New York: St. Martin's Press, 1995.
- Harlow, Vincent T. *The Founding of the Second British Empire 1763-1793*. Vol. 1. London: Longmans, Green, and Co., 1952.
- Kent, H.S.K. *War and Trade in Northern Seas: Anglo-Scandinavian Economic Relations in the Mid-Eighteenth Century*. Cambridge, UK: Cambridge University Press, 1973.
- Knight, R.J.B. "New England Forests and British Seapower: Albion Revised." *American Neptune*, 46 (Fall 1986): 221-229.

- Lavery, Brian. *Nelson's Navy: The Ships, Men, and Organization, 1793-1815*. Annapolis, MD: Naval Institute Press, 1989.
- . *The Arming and Fitting of English Ships of War 1600-1815*. Annapolis, MD: Naval Institute Press, 1987.
- Lower, Arthur R.M. *Great Britain's Woodyard: British America and the Timber Trade, 1763-1867*. Montreal: McGill-Queen's University Press, 1973.
- Malone, Joesph J. "England and the Baltic Naval Stores Trade in the Seventeenth and Eighteenth Centuries." *Mariner's Mirror*, 58 (November 1972): 375-391.
- Mitchell, B.R. *Abstract of British Historical Statistics*. Cambridge: Cambridge University Press, 1962.
- Morriss, Roger. *The Foundations of British Maritime Ascendancy: Resources, Logistics, and the State, 1755-1815*. Cambridge, UK: Cambridge University Press, 2011.
- Mostert, Noel. *The Line Upon a Wind: The Great War at Sea, 1793-1815*. New York: W.W. Norton & Company, 2007.
- O'Brien, Patrick. *Trade, Economy, State, and Empire, The Oxford History of the British Empire, The Eighteenth Century*. Edited by P.J. Marshall. Vol. 2. Oxford: Oxford University Press, 1998.
- Pivka, Otto von. *Navies of the Napoleonic Era*. New York: Hippocrene Books Inc., 1980.
- Rasor, Eugene L. *British Naval History Since 1815: A Guide to the Literature*. New York: Garland Publishing Inc., 1990.
- . *English/British Naval History to 1815: A Guide to Literature*. Westport, CT: Praeger Publishers, 2004.
- Rodger, N.A.M. *The Command of the Ocean: A Naval History of Britain, 1649-1815*. New York: W.W. Norton & Company, Inc., 2004.
- Rose, J. Holland, A.P. Newton, and E.A. Benians, ed. *The Cambridge History of the British Empire*. Vol. 2. Cambridge: Cambridge University Press, 1940.
- Ryan, Anthony N. "Defence of British Trade with the Baltic, 1808-1813." *English Historical Review*, 74 (July 1959): 443-466.
- Ryan, Anthony N. "The Causes of the British Attack Upon Copenhagen in 1807." *English History Review*, 68 (January 1953): 37-55.

Steinberg, Jonathan. "The Copenhagen Complex." *Journal of Contemporary History*, 1 (July 1966): 23-46.

Turner, L.C.F. "The Cape of Good Hope and the Anglo-French Conflict, 1797-1806." *Historical Studies: Australia and New Zealand*, vol. 2, issue 36 (1961): 368-378.

Warner, Oliver. *The Sea and the Sword: The Baltic 1630-1945*. New York: William Morrow and Company, 1965.

West, Jenny W. "Gunpowder, Government and War in the Mid-Eighteenth Century." In *Royal Historical Society Studies in History, Issue 63*. Woodbridge, UK: Boydell, 1991.

Woodman, Richard. *The Victory of Seapower*. London: Chatham Publishing, 1998.

