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Aeolian Empires: The Influence of Winds and Currents on European Maritime Expansion in the Days of Sail

The great European maritime empires of the modern era depended more on wind than they did on water. Before the conquistadors, priests, company merchants or colonial bureaucrats could subdue, evangelise, exploit or administer their overseas possessions, they first had to be taken there, conveyed over the water in ships powered by the wind. Wind played a formative role in deciding where would-be adventurers and colonisers first made landfall. Oceans might have been the highways or "marineways" of the past upon which flowed the traffic of the pre-industrial age but water is only a medium and wind constituted the primary source of energy available for long-distance transportation in the pre-industrial age. Referring to the activities that transpire across its expanses as maritime fails to draw specific attention to the influence winds and currents played in determining the routes taken, the peoples linked together, the environments connected, and the timing of such activities. There were "winds of empire" blowing backward and forward across the Atlantic, Indian and Pacific Oceans during the days of sail between the sixteenth and nineteenth centuries.

Historiography has generally paid insufficient attention to the influence of winds and currents. While their significance is readily acknowledged, the discussion is usually limited to an initial contextual page or two.[1] Winds are more prominent in recent scholarship but the focus is more on the impact of extreme events or anomalous weather patterns on specific societies or even entire civilisations.[2] However, as Felipe Fernández-

Armesto observed in his global history of exploration, there is "not enough wind" in explaining the course of human interactions in general and the rise and form of European maritime expansion in particular.[3] The general atmospheric circulation (the prevailing wind directions at any time of year) and the dominant flow of the currents (themselves largely determined by the winds) not only dictated the place and pace of maritime exchange but also greatly influenced the contours of imperial endeavour. The rise of Western European states to world empires from the sixteenth century is usually characterised as maritime in nature but should more fittingly be described as Aeolian or wind-driven to denote their dependence on the prevailing patterns of atmospheric circulation.

This article examines the role winds and currents played in influencing the outline, structure and nature of Western European seaborne empires. It incorporates the patterns of winds and currents in each ocean, and the endeavours and ventures of each major European maritime power into a single global portrait that reveals the extent of the historical influence such factors exerted in the age of sail.[4] Unlike previous great seafaring peoples like the Arabs, Malays and Polynesians, Europeans were the first to operate across all the world's oceans, coordinating and utilising winds and currents on a truly global scale. The gradual discovery of global circulation patterns by European mariners beginning with the Portuguese and Columbus revealed only two feasible contours of empire available to Western European states: one utilising the North and South Atlantic gyres and the monsoon winds to the Indian Ocean and beyond, and the other employing the North Atlantic gyre to the Americas. The Portuguese and Spanish

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imperia pioneered these models. The Dutch first emulated and then circumvented them. The French and English maritime empires were largely variants on a theme. Where winds and currents converged, key settlements were founded that facilitated imperial designs and spawned new cultures and ecologies. Only the demise of sail as the primary engine of maritime locomotion and its replacement by steam-powered vessels in the second half of the nineteenth century led to a new geography of empire largely unconstrained by meteorological and oceanographic limitations. While there has been something of a renaissance in maritime history in recent years, the insufficient recognition given to the guiding influence of winds and currents has impeded a proper understanding of the nature and exercise of European maritime power in the heyday of empire.[5]

Depends which way the winds blow

The imperial drive may have been motivated by a combination of "god, gold and glory" but its realisation – its form, extent and pulse were largely determined by the direction in which the winds blew. The global wind pattern splits the surface winds of each hemisphere into three belts: the easterly-blowing polar winds above 60^{o} latitude, the prevailing westerlies between 30-60^{o}, and the tropical easterlies (trade winds) between 0-30^{o} degrees.[6] As a result of the earth's rotational motion, winds do not blow directly northward or southward but are deflected to the right in the Northern Hemisphere and to the left in the Southern.[7] Air diverging from a high-pressure region spirals outward, clockwise north of the equator and counter-clockwise in the south. The horizontal effect of this force varies in proportion to the latitude; it is strongest at the poles and vanishes altogether at the equator. Moreover, near the equator, the easterly trade winds of both

hemispheres form a narrow zone of low pressure known as the Inter-tropical Convergence Zone. This is an area of cloud and humid conditions where winds are alternating fitful or strong and vessels can be becalmed for days or even weeks in what mariners called the "doldrums".

Figure 1: Schematic global wind patterns (general circulation)

This zonal pattern of winds provides only a rough approximation of the actual atmospheric circulation. In reality, the latter is considerably modified by the unequal distribution across the globe of continents that constitute significant thermal and topographical barriers.[8] In particular, large landmasses heat up during the summer and cool rapidly in winter. The seasonal variation of solar heating depending on the tilt of the earth's rotation means that areas of high pressure tend to build up over cold continental land masses in winter, while low-pressure development takes place over the adjacent, relatively warm oceans. Exactly the opposite conditions occur during summer, although to a lesser degree. These resulting and contrasting pressures over land and water are the cause of the monsoon winds.

Superimposed upon the general circulation are many lesser disturbances such as the common storms of temperate mid-latitudes and the cyclones, typhoons and hurricanes of the tropics. These generally move along the path of the prevailing winds and upper air streams. Wind systems are further complicated by hemispheric variations. In the Pacific, the region is characterised by a distinctive phenomenon known as the Southern

Oscillation in which variations in atmospheric pressure over the Indian Ocean (in the West) are mirrored by the opposite changes over the south-eastern Pacific (in the East), so that if one is falling the other is invariably rising. An El Niño Southern Oscillation (ENSO) event is a combination of interrelated oceanic and atmospheric processes that occurs every two to seven years when atmospheric pressures shift and the normally easterly trade winds slacken and even temporarily reverse. Wind intensities are affected too, especially close to the equator. Sailors might encounter unexpected variations in the strength of the usually predictable northeast and southwest monsoons as well as more localised fluctuations in direction and speed influenced by local island topography.[9]

A somewhat analogous phenomenon of atmospheric variability is found over the North Atlantic. The North Atlantic Oscillation (NAO) refers to alternations in the pressure differences between the subtropical atmospheric high-pressure zone centred over the Azores and the atmospheric low-pressure zone over Iceland. It is the dominant mode of atmospheric behaviour in the North Atlantic throughout the year and its inter-annual variability and inter-decadal fluctuations are largely responsible for the severity of boreal winters and the degree of sea-ice cover. It also affects the strength and character of the Atlantic thermohaline circulation that drives the Gulfstream and the North Atlantic Drift, and is associated with consequent changes in the mean wind speed and direction, variations in temperature and moisture distribution, and the intensity, number and track of storms in the North Atlantic region.[10] Recent studies have uncovered significant coherence between NAO and warm ENSO events with each influencing the other under certain conditions.[11]

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Figure 2: Ocean currents of the world

The oceans, too, are not inert bodies and have their own complex circulatory systems. However, surface currents tend to conform closely to the prevailing wind system, especially across the equatorial belt that girdles the globe.[12] Two surface currents, the North and South Equatorial Currents, flow westward blown by the trade winds and separated by an eastward flowing surface Equatorial Counter-current.[13] Near the western margins of all oceans, moreover, the cumulative flow of the equatorial currents pile up warm water against the continental boundaries. A portion of this surplus water returns eastward via the surface and subsurface counter-currents but most of the water forms deep narrow fast-moving western boundary currents that are mainly guided poleward by the margins of the continental shelves at speeds of between three to five knots.[14] These winds and currents provide the Aeolian framework from which maritime empires were formed.

Empires of the wind

The great European maritime empires of the modern era, what territories belonged to which states largely owed their existence to a global pattern of winds and currents whose outline was only beginning to be discerned by the sixteenth century. Prevailing European knowledge had remained little changed since Aristotelian notions of a fixed earth (*primum mobile*) around which body rotated the winds and oceans.[15] Though both air and water were considered to move from East to West, there is no evidence that people

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believed the two to be linked.[16] While mariners' practical knowledge of winds and currents expanded rapidly with the voyages of exploration and the drawing up of oceanic rutters by the Portuguese and others in the sixteenth and seventeenth centuries, the gradual acceptance of the Copernican system of the universe did not lead to any better understanding of why winds blew or their origins.[17] However, gradual improvements in the design of ships as wind-catching devices and the development of precision instrumentation to better determine position and speed represented a profitable marriage between science and imperial design that greatly enhanced Europeans' ability to navigate these oceans.[18] The eighteenth century was preoccupied by the successful search to determine longitude at sea, and, with industrialisation, the development of precision measurement that made tidal charts available to ships' captains for home and colonial ports. As Michael Reidy observes, science created "a geographical space that the maritime powers of Europe could then control".[19] But there were also limits to this control that historiography has largely overlooked.

Superimpose a map of European imperia on a chart of atmospheric circulation over the oceans of the world and there is a remarkable "fit" between the prevailing winds and currents and the form and extent of the various European empires. The routes that the explorers took and so their initial landfalls were largely dictated by the prevailing winds and the inter- and intra-oceanic currents.[20] Territories and islands that served these routes were largely incorporated within the imperial mantle, especially those strategically located way stations or "maritories", pivotal points where winds and currents intersected.[21] Those that did not were left outside of the imperial embrace despite their

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initial "discovery". Any historical appreciation of the spread of European colonialism and culture is incomplete without due recognition of the central role of winds and currents in shaping the form and nature of empires. This Aeolian logic also explains why Portugal and Spain, states favourably placed along the Atlantic littoral with respect to the pattern of general circulation, were at the forefront of European maritime expansion in the sixteenth century.

The Portuguese Aeolian Empire

The Portuguese initiated regular seaborne-traffic between the North and South Atlantic, the African Atlantic and South America, Western Europe and West Africa, as well as between Europe and the Indian Ocean. The wind systems along the Atlantic coast of the Iberian Peninsula and North Africa between about 35 and 42^{o}N favour ocean-going expeditions by sail. During the summer months, the trade winds blow mainly south and west towards the coast of Guinea or the Americas but, for the rest of the year, the wind blows predominantly from the west. Outward-bound vessels utilised the winds on the southern flank of the sub-tropical anticyclones, while return voyages took place on their northern margins. Routes across the Atlantic in the fifteenth and sixteenth centuries, therefore, were effectively successive superimposed loops, known in Portuguese as *voltas*, allowing ships originating from south-western ports such as Lisbon to return home within a few months, sailing all the time either before the wind or with the wind on their quarter.[22]

Figure 3: Great oceanic wind gyres

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The two long-distance axes of the Portuguese imperium were the *carreira do Brasil* and the *carreira da India*, the sea routes between Lisbon and Brazil and Lisbon and Goa via the Cape of Good Hope. Routes and sailing times on these voyages were determined by the wind systems and currents in the Atlantic and by the seasonal monsoons in the Indian Ocean and South China Sea. As winds and currents circulate clockwise in the North Atlantic and counter-clockwise in the South Atlantic, the initial lap in both voyages was from Lisbon to one of the North Atlantic maritories driven by winds from the north and northwest. Ships heading to Brazil made for Madeira or the Azores to pick up the northeast trade winds which made for an easy run to the northern coast of South America. The homeward voyage was facilitated by way of the westerlies and north-westerlies. It was an appreciation of the circulatory wind patterns of the North Atlantic gyre (and its oppositely gyrating South Atlantic counterpart) gained during the fifteenth century and an inherited Arabic-Hebrew tradition in trigonometry that led to the development of the quadrant (and later the sextant and octant), and allowed the so-called *volta do mar* or return passage.[23] Sailing times from Portugal, however, depended on the final destination in Brazil with voyages south of Cape São Roque (the easternmost tip of South America) taking appreciably longer to complete. Round-trips, including time in port, ranged from seven months to a year.[24]

India-bound *náos* ("great ships") either carracks or galleons, initially followed the same outward-bound path via Madeira and the Cape Verde Islands, leaving the Tagus in March or early April and setting course for Pernambuco on the northeast coast of Brazil.[25] South of Cape São Roque, after negotiating the uncertain winds and currents of the doldrums,

vessels picked up the southeast trades of the South Atlantic gyre.[26] About 20°S, ships were able to catch the south-westerly winds which carried them east-south-east around the Cape of Good Hope. Once in the Indian Ocean, voyages were regulated by the monsoon winds. Vessels bound for Goa or Cochin in India needed to round the Cape by July in order to catch the southeast monsoon that blows between May and September. *Náos* then sailed up the Mozambique Channel and the East African coast as far as Malindi where the south-westerlies enabled them to strike straight across the open ocean to Goa.[27]

Figure 4: The monsoon winds

Conversely, returning vessels left Indian ports around New Year in order to catch the northeast monsoon between October and April and mainly followed the outward bound route in reverse as far as the Cape.[28] Once in the South Atlantic, ships picked up the south-easterlies as far as the equator and then ran before a west wind on the northern flank of the sub-tropical anticyclones homewards to the Azores and Lisbon. Voyages bound for Macao and Japan were subject to a further set of monsoon winds. Vessels left Goa in April or May to catch the southwest monsoon in the South China Sea and returned on the northeast monsoon between November and March. A round trip could be completed in six months but ships might be away as long as three years if delay occasioned missing the monsoons in either Malacca or Macao. Voyages to Japan could extend to five years. Malacca was also the port of departure for destinations in the Spice Islands of Banda and the Moluccas.[29]

Even this brief description of the "Aeolian mechanics" incumbent in its principal commercial arteries outlines the form and limitations imposed upon the Portuguese empire. It is a striking example of an imperium whose extreme geographical dispersion and dynamics were shaped and held together by wind and current. The paramount importance of the Atlantic islands, Madeira, the Azores, and the Cape Verdes as maritories is evident for ships bound either west or east. These islands, explored and colonised in 1340-1420, were "points of articulation between the North and South Atlantic, North and South America and the Caribbean, Africa and America, Africa and Europe, and Europe and America".[30] The importance of the Atlantic littoral of South America is evident, too, and its "discovery" in 1500 a not altogether unexpected development.[31] It also might explain why Pernambuco, so close to Cape Sao Roque and a pivotal maritory on the voyage to India, was chosen as a site of initial Portuguese settlement.[32] The location of São Vicente (in the modern state of São Paulo), also selected as an early colony, depended much more upon the southward flowing Brazil Current that enabled ships to navigate along a lee shore across the face of the countervailing southeast trades.[33]

Portugal's East African empire was centred on the maritory of Mozambique Island, sited strategically between the mainland and Madagascar. It served as a waystation for homeward bound Indiamen and remained the colonial capital until 1898.[34] The monsoon winds and market opportunities made Goa on the west coast of India (annexation in 1510) a natural pivotal nexus for trade in and out of the Indian Ocean and it became the

official seat of the Viceroy of the Estado do India.[35] The conquest of Malacca in the following year secured the gateway to both the Spice Islands on the one hand and the South China Sea on the other. The port's position on the Strait of Malacca made it a key maritory for vessels transiting between the Indian Ocean and the South China Sea. Malacca provided a convenient place for merchants to sojourn while waiting for the winds to change from east to west. The monsoon winds also made Macao (occupied circa 1557) a natural destination for trade with China and Japan and had transformed both it and Nagasaki from obscure fishing villages to flourishing seaports by the close of the sixteenth century.[36] These ports of call on a global web of winds and currents necessitated that the Portuguese empire was as much an intra-Asian trade network as one between Europe and the Indian Ocean world.[37]

It was the winds, too, that governed the timing and place of exchange, not only the seasonal nature of the monsoons but the synergy between their alternations and the fixed winds of the Atlantic. Even Portugal's West African voyages of the fifteenth century that initiated the entire maritime enterprise provided the necessary "schooling" in the operating of the North Atlantic gyre. In particular, the technical and psychological difficulties incumbent upon rounding Cape Bojador (the Cape of Fear) by sailing far out to sea on a west-south-west course before finding an easterly wind were instrumental in unlocking the routes to America, the South Atlantic, and ultimately egress into the Indian Ocean. Incidentally it also laid the foundations for the Portuguese colony at Luanda and its imperial and missionary endeavours in the Kingdom of the Kongo.[38] Portugal, though a relatively minor European power, was able to take advantage of its favourable

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geographical location vis-à-vis the pattern of general atmospheric circulation to become the first Aeolian empire. In many respects, too, its imperium was also the clearest expression of the importance of wind over water in determining the contours of imperial design.

Figure 5: European Aeolian empires

The Spanish Aeolian Empire

A unified Spain after 1492 enjoyed the same geographical advantages as Portugal in that the ports of Cádiz and Seville had access to the southwest Atlantic coast of the Iberian Peninsula. The contours of the Spanish empire were no less shaped by winds and currents than those of their Portuguese neighbours. Columbus's novel idea that a vessel might reach the Indies by sailing west was premised on his knowledge of the winds at certain latitudes. That the Americas lay in the path of that realisation was simply an Aeolian "accident" of History.

Spanish seamen were also able to take advantage of the seasonal variation in prevailing winds to sail and return to their home port using the southern and northern flanks of the sub-tropical anticyclones. Like Portugal, Castile colonised its own Atlantic maritory as a springboard for voyages into the deep North Atlantic.[39] The Canary Islands, the conquest of which began in 1402, served much the same pivotal role as the Portuguese Atlantic islands as "a point of articulation" between Europe and the Americas.[40] Situated around 28^{o}N off the African coast, they lie on the northern fringes of the northeast trade winds so

that a ship sailing due west will reach the Caribbean. Many Spanish seamen had also participated in Portuguese expeditions and acquired the same familiarity with winds and currents.[41] Christopher Columbus knew from living in the Azores that the winds blew steadily from the west, while between 28-30^{o}N the wind blew steadily from the east. On his first voyage to the Americas in 1492, he sailed south to the Canaries and then virtually due west till he reached the Bahamas.[42] Castile's possession of the Canary Islands ensured that the Americas were predominantly Spanish rather than the colony of some other European royal house.[43] Indeed, Nicolás Wey Gómez maintains that Columbus's choice of the Canary Islands was premised on its location as Europe's most southerly outpost lying close to the path of the northeast trade winds.[44]

Columbus's route brought him to the Caribbean that as the Spanish Main was to remain the fulcrum of Spain's empire in the New World.[45] In a sense, all routes in the North Atlantic lead to this "American Mediterranean Sea".[46] The conflux of the North and South Equatorial Currents, particularly the latter which is deflected north-westwards along the north coast of South America (the Guiana Current) diffuses into the Caribbean Basin.[47] Even when Columbus struck further south on his third voyage in 1498, this westward drift still carried him back there.[48] On entering the Caribbean, the current funnels through the Yucatán Straits and splits in two: the stronger flow reverses direction around the east end of Cuba and accelerates as it passes north-easterly through the Florida Straits, and a weaker secondary current circulates clockwise around the circumference of the Gulf of Mexico.[49] Thus the nexus of Spain's American empire was set: Hispaniola and Cuba as the launch pads of exploration, conquest and settlement in the New World.

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The former provided the base from which Vasco Núñez de Balboa established the isthmian colony of Castilla del Oro and the city of Darien in 1510, and the latter was where Hernán Cortés embarked upon the conquest of Mexico in 1519.

Figure 6: Winds and currents in the Caribbean

The homeward voyage also proved formative in creating the imperial framework. On his initial return passage, Columbus discovered the necessity of standing well to the north on leaving the West Indies before attempting the Atlantic crossing. Around the latitude of Bermuda (32.30ºN), he found a westerly wind that ships could run before all the way across the Atlantic to the Azores.[50] The Florida Current as it exits the Caribbean Basin encourages such a route as it immediately swings northwards along the coastline, merging with the Antilles and North Equatorial Currents to form the mighty Gulfstream that continues undiminished in a north-easterly direction as far as Cape Hatteras.[51] Given Florida's strategic position at the confluence of currents, it was an early object of Spanish exploration beginning with Ponce de León's expedition in 1513. Construction of the oldest masonry structure in the United States, the Castillo de San Marcos situated in the city of St. Augustine was begun in 1672 to protect this return passage.[52]

Columbus's voyages to the Americas, his passage southward to the Canary Islands and then westward to the Caribbean using the prevailing northeast trade winds remained the prevailing route followed by annual treasure fleets until 1779. The two components of this fleet, one originating from the port of Veracruz bearing the mineral wealth of New

Spain and the other from South American ports bearing the riches of Tierra Firme rendezvoused at Havana by using the clockwise circulatory current around the Caribbean Basin.[53] The combined fleet then exited via the Florida Straits and followed the Gulfstream north to pick up the homeward-blowing westerly winds. Timing was dictated by the winds. Outbound ships left Spain between February and September so as to enter the Caribbean between May and November. Ships wintered in the Americas (also to allow goods from the Manila Galleon to come overland from Acapulco) and returned between February and August.[54] Again winds and currents dictated this timetable as the so-called contrary "northers" during the winter months made sailing between Veracruz and Havana well-nigh impossible, even to the extent of reversing the prevailing direction of the current.[55] A recent study of *derreteros* (sailing directions) concludes that the routes followed by Spanish sailing vessels were "the most favourable to make the voyage from Veracruz to Havana in the shortest time in summer".[56] Unfortunately, late summer and early autumn were also the months for hurricanes.[57]

Spain's empire extended into the Pacific as well: The first Spaniard to actually set eyes on the "Southern Ocean" was Balboa who crossed the Isthmus of Panama in 1513. Superimpose a map of the Spanish imperium in the Pacific on a chart of that ocean's atmospheric circulation and again there is a remarkable "fit" between the prevailing winds and the form and extent of Spanish colonisation. The routes the initial explorers took and therefore the landfalls they made were largely dictated by the trade winds. The shape of the Manila-Acapulco galleon trade, the economic lifeblood of the whole Spanish endeavour in this part of the world, was likewise dependent on the westerlies for the

passage out to Mexico, and on the northeast trades for the return route to the Philippines. Islands that served this purpose fell within the Hispanic mantle; those that did not were ignored. Even the settlements on the west coast of North America partially owe their rationale to the dictates of this economic system. Likewise, islands like Hawai`i that one might expect to have come within the orbit of Spanish influence were passed over because of their location in relation to the winds. In this way, one can talk about there being "winds of colonisation" blowing backward and forward across the Pacific during the days of sail.[58]

The correlation between prevailing winds and colonization begins with the initial crossing of the Pacific in 1520-1521. Ferdinand Magellan first headed north along the South American coast before striking away from land between 32-34^{o}S. Here he encountered the prevailing southeast trade winds that carried him across the Pacific as far as the Marianas. Needing to obtain fresh supplies, Magellan headed towards the largest of these islands, Guam, before sailing on now driven by the northeast trades till he reached the Philippines a week later.[59] Thus from the first, the pivotal reference points of Spain's imperium in the Pacific were set by the general circulation: the Philippines as a base in the East and Guam as the principal maritory.

Early Spanish enterprise in the Pacific was dominated by finding a return passage to Mexico. The voyage was finally accomplished in 1565 by the veteran pilot, Andrés de Urdaneta.[60] Sailing before the monsoon winds, he climbed in a north-easterly direction to about 30^{o}N where the ship encountered the Kuroshio Current and the prevailing

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westerlies that then carried it across the ocean to the American coast. There the California Current took the vessel south where it dropped anchor in Acapulco on 8 September after a voyage of 129 days. The route from Mexico was more direct and much quicker. Galleons dropped from Acapulco to between 10-14^{o}N where they encountered the northeast trade winds that carried them across the ocean to Guam and thence to the Philippines.[61] This route was the one favoured during the ensuing 250 years of the Manila Galleon's history.[62]

Not only did the prevailing winds and currents set the routes and therefore the form and extent of Spain's imperium in the Pacific but they also established the pulse at which it operated. The date of departure from Manila was dependent on favourable winds for timing. The seasonal capriciousness of the atmospheric circulation around the archipelago made it advantageous for a galleon to commence its outward passage before late June as failure to do so could lengthen the crossing considerably from four to eight months. Such a delay might have serious medical consequences leading to disease, famine and death on board. Mortality was high even at the best of times and exceeded fifty per cent on some voyages. The great trade fair held annually at Acapulco in February was similarly determined by this rhythm of the winds.[63]

Departure from Acapulco was also a matter of critical importance. The galleon had to be underway by March as the monsoon begins to dominate the atmospheric circulation in the Western Pacific by May. A ship approaching the Philippines before the end of June generally enjoyed easier sailing with the trade winds extending all the way; vessels

making a later passage often had to contend with southwest winds for the second half of the crossing.[64] Greater variation in the general circulation of the Western Pacific caused by more frequent ENSO events, such as occurred during the seventeenth century, considerably exacerbated matters and lengthened voyages undertaken between 1630 and 1670. This period also witnessed the high-water mark of Spain's imperial power and the beginning of its slow decline punctuated by constant warfare and poor harvests due to the extreme weather of the Little Ice Age.[65]

Just as the winds facilitated Spain's imperial endeavour in some directions, they impeded it in others. Spanish dominion along the Pacific coast of South America was dominated by the problem of maritime communications between centres of power: in particular, by passage through the doldrums which cuts Pacific South America in two; and the Humboldt Current that persistently flows northward from around 45°S to the Equator. For most of the year, winds in this region blow south to southeast making the length of the voyage between Acapulco or Callao to Valparaiso or Concepcion from three months to a year. The return trip northwards, however, was accomplished in three to four weeks. It was not until the discovery of an open sea route that the problem was partly resolved. Vessels struck out from the mainland south across the trade winds till around 30°S and only then turned northeast to pick up the southerly winds and the Humboldt Current to reach their destinations. These Aeolian complications seriously impeded the development of Chile as a Spanish colony.[66]

Later Aeolian empires

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With the discovery of the routes across the Pacific, the Aeolian mechanics of empire were revealed. Two models emerged, the *carreira da India* (Portuguese) between Europe and the Indian Ocean, and the *carrera de las Indias* (Spanish) between Europe and the Americas. That both routes bore the same name to encompass contrary directions was a reflection of how the scientific revolution in early modern knowledge had created a maritime representation of the world that was understood in terms of a global system of winds and currents upon which framework was sketched the imperial endeavour.[67] The rulers of these first Aeolian empires were quick to reach accommodation, dividing the globe between them. The maritime boundaries imposed by the treaties of Tordesillas (1494) and Zaragoza (1529) may have fixed an imaginary line that ran from pole to pole 370 nautical miles west of the Canary Islands but the organising principle of this settlement was premised on the direction in which the winds blew. More particularly, they were Aeolian treaties, agreements that split the world in half based on sailing routes: the "southern Antipodes" for Portugal or all land that lay south of the Cape Verde Islands; and the "western Antipodes" for Spain, territories encountered sailing west and south from the Canaries.[68] That the South dominated in these early modern European conceptualisations of the world was largely premised on a discourse that accorded wealth and riches to lands "wherever the sun is strong".[69]

The north-western maritime states of Europe, however, did not enjoy such a favourable geographical position as their Iberian rivals: the North Atlantic Drift passes south of the British Isles.[70] The disadvantage this partial Aeolian exclusion wrought on the states of north-western Europe was evident to any ship's captain. Winds in the English Channel, a

vital waterway for both Dutch and English shipping are very variable: westerlies predominate in mid-winter (December-January) and mid-summer (July-August), while easterlies occur most frequently in autumn (October-November) and between February and June.[71] Moreover, wind constancy fluctuates over time. For example, westerlies predominated in all months between 1685 and 1750, and easterlies only blew on average less than once every five days.[72] In contrast, easterly winds were more prevalent during the sixteenth century, and from the mid eighteenth to early nineteenth centuries.[73] Quite apart from the frequency of hostilities in north-western Europe in the late seventeenth and early eighteenth centuries, this variability often left ships languishing in port waiting for an easterly wind to take them down the Channel to catch the North Atlantic gyre. Dutch vessels even found it expedient to sail around the coast of Scotland to reach the North Atlantic.[74] Once in the open ocean, however, the ships of Dutch, English, French and other European maritime powers had little option but to follow in the wake of their Iberian rivals.

The Dutch

The Dutch caught the same winds and currents as had the Portuguese before them and so the two imperia initially mirrored each other closely. In fact, most of the early Dutch knowledge about winds and routes came from foreign, mainly Iberian sources.[75] Dutch maritime expansion begins in 1598 with the capture of trade forts along the West African coast, many of them like Fort Elmina seized from the Portuguese.[76] They also temporarily seized Luanda from the Portuguese (1641-1648). The Dutch, too, followed the winds and the Portuguese into the Indian Ocean replacing the latter as the primary

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European power in India along the Coromandel and Malabar coasts, in Bengal, and at Surat during the seventeenth century.[77] Between 1638 and 1640, the Dutch ousted the Portuguese from their main possessions in Ceylon, establishing Galle, an east-west orientated port approachable by ships nearly all year round, as an important martitory.[78] They then proceeded to establish de facto rule over the island until they, in turn, were replaced by the British in 1815.[79] Their biggest success, however, came in the Spice Islands where they established themselves in 1619 at the little Javanese port of Jacarta (Batavia) which they used as a base to establish a spice-monopoly in the Moluccas and a pepper-monopoly across the entire archipelago.[80] The Dutch developed Batavia as their principal maritory for the lucrative trade with China and Japan, replacing the Portuguese on Formosa (1624-1662) and at Nagasaki up until 1853.[81]

Winds also governed when ships sailed. Outward-bound vessels left port in three successive fleets: the *Kermis* (harvest fair fleet) departed in September, the Christmas fleet sailed in December or early January, and the Easter fleet left in April or May. Cargoes on the first of these fleets reached Batavia in March or April in time for the southwest monsoon and trans-shipment to East Asian markets. Homeward bound fleets left Batavia between late December and early February after the arrival of goods on the northeast monsoon from ports in the South China Sea.[82] Even short delays, though, had major consequences if a connecting monsoon was missed.[83] Homeward-bound fleets called in at the Cape of Good Hope to take on supplies of water and fresh food leading to the establishment of a Dutch settlement at Table Bay in 1652. Cape Town subsequently became known as *de Indische Zeeherberg* ("The Tavern of the Indian Ocean") because of

its strategic Aeolian location as a maritory on the passage between Europe and the Indian Ocean.[84]

Dutch ships also followed the winds (and Portuguese and Spanish rutters) to the Americas, creating, albeit for a short time, an Atlantic empire. The colonies of New Holland based around Recife near Cape São Roque, one of the principal maritories for the South Atlantic, and New Netherlands on the banks of the Hudson River and the shores of Manhattan Island were short-lived and attracted few settlers.[85] Yet even after their colonial possessions in the Atlantic were reduced to six small Caribbean islands, a string of settlements along the north coast of South America and Fort Elmina on the Gold Coast, Dutch vessels retained a lasting presence in American waters carrying much of the trade that maintained the Spanish *carrera de las Indias* throughout the seventeenth century, an empire of trade if not of territory.[86]

The Dutch, however, were not merely imitators. Their joint-stock chartered companies were organised on a very different basis than those of Portugal or Spain.[87] The Dutch (like the French and English after them) established fortified factories (*factorijen*) where they could store their merchandise securely and conduct trade in safety.[88] A particularly important innovation pioneered by the Dutch was their use of the Roaring Forties, the strong westerly winds in the southern hemisphere, as a route for their East Indiamen in the Indian Ocean. Once round the Cape, ships steered due east for approximately 1,000 miles until the vicinity of the islands of St Paul and Amsterdam. Depending on the

season, vessels then either sailed directly north (October-March) or set an east-north-east course for the Straits of Sunda and Batavia. This route had certain distinct advantages: the passage across the Indian Ocean was considerably shortened, it "outflanked" the monsoonal system, there was less chance of encountering cyclones at these latitudes, and foodstuffs conserved for longer as the temperature was cooler.[89] One danger, however, was for ships to be carried too far eastward and end up running aground off the coast of New Holland (Western Australia).[90]

As a result, the Mascarenes, islands first discovered by the Portuguese and largely ignored during the sixteenth century were occupied by the Dutch (Mauritius) in 1638 and by the French (Rćunion and Rodriquez) in 1665 and 1691. The "great route" to the Indies discovered in 1611 passed just south of the Mascarenes converting these islands into important maritories for eastbound vessels.[91] Batavia, too, became a key maritory for the Dutch, the fulcrum or "traffic control centre" for most shipping in Asia.[92] One of the key advantages of Batavia was that ships were able to reach port in all seasons and were not dependent on the monsoons.[93] Vessels were required to dock there before continuing their voyages to other locations in the Indian Ocean or onward into the South China Sea. This rule was periodically relaxed after 1660 and voyages were permitted directly to and from South Asia (e.g. Galle, Surat and Hugli) and China (e.g. Canton).[94] Cargos from the *Westerkwartieren* (western Indian Ocean) also had to be transhipped through Batavia as long as goods reached there in good time before the departure of the return fleet, a proviso that allowed for considerable latitude in the implementation of the regulations.[95] However, where the Dutch really excelled was in logistics and keeping their ships at

sea.[96] From Batavia ships fanned out in all directions sailing to the rhythms of the wind: to Japan in May and June, to the Coromandel and Bengal in July and August, to Ceylon and further west later in the year, and to the Moluccas between November and February.[97] Dutch ships were seldom laid-up in port. The primacy afforded Batavia in this Aeolian framework partially explains the relative lack of interest the Dutch showed in displacing the Portuguese from Goa, a port highly monsoon-dependent and especially dangerous between April and September.[98]

French and English

The French and English/British built on the Dutch precedent to establish Aeolian empires that embraced both the Portuguese and Spanish models. Early maritime endeavours were in the North Atlantic but both crowns also went on to establish Indian Ocean empires. France, however, was better situated than its rival as westerly winds and currents in the Channel frequently hindered ready access for English shipping, and the French ports of Brest, La Rochelle and Bordeaux enjoyed the advantage of being located further west with easier access to the southward-flowing Canary Current. Only vessels operating from south-western English ports such as Falmouth and Plymouth experienced minimal delays waiting for a favourable wind.[99]

The North Atlantic figures more prominently in the history of the French and English Aeolian empires. The so-called "sugar" and "tobacco" routes pioneered by Christopher Columbus continued to be the most direct means of access to the plantation colonies of the Caribbean. A West Indian landfall also remained a viable route to the colonies along

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the southern Atlantic seaboard of North America but the most popular passage involved sailing in an arc that might be very flat or just fall within the tropics to catch the edge of the trade winds. These routes were referred to by mariners respectively as "the string" and "the bow".[100] Vessels, however, heading for north-eastern American ports had a much more arduous voyage, holding as close to west-by-south as headwinds and seas allowed.[101] A completely alternate route was taken by ships heading for Newfoundland and Hudson Bay. Steering a northerly course from Ireland, ships caught the polar easterlies that blow above latitude 60^{o}N and availed themselves of the currents that curl around the Arctic Circle linking Northern Europe to North America much as Norse navigators had done in the tenth century.[102] The East Greenland Current also wends its way along the coast of Greenland and Baffin Bay before turning south along the Labrador coast to meet the Gulfstream off the Grand Banks.[103] Originally the route to the Newfoundland fisheries, this "north-about" passage was also favoured by the Hudson Bay Company.[104]

The development of such important Atlantic seaports as Boston, Philadelphia and New York, however, cannot be accounted for in this manner. To some extent, Northeast America represents a partial exception to the Aeolian argument outlined here though the return passage to Europe was easily accomplished running before westerly winds. Indeed, a reverse logic may even apply that has more to do with the inherent difficulties in sailing from Western Europe as a factor in determining the initial choice of settlement. Boston and Philadelphia were founded by Puritan and Quaker colonists respectively anxious to distance themselves from the mainstream of contemporary society and the reach of the

English Crown. Moreover, these ports were slow to develop and remained marginal and impoverished settlements until the mid-to late eighteenth century.[105] Perhaps, part of the attractiveness of such locations lay precisely in their character as Atlantic circulation backwaters.

The French and English/British empires more fully realised the Dutch vision of a dual model Aeolian empire, in many cases simply following the same winds and currents to replace them as colonial overlords. In the Atlantic, the French colonised extensive areas of North America (New France), acquired an Antillean empire in the West Indies, attempted unsuccessfully to establish colonies in Brazil and Florida in the mid-sixteenth century, settled French Guiana, and built a slave station at Saint-Louis in what is now northern Senegal.[106] In the Indian Ocean, they were more successful founding colonies in the Mascarene Islands, the Seychelles and a string of fortified trading posts (*comptoirs*) in India, the most important of which was Pondichéry.[107]

The English likewise mirrored this Aeolian rationale. In the Atlantic, fishing fleets making use of the polar easterlies led to the establishment of English settlements along the northeast coast of North America. More colonies at Jamestown in Virginia and New Plymouth in New England followed in the early seventeenth century. Further south, the English established plantations in the Caribbean based on sugar and slavery. The significance of the winds was reflected particularly in the nomenclature of the Leeward and Windward Islands, so called because of the formers' supposedly more sheltered position from the northeast trade winds despite their actual location to the north (not

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west) of the latter.[108] They also established a presence in West Africa on the Gold Coast (now Ghana).[109] The first English ship in the Indian Ocean arrived in 1591 and soon led to the establishment of an East India Company whose vessels traded with the Spice Islands and India. A number of coastal factories were established along the shores of the Indian Ocean from Madras to Amboyna in the Moluccas.

These imperia reflected the same Aeolian logic as had the Portuguese, Spanish and Dutch before them. Only in Oceania and the Pacific did the French and English follow where the winds blew into oceans less explored by their predecessors, eventually incorporating new territories like Australia, New Zealand, Fiji and Tahiti into the Aeolian framework of empire. But even here, imperial pathfinders like James Cook and the Comte de Lapérouse were often following in the wake of earlier Dutch explorers like Abel Tasman. And wind remained a significant factor influencing colonisation well into the nineteenth century. James Stirling's submission to the Admiralty in 1829 advocated a British settlement at Swan River (Perth) precisely because of its advantageous location with respect to the prevailing winds: westerlies that speedily carried ships to its shores and the proximity of the southeast trades that assured vessels ready access to ports in the northern Indian Ocean.[110] However, these later British and French empires span the transition to steam and a post-Aeolian maritime world, one in which the dynamics of imperial geography changed out of all recognition.

Other Aeolian imperial structures

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Wind rather than water shaped much more than merely the contours of a European imperial world and provided a conduit through which people, animals, plants and pathogens circulated freely. Once formed, these ties precipitated a cascade of changes that transformed the cultures and ecologies of both the New and Old World. The new transnational landscapes created as a result of these exchanges were also the product of an Aeolian logic that was given shape and form by a European maritime imperial order.

Winds of bondage and ethno-genesis

The way in which the wind blew was also instrumental in determining the dispersal of different ethnicities to various landmasses across the globe. In particular, slavery and the transatlantic triangular trade were largely responsible for the repopulation of the Americas after the sixteenth century holocaust of the Iberian colonisation.[111] As Pieter Emmer and Wim Kloosters observe "the New World was demographically speaking an extension of Africa rather than of Europe" until the mid-nineteenth century. More than 12 million Africans were brought to the Americas between 1500 and 1850 as opposed to the settlement of no more than two to three million Europeans.[112] The destination of these forced migrants to the Americas, however, was not random. There were distinct geographical concentrations where slaves from certain areas of Africa originated. Thus two-thirds of Africans from the Bight of Benin and half the slaves from the Gold and Windward Coasts left for the British Caribbean. Similarly, half the people leaving from Senegambia went to the French Caribbean. On the other hand, three quarters of Africans shipped from southeast Africa went to south-central Brazil, and half of those from west-central Africa went to South Brazil.[113]

Figure 7: Slavery and the Aeolian Exchange

All regions of Africa sent slaves to almost all regions of the Americas but people tended to flow along certain marineways or corridors. Of course, many factors influenced the ultimate destination of Africans in the New World: the European power that controlled the port of embarkation, the flag under which the slave vessel operated, demand at any time, and trans-shipment between various entrepots in the Americas.[114] Ultimately, however, the defining consideration was the point of embarkation in relation to the dominant wind system. The respective wind gyres and their associated currents operating in the North and South Atlantic effectively divide Africa in two. Most of the slaves destined for the markets of North America, the Caribbean and the northern captaincies of Brazil came from ports between the Upper Guinea coast and the Costa da Mina. Those that arrived further south mainly embarked at African markets in the South Atlantic.[115] The reason for this division, as any slave ship captain knew, was that vessels leaving from the South Atlantic for northern ports risked prolonged delays in the doldrums, the calm waters either side of the equator, and the loss of their "all-too-perishable" cargos. The nature of the black diaspora and the ethno-genesis of distinctive Afro-American cultures depended, at least to some extent, on the winds. The nineteenth and twentieth centuries also witnessed a dramatic increase in voluntary migration and settlement. Between 1851 and 1924, 45 million people migrated from the Old World to the Americas.[116] However, these population movements largely occurred as the age of sail

was waning and the Aeolian framework of empire was replaced by the very different dynamic of steam-powered locomotion.

The Aeolian exchange

The ships of empire also carried non-human cargoes. Alfred Crosby argues that the European conquest and settlement of the New World was facilitated by Old World biota that accompanied the invaders. Eurasian plants, animals and diseases, brought either purposely or inadvertently, displaced supposedly weaker and less vigorous native species in a process of "ecological imperialism" that paralleled the human succession.[117] Europeans brought with them the same Mediterranean agro-system which they adapted, with varying success, to the diverse ecological conditions found in the New World. There they also encountered very resilient indigenous farmers that proved adept at selecting and incorporating new cultivars and animal domesticates into their own diets in complex and different ways.[118]

The scale of this "Aeolian Exchange" was truly global and not confined to Europe, the Americas and Australasia.[119] Across the Atlantic, ships, their crews and passengers brought wheat, sugar, grapevines, olive trees, coffee (via Africa), sugar cane and bananas (via Southeast Asia), pigs, cattle, horses, donkeys, sheep and goats. In reverse, flowed rubber, tobacco, cocoa, cinchona, tomato, chilli peppers, maize, potatoes, pineapples and various varieties of beans.[120] Many Old World crops like sugar and coffee grew better in New World soils in the absence of pests and parasites. The impact of New World foods

on European diets was dramatic: the tomato, for instance, transformed Italian and Greek cuisines, as did the potato in North-western and Eastern Europe.[121]

In many cases, though, Europe acted only as a transit point for plants in this worldwide network of interlinking winds. Many New World staples such as maize, cassava and the potato are now more heavily consumed in the Old World, while other crops have become essential to national cuisines.[122] Capsicum, for example, forms the basis of many dishes in South and Southeast Asia as well as in south-western China.[123] The slave trade also acted as a "corridor of crop diffusion". The prevalence of African food staples on slave ships such as plantains, cowpeas, yams and sorghum provided the seeds and cuttings for the Africanization of food systems in the Americas, while enslaved Africans provided the agricultural skills necessary for the cultivation of new crops like rice.[124] John McNeill talks about the creation in Atlantic America of low-latitude Neo-Africas and temperate Neo-Europes divided by transition zones of "creolized biotas".[125] As with slavery, the eastern seaboard of the Americas was divided in two by the North and South Atlantic gyres.

Just as wind determined the sailing routes of the slave trade and so influenced the ethno-genesis of distinctive Afro-American cultures, so the same general circulation gave rise to new ecologies populated by plants and animals transplanted from distant landmasses. Many new breeds of horse around the Indian Ocean, for example, were "invented" through the transfer of equine genes and phenotypes along imperial networks of trade based on wind patterns and sailing routes that linked Southern Africa to Southeast Asia.

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As a result, horses in Thailand, the Philippines, South Africa, and Lesotho share a common genetic lineage with the horse found in the Indonesian Archipelago.[126] In some cases, fauna and flora transported along these Aeolian corridors proved invasive in their new surroundings, threatening the native ecology. Much of the distinctive fauna of the fynbos in the Western Cape of South Africa is either extinct or is endangered by introduced species such as the golden wattle (*Acacia pycnantha*) from Australia and the pohutukawa (*Metrosideros excelsa*) from New Zealand.[127]

A better understanding of the underlying dynamics of this Aeolian Exchange and particularly the role of key maritories might explain why some environments underwent extensive transformation more than others. St Helena, for instance, used as a frequent watering and provisioning place for first Dutch and then English East Indiamen was altered out of all recognition, allowing "Paradise" to "become a desert" in the words of Joseph Banks who visited the island in 1771.[128] Other ports-of-call, such as the Canary Islands, facilitated the transoceanic transfer of tropical plants like sugar, coffee and bananas around the world.[129] Maritory was linked to maritory and continent to continent by winds and the ships that sailed between them were often the unwitting Arks responsible for many of today's terrestrial ecosystems.[130]

Empires against the wind

All this began to change in the latter nineteenth century as steam-powered and iron-bottomed vessels began to supplant wooden sailing ships on long ocean routes. Though the first circumnavigation of the globe by steam occurred in the 1840s, sailing ships were

not fully eclipsed until the 1880s. Indeed, the intervening decades represent the peak in sail craft technology with advances in ship construction and the systematic study of ocean tides, currents and winds significantly improving sailing times. For instance, Lt. Matthew Maury U.S.N.'s systematic investigation of ships' logbooks optimised sailing routes in all seasons.[131] Sailing vessels were to remain competitive on most long-distance routes until the development of the steel triple expansion engine able to withstand pressures of up to 200lbs psi. Though the total registered tonnage for sail (3.85 million) was still greater than that of steam (2.7 million) in 1880, the decline of the former was relentless in the years that followed.[132] Iron steamships that carried larger cargoes at increasingly competitive prices, provided a more regular service, and did not depend on the wind heralded the end of sail as an agent of imperial endeavour.

The post-Aeolian empires that emerged in the aftermath of this revolution in transport were based on a different dynamic of locomotion. Changes were slow at first as early steamships still depended on sail and only used engines as a supplementary source of power. Steamships, therefore, did not initially forge new routes across the oceans as they also benefited from winds and currents. But as boiler pressures increased and sailing times became more reliable, steamships were able to strike more direct routes. The effect was most noticeable in the North Atlantic between American and European ports where the prevailing westerlies necessitated lengthy detours for vessels under sail.[133] The primary consideration for steamships was not necessarily winds or currents but the amount of coal and later oil that they could carry and the distance between bunkering depots. Strategically placed island atolls such as Diego Garcia in the Indian Ocean and

Midway Island in the Pacific or major naval stations such as Singapore and Hong Kong created a completely new geography of empire.[134] According to Fernández-Armesto, steam also wrenched trade in new directions "away from coasts, towards interiors and across continents".[135] The maritime empires of the later nineteenth century, those of Britain and France, and especially the United States and Japan were not shaped by the same Aeolian limitations and took different forms. In a sense, they were empires against the wind.

Oceans have attracted increasing historical attention in recent years.[136] In many cases, these studies offer a radical alternative historiography to state-centred master narratives by pursuing issues and questions that transcend the spatial and temporal boundaries of any one place or region.[137] Between 1500 and 1880, the framework of European empires was to a large extent shaped by winds and currents that human ingenuity was increasingly able to exploit but never fully direct to their own ends. The ability of shipwrights and seamen, of human skill and technology to harness these natural forces steadily improved over the centuries even if the scientific understanding of the laws and principles that govern their motion required advances in instrumentation and state patronage that were not forthcoming until the days of sail were on the wane.[138] Certain patterns of empire emerged as Aeolian corridors were explored and as one European seaborne power successively replaced another: the Portuguese and Spanish by the Dutch, the Dutch by the French and English. The ships that traversed these marineways were not simply instruments of empire but carried with them the peoples, plants, animals and diseases from which were fashioned many of the new hybrid cultures and ecologies of today.

"To master an oceanic environment, you have to penetrate the secrets of winds and currents", observes Fernández-Armesto, adding: "In most of our explanations of what has happened in history, there is too much hot air and not enough wind".[139] Michael Pearson accuses him of "putting it a bit strongly",[140] but a fuller consideration of the Aeolian dimension invites a reassessment of larger historical narratives even if it does not go so far as to propose a new, more radical model of empire.

In the first place, understanding where the winds blow identifies certain geographical "choke points" and "pockets". Choke points are the maritories or key ports and islands where wind systems and currents converge, where vessels waited or refitted, where merchandise was trans-shipped or traded, and where battles were won or lost over their control. Havana, Pernambuco (Cape São Roque), Table Bay (Cape of Good Hope), Goa, Galle, Malacca, Batavia, Guam, Madeira, the Azores, the Canaries and the Cape Verde Islands all rose to prominence and prosperity on the strength of the winds and currents that blew or flowed their way. At the same time, the creation of these marineways across the oceans created pockets of "still water", territories, so to speak, that lay between the winds and currents. Hawai`i, the Mascarenes (until 1611), the islands of the South Pacific, Chile, southern Brazil and much of the northeast seaboard of North America were slow to be colonised or remained imperial backwaters whose future development was largely determined by a very different set of historical factors.

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Secondly, a more Aeolian perspective also suggests the outlines of a truly global transnational historiography.[141] Too often what purports to be oceanic studies are in reality accounts of Anglophone endeavours with disproportionate prominence given to the Atlantic Rim.[142] There is a need to break away from this "oceanic regionalism" and focus instead on the creation of global networks and the underlying dynamics of maritime empire-building unconfined to any one region or European power.[143] The Atlantic was as much a Spanish and Dutch ocean as it was an English one and the Pacific remained a "Spanish Lake" for centuries.[144] The Indian Ocean was first Portuguese and then Dutch long before it was ever English and it always remained an Arab one.[145] Winds and currents both facilitated and impeded European maritime powers in the days of sail directing, at one time or another, vessels and their cargoes (literal as well as metaphorical) to some locations and away from others. In fact, many of today's cultures and ecologies owe their ethno-genesis to the ways in which the wind blows. To better understand the endeavours and motivations of people in the past, historians need to overcome their inherent "terracentricism" and look at the world more through the eyes of a ship's captain preparing his vessel for sail and, inadvertently, setting a course for empire.

[1] Classic works in this vein include: C. R. Boxer, *The Portuguese Seaborne Empire 1415-1825* (London: Hutchinson and Co., 1977); C. R. Boxer, *The Dutch Seaborne Empire 1600-1800* (London: Hutchinson and Co., 1977); John Horace Parry, *The Spanish Seaborne Empire* (London: Hutchinson and Co. Ltd, 1977). Recent studies largely continue to treat winds and currents in a similar fashion: Jeremy Black, *The British Seaborne Empire* (New Haven and London: Yale University Press, 2004). Somewhat more prominence is

accorded the monsoons in the Indian ocean as in K. N. Chaudhuri, *Trade and Civilisation in the Indian Ocean: An Economic History from the Rise of Islam to 1750* (Cambridge: Cambridge University Press 1989) though a more recent study reverts to the more classical pattern, Edward A. Alders, *The Indian Ocean in World History* (Oxford: Oxford University Press 2014).

[2] The Caribbean figures prominently as a focus of this type of scholarship: Louis A. Pérez, *Winds of Change: Hurricanes and the Transformation of Nineteenth-Century Cuba* (Chapel Hill: University of North Carolina Press 2001); Matthew Mulcahy, *Hurricanes and Society in the British Greater Caribbean, 1624–1783* (Baltimore, John Hopkins University Press 2005); and Stuart B. Schwartz, *Sea of Storms: A History of Hurricanes in the Greater Caribbean from Columbus to Katrina* (Princeton and Oxford: Princeton University Press 2015). The El Niño Southern Oscillation (ENSO) is often the subject of the latter form of study; see, for example: Brian Fagan, *Floods, Famines and Emperors, El Niño and the Fate of Civilizations* (New York: Basic Books 1999); and Richard Grove and John Chappell (eds.) *El Niño: History and Crisis* (Isle of Harris: White Horse Press 2000).

[3] Felipe Fernández-Armesto, *Pathfinders: A Global History of Exploration* (Oxford: Oxford University Press, 2006).

[4] As such, it builds on an earlier article of mine that looked at how winds and currents influenced the Spanish in the Pacific Ocean. Greg Bankoff, 'Winds of Colonisation: The Meteorological Contours of Spain's Imperium in the Pacific, 1521-1898', *Environment and History* 12, 1 (2006): 65-88.

[5] A review of recent maritime history (albeit with a British bias) is provided in Glen O'Hara, '"The Sea is Swinging into View": Modern British Maritime History in a Globalised World', *English Historical Review* 124, 510 (2009): 1109-1134. See also the forum on 'oceans of history' published in the *American Historical Review*, 111, 3 (2006).

[6] Winds are named according to the point of the compass from which they blow.

[7] The deflection away from the straight path of high to low pressure is known as the *Coriolis effect*.

[8] Wind conditions are even more affected by local topographical features that "are far more significant to the practical seamen than general wind patterns". Renard Gluzman, 'Between Venice and the Levant:

Reevaluating Maritime Routes from the Fourteenth to the Sixteenth Century', *The Mariner's Mirror* 96, 3 (2010): 271.

[9] The discussion of atmospheric circulation is based mainly upon William van Dorn, *Oceanography and Seamanship* (Centreville, Maryland: Cornell Maritime Press, 1993), 59-67.

[10] James Hurrell, Yochanan Kushnir, Geir Ottersen and Martin Visbeck, 'An Overview of the North Atlantic Oscillation', in the *North Atlantic Oscillation: Climatic Significance and Environmental Impact*, eds. James Hurrell, Yochanan Kushnir, Geir Ottersen and Martin Visbeck (Washington DC: American Geophysical Union, 2003), 1-35. Such climatic fluctuations affect agricultural harvests, water management and fishery yields from eastern North America to western Siberia. Geir Ottersen, Benjamin Planque, Andrea Belgrano, Eric Post, Philip C. Read and Nils C. Stenseth, 'Ecological Effects of the North Atlantic Oscillation', *Oecologia* 128 (2001): 1-14.

[11] Jianping Huang, Kaz Higuchi and Amir Shabbar, 'The Relationship Between the North Atlantic oscillation and El Niño-Southern Oscillation', *Geophysical Research Letter* 25, 14 (1998): 2707-2710; A. B. Polonsky, D. V. Basharin, E. N. Voskresenkaya, S. J. Worley and A. V. Yurovsky, 'Relationship Between the North Atlantic Oscillation, Euro-Asian Climate Anomalies and Pacific Variability', *Pacific Oceanography* 2, 1-2 (2004): 52-66. On both ENSO and NAO, see also Fagan, Floods, Famines and Emperors, 39-70.

[12] Currents in the oceans are driven by a complex variety of factors that include temperature differences, water densities and tides as well as the wind.

[13] There are also subsurface Equatorial Counter-currents that flow eastward beneath the surface currents.

[14] Principal among these oceanic currents are: the Gulfstream, a deflection of the North and especially the South Equatorial Currents and including its subsidiary the Caribbean Current that flows northward up the east coast of North America; the Brazil Current, a seasonal, much weaker southern equivalent of the Gulf Stream; the Kuroshio Current (also known as the Japan Current) off the north-east coast of Japan running eastward at around 36ºN in the direction of the prevailing westerlies as far as about 160-170ºE; the California Current in the eastern North Pacific flowing southward off the coast of North America; the New Guinea and East Australia Current providing a local counter clockwise circulation between Australia and New Zealand; the warm, poleward flowing Leeuwin Current off the west and south coasts of Australia

driven by a large-scale meridional (north-south) pressure gradient; and the Western Boundary Currents of the Indian Ocean split between the North Equatorial Current that circulates generally westward during the northwest monsoon and eastwards during the southwest monsoon, and the South Equatorial Current with its strong southward flow down the Mozambique coastline. Dorn, *Oceanography and Seamanship*, 101-117.

[15] R. G. Peterson, L. Stramma and G. Kortum, 'Early Concepts and Charts of Ocean Circulation', *Progress in Oceanography* 37 (1996): 8-15.

[16] Margaret Deacon, *Scientists and the Sea 1650-1900: A Study of Marine Science* (Aldershot: Ashgate, 1997), 48-49. The most common explanation for the pattern of ocean currents during the first half of the sixteenth century derived from the supposed effect of evaporation and precipitation, and the consequent movement of water from a higher to a lower level.

[17] Oceanic rutters provided information on winds and currents while traditional rutters gave advice on coastal navigation. A, Teixeira da Motu, 'Atlantic Winds and Ocean Currents in Portuguese Nautical Documents of the Sixteenth Century', *Proceedings of the Royal Society of Edinburgh* 73 (1972): 61. Da Motu cites two sixteenth century Portuguese sources with practical experience of navigation that had begun to associate currents with winds (p.66). Arab seamen, however, had employed celestial navigation to ply routes across the Indian Ocean and beyond as far as China from the eighth century. A. A. Aleem, 'Concepts of Currents, Tides and Winds among Mediaeval Arab Geographers in the Indian Ocean', *Deep-Sea Research* 14 (1967): 459-463. See also, R. J. Barendse, *The Arabian Seas: The Indian Ocean World of the Seventeenth Century* (Armonk, New York and London: M.E. Sharpe 2002), 13-19; and Lincoln Paine, *The Sea and Civilization: A Maritime History of the World* (New York: Kopf 2013).

[18] On advances in European shipbuilding between the thirteenth and fifteenth centuries, see Pierre Chaunu, *European Expansion in the Later Middle Ages* (Amsterdam, New York, Oxford: North-Holland Publishing Company, 1979), 231-275.

[19] Michael S. Reidy, *Tides of History: Ocean Science and Her Majesty's Navy* (Chicago and London: University of Chicago press 2008), 7-9.

[20] European ship's masters and captains followed existing patterns of shipping borne of long experience wherever possible.

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[21] Maritory is used here to signify a pivotal point of maritime interaction that links adjoining atmospheric systems according to the French term, *merritoire*. Camille Parrian, 'Sailing Routes and Stopovers: Spatial Disparities across the Atlantic', *Journal of Coastal Research* SI 61 (2011): 140-149. The term is also used in both ethology – to describe a marine mammal's mating territory – and in archaeology to denote the marine area between communities separated by a body of water. In particular, Stuart Needham used the term to indicate "a definable zone of privileged or high-flux interaction used for the execution of certain specialist maritime 'exchanges'". Stuart P. Needham, "Encompassing the Sea: 'Maritories' and Bronze Age Maritime Interactions", in P. Clark (ed.), *Bronze Age Connections: Cultural Contact in Prehistoric Europe* (Oxford: Oxbow Book, 2009), 18.

[22] Pierre Chaunu, *European Expansion in the Later Middle Ages* (Amsterdam, New York, Oxford: North-Holland Publishing Company, 1979), 96-97.

[23] Fernández-Armesto, *Pathfinders*, 149-151. The Muslim world's prowess in trigonometry was developed largely as a by-product of the need to orientate mosques in the direction of Mecca. Patricia Seed, *Ceremonies of Possession in Europe's Conquest of the New World, 1492-1640* (Cambridge: Cambridge University Press 1995), 108-125

[24] A. J. R. Russell-Wood, *The Portuguese Empire, 1415-1808: A World on the Move* (Baltimore and London: Johns Hopkins University Press, 1998), 32-35.

[25] John Law, 'On the Methods of Long-Distance Control: Vessels, Navigation, and the Portuguese Route to India' in *Power, Action and Belief: a New Sociology of Knowledge*? *Sociological Review Monograph 32*, ed. John Law (Henley: Routledge 1986), 245.

[26] Ships traversing the doldrums between the North and South Atlantic gyre had to contend with the influence of the Guinea Current, North Equatorial Current, Equatorial Counter Current, South Equatorial Current and Brazil Current. Da Motu, 'Atlantic Winds and Ocean Currents', 61.

[27] Barendse, *Arabian Seas*, 299-380. Alpers, *Indian Ocean*, 7-9.

[28] Boxer, *Portuguese Seaborne Empire*, 206.

[29] Russell-Wood, *Portuguese Empire*, 35-38.

[30] Ibid., 40.

[31] The Portuguese discoverer of Brazil, Pedro Cabral, was incidentally in command of a fleet en route to India.

[32] Boxer, *Portuguese Seaborne Empire*, 86-87.

[33] Fernández-Armesto, *Pathfinders*, 150.

[34] Russell-Wood, *Portuguese Empire*, 37. It was by all accounts a very unhealthy place for Europeans and often only kept manned through its simultaneous role as a penal colony. Barendse, *Arabian Seas*, 23-25. Once steam finally replaced sail as the principal means of maritime location, the island's strategic importance declined.

[35] Chaudhuri, *Trade and Civilisation in the Indian Ocean*, 71. Goa rose from being a fairly minor to a major centre of exchanged based on the coercion exercised by the Estado da India. As a market, it always ranked behind the major trading ports of Gujarat especially Suratte. Michael Pearson, *The Indian Ocean* (London and New York: Routledge 2003), 135

[36] Boxer, *Portuguese Seaborne Empire*, 63-64.

[37] Pearson, *Indian Ocean*, 121.

[38] Chaunu, *European Expansion in the Later Middle Ages*, 111-112, 118-119.

[39] Ibid., 106.

[40] Unlike the other Atlantic islands, the Canaries were inhabited by an aboriginal Berber population, the Guanches, who resisted Spanish occupation. As an ethnicity, Guanches are no longer considered to exist. Felipe Fernández-Armesto, *Before Columbus: Exploration and Colonisation from the Mediterranean to the Atlantic 1229-1492* (Philadelphia: University of Pennsylvania Press, 2007).

[41] Chaunu, *European Expansion in the Later Middle Ages*, 96.

[42] Rick Sanders, 'The Science Behind Columbus', *Fidelio Magazine* 1, 2 (1992), 43-44.

[43] Attempts to explore the Atlantic from the Azores, though tried, failed possibly because the islands lay close to the sub-tropical anticyclones where winds are more uncertain unlike on their margins where air pressure gradients are steep and the winds more reliable.

[44] Nicolás Wey Gómez, *The Tropics of Empire: Why Columbus Sailed South to the Indies* (Cambridge: MIT Press 2008), 43. Gómez argues that Columbus purposely played down the extent to which he sailed south, even to the point of dissimulation, as, by the Treaty of Alcáçovas (Toledo) 1479-80, Castile

recognised Portuguese sovereignty of everything south of the Canary Islands in exchange for the latter's recognition of Spanish claims to the archipelago. Gómez, *Tropics of Empire*, 10-11. Fernández-Armesto, *Before Columbus*, 207.

[45] Schwartz, *Sea of Storms*, 39.

[46] Matthias Tomczak and J. Stuart Godfrey, *Regional Oceanography: An Introduction* (Oxford: Elsevier Science Ltd., 1994), 283-290.

[47] Dorn, *Oceanography and Seamanship*, 104.

[48] Arthur Davies, 'The "Miraculous" Discovery of South America by Columbus', *Geographical Review* 44, 4 (1954): 573-582.

[49] Dorn, *Oceanography and Seamanship*, 104.

[50] Parry, *Spanish Seaborne Empire*, 44-45.

[51] Dorn, *Oceanography and Seamanship*, 104.

[52] L. D. Scisco, 'The Track of Ponce de Leon in 1513', *Bulletin of the American Geographical Society* 45, 10 (1913): 721-735. Schwartz, *Sea of Storms*, 34. On the Castillo de San Marcos, now part of U.S. National Park Service, see: http://www.nps.gov/casa/index.htm.

[53] The South American ports were Cartagena (Colombia), Nombre de Dios and Porto Bello (both Panama).

[54] A. Lugo-Fernández, G. A. Ball, M. Gravois, C. Horrell and J. B. Irion, 'An Analysis of the Gulf of Mexico's Veracruz-Havana Route of La Flota De Nueva España', *Journal of Marine Archaeology* 2, 1 (2007): 27-28.

[55] Ibid., 35.

[56] Ibid., 37.

[57] Ricardo Garcia-Herrera, Luis Gimeno, Pedro Ribera and Emiliano Hernández, 'New Records of Atlantic Hurricanes from Spanish Documentary Sources', *Journal of Geophysical Research* 110, D3 (2005), 1-7. Schwartz argues that Spaniards "learned to live with the storms and to adjust the rhythms of agriculture, navigation, and commerce to their patterns". Schwartz, *Sea of Storms*, 38.

[58] Bankoff, 'Winds of Colonisation'.

[59] Oskar Spate, *The Spanish Lake The Pacific since Magellan Volume 1* (London: Croom Helm, 1979), 47-9.

[60] On the early history of Spain in the Philippines, see John Leddy Phelan, *The Hispanicization of the Philippines: Spanish Aims and Filipino Responses 1565-1700* (Madison: University of Wisconsin Press, 1959).

[61] William Schurz, 'The Manila Galleon and California', *Southwest Historical Quarterly* 21, 2 (1917): 107-126; Rolando Garcia, Henry Díaz, Ricardo García-Herrera, Jon Eischeid, Maria del Rosario Prieto, Emiliano Hernández, Luis Gimeno, Francisco Rubio Durán and Ana María Bascary, 'Atmospheric Circulation Changes in the Tropical Pacific Inferred from the Voyages of the Manila Galleons in the Sixteenth-Eighteenth Centuries', *Bulletin of the American Meteorological Society* 82, 11 (2001): 2346.

[62] Spate, *Spanish Lake*, 104-6; William Schurz, *The Manila Galleon* (Manila: Historical Conservation Society), 178-82.

[63] Francisco Santiago Cruz, *La Nao de China* (Mexico: Editorial Jus, 1962), 103, 125-6, 130, 138, 140; Garcia et al., 'Atmospheric Circulation Changes in the Tropical Pacific', 2448-50.

[64] Garcia et al., 'Atmospheric Circulation Changes in the Tropical Pacific', 2440, 2442, 2447-8.

[65] ENSO events occurred in 1638, 1639, 1641, 1642, 1646, 1648, 1650, 1651, 1652, 1659, 1660 and 1661 or twice as often as previously. Geoffrey Parker, *Global Crisis: War, Climate Change and Catastrophe in the Seventeenth Century* (New Haven and London: Yale University Press 2013), 3-17, 254-290. Garcia et al., 'Atmospheric Circulation Changes in the Tropical Pacific'. On the Little Ice Age, see John L. Brooke, *Climate Change and the Course of Global History: A Rough Journey* (Cambridge: Cambridge University Press 2014).

[66] Spate, *Spanish Lake*, 115-117.

[67] Antonio Barrera-Osorio, *Experiencing Nature: The Spanish American Empire and the Early Scientific Revolution* (Austin: University of Texas Press, 2006).

[68] H. Vander Linden, 'Alexander VI and the Demarcation of the Maritime and Colonial Domains of Spain and Portugal, 1493-1494', *American Historical Review* 22, 1 (1916): 12.

[69] Christopher Columbus 7 July 1503 as quoted in Gómez, *Tropics of Empire*, 40.

[70] The North Atlantic Drift (Gulfstream) circles the Bay of Biscay (though a side branch flows into the English Channel) before continuing along the Iberian and West African coasts to become the Canary Current. Dorn, *Oceanography and Seamanship*, 106.

[71] *Sailing Directions (En Route) English Channel*, Pub. 191 (Bethesda, Maryland: National Geospatial-Intelligence Agency, 2010), 3

[72] D. Wheeler, R. Garcia-Herrera, C. W. Wilkinson, C. Ward, 'Atmospheric Circulation and Storminess Derived from Royal Navy Logbooks: 1685 to 1750', *Climatic Change* 101, 1-2 (2010): 257-280

[73] C.E.P. Brooks and Teresa M. Hunt, 'Variations of Wind Direction in the British Isles since 1341', *Quarterly Journal of the Royal Meteorological Society* 59, 252 (1933): 383, 386.

[74] Jaap R. Bruijn, 'Between Batavia and the Cape: Shipping Patterns of the Dutch East India Company,' *Journal of Southeast Asian Studies* 11, 2 (1980): 259.

[75] Pieter C. Emmer and Wim Klooster, 'The Dutch Atlantic, 1600-1800 Expansion without Empire', *Itinerario* 23, 2 (1999): 52.

[76] Dutch voyages to the Guinea coast may have begun as early as the 1560s. W.S. Unger, 'Nieuwe gegevens betreffende het begin der vaart op Guinea', *Economisch Historisch Jaarboek* 21 (1940): 194-217. Together these forts formed the colony of the *Nederlandse Bezittingen ter Kuste van Guinea* until 1872 when they were ceded to Great Britain. Johannes Postma, *The Dutch in the Atlantic Slave Trade, 1600-1815* (Cambridge: Cambridge University Press, 1990).

[77] Barendse, *Arabian Seas*, 381-423.

[78] Robert Parthesius, *Dutch Ships in Tropical Waters: The Development of the Dutch East India Company (VOC) Shipping Network in Asia 1595-1660* (Amsterdam: Amsterdam University Press 2010), 55-56, 57.

[79] Boxer, *Dutch Seaborne Empire*, 92-97.

[80] Anthony Reid, *Southeast Asia in the Age of Commerce, 1450-1680: Expansion and Crisis Volume Two* (New Haven: Yale University Press, 1993), 30-31.

[81] Chiu Hsin-Hu, *The Colonial 'Civilizing Process' in Dutch Formosa, 1624-1662* (Leiden: Brill, 2008); Grant Kohn Goodman, *Japan and the Dutch, 1600-1853* (Richmond, Surrey: Curzon Press, 2000).

[82] Boxer, *Dutch Seaborne Empire*, 197-198. Bruijn, 'Between Batavia and the Cape': 258-260.

[83] Femme Gaastra, *The Dutch East India Company: Expansion and Decline* (Leiden: Walburg Press 2003), 111.

[84] Bruijn, 'Between Batavia and the Cape': 243. The island of St Helena was also used to provision ships returning from Asia. Parthesius, *Dutch Ships in Tropical Waters*, 60.

[85] The colonies of New Holland lasted between 1624 and 1654, and New Netherlands between 1609 and 1664.

[86] Emmer and Klooster, 'The Dutch Atlantic': 48-50, 58-61.

[87] The United Netherlands Chartered East India Company (VOC) in the East and the Dutch West India Company (WIC) in the West.

[88] In this use of fortified factories, the Dutch copied the Portuguese who, in their turn, had only followed the Genoese pattern established earlier in the Mediterranean. Geoffrey Vaughn Scammell, *The World Encompassed: The First European Maritime Empires, C. 800-1650* (Berkeley: University of California Press, 1981).

[89] Bruijn, 'Between Batavia and the Cape,' 255-256.

[90] In the event, only four vessels suffered this fate, although at least another three were reported as missing. Gaastra, *Dutch East India Company*, 114.

[91] Francis Gooding, 'Of Dodos and Dutchmen: Reflections on the Nature of History', *Critical Quarterly* 47, 4 (2005): 38-40; P. J. Moree, *A Concise History of Dutch Mauritius, 1598-1710: A Fruitful and Healthy Land* (London: Kegan Paul International, 1998), 9-12.

[92] Parthesius, *Dutch Ships in Tropical Waters*, 51.

[93] Gaastra, *Dutch East India Company*, 118.

[94] Ibid., 115-116; Parthesius, *Dutch Ships in Tropical Waters*, 62.

[95] Bruijn, 'Between Batavia and the Cape,' 253-254.

[96] Parthesius, *Dutch Ships in Tropical Waters*, 57.

[97] Gaastra, *Dutch East India Company*, 121.

[98] Parthesius, *Dutch Ships in Tropical Waters*, 54.

[99] Ian Steele, *The English Atlantic 1675-1740: An Exploration of Communication and Community* (New York, Oxford: Oxford University Press, 1986), 21.

[100] Ibid., 45-49.

[101] *Ibid.*, 57-50.

[102] Fernández-Armesto, *Pathfinders*, 52-53.

[103] Dorn, *Oceanography and Seamanship*, 117.

[104] Steele, *The English Atlantic*, 86. Henry VII of England issued a charter to John Cabot in 1497 to find a northwest-passage, and François I of France commissioned Jacques Cartier between 1534 and 1542 to explore the North American coast of what later became New France. Both destinations lay on the route of the polar easterlies.

[105] For a cognate but different interpretation that considers the broader ecological and environment context, see Carville Earle, *Geographical Inquiry and American Historical Problems* (New Haven: Stanford University Press 1992), 25-87.

[106] The territory of New France was divided into five colonies, each with its own administration: Canada, Acadia, Hudson Bay, Newfoundland (Plaisance), and Louisiana.

[107] Robert Aldrich, *Greater France: A Story of French Overseas Expansion* (Basingstoke: Macmillan Press, 1996), 11-17; Frederick Quinn, *The French Overseas Empire* (Westport, London: Prager, 2000), 24-29, 45-60.

[108] The current definition of which island in the Lesser Antilles belongs to which group originates from the English presence in the Caribbean, with the Windward Islands starting at Dominica in the north and ending with the Grenadines in the south, and the Leeward Islands comprising those islands lying between Dominica and the Virgin Islands. The Windward Islands were so-called as they were the first (windward) islands ships (most of them slavers) encountered when crossing the Atlantic from Africa. However, other European powers made much the same distinction regarding an island's relative location with respect to the trade winds. To the Spanish, all islands to the north of South America lying away from the trade winds were the *Islas de Sotavento* (Leeward Islands) and every island from Trinidad to the Virgin Islands were referred to as the *Islas de Barlovento* (Windward Islands). The Dutch held a similar distinction with regard to their own colonies now municipalities integrated into the Netherlands, denominating Saba, St Eustatius and St Maarten as *Bovenwindse*, and Aruba, Bonaire and Curaçao as *Benedenwindse*, literally above and below the winds. Robert L. Paquette, *The Lesser Antilles in the Age of European Expansion* (Gainesville: University of Florida Press 1996), 11-12.

[109] Cape Coast, the initial site of English interest on the Gold Coast exemplifies the sequential nature of Aeolian colonisation being first settled by the Portuguese, then fortified by the Dutch, later seized by the

Swedes before passing to the British. Crown Jeremy Black, *The British Seaborne Empire* (New Haven and London: Yale University Press, 2004), 40-46, 54.

[110] R. T. Appleyard and Toby Manford, *The Beginning: European Discovery and Early Settlement of Swan River Western Australia* (Perth: University of Western Australia Press 1979), 38-42. Vessels are able to pick up the southeast trades at around 28ºS approximately 400km north of Perth and incidentally close to site of the major regional port of Geraldton.

[111] Herbert S. Klein, *The Atlantic Slave Trade* (Cambridge: Cambridge University Press, 1999), 130-160.

[112] Emmer and Klooster, 'The Dutch Atlantic', 55.

[113] Philip D. Morgan, 'The Cultural Implications of the Atlantic Slave Trade: African Regional Origins, American Destinations and New World Developments' in *Routes to Slavery: Direction, Ethnicity and Mortality in the Transatlantic Slave Trade*, eds. David Eltis and David Richardson (London and Portland, Oregon: Frank Cass, 1997), 125.

[114] David Eltis, *The Rise of African Slavery in the Americas* (Cambridge: Cambridge University Press, 2000), 244-250.

[115] Daniel B. Domingues da Silva, 'The Atlantic Slave Trade to Maranhão, 1680-1846: Volume, Routes and Organisation', *Slaver y and Abolition* 29, 4 (2008): 485.

[116] Nathan Nunn and Nancy Qian, 'The Columbian Exchange: A History of Disease, Food, and Ideas, *The Journal of Economic Perspectives* 24, 2 (2010): 181-182.

[117] Alfred W. Crosby, *The Columbian Exchange: Biological and Cultural Consequences of 1492* (Westport, Connecticut: Greenwood Press, 1972); Alfred W. Crosby, *Ecological Imperialism: The Biological Expansion of Europe, 900-1900* (New York: Cambridge University Press, 1986). Subsequently, this exchange has proven to be much more complex if for no other reason than it is very difficult to decide upon the criteria necessary to assess such directional flows. William Beinart and Karen Middleton, 'Plant Transfers in Historical Perspective: A Review Article', *Environment and History* 10 (2004): 8.

[118] Karl W. Butzer, 'Biological Transfer, Agricultural Change, and Environmental Implications of 1492' in *International Germplasm Transfer: Past and Present*, ed., R. R. Duncan (Madison, WI: Crop Science Society of America, 1995), 3-29. Exchanges have taken place over much longer periods of time than simply the era of European imperial dominance. Haripriya Rangan, Judith Carney and Tim Denham,

'Environmental History of Botanical Exchanges in the Indian Ocean World', *Environment and History* 18 (2012): 311-342; Elizabeth Ann Pollard, 'Pliny's *Natural History* and the Flavian *Templum Pacis*: Botanical Imperialism in First-Century C.E. Rome', *Journal of World History* 20, 3 (2009): 309-338.

[119] Eric Pawson, 'Plants, Mobilities and Landscapes: Environmental Histories of Botanical Exchange', *Geography Compass* 2, 5 (2008), 1465.

[120] Crosby, *The Columbian Exchange*.

[121] Pawson, 'Plants, Mobilities and Landscapes': 1467.

[122] The People's Republic of China accounted for 76 per cent of the world's total production of sweet potatoes in 2012. http://www.unctad.info/en/Infocomm/AACP-Products/COMMODITY-PROFILE---Sweet-potato/ (accessed on 23 July 2013)

[123] Nunn and Qian, 'The Columbian Exchange': 167-171.

[124] Judith A. Carney Richard Nicholas Rosomoff, *In the Shadow Slavery: Africa's Botanical Legacy in the Atlantic World* (Berkely: University of California Press, 2009); Judith Carney, *Black Rice: The African Origins of Rice Cultivation in the Americas* (Cambridge: Harvard University Press, 2002).

[125] These transition zones of "creolized biotas" lay between Cuba and Maryland (between 22-38º) in northern latitudes and encompassed the Brazilian states of Minas Gerais, Espírito Santo, Rio de Janeiro and São Paulo (between 16-26º) in southern latitudes. John R. McNeill, 'Biological Exchanges in World History' in *The Oxford Handbook of World History*, ed., Jeremy Bentley (Oxford: Oxford University Press, 2011), 338.

[126] Greg Bankoff and Sandra Swart, *Breeds of Empire: the "Invention" of the Horse in South-East Asia and Southern Africa 1500-1950* (Copenhagen: Nordic Institute of Asian Studies Press, 2007).

[127] Pawson, 'Plants, Mobilities and Landscapes': 1469.

[128] Sir Joseph Banks, diary entry, dt May 1771 as quoted in Richard Grove, 'Conserving Eden: The (European) East India Companies and Their Environmental Policies on St. Helena, Mauritius and in Western India, 1660 to 1854', *Comparative Studies in Society and History* 35, 2 (1993): 329; Parthesius, *Dutch Ships in Tropical Waters*, 60.

[129] Butzer, 'Biological Transfer'. The establishment of botanical gardens later institutionalised this exchange on a truly global scale. Lucile Brockway, *Science and Colonial Expansion: The Role of the British Royal Botanic Gardens* (New York and London: Academic Press, 1979).

[130] Crosby, *Ecological Imperialism*.

[131] J. M. Lewis, 'Winds over the World Sea: Maury and Köppen', *Bulletin of the American Meteorological Society* 77, (1996): 935–952.

[132] Gerald S. Graham, 'The Ascendancy of the Sailing Ship 1850-85', *Economic History Review* 9, 1 (1956): 74-88.

[133] Sailing ships, however, remained the chief means of replenishing these overseas coaling bases. Graham, 'The Ascendancy of the Sailing Ship': 84.

[134] Fernández-Armesto, *Pathfinders*, 375-376.

[135] Ibid., 377.

[136] Jerry H. Bentley, 'Sea and Ocean Basins as Frameworks of Historical Analysis', *Geographical Review* 89, 2 (1999): 215-224. See also the AHR Forum, "Oceans of History," *American Historical Review* 111, 3 (2006) and the articles by Peregrine Horden and Nicholas Purcell on the Mediterranean, Alison Games on the Atlantic, and Matt K. Matsuda on the Pacific.

[137] David Lambert, Luciana Martins and Miles Ogborn, 'Currents, Visions and Voyages: Historical Geography of the Sea', *Journal of Historical Geography* 32 (2006): 482.

[138] Deacon, *Scientists and the Sea 1650-1900*; Reidy, *Tides of History*.

[139] Felipe Fernández-Armesto, *Civilizations* (London: Macmillan 2000), 488.

[140] Pearson, *Indian Ocean*, 20.

[141] Akira Iriye, 'Transnational History', *Contemporary European History* 13 (2004), 211–222.

[142] David Armitage, 'Three Concepts of Atlantic History' in *The British Atlantic World, 1500-1800,* eds. David Armitage and Michael Braddock (Basingstoke and New York: Palgrave Macmillan 2009), 11-27.

[143] O'Hara, '"The Sea is Swinging Into View": 1115-1118.

[144] Spate, *Spanish Lake*. See also Rainer F. Buschmann, *Iberian Visions of the Pacific Ocean, 1507-1899* (New York: Palgrave Macmillan 2014).

[145] Paine, *The Sea and Civilization*; Barendse, *Arabian Seas*. See also G. R. Tibbetts, *Arab Navigation in the Indian Ocean before the Coming of the Portuguese: Being a Translation of Kitab al-Farawa'id fi usul al-bahr wa'l-qawa'id of Ahmad b. Majid al-Najdi* (London: oriental Translation Fund 1971), originally published in 1490.