Polar Opposites

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Abstract:
The frigid extremes of the planet are often ignored and largely misunderstood, even though they cover 11 million square miles (37.7 million square kilometres) and are often dismissed as uninhabitable, unimportant, frozen wastes that constitute the white margins at the edge of the map of the world. Their harsh environment and geographical isolation make them difficult to visit and challenging to live in. However, these two regions are so geographically different from each other, but play a fundamental role in the environmental balance of the globe's climate. They are both strategically important and could act as geopolitical flashpoints. It is therefore crucial that we begin to look at these two areas from a more critical perspective, understand their pivotal importance to the future. The politics that surround these two areas are complex and fascinating, the economic value is significant, the social characteristics of the two regions are very different but equally important. As technology evolves mastering these two areas will alter, which will throw up a range of legal and environmental hurdles. The Arctic and Antarctic are both maritime domains and managing the maritime security concerns will be considerable. This article is designed to describe some of the aspects of the polar regions, provide some background and prompt discussion. These regions are destined to be more important to our future than most of have imagined.

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Photo 1 & 2: Arctic and Antarctic, which is which?

Introduction:

Like many people, I had always regarded the Arctic and Antarctic regions as being more similar than different; extremely cold, windy and inhospitable. I would have had a 50/50 chance of placing the two photographs above to the correct region. The most obvious differentiator for me was that polar bears inhabited the Artic regions, whilst penguins inhabited the Antarctic regions and beyond (I saw my first wild penguin in Australia). As a Royal Marine I visited and operated in the Arctic, both winter and summer, as part of protecting NATO's Northen Flank in northern Norway. I learned how to live and work in sub-zero temperatures down to -20°C and colder. I appreciated the brutality of the environment whilst also appreciating how breathtakingly beautiful it can be. A few years ago, my wife and I took the Norwegian Hurtigruten postal boat from Bergan north along the Norwegian coast, navigating the picturesque Indre led (narrow waters between a chain of small coastal islands and mainland Norway), crossed the Artic Circle, steamed around the northern tip of the country to a small coastal town near the Russian border called Kirkenes and back. I have also stood in awe on the upper deck of a ship watching the amazing Aurora Borealis or northern lights dance across the Arctic skies.

But before I visited the Antarctic earlier this year, I had not appreciated the extent of the differences between the two polar regions. Spending four weeks, at sea, in the company of geologists, glaciologists and naturalists, with almost daily trips to the archipelagic islands and continental landmass in the Antarctic, I was able to explore, albeit a minute area of this vast region, but more importantly begin to appreciate the stark differences of the two extremes of the globe. Interestingly, when I returned home and told people I had just returned from the Antarctic, I was often asked; "did you see any polar bears?" which emphasised to me that many people look upon the two polar regions in a similar way to that which I had done before I visited the Antarctic.

Like many people, my understanding of the polar regions was shaped by the stories of intrepid explorers like Peary, Amundsen, Scott, Shackleton and Mawson who made their epic journeys across the frozen wastes of the two poles. The plethora of outstanding documentaries and films about the poles, often narrated by Sir David Attenborough, have taught me about the flora and fauna of the two regions, describing how plants and creatures have adapted to the harsh unforgiving conditions. However, what I had failed to properly grasp, apart from them being at geographically opposite ends of the planet, is quite how different they are, despite their obvious commonalities. It struck me they are as similar and yet just as different as two children from the same parents.

In this article I shall bring out the commonalities and linkages between the two regions, then highlight the significant differences. I shall then examine why the two polar regions are important to us from a political, economic, social, technological, legal and environmental aspect and look at the maritime security implications in the short, medium and longer term. I shall finish by taking a leaf out of Donald Rumsfeld's book by identifying some known knowns, known unknowns, unknown knowns and unknown unknowns of the polar regions and how they could impact maritime security.

Polar Similarities: It is useful to first outline the aspects of the Arctic and Antarctic that are common to both polar regions before delving into the differences.

The Polar regions are both effectively bounded by the two polar circles (Arctic Circle, Antarctic Circle), which are the two lines of latitude marked on maps and globes of the world at the top and bottom (66° 33'50.0" N in the Arctic, 66° 33'50.0" S in the Antarctic) along with the Tropics of Cancer, Equator and Tropic of Capricorn (from north to south) in between. These two imaginary circles on the surface of the globe denote the arc which experiences 24-hours darkness at their respective winter solstice (Arctic 22 December, Antarctic 22 June) and 24-hours daylight at their respective summer solstice (Arctic 22 June, Antarctic 22 December). The Arctic and Antarctic Circles are not fixed, as they alter, depending on the Earth's axial tilt, which fluctuates within a margin of about 2° over 41,000 years, because of tidal variations caused by the

orbits of the Moon. These all or nothing differences of daylight and radiated heat from the sun result in the severely cold temperatures in both polar regions during their long, dark winters.

Both ends of the globe are also home to the geographical, magnetic and geomagnetic poles, both north and south. The geographical north and south poles are the imaginary points on the surface of the planet where all the lines of longitude both north and south come together. The geographic poles are stationary and are crucial to navigation and referred to as "True North" and "True South". The magnetic poles are effectively the dipoles at the two extremes of the earth where the planet's magnetic field enters the earth's surface vertically, which is the location that magnetic compasses point to. The difference between magnetic north and geographical (true) north are known (the term used to denote the angular difference is called Variation, which can be found on maps, aeronautical and maritime charts) and can be calculated with relative certainty for the purpose of navigation using a magnetic compass. However, the earth's magnetic field is dynamic and asymmetric meaning that the two poles wander independently of each other and are not directly opposite each other on the globe.[1] Movements of the two poles can be as much as 40km per year, but they can be measured and predicted to within a reasonable margin, accurate enough for navigation using a magnetic compass. The geomagnetic poles are antipodal points where the axis of a best-fitting dipole intersects the surface of the Earth; the two positions are where it intersects the Earth's surface are called the North and South geometric poles.

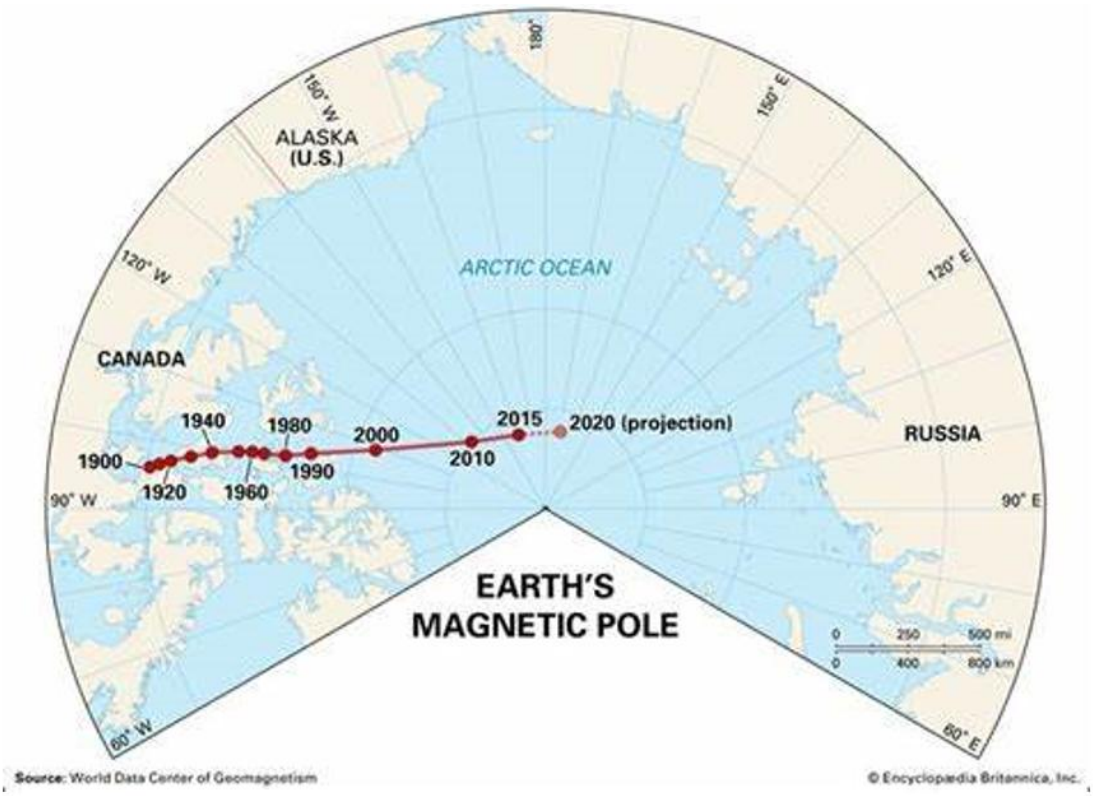


Diagram 1: Movement of the North Magnetic Pole 1900-2020 Source: The three norths align over Great Britain | Blog | OS (ordnancesurvey.co.uk)

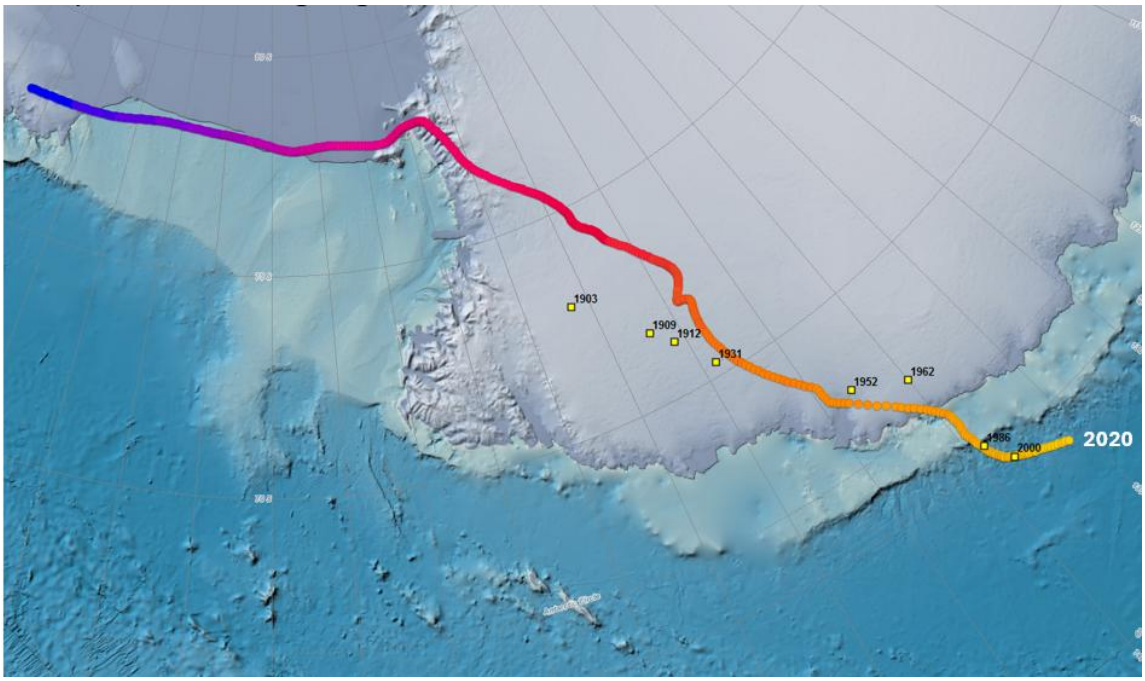


Diagram 2: Observed south dip poles during 1903–2000 are yellow squares. IGRF-12 Modelled pole locations from 1590 to 2020 are circles progressing from blue to yellow. Source South pole historical map - South magnetic pole - Wikipedia

The lines of longitude that cross maps and charts vertically from north to south. The lines of latitude which cross maps and charts horizontally. By using a combination of our latitude and longitude we can pinpoint our position on the face of the earth. We also use the lines of longitude in 15° blocks to mark the boundaries of the international time zones across the world[2]. Whilst the lines of latitude sit around the globe like different sized parallel hoops maintaining a constant distance from each other so they never meet or cross. The lines of longitude all converge at the two poles. As the lines of longitude help to denote the time zones, there is no time zone for either the Arctic or Antarctic, so travellers can use any time they wish.

The polar extremes are also a very effective barometers of climate change, because of a phenomenon called Polar Amplification. Amongst other factors, the range of polar temperature changes over a 12-month period are starkly different to the range of tropical temperature changes over the same period. Within the equatorial zone there is a year-round constant of approximately 12 hours sunshine and 12 hours darkness every day resulting in average temperatures of 31°C in the afternoon and 23°C at sunrise throughout the year a fluctuation of just 8°C every day throughout the year. Whereas within the Arctic and Antarctic Circles, the radiant energy from the sun ranges from 24 hours per day at the summer solstice to zero sunlight at winter solstice meaning the average temperatures in the winter at sea level are around -40°C and average summer temperatures are around +10°C[3], meaning more than a 50°C difference across the year. The effects of the wind, in the Arctic and Antarctic, which cause wind chill factor, can drop the apparent temperatures far below the average ambient temperature at sea level. Differences in altitude, especially in the Antarctic (up to 4,000m) can pull temperatures well below the averages assessed at sea level.

A layer of Ozone[4] high in the stratosphere of the Earth's atmosphere absorbs most of the sun's harmful medium frequency ultraviolet rays. However, because we (unknowingly at the time) used dangerous chemicals called chlorofluorocarbons (CFCs), mostly in refrigerators, aerosol cans and plastics in the mid twentieth century, the Ozone layer was depleted. Most ozone is created around the tropics and then moves

to higher latitudes at the poles, with more ozone travelling north than south. When the ozone layer is particularly thin it is sometimes referred to as a "hole" in the ozone layer. The preponderance of mountains and land mass in the northern hemisphere which alters the flow of air, making it a stronger circulation, whereas the southern hemisphere the surface is mainly open ocean, which does not disrupt air flow and circulation to the same extent. Consequently, the Antarctic has lower levels of ozone cover, especially during the Austral summer when the sun shines for up to twenty-four hours. The use of CFCs was banned internationally in the 1980s and it was estimated in 2016, the ozone could recover by the mid-twenty-first century. However, the depletion of the Ozone layer combined with long summer days in both polar regions, the average temperatures in both the Arctic and Antarctic have risen.

The increasing average temperatures have caused thawing of snow and ice in the polar regions exposing the dark coloured land and sea. The level of the sunlight's radiant warmth absorption by different surfaces is called the albedo effect. More reflective surfaces like snow and ice have a much higher albedo rating than dark coloured land and open sea. Consequently, the greater proportion of dark coloured surfaces exposed to sunlight the more radiant heat is absorbed, causing a vicious circle, raising the average ambient temperature, causing more thawing and exposure of more absorbent surfaces.

The geographic configuration of the Arctic with ocean surrounded by land which is deeply frozen permafrost[5]. As the ambient temperatures rise the permafrost starts to thaw, releasing large quantities of methane and carbon dioxide, two greenhouse gases, into the atmosphere. The consequences of the release of these greenhouses gasses by permafrost thawing is yet to be fully accounted for in global warming calculations. The liquification of the permafrost also softens the previously hard frozen ground, destabilising infrastructure like roads, railways, airfields and the foundations of buildings across Arctic nations.

Whilst both polar regions are mostly white, which many of us associate with snow in sub-zero temperatures, the polar regions are cold weather deserts. The Arctic receives less than 500mm of precipitation (mostly snow) and the Antarctic around 150mm of precipitation annually. Therefore, most of the thawing snow and ice, especially around the periphery of the frozen cores, is not replaced by annual snowfall, exacerbating the problem incrementally.

The great variations in temperature across the regions along with topographical differences, especially in Antarctica cause phenomenally sustained strong winds in both regions, which can seem relentless.

The albedo effect also warms the exposed waters of the Arctic and Southern Oceans altering the thermodynamics of the water and the flow of oceanic currents in the high latitudes, dangerously impacting the fragile biosphere in both the Arctic and Antarctic.

The extensive area of polar glaciers in Greenland and across Antarctica are dynamic, born of thousands of years of precipitation, which has fallen as snow. Because of the sub-zero temperatures the snow never thaws, so as subsequent snowfalls add to the previous layers, the cumulative weight of millennia of snowfall compresses the snowflakes together, so they fuse into glacial ice. The mountainous topography of Greenland and the Antarctic, formed millions of years earlier when both areas of land were warmer, shaped by rainwater carving valleys, creating canyons and floodplains as the rivers weaved their way to the sea, are now covered by thousands of years' worth of snow and ice. The incline of the land from the high mountains down to the ocean means these massive glaciers are perpetually moving, drawn by gravity, at glacial speed.

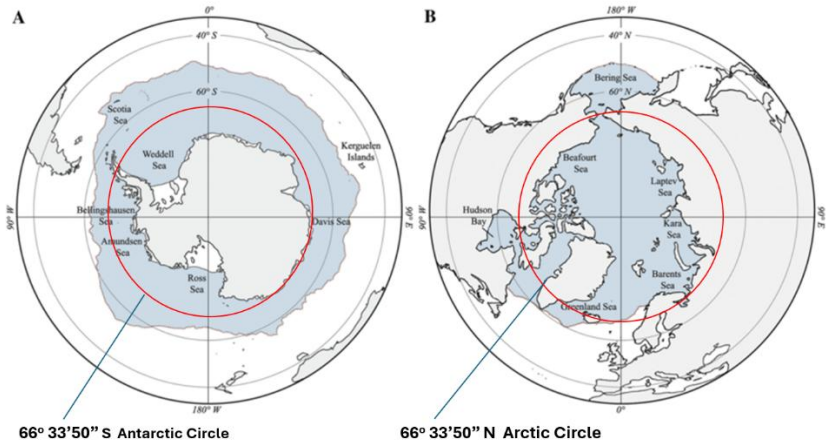
As the glacier edges reach the sea, massive blocks of ice "calve"[6] off the face of the glacier into the sea as icebergs[7]. The glaciers in Greenland produce up to 50,000 icebergs per year[8]. Arctic icebergs that enter the Atlantic Ocean are dangerous navigational hazards for shipping and have taken some notable casualties like the Titanic in 1912. Due to the size and scale of Antarctica, icebergs can be much larger; the A23a iceberg[9], a large tabular iceberg was calved from the Filchner Ronne Ice Shelf and broke away from the

Antarctic coastline, in the Weddell Sea in 1986. For over 30 years the berg was grounded and static, but gradual melting of the bottom of the iceberg in the warmer sea water has allowed it to refloat. The enormous berg is now approximately 1,500 square miles/3,800 square kilometres (larger than Greater London) and floating in a northeasterly direction. The isolation of the Antarctic and lack of proximity to busy shipping lanes that far south means Antarctic icebergs currently pose less of a danger to shipping.

Sea ice, as the name suggests, is frozen sea water that can amass into extensive areas of sheet ice across the sea. Sea ice occurs in both the Arctic and Antarctic, and the extent of the sea ice coverage in both polar regions is different every year, safe to say the sea ice coverage around Antarctica can double its solid surface area during the winter. Lying on the surface of the sea, the sea ice is dynamic, pushed by currents, tides and winds, which exert phenomenal pressures that can break and buckle great swathes of sea ice. A significant proportion of sea ice will freeze and thaw each year. If the first-year sea ice survives the spring/summer thaw, it will be between 30-70cm thick and then become second year ice, which can be as thick as 2-4m. Because of the seasonal freeze-thaw process, the ice can form pressure ridges as the external sea currents, tides and wind forces push the sheets of ice against each other. Multiyear ice is far more common in the semi-enclosed Artic Ocean than the more exposed coast of the Antarctic.

The significant difference between the icebergs from the glaciers of Greenland and the Antarctic Continent and the expanses of sea ice is that icebergs are frozen fresh water, comprising the accumulated precipitation, falling as snow, on the land masses of Antarctica and Greenland over thousands of years. Consequently, a staggering 70% of all the fresh water in the world is held in the Antarctic glaciers. It is estimated if the Antarctic glaciers were all to melt, the volume of fresh water, they contain would raise the global sea level by around 61 metres[10]. And if the Greenland glaciers were to melt that would add another 7 metres[11] to the sea level. Whereas sea ice is frozen salt water and already part of the global ocean volume equation and wouldn't markedly alter the global sea level.

Polar opposites: The differences between the two polar regions are both natural, as shown in the two maps below, and from the human viewpoint (the polar opposites from a natural and human perspective are summarised in Table 5 below). This section will firstly identify and highlight the immutable physical geographic characteristics between the two poles and then compare the two regions from the human perspectives of political, economic, social, technological, legal and environmental.



Map 1: A. Antarctica dominated by the Antarctic Continent. B. Arctic dominated by the Arctic Ocean (Arctic and Antarctic Circles added by E-i-C).

Geographical Characteristics - the geographical characteristics of the two polar regions are completely different as the first polar explorers discovered.

The first team to reach the North Pole was led by an American explorer, Robert Peary in April 1909. The team set off from the northern Canadian shore, at "Cape Columbia to the North Pole, straight going, is 413 geographical miles[12], and Peary[13] who took on his expedition 246 dogs, covered the distance in 37 days."[14] There has been some doubt as to the veracity of Peary successfully reaching the exact position of the geographic North Pole, because of unverifiable navigational calculations and achieving the distance uncharacteristically fast. Moving across relatively flat sea ice could have been possible, but it was quick, and uncertainty remains. Whereas "From Hut Point to the South Pole and back is 1,532 geographical or 1776 statute miles,"[15] It was the Norwegian explorer Roald Amundsen who first reached the geographical South Pole; "With my four comrades Wisting, Hanssen, Hassel and Bjaaland, we reached the South Pole on 14 December 1911."[16] Not only was the distance significantly greater, but it included an ascent to 2,800m and crossing miles of deep, treacherous crevasses that lurk in the great glaciers. Scott's doomed party which arrived at the pole 34 days after Amundsen's were travelling across the ice for 147 days, before they perished at their final camp.

Arctic: The largest central portion of the north polar region is the Arctic Ocean[17], effectively a semi-enclosed sea surrounded by Canada, Greenland (Denmark), Iceland, Norway, Russia and the USA (Alaska). Access to the Pacific Ocean is via the relatively narrow (44 nautical miles at the narrowest point) Berring Strait and to the Atlantic Ocean either via the gap between the east coast of Canada and the west coast of Greenland, transiting Baffin Bay, when it is not covered in sea ice. Alternatively, the second and larger access to the North Atlantic is via the gap between Greenland, Iceland and Norway referred to as the Northern Maritime Corridor (NMC). The tidal and wind-driven near-inertial currents in the Arctic Ocean play a vital role in the changing Arctic climate and the marine ecosystems[18].

The **Antarctic** is the complete opposite. The region is dominated by the fifth largest continental landmass (approximately 1.4 times the size of Europe), which is surrounded by the swirling Southern Ocean, acting "Like a moat around a frozen castle"[19]. The Circumpolar Current, which runs in a clockwise direction (west to east) around the Antarctic continent, when viewed from the south, with no land mass impediment to interrupt the flow, is the largest global ocean current. The waters south of 60°S, often referred to as the Southern Ocean, which is characteristically rough and can be treacherous for seafarers.

Area – the Arctic and Antarctic both cover about 5.5 million square miles (i.e. north or south of the respective 66.5°N/S Arctic/Antarctic Circles). The Artic region is dominated by ocean, much of which develops into sea ice in the winter and returns to its fluid state in the summer. The Antarctic is dominated by the Antarctic continent.

Topographical Characteristics –

Arctic: The northern edges of the landmasses of North America, Europe and Asia are mostly coastal plain which constitute an outer ring of the Artic circle. The exception is the largest island in the world, Greenland, a mountainous land reaching 3,375m with 85 percent of it is under the second largest continuous ice sheet covering 656,000 square miles. The depth of the ice is between 2-3 kilometres making it difficult to ascertain the exact topography of the island underneath.

The **Antarctic** is the highest geographical continent in the world with a mean height of almost 2,000m, comprising several large topographical features. The Antarctic Peninsula, is effectively an extension of the South American Andes, rising out of the Southern Ocean 600nm/1,000km from the tip of South America. The peninsular is a mountainous range 800 miles/1,300 km long including many unnamed peaks, leading to Mt Hope (3,239m) where the peninsular joins the main land mass. The continent is bisected by the Transantarctic Mountains running from the Ronne Ice Shelf and Mt Vinson (4897m) to the Ross Ice Shelf on

the opposite side of the continent with several surveyed peaks of over 4,000m. Across the continent there are also several large ice features, called domes, the highest being Dome Argus at 4087m. The geographical south pole is on a plateau at an altitude of 2,800m.

Flora and Fauna – The **Arctic** Ocean is surrounded by land that extends into the lower latitudes with more temperate and warmer climates. The terrestrial connection means there is an interconnected ecosystem with an abundance of flora and fauna that inhabit the sub-Arctic and Arctic regions. There is an array of iconic terrestrial mammals like polar bears, wolves, caribou, musk ox and other smaller mammals that inhabit the Arctic region. The frigid waters (seas and rivers that run into the Arctic Ocean) offer a thriving maritime biosphere for a vast range of animals from sea birds (resident and migratory) to the microscopic invertebrates which support the abundant sea life including fish, seals and enormous cetaceans. Archaeological evidence suggests that seals have been hunted by indigenous peoples for their meat and skins for over 4,000 years and whales for almost as long to support the small coastal communities. The first commercial hunting of seals is believed to have occurred in the sixteenth century and became a very lucrative business by the eighteenth century. Whales were also hunted extensively for their blubber, which could be rendered to make a non-smoking oil for lighting houses, soap and other food products. In a pre-plastic world, the whale's baleen[20] allowed women's garments, like corsets, to be stiffened. Within the Arctic Circle there are Boreal forests with tree lines creeping slowly north and vast areas of tundra, which support a diverse terrestrial eco system.

The **Antarctic** continent is very cold and dry, which along with lack of sunlight for several months of the year and poor-quality soil means it is unable to support any form of vascular plants. There are however species of lichens, liverworts and a range of terrestrial and aquatic algal species. The separation of the Antarctic continent from other land masses means Antarctica's ecosystem is based on animals that thrive in the oceanic environment. The only terrestrial mammals are introduced vermin that are able to survive on sub-Antarctic islands like South Georgia. Ever since Captain Cook's first venture south of the Antarctic Circle in January 1773 sailors and entrepreneurs have ventured south to exploit the region, carrying a range of introduced species including rats and cats that have significantly disrupted some sub-Antarctic areas of the fragile ecosystem. The discovery of large seal and whale populations in Antarctic waters, along with the near extermination of these species in Arctic waters by the late eighteenth century attracted sealers and whalers to sail south and apply their devastating industrial practices on the Antarctic region, pushing the austral populations to the brink of extension. The emergence of the International Whaling Commission (IWC) and the replacement of most seal and whale products with alternatives (natural and manufactured) resulted in a shrinking demand along with a growing social abhorrence of the practice has allowed these creatures to recover and, in some cases, thrive with growing populations. The predominance of the ocean and the extremely harsh conditions ashore mean Antarctic inhabitants are extremophiles and mainly migratory, spending most of their time at sea moving across vast tracts of the globe's oceans.

Polar opposites (human perspective)

Political – In accordance with the **Arctic** Council[21] "The Arctic States have territories within the Arctic [Circle] and thus carry the role as stewards of the region."[22], which brings in Finland and Sweden to join the other 6 coastal states of the Arctic Ocean. The predominance of different countries around the Arctic Ocean, the abundance of untapped resources and the potential for greater access as seasonal sea ice recedes provides potential for the Arctic to be a contested region. In December 1982, the United Nations Convention of the Law of the Sea (UNCLOS) was opened for signature. It was ratified by 60 nations and came into force in 1994. This extensive internationally agreed document provided the first substantial document for the law of the sea, including a ""package" of zones, … provided by the Convention … designed to satisfy the interests of all states"[23], the designation of areas of formerly undesignated open sea

coming under the jurisdiction of the adjacent coastal state. UNCLOS laid out these boundaries with clearly defined national rights and responsibilities.

From the "Base Line" (effectively the low-water mark) to 12 nautical miles (nm) out is Territorial Sea, which provides "full sovereignty of the coastal state in this area (Art 2)"[24]. From the edge of the Territorial Sea to the 24nm point from the Baseline is the Contiguous Zone (Art 33), in which coastal states have jurisdiction over "customs, fiscal, immigration and sanitary laws"[25]. From the edge of the Contiguous Zone, out to 200nm is known as the Exclusive Economic Zone (EEZ), within this zone the adjacent coastal state has "sovereign rights for the purpose of exploring and exploiting, conserving and managing the nautical resources, whether living or non-living, of the waters superjacent to the seabed and of the seabed"[26]. Inevitably, in areas such as the Arctic Ocean, where countries are proximate to each other, some of these boundaries can overlap. Art 59 of UNCLOS states that conflicts between states "should be resolved on the basis of equity and in the light of all relevant circumstances,"[27]. UNCLOS also provides guidance on dividing boundaries of straits, where different countries are on each side of the narrow passage of water (Bering Strait for example, the access point/choke point between the Arctic Ocean and the Pacific Ocean, is 51nm wide), with Russia being the coastal state on the western side and USA (Alaska) being the coastal state on the eastern side of the strait. UNCLOS also provides Articles which specify demarcation for archipelagic waters (Part IV, Art 46) and zones, islands, enclosed and semi-enclosed sea and the continental shelf (Part VI, Art 76), all of which exist in the Arctic region.

Tensions between Arctic coastal states specifically related to sovereignty over areas of the Arctic Ocean and the seabed are ongoing. Sovereignty over an area of resource rich sea and of the seabed means that a coastal State potentially owns some extremely valuable nautical real estate with great commercial potential. Table 1 lists the Ongoing Arctic Circle Territorial Conflicts.

Whilst the Arctic may be a contested space, the icy environment lends itself more to submarines than surface warships. Modern warships are designed for speed, agility and progressively stealth in open waters of the oceans rather than ramming and cutting routes through layers of sea ice. On 3 August 1958, shortly after the Soviet Union had launched Sputnik, the first satellite to orbit the earth, *USS Nautilus*, the first nuclear-powered submarine, navigated under the sea ice of the Noth Pole. A week later *USS Skate,* another nuclear-powered boat, surfaced nine times through the Arctic ice sheet, demonstrating a strategic capability for launching intercontinental ballistic missiles.

Ongoing Arctic Circle Territorial Conflicts	
Date	**Claim**
1 Jun 1925	Canada is first state to extend its national borders up to geographic North Pole
15 Apr 1926	USSR established a large swathe of area including all islands between its state and the North Pole as national territory.
Jul 1946	Canada claims territorial rights from east and west boundaries to geographic North Pole
28 Jul 1984	Denmark claimed territorial sovereignty of Hans Island, which located equidistant between Greenland (Denmark) and Canada who have also submitted a territorial claim of the island.
20 Dec 2001	Russia claimed Lomonosov Ridge (this underwater feature is estimated to have high levels of natural resources) reasoning that it was an extension of their continental shelf, this claim constituted that Russia had sovereignty over nearly half the Arctic Ocean.
2 Aug 2007	Russia plants a national flag on Lomonosov Ridge by submarine.
Dec 2013	Canada announced territorial claim over Lomonosov Ridge
16 Dec 2014	Denmark officially submitted a territorial claim of the Lomonosov Ridge arguing it is an extension of the Greenland landmass and is therefore Danish territory.

Table 1: Ongoing Arctic Circle Territorial Conflicts

Ships designed to operate within the polar regions need to be strengthened against the sea ice and icebergs they will encounter in the regions. Ice Breakers are ships specifically designed to break a course through sea ice, by using very powerful engines to push the bow (front section of the vessel) of the ship forward so it rides up onto the surface of the ice. Gravity and the weight of the ship will then break the ice under the front of the ship, so it floats again and repeats the process. This continuous method of breaking a route through the ice slowly allows the ship to make progress, however as the ship moves forward the ice is likely to refreeze behind the ship, potentially trapping it in ice. Whilst the forward end of the ship is specially reinforced for the task of breaking the ice, the ship's rudder and propulsion are vulnerable to damage during ice breaking operations, which can be very dangerous.

Ice strengthened ships are expensive vessels. Additionally, the Master, his officers and crew require specialist training, followed by the acquisition of extensive experience to be able to effectively and safely conduct operations in polar regions. The physical isolation of vessels working in polar conditions requires effective risk assessment considering not only the ice conditions, but meteorological conditions, tides and currents, and the way in which these forces may exsert additional pressures on the hull, steering gear and propulsion of the vessel.

An effective ice-capable fleet is a key tool to project power in the polar regions, especially the semi-enclosed waters of the Arctic Ocean. The Russians have a fleet of around 50 ice capable ships including nuclear powered vessels[2829]. The Russians also importantly have a ship building capability, expertise and experience specifically for ice capable ships, which has attracted orders from other nations including China. Other states, including the US, suffer from a lack of investment in ice capable vessels, often using ships that are old[30]. Without a national ship building industry and lacking the qualified and experienced crews, operators and ship building resources to conduct effective operations in the Arctic and Antarctic regions.

Only Russia, Canada and Norway have national port networks within the Arctic Circle. Without ports, ships lack the essential safe haven and logistical support (fuel, supplies, food and crew change options) necessary for effective and continuous maritime operations in polar conditions.

Conducting air operations in polar conditions can often require specialist aircraft, with specifically trained aircrews that maintain regional flying currency. Flying operations are limited by weather conditions and restricted cargo carrying capacity. Only the Russians, Norwegians and Canadians have airfields within the Arctic Circle

The inhospitable nature of the Arctic region deters all but the hardiest people to brave the conditions to work and live in the region. Consequently, lines of communication (road and rail) are sparse, according to the Russian Academy of Sciences, in the "Arctic regions of Siberia and the Far East [of Russia], ground transport communications are nearly absent," making the exploitation of resources across the regions extremely challenging. The Arctic Ocean provides the most effective means of access to this extensive region.

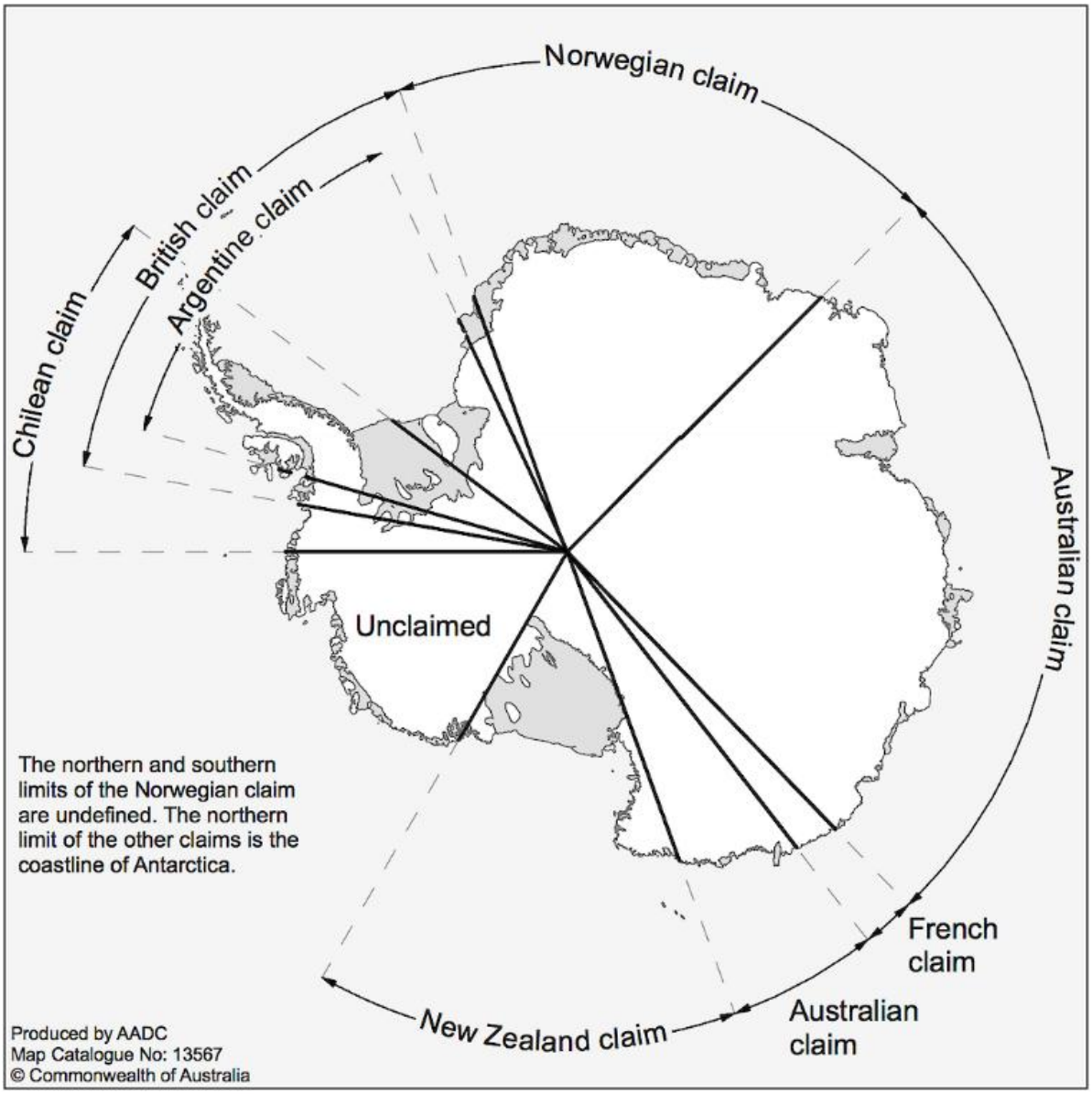
Map 2: Extent of Arctic coastal states exclusive Economic Zone boundaries in the Arctic Ocean

The geographical location of the **Antarctic** in the southern hemisphere and the continent's isolation surrounded by tempestuous seas and icebergs, without any form of land link meant that the first recorded discovery was not until 1773, when Captain James Cook, on his second voyage of discovery, went in search of a southern continent "Terra Australia Incognita" (unknown southern land). Despite getting to within about 75nm of the continent, his observations "from the mast head I could see nothing to the Southward but Ice, in the Whole extent from East to WSW[31] without the least partition … I could see no end to it,"[32] This extensive mass of seemingly endless ice convinced him that taking his two ships further south would be unsafe. During the nineteenth century other explorers ventured south but it was the commercial sealers,

followed by the whalers that pioneered the frigid waters of the Antarctic. Their desire to take advantage of the bounteous waters of the region led to over-exploiting the sea mammals. Millions of seals were killed principally for their fur and oil, which could be rendered from their blubber. Whales also provided oil in much larger quantities along with their bones and baleen, used as corset stiffeners. The desire to keep the best hunting grounds secret from competitors mean records of activities are sparse.

Whilst there were various trips of exploration to the Antarctic by teams from several nations, it was the period of the "Heroic Age of Antarctic Exploration" from the end of the nineteenth century to the beginning of the First World War, that Antarctic exploration gathered momentum. The race to the geographical south pole between Norway's Amundsen and Britain's Captain Scott being the most emblematic of the time. These seemingly superhuman demonstrations of determination and perseverance also led nations from the northern and southern hemispheres to claim parts of this enormous undiscovered land for themselves. Between 1840 (French claimed Adélie Land) and 1943, seven nations took part in a kind of land grab (the Argentinian, British and Chilean claims overlapping) see Map 3. In 1908 the British made an extensive claim including both Antarctic and sub-Antarctic areas including South Georgia, which would be administered from the Falkland Islands. Their justification was they wanted to regulate the whaling industry by imposing taxes to reduce the risk of overexploitation and create a revenue stream from their newly acquired territories.

The competing claims, especially between Argentina, Britain and Chile were entrenched, seemed unresolvable and potentially disruptive, especially between prospective allies as the Cold War of the 1950s and 1960s gathered momentum. "As such, the Antarctic was no longer considered a strange and remote place on the margin of world affairs, rather it was viewed as an essential component of the Earth's geophysical condition[33]. Global scientists proposed an International Geophysical Year (IGY) in 1957-8. The Special Committee for the IGY was created, with 67 nations committing to global scientific investigation.[34] Whilst the process was not smooth, the upshot of the IGY was the signing of the Antarctic Treaty (AT) on 1 December 1959, which entered into force in 1961 and sets aside Antarctica as a scientific preserve, and established the freedom for scientific investigation, it also banned military activity on the continent. The AT has now been signed by 54 countries including all claimant countries, most European states, China, India the USA and a collection of others.



Map 3: Territorial Claims in Antarctica

Whilst there are no indigenous peoples in Antarctica, there is quite a lot of human activity on the continent. There are 44 permanently active stations spread across the continent, managed by different 21 nations, that can accommodate a maximum of almost 4,100 personnel. There are also 45 summer-only stations, managed by 24 nations, that can house more than 900 personnel over the Austral summer (Nov-Mar). In addition, there are 9 sub-Antarctic stations, from 6 nations with up to 271 personnel. There are furthermore over 60 inactive stations that have been closed or deserted in various states of repair. The

personnel at the active stations are a mixture of scientists and support staff that provide the logistical backup to accommodate, feed and provide the safety infrastructure for the stations utilising 70 airports that can take either fixed wing or just rotary aircraft; but all are very weather dependent. These scientific stations, scattered across the 14.2 million square kilometres of the Antarctic continent also need to be resupplied with thousands of tons of equipment, fuel and food required for the bases to operate and the thousands of tons of waste to be taken away. This perpetual process of ferrying cargo and personnel requires both ships and aircraft. Most of the activity is conducted in the Austral summer by sea, utilising a combination of national ice capable support ships to accompany the international cargo carrying ships.

The AT will be up for renegotiation in 2048, by which time the world will look very different to that which it did in the 1950s. Some of the original consultative parties (US, UK, Australia, New Zealand, Russia, Norway, Germany, Chile and Argentina) may or may not be as influential as the global balance of power alters. Climate change and its ramifications are likely to be better understood, but there may be a greater demand for resources that can be mined, fished or harvested on or around the continent making the continuation of Antarctica's unique status not a forgone conclusion.

Economic – There are three major strands of economic potential in the **Arctic** region: resources, commercial ship access and cruise industry utilisation.

The majority of the identified resources are in the Russian Arctic, as are most of the fossil fuel reserves "About 91% of her [Russia] natural gas production and about 80% of her natural gas reserves are in the Arctic. It is estimated that 90% of Russia's offshore reserves of hydrocarbons are in the High North."[35] In addition "United States Geological Survey [estimates] 22% of the world's undiscovered oil and gas are to be found in the Arctic and most of that is thought to be in offshore fields in Russian-controlled Arctic waters."[36]

Historically the Arctic Ocean has been dominated by sea ice with very little access for most international commercial ships, limiting the economic importance of the area. However, with reducing sea ice coverage and thickness the Arctic Ocean is going to offer more options for ships transiting a northern rather than a southern (via Suez Canal or Panama Canal) route.

"Over the last 30 years, sea ice thickness in the Central Artic Ocean has decreased by 42%, a decrease of 1.3 meters – from 3.1 to 1.8 meters, with an accompanying reduction of some 73% in frequency of deep pressure ridges. The influx of multiyear ice from the Central Arctic Ocean to the coastal areas has decreased by 14 percent from 1978-1998. This decrease greatly benefits economic activities in coastal waters."[37]

There are three main Arctic Ocean routes: the Northeast Passage (NEP - from the Pacific Ocean, through the Bering Strait, in a clockwise direction, along the Artic Russian coastline around the northern coast of Norway and into the North Atlantic Ocean between Iceland and the UK and vice versa), the Northwest Passage (NWP – from the Pacific Ocean, through the Bering Strait, in an anti-clockwise direction along the Alaskan and Canadian coast, through archipelagic waters and into the North Atlantic through Parry Channel, into Baffin Bay between East Canada and Greenland and vice versa) and the Transpolar Passage (TTP - from the Pacific Ocean, through the Bering Strait, then straight across the centre of the Artic Ocean crossing the geographic North Pole to either the Canadian or Norwegian exit points into the North Atlantic and vice versa). Table 2 provides a useful comparison of the distances and times taken to travel each of the routes.

Route	Panama Canal	NWP	Difference	NEP	Malacca Straits/Suez Canal	Difference
Shanghai - Rotterdam	13,816nm @ 12kts = 48 days	9,487nm @ 12kts = 33 days	4,329nm (31%/15 days shorter via NWP)	8,528nm @ 12kts = 29.6 days	11,999nm @ 12kts = 41.6 days	3,471nm (29%/12 days shorter via NEP)
New York Shanghai	11,274	9,195nm	2,079nm (18% shorter via NWP)	10,741nm@ 12kts = 37.3 days	12,381nm @ 12kts = 43 days	1,640nm (15%/5.7 days shorter via NEP)

Table 2: Comparison of distance and time of using conventional southern routes versus northern polar routes.

N.B.

1. Size restrictions of Panama Canal (length, beam, draft and height of ships) preclude larger vessels' access to the canal (for example container ships carrying more than 15,000 TEU, are too big for the locks. The largest container vessels can now carry more than 24,000 TEU).
2. Alternative route is around South America via Cape Horn, adding 30% to total distance.
3. Panama Canal relies on rainwater to feed canal system. Additional draft restrictions were imposed at the beginning of 2024 due to drought reducing traffic by 49%.
4. Geopolitical situation in Middle East region can impact transits of Suez Canal/Red Sea. Transits were down by 49% in January 2024. Alternative route is via Cape of Good Hope, adding another 25% to the total distance.

Utilising the NEP/NWP would significantly reduce the distance ships would have to travel when transiting between the Pacific and Atlantic Oceans, in comparison to the southern routes which require routing via the Suez Canal or Panama Canal for most commercial vessels or via the Cape of Good Hope or Cape Horn for larger vessels. However, the risks, physical and commercial, of using the NEP/NWP could outweigh the time and distance advantages.

In addition to the three routes described above, the Russians have long used the North Sea Route (NSR) shown in Map 3 below. Indeed "more than 90% of the currently used economic and infrastructural potential of the [Russian] Arctic *macroregion*[38] was created during the period of its Soviet development"[39]. Arctic Russia and northern Siberia has never had a broad network of roads or railways to link it to the south. The Artic coastline ports has been the only way to take advantage of the natural resources located in the Arctic zone of the Russian Federation (AZRF). "The development of the Arctic transport system is undoubtedly of great importance not only for the Arctic zone of the Russian Federation, but also for the country as a whole."[40]

On 1 January 2017 the International Maritime Organisation's (IMO) International Code for Ships Operating in Polar Waters (Polar Code) entered into force. The Polar Code is mandatory under both the International Convention for the Safety of Life at Sea (SOLAS) and the International Convention for the Prevention of Pollution from Ships (MARPOL). The Polar Code covers the full range of design, construction, equipment, operational, training, search and rescue and environmental protection matters relevant to ships operating in the inhospitable waters surrounding the two poles.[41] Many of the requirements of the Polar Code impose an additional cost on ship owners/charterers in many different ways that will constitute part of the ship owner's/charterer's cost-benefit analysis when deciding whether or not using one of the Arctic routes is commercially advantageous.

Factors	NEP	NWP
Navigability	Sea Ice coverage is seasonal, with portions being kept open by icebreaking ships for 12-months of the year.	The geography of islands across the passage makes the waters far more prone to sea ice coverage and year on year build up making the route currently unpredictable.
Infrastructure	There are 19 ports along the route (Russia 13, Norway 5, Iceland 1)	There are 7 ports along the route (Canada 3, Greenland 2, USA 3)
Jurisdiction	From Bering Strait to the Barents Sea, the route is all within Russian EEZ and sometimes Russian TTW. Having passed the port of Murmansk ships would enter the Norwegian EEZ.	From the Bering Strait across the Chukchi Sea and Beaufort Sea ships are in US EEZ. Navigating through the Canadian Archipelago through to Baffin Bay is Canadian TTW and EEZ and then USA when Davis Strait is reached.
Search and Rescue including Resources	Search and Rescue Zones are shared by Russia and Norway. Russia has 50 active ice strengthened vessels, 15 under construction/planned. Norway has 2 ice strengthened vessels.	Search and Rescue Zones are shared between Canada and USA. Canada has 10 ice strengthened vessels, 7 under construction/planned. USA has 5 ice strengthened vessels, 3 under construction.
Transit Costs[42]	Russia does charge vessels a fee for transiting the route for mandatory Ice Breaker escort services.	Canada/USA does not charge ships for transiting the route through their waters.
Marine Insurance[43]	Marine insurance is market driven, depending on the risk and how those risks can be mitigated. Transiting Arctic waters is a relatively new area for marine insurance, it will be a commercial decision based on a cost-benefit analysis for the ship owner/charterer. The more incident free transits of each route are likely to reduce the premium.	

Table 3: A selection of factors that would assist with the cost benefit analysis of using the northern polar routes

On 28 November 2024, the Centre for High North Logistics (CHNL), based at Nord University in Bodø, Norway, published a report with their main results of NSR Transit Navigation in 2024[44]. The report stated 2024 was a record year for NSR transits (around 50% increase on 2023 figures) with an estimated 3.07 million tons of cargo[45] transiting the Arctic route. There was a total of "97 voyages, 56 with cargo and 41 in ballast."[46] The largest proportion (95.2%) of the trade was from Russia to China with 61.6% was crude oil. Trade from Chia to Russia constituted 4% of the trade and cabotage between Russian ports was less than 1%.[47] The ice conditions in 2024 were broken down into 5 periods between 1 August to 31 October with the route being totally clear of ice between mid-September and mid-October. Russian nuclear ice breakers were present along the route throughout the period. Almost all of the vessels transiting the NSR were ice capable to varying extents. The CHNL report provides a wealth of details and clearly demonstrates the increased push to use the NSR in both 2023 and 2024 by China and Russia.

Source: Mapping Solutions, Lawson Brigham, USARC Anchorage 2006

Map 4: Maritime Routes across the Arctic Ocean.

The Arctic coastline and adjacent national EEZs are already financially important to the coastal states. The Arctic is rich in natural resources including oil, gas, minerals, seafood and forests (Russia has forest resources beyond anything seen elsewhere.[48]). As similar resources in other regions of the world become in short supply the incentive increases to overcome some of the challenges of the Arctic conditions to take advantage of the abundance in the far north.

The cruise industry is one of the fastest growing areas of the tourist industry and cruise companies are actively increasing their activities in both the Arctic and Antarctic. The fastest areas of growth within the industry are the expedition itineraries (which includes polar cruising) with a 71% increase between 2019 and 2023[49]. Whilst specific statistics are not available, the number of Alaska based cruises have increased by almost 36% over the past four years[50].

Cruises visit the two polar regions during their respective summer periods, meaning the same ice adapted ships can conduct cruises in both regions each year. Activities within the regions are controlled by voluntary organisations: Association of Arctic Expedition Cruise Operators (AECO[51]) and Antarctic (International Association Antarctica Tour Operators (IAATO[52]). Both organisations promote responsible tourism and aim to maintain the sustainability of both regions as pristine tourist expedition environments. Destinations in the Arctic include Alaska, the Canadian High Arctic, Greenland and Norway, including the island Svalbard. Destinations in the Antarctic region are reached from a South American departure point including the Antarctic Peninsula (including ventures south of the Antarctic Circle), Weddell Sea, Falkland Islands, South Georgia and South American Patagonia. Trips from Australia and New Zealand visit the Ross Sea on the other side of the continent.

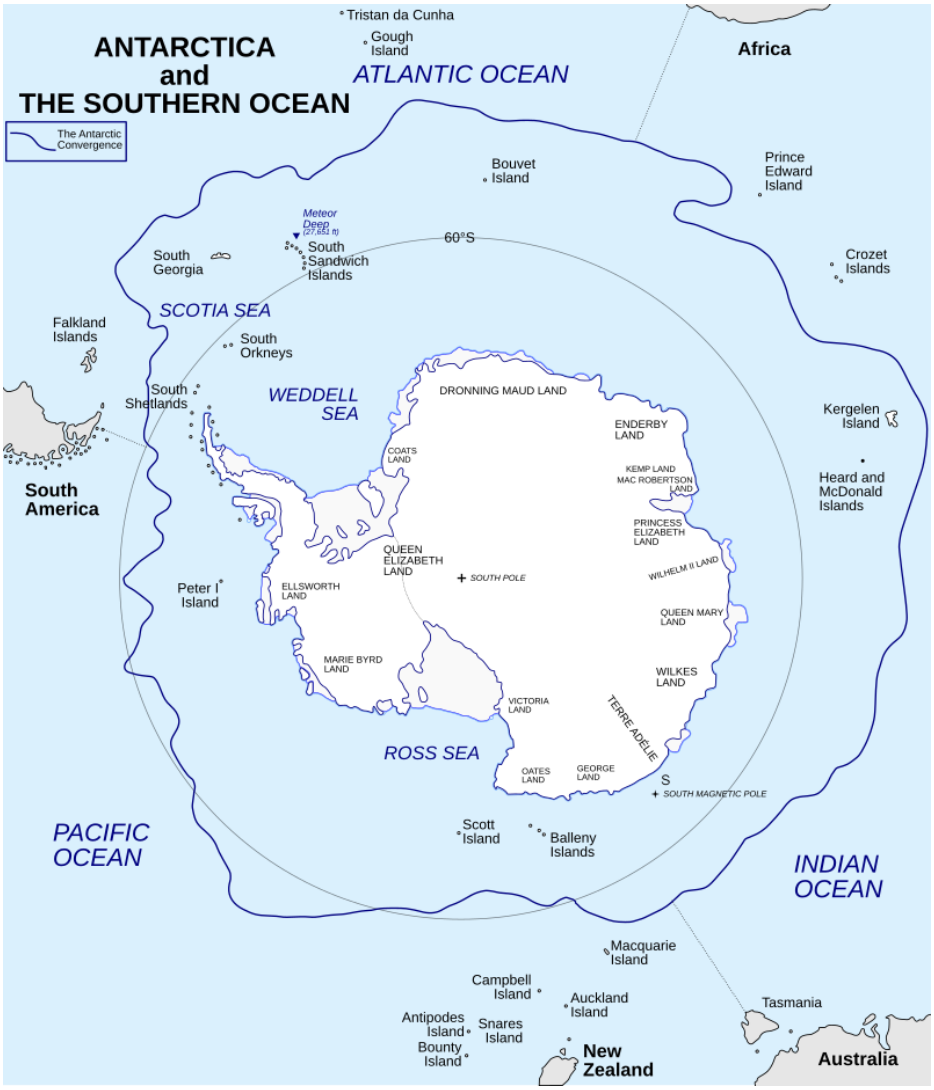
During the nineteenth and first half of the twentieth century there was a significant **Antarctic** sealing and then whaling industry that exploited seals and whales, decimating several species to the very edge of extinction. By the 1930s it was estimated that globally 50,000 whales were being killed each year, a significant proportion of which were hunted in Antarctic waters where the whales concentrated to feast on the abundant krill, making the slaughter of these magnificent beasts easy for the whalers. In 1946 the International Whaling Commission (IWC) was established as the global body responsible for the management of whaling and conservation of whales. Following considerable debate, a commercial whaling moratorium was adopted in 1982 and came into full force in 1986. This pause of almost 40 years has resulted in substitutes for whale products being procured and tastes across much of the world have altered, hopefully weaning humans off the need to return to the mass slaughter of whales in the future. However, recently the commercial fishing industry has started to exploit Krill, by fishing it in vast quantities. The Krill oil is then sold as a health supplement in the western world. Krill is the critical foundation of the food chain for both Arctic and Antarctic sea life, including fish, mammals (seals and whales), birds (including Penguins). Any disruption to the fragile ecosystems could have unknown and unintended long-term consequences.

The climatic hostility and logistical challenges of Antarctica have deterred the large-scale prospecting for fossil fuels and minerals in the region, which exist, reinforcing the validity of the AT and protecting the region from potential human exploitation again. The AT will be up for renewal in 2048, when the world is likely to look quite different to that which it did one hundred years earlier in the 1940s from a political perspective[53].

Social – The **Arctic** Ocean is bounded by the land mass of 6 nations within the Artic Circle, including several major cities, Murmansk, Russia being the largest (population greater than 300,000). The total population for the region is around 4 million people. The Artic peoples comprise 40 indigenous groups[54] that have inhabited this harsh environment for around 30,000 years. It is very difficult to determine the proportion of indigenous people to settlers, as certain countries do not differentiate between the two but a ratio of 8:1 in favour of settlers from the south is not unrealistic[55].

Arctic indigenous communities in Alaska, Canada, Greenland and Norway are largely self-governing with differing degrees of autonomy, but the indigenous people who live in Arctic Russia don't have the same political freedoms or influence. However, all Artic communities were common in so much as they orientated their way of life around the intense cold, harsh weather, drastic annual sunlight changes and seasonal coverage of sea ice along with the utilisation of native animals they either hunt or herd. The increasing temperatures and reducing sea ice coverage has altered the habitat for animals and humans alike forcing them all to alter their ways of life and the indigenous peoples are forced to adapt their cultures. The settlers paradoxically adjust to the climatic changes more easily and find ways to exploit the differences with relative ease.

Whilst early Patagonian and Polynesian explorers may have visited some of the islands in **Antarctica**, no evidence of communities settling on any of the islands has been discovered thus far. It is likely that sealers and whalers of the 18th and 19th centuries established short term summer bases on a few of the islands within the Antarctic Convergence[56] but these bases were temporary and functional rather than communal. Consequently, there are no indigenous peoples that inhabit Antarctica.



Map 5: Antarctica and the Southern Ocean

The transitory scientific community of around 5,200 across the continent occupying the permanent, summer and sub-Antarctic bases, require significant logistical support to be imported by sea and air to survive. In addition, there is a growing number of cruise ships with many thousands of passengers who visit the region, most of whom never set foot on the continent or any of the islands included under the AT[57].

Technological – Indigenous peoples have inhabited the **Arctic** region for thousands of years, relying on knowledge accrued over many generations for the various ethnic groups to survive and flourish. In the last few centuries however, major technological advances have allowed man to exploit the two polar regions. From the early explorers who tentatively ventured into the frozen icescapes to modern adventurers who attempt trans-polar expeditions, supported and unsupported, reliance on technological advances have been fundamental to their success. Initially, the intrepid explorers who took part in the "Heroic Age of Antarctic Exploration" utilised wisdom, equipment and techniques from the indigenous peoples who inhabited the Arctic. The race to the south pole by Norwegian and British teams utilised much of the clothing, equipment and techniques used by the peoples of the north and the Norwegians used sledge dogs extensively and successfully to pull the heavily laden sledges and food[58] to great effect.

The unusual phenomena of the magnetic poles perpetually moving and the "Earth's invisible magnetic field lines travel in a closed, continuous loop and are nearly vertical [almost perpendicular to the Earth's surface] at each magnetic pole." This means the compass needle would be attracted vertically downwards towards the compass card, leading to inaccuracies. These unique occurrences led scientists to invent innovative pieces of equipment that would allow them to accurately measure these events, formulate and prove theories that we now take for granted. Working in subzero temperatures pushed further innovation to develop and design methods and procedures for humans to live and operate in these unnatural environments.

Initially ships venturing to the poles were constructed of wood and powered by sail, which limited their ability to operate in icy waters. The transition to steam power and metal construction made ships more robust and independent of the wind. With more adventurous expeditions into previously closed areas, ships had to be strengthened so they could deal with icebergs and sea ice. Human innovation, endeavour and technological advances have developed the sciences of meteorology, geology and glaciology prompting more revealing and detailed experiments to be conducted. The introduction of computers has allowed significant volumes of data to be processed, producing enormous amounts of statistics leading to amazing discoveries and scientific breakthroughs in so many fields.

It is important to note however that due to the uniqueness of the polar regions, models developed for use in lower latitudes are not always able to be applied effectively to the two polar regions and measurements sometimes require adjustment, inevitably leading to inaccuracies and inconsistencies in the data. Additionally, as most satellites are in a geosynchronous orbit above the main inhabited land masses of the globe, the two poles are not as well served for the collection of many forms of data, slowing down the accumulation of information and in some cases decreasing the accuracy of data collected. Consequently, there are some areas of scientific research and development that can only be carried out by scientists going to the poles to conduct field work, at sea, on ice, on the land and in the atmosphere. The geographic isolation and severe climatic conditions make Antarctic scientific field trips high risk and extremely expensive, which limits the number and thereby the scope of expeditions mounted.

As technologies including robotics, autonomous and semi-autonomous vehicles including drones' operating on land/ice, at sea, both surface and subsurface, and airborne continue their exponential increase in competencies and capabilities, possibly using quantum computing[59], digital satellite communications[60] develop at an unprecedented rate, it is entirely plausible that future polar exploratory devices and systems will be able to overcome the extreme polar conditions. We only have to look to space exploration to understand the level of fantastical achievements with mind-boggling results that have been achieved in outer space, another uninhabitable environment for humans[61], to begin to imagine the possibilities for the future uses of these technologies across the polar wastes.

Legal - The **Arcti**c region comprises a vast expanse of ocean, where some or all the surfaces can be frozen solid at any one time, surrounded by six sovereign states. Each nation has their own ideologies,

constitutions, laws and political systems founded on collaboration and aspiration. Within each of these nations there are ethnically diverse groups with their own beliefs, customs, codes and practices based on thousands of years of robust survival in possibly the harshest environment on the planet.

The governance of the ocean is based on UNCLOS, although as an internationally collaborative document, to which not all the Arctic nations are signatories[62], rather than enforceable legislation it is prone to diverging interpretation and implementation. The discovery of valuable raw materials within and without recognised territorial boundaries can cause friction, testing the legal status and viability of UNCLOS. As shown in Table 1, there are eight ongoing Arctic Circle Territorial Conflicts.

The Arctic Council (comprising the eight Arctic States, within the Arctic Circle) "established the Council as a high-level forum to provide means for promoting cooperation, coordination and interaction among the Arctic States – including the full consultation and full involvement of Arctic Indigenous communities and other Arctic inhabitants."[63] The six indigenous peoples' organisations[64] represent approximately 500,000 people spread across the Artic region. These six organisations have been granted Permanent Participant status in the Arctic Council. The Permanent Participants have full consultation rights in connection with the Council's negotiations and decisions.[65]

"Arctic States have negotiated legally binding agreements under the auspices of the Arctic Council. These aim at enhancing international cooperation on issues related to maritime search and rescue, marine oil pollution, and Arctic scientific cooperation respectively:

- Agreement of Cooperation on Aeronautical and Maritime Search and Rescue in the Arctic (signed 2011).
- Agreement on Cooperation on Maritime Oil Pollution Preparedness and Response in the Arctic (signed 2013)
- Agreement on Enhancing International Scientific Cooperation (signed 2017)"[66]

Utilisation of the NEP, NWP and NSR are likely to raise the stakes with regards to legal jurisdiction across the region from several aspects including freedom of navigation, search and rescue and insurance claims delving into international and Admiralty law. The complexities of these issues are likely to test the effectiveness of the Arctic Council.

The **Antarctic** Treaty[67], signed by twelve nations,[68] came into force on 23 June 1961. Seven of the original signatories have claimed territorial sovereignty over areas of the Antarctic (see map 2). The Treaty now comprises 57 parties, of which 27 are consultative, which means they have voting rights. "The states do not all recognize each other's claims to the respective areas, and the claims of three of the states [Argentina, Chile and UK] overlap. Furthermore, no other states have expressly recognized the territorial sovereignty of any of the claimant states."[69] The Treaty comprises 14 Articles and will expire, if not reinstated in 2048. The premise of the articles is as follows:

- Antarctica shall be used for peaceful purposes only (Art I).
- Freedom of scientific investigation in Antarctica and cooperation toward that end… shall continue (Art II)
- Scientific observations and results from Antarctica shall be exchanged and made freely available (Art III)
- "No acts or activities taking place while the present Treaty is in force shall constitute a basis for asserting, supporting or denying a claim to territorial sovereignty in Antarctica or create any rights of sovereignty in Antarctica. No new claim, or enlargement of an existing claim to territorial sovereignty in Antarctica shall be asserted while the present Treaty is in force. (Art IV).

- All Areas of Antarctica, including all stations, installations and equipment within those areas, … shall be open at all times to inspection (Art VII).

In addition to the Treaty, there are six[70] other agreements that have been introduced since the adoption of the AT.

Major criticisms of the AT include the lack of a separate formalised Secretariat to ensure the Treaty is implemented to the same standard by all parties. It also means that there is no formal body to report breaches of the Treaty to. Secondly, the Treaty has no force over the 140 non-parties of the Treaty if they were to send a team to the Antarctic. It is also lacking in the governance of jurisdiction, which makes it difficult to enforce civil and criminal law with respect to non-scientific visitors, including tourists. And, whilst the Treaty provides wide powers of inspection and observation, it is incumbent on the inspectors to fund and conduct the inspections (which is no small feat in Antarctica), if they do discover a breach of the Treaty, they lack powers of enforcement[71] Additionally, IAATO is a voluntary, self-regulating organisation for the management of tourism in the Antarctic, which is arguably the greatest threat to this pristine environment[72].

Environment – The harsh and unforgiving condition in the two polar regions has prevented more than minimal physical exploration of these vast expanses. The geographical locations, extremes of annual solar radiation across both regions and intensely cold temperatures continue to act as a physical, financial and practicality barriers for human habitation. Both polar regions are in a slow but continual process of change with the annual lunar cycle including the forming and thawing of sea ice and movement of glaciers. Whilst the Arctic region is more inhabited, habitation is around the periphery of the region rather than evenly distributed. The limited number of stations sprinkled across the Antarctic tend to be selected for access more than anything else. It is therefore it is very difficult to accurately quantify and almost impossible to predict with any degree of certainty to what extent global warming may or may not escalate and possibly be exacerbated by the polar regions. It is therefore practically impossible to predict how things will unfold globally.

The Intergovernmental Panel on Climate Change (IPCC) reports grow in scope and complexity, but it wasn't until 2019 that they included the thawing of permafrost, and its likely effects in their Special Report on the Ocean and Cryosphere in a Changing Climate.[73]

This article is not designed to cover in depth the concerns about global warming although the two polar regions are undergoing significant physical alteration because of the changing climate and the effects of polar amplification described above. Therefore, we are summarising some of the greatest apparent changes paraphrasing Donald Rumsfeld's four quadrant matrix[74] to provide a format for looking at what the environmental future of the polar regions may look like and attempt to imagine the consequences for the globe:

Matrix	Arctic	Antarctic
Known Knowns: facts and variables we understand.	Sea Ice contraction Deglaciation, Iceberg proliferation, Habitat alteration impact for indigenous species (particularly terrestrial mammals) moving north to capitalise on new grazing lands/prey. Altering of maritime ecosphere as water temperatures and salinity change.	Sea Ice contraction. Deglaciation, Iceberg proliferation. Altering of maritime ecosphere as water temperatures and salinity change.
Known Unknowns: factors we know exist but don't fully understand.	Thawing rate of permafrost across the Arctic region is estimated to release the equivalent of several years global fossil fuel emissions annually, whilst the melting buried ice results in unpredictable land subsidence which gives way to developing wetlands. Albedo effect on the increasing area of dark sea water in the Arctic Ocean no longer covered in reflective sea ice. The sun heats the ocean altering sea temperature changing the established Arctic eco system.	Albedo effect on exposed dark coloured rock which warms and retains heat causing additional thaw and greater expanse of dark heat absorbing surfaces, which are likely to grow in area exponentially. Faster thawing of glaciers releasing significant volumes of frozen fresh water into the Southern Ocean altering the chemical salinity and raising global sea levels.
Unknown Knowns: elements we don't realise we know about.	Influence of polar regions on global weather and oceanic currents. Significant alteration of oceanic eco systems within Artic and Antarctic Circles, could alter the fragile and interconnected oceanic eco systems globally.	
Unknown Unknowns: factors not aware of and cannot predict.	Additional Oceanic factors including how a warming sea may render some sea life extinct due to lack of food, increasing acidity of sea, extent of subsurface environmental change due to rising sea levels. Cryosphere factors. Terrestrial habitat factors (flora and fauna alike). Climatic factors.	

Table 4: Rumsfeld's four quadrant matrix applied to the environmental impacts of climate change

Polar Opposites		
Arctic	**Criteria**	**Antarctic**
Natural		
Arctic Ocean surrounded by the land mass of 5 polar nations with two access points to Atlantic Ocean (via Baffin Bay, Greenland Sea and Barents Sea (ice dependent)	**Geographical Characteristics**	Antarctic Continent surrounded by Southern Ocean and Circumpolar Current
7,700,000 million square miles/20,000,000 square kilometres, around two thirds of which is the Arctic Ocean, which is about the same size as the continent of Antarctica. Greenland is the world's largest island, Baffin and Ellesmere islands to the north of mainland Canda are the fifth and tenth largest islands respectively.	**Area (both regions are bounded by the Arctic/Antarctic Circles)**	Antarctic Continent is 5,500,000 square miles/14,200,000 square km, which is around two thirds of the Antarctic region inside the Antarctic Circle.
The predominance of the Arctic Ocean in the region, which seasonally develops into an extensive area of sea ice (historically 14-16m km square by the end of winter, down to about half of that in summer) means the mean elevation of the Arctic is just around 2m.	**Topographical Characteristics**	The Antarctic Continent is the highest continent in the world, with a mean height of 1,958m, including Mt Vinson 4,897m. The mean thickness of the ice across the continent is 1,937m, with a maximum thickness of 4,776m.
The dominance and extent of the ocean and the stability of the temperature at around 0°C combined with the almost consistently flat sea ice provides a more stable and warmer average temperature with longer term weather patterns.	**Climatic conditions**	The Antarctic is the highest, coldest, windiest continent in the world. Weather systems can be unpredictable, fast moving and last several days, making the region very inhospitable and dangerous to all but the hardiest of creatures that are fully acclimatised.
Both flora and fauna have adapted to living in the hard sub-Arctic and Arctic conditions including terrestrial mammals, from large carnivores like Polar Bears and Wolves, large herbivores Mouse, Musk Ox to smaller creatures supported by a range of robust flora resulting forming healthy food chains. The Artic land mass extends south into temperate and even equatorial climatic regions making a warming Arctic landmass more habitable for a greater range of flora and fauna.	**Flora & Fauna**	The lack of terrestrial linkage to any other landmass outside the Antarctic circle and the sub-zero temperatures make it very difficult for many animals to live in the region. Almost all seabirds that inhabit the region (Albatross, Petrels, Skuas and Penguins), only go on land for a few months to breed during the Austral summer, then return to sea for the winter. Sea mammals like whales and seals take advantage of the high density of Krill and creatures that feed on it during the summer to feast.
Human		
Arctic Nations include all nations within the Arctic Circle (Canada, Finland, Iceland, Norway, Russian Federation, Sweden, USA). Arctic Council established ongoing territorial boundary disputes (The Northwest Passage, Hans Island, Beaufort Sea and Lomonosov Ridge). Arctic nations with Ice Breaker fleets/airfields/ports within Arctic Circle: Russia 50 active vessels, 15 under construction/planned, 10 ports and around 16 airfields within the Arctic Circle. Canada 10 active vessels, 6 under construction/planned, one airfield and 3 ports within the Arctic Circle. Greenland (Denmark) 7 active vessels, six ports and two airfields (1 US) within the Arctic Circle.	**Political**	Portions of the Antarctic continent have been claimed at different times by Sovereign states. The Spanish, in accordance with the Treaty of Tordesillas and Zaragoza claimed about one third of the continent from 1539-1555 for the Spanish Empire. The French claimed a slither of the continent (136°E-142°E), which they call Adélie Land in 1840. The British Antarctic Territory (20°W-80°W), including most of the Antarctic Peninsula and land adjacent to the Weddel Sea, was claimed in 1908. New Zealand claimed the Ross Dependency (150°W-160°E) in 1923. In 1933 the Australian's claimed almost 42% of the continent (160°-142°E, 136°E-44°33'E) on both sides of the French claim. In 1931 the Norwegians claimed the small Peter Island, followed by a larger portion (44°38'E-20°W) in 1939.The Chilean's also claimed parts of the Antarctic Peninsula (53°W-90°W) in 1940. The Argentinian's claim (25°W-

US has two Ice Breakers (only one is operational and largely used to resupply Antarctic bases). It does not have any airports or ports in Alaska but does have a base with port access in Greenland. Norway has two ice capable vessels, nine ports and five airports within the Arctic Circle. Sweden has four ice capable vessels with three on order, but it doesn't have any ports/airports within the Arctic Circle. Finland has eleven ice capable ships but no ports and only one airport within the Arctic Circle. Iceland has no ice capable ships, four ports and one airport just south of the Arctic Circle.		74°W) was made in 1943. Parts of the Argentinian, British and Chilean claims overlap.
The Artic coastline is important to many economies, oil/gas/minerals, sea lanes, chokepoints Berring Strait/Greenland, Iceland, Norway	**Economic**	The isolation and inhospitable nature of the Antarctic have prevented any major industries being established in Antarctica after the sealing and whaling ceased in the 1960s. There remains some fishing and a growing tourist industry who visit the region.
Human history that is around 30,000 years old There are more than 4 million people living north of the Arctic Circle, both indigenous and immigrant populations	**Social**	The first person to cross the Antarctic Circle was Capt James Cook in 1773. Throughout the 19th century some explorers visited the region, but the main draw for humans was initially commercially motivated to acquire seal skins and then whale products. Humans cannot survive in Antarctica with considerable outside life support. There are ? scientific bases across the region.
The strategic importance of the Arctic region and its resources has prompted many technological advances	**Technological**	Scientific challenges of the Antarctic – necessity is the mother of invention
Relative instability, competing ownership and ongoing disputes	**Legal**	Relative stability – renegotiation of Arctic Treaty 2048
Due to the relative stability of Arctic temperatures, any change can be easily detected. Melting Greenland Ice Sheet = thawing of permafrost	**Environmental**	Geographical isolation and circumpolar current make the Antarctic a unique climatic system that is very difficult for scientists to develop and refine accurate climate models to 70% of the globe's fresh water – if it melts – sea level rises by around 58m, which would destroy all coastal ports and capital cities

Table 5: Natural and humanity imposed polar opposites.

Maritime security at the polar opposites:

Maritime security for both polar regions is complex and challenging from many angles. There are threats in the short (10 years), medium (20-50 years) and long (50-100 years) term. Many of which are within human control, in the short and possibly medium term but unless the relentless slide into the climate change spiral is arrested, the impacts of the change will be beyond human control, and the unparalleled force of nature will dictate our destiny.

In Vol 1, Issue 1, of this Journal, I wrote an opinion piece about the emerging spectrum of maritime security, using the seven dimensions of maritime security identified by Dr Dave Sloggett (State on State, Trade Protection, Resource Management, Smuggling, Terrorism, Disasters and Oceanography[75]) I discussed the way in which our perception of maritime security can be undermined and limited by historical expectations of how aspects of maritime security are habitually segregated into distinct silos, viewed as separate and discrete areas.

In that article, I used the analogy of a single beam of white light representing the *old* view of maritime security. However, when this beam of white light is projected through a glass prism the light is dispersed into the seven colours of the spectrum. I then assigned one of the seven colours of the spectrum to seven dimensions of maritime security Dr David Slogget defined in his book. The point being, maritime security is not a simple singular white beam, but a multifaceted phenomenon which is dynamic and changes in appearance as the angle of the prism is altered. The colours of the visible spectrum will change in intensity and clarity, some colours will merge with others. The visible colours will also alter if the observer moves, and the order of the colours can even be reversed (if two rainbows appear in the sky at the same time the colours of one will be reversed to the other). The edges of the spectrum verge into the less visible wavelengths of infrared, microwaves and so on, whilst at the other extreme there is non-visible ultraviolet, x-rays and gamma-rays. These invisible parts of the spectrum could cover the imperceptible elements of maritime crime. I think this image provides a useful metaphor for the changing view of maritime security and its complexity depending on when you see the spectrum and where from.

In the table below, I have attempted to outline some of the potential areas of friction and flash points that could lead to diplomatic disagreements and possibly maritime security problems either within or because of factors affecting the polar regions. Whilst some of the suggestions and proposals may seem a bit fantastical, they mostly follow the broad themes of IPCC reports with some less scientific, more imaginative projections. I am very happy to concede I may not get everything correct (and I hope I have), but we must start thinking imaginatively about how things will and could change in the polar regions before it is too late.

As many languages, especially those tongues used by seafarers and the shipowners[76] use the same word for safety and security I have not remained strictly within the parameters of the accepted meaning within the English-speaking nations; security (definition: a secure condition or feeling[77]), but have used a broader international interpretation to include aspects of safety (definition: the condition of being safe; freedom from danger or risks[78]).

The **Artic** region is undeniably dominated by Russia with an Arctic coastline of more than 13,000nm, including 10 Arctic ports and 16 airfields within the Arctic Circle[79]. As a nation Russia is asset rich but cash poor, with an abundance of raw materials within its territories, especially across its frozen wastes and hidden under the frigid waters of it EEZ and area claimed to the north pole. Of all the Artic nations, Russia has the greatest capability and capacity to exploit its natural resources via the NSR and NEP. It also has several friendly nations (China, India and others) which growing appetites for these important commodities. Utilising its 50 plus ice capable vessels, including several nuclear-powered ice breakers, the Russians aspire to ensure year-round use of the NSR by commercial ships. It is unlikely that any other Arctic nation (without a functioning and active shipbuilding industry, relevant expertise and experience) can realistically compete with Russia across the region in the short to medium term. Reliance on the NSR will however make the Bering Strait a strategically important maritime choke point that is crucial to Russia's economic potential and a potential hot spot for friction.

Whilst other Arctic nations have natural resources within their Arctic lands and EEZs they lack robust logistic networks that are functional. Several Arctic nations have developed Arctic security strategies[80], but their surface and maritime logistic assets are extremely limited in comparison to Russia. Both NATO and Russia regularly deploy nuclear powered submarines to patrol the Arctic Ocean and surface through the sea ice to demonstrate capability and presence.

China looks upon itself as a "near-Arctic state[81]", joining the Arctic Council as an observer in 2013. It aspires to collaborate with other Arctic nations to build a "Polar Silk Road"[82] which will include working not only with their Russian allies but the Nordic states as well. According to Yun Sun, a senior fellow at the Stimson Centre in Washington D.C. China's attitude is "We know that we don't have claims in the Arctic, but if there's anything in the Arctic that we can get, we don't want to be left out."[83] The Chinese have invested significantly in some of the less well functioning Russian Arctic ports as well as the Norwegian port of Kirkenes with the objective to establish it as a transhipment port between China and Europe[84] potentially making the NSR/NEP a key shipping route for Chinese goods to East Coast of North America, Europe and vice versa.

The Chinese are in the process of acquiring an ice capable fleet of ships. They have the largest shipbuilding industry in the world, in 2023 they built 51 percent of the 64.7 million GT constructed globally[85]. However, they are not yet familiar with building ice capable vessels, so they have collaborated with foreign companies (Finnish and Russian), and are now reported to be building ice capable vessels in Chinese shipyards including a nuclear ice breaker. The key advantage to ice capable vessels is they can be used in both polar regions during the respective seasonal summers. The current Russian polar fleet and the vessels China is constructing now, will make these allies dominant, as far as ice capable ships is concerned in both polar regions.

Similarly, China is one of the fifty-seven signatories of the **Antarctic** Treaty. The Chinese have five Antarctic stations spread out across the continent including one of the most isolated, Kunlun, a summer only station, on Dome Argus at an altitude of more than 4,000m. The Kunlun station reputedly is "the best observing site on the Earth's surface"[86], and the Chinese have installed an automatic weather data collection system collecting and are transmitting data from it throughout the year. As Dr Elizabeth Buchanan of the Australian Strategic Policy Institute (ASPI) comments in her Special Report "Ice Panda", "Antarctica is enticing. Especially for powers seeking to future proof their resource insecurities, partake in strategic competition activities like global governance, and to enhance their currency prestige wise in the scientific realm."[87] Dr Buchanan also warns of "Beijing's erosive Antarctic activities"[88] as it blocks progress, possibly jeopardising the continuance of the Treaty in 2048.

Any increase in the use of the NEP will highlight the vulnerability of commercial ships transiting this remote area of ocean far away from ports, support along with search and rescue resources and any form of constabulary force to provide a consistent network for security. Whilst the NEP may not be the obvious region for acts of physical piracy, opportunities for cyber-attacks from remote actors could pose a significant threat with criminals potentially controlling vessels and possibly holding them for ransom in the dangerously cold and physically hostile waters.

The management of resources such as oil and gas, minerals, fish and other seafoods in both polar regions have the potential to be significant. The practicalities of implementing restrictions agreed by the two regional bodies across such vast areas of inhospitable sea areas with very limited assets will be almost impossible to enforce. The most obvious exploitation of an intrinsic resource that is a fundamental element of the Antarctic aquatic ecosystem is the industrialised fishing of krill, the principal source of food for many sea mammals, especially baleen whales[89]. The avoidance of internationally agreed[90] limits and restrictions by nationally flagged fishing fleets could constitute both trafficking (the selling of internationally restricted items, making them illegal for some countries) and smuggling (the landing of items without appropriate declaration and paying duty).

In 1982, the International Whaling Commission (IWC) "decided there should be a pause in commercial whaling on all species and populations from the 1985/1986 season."[91] However, Iceland, Japan and Norway continue to conduct whaling commercially[92]. In 2023, 825 whales were killed by the nations listed, despite the moratorium of 1982.

Maritime polar terrorism could take many forms from indigenous peoples in the Arctic attacking port installations, severely handicapping maritime operations. Alternatively, environmental groups, with increased vigour, prompted by perceived national inactivity to fulfil environmental promises and obligations, conducting terror attacks against cruise ships, fishing vessels or offshore oil and gas installations. The terrorists could also utilise sophisticated cyber-attacks to disable ships and land-based stations stranding them without communications in merciless polar conditions.

Ironic, the once controversial, not for profit organisation Sea Shepherd, international direct-action ocean conservation movement was accused of "eco-terrorism"[93] by the Japanese for the way in which they attacked and disrupted Japan's annual whaling operations in the Antarctic. Sea Shepherd, with

its fleet of ten vessels, is now utilised by several nations and law enforcement agencies, including INTERPOL, to manage IUU Fishing and bring poachers to justice.[94] This non-government organisation (NGO) is providing useful and sometimes disquieting evidence of national fishing fleets exploiting perceived legal loopholes with UNCLOS signatories apparent blessing.

In Table 6 below I have provided the seven dimensions of maritime security proposed by Dr David Slogget with my own reflection on how those areas could evolve over the short, medium and long term. Some of the idea may appear fantastical, especially when projecting into the medium and longer term, but this is designed to get the reader thinking about the criticality of the two polar regions, how pivotal they are and what consequences may occur if we don't take threats seriously.

Arctic/Antarctic Maritime Security Projections						
Maritime Security Dimension	**Short Term (10 years 2024-2034)**		**Medium Term (10-50 years 2034-2074)**		**Long Term (50-100 years 2074-2124)**	
	Arctic	**Antarctic**	**Arctic**	**Antarctic**	**Arctic**	**Antarctic**
State on State	Deterioration of the ongoing (Table 1) territorial disputes. Increasing number	Any one of the nations with scientific stations in region are found to be exploiting or undermining the Artic Treaty for national objectives could cause tensions between signatory nations building diplomatic tension.	Abundance of Arctic natural resources alter the climate change dynamic for Arctic nations increasing interstate tensions.	AT is not renegotiated in 2048 resulting in the reinstatement of continental territorial claims, along with new claims from emerging global powers, prompting renewed tension.	Climate change causes significant thawing of Greenland Ice sheet resulting in substantial sea level rising, inundating global ports, making them unusable and disrupting supply chains and human habitation resulting in major international tensions.	Climate change causes significant thawing of Antarctic Ice sheet resulting in substantial sea level rising inundating global ports and human habitation resulting in major international tensions.
Trade Protection	Utilisation of NEP/NWP, access through Bering Strait maritime choke point could lead to polar piracy using either cyber or conventional methodology.	If there is an increase in massive Icebergs (like A23a – see above), calving from the Antarctic Ice shelf and moving north could cause a navigational danger in shipping lanes in the southern hemisphere.	Global warming speeds up deglaciation on Greenland Ice Shelf increasing number of Icebergs in N Atlantic altering transatlantic trade routes.	Global warming increases speed of deglaciation, causing sea level rises pushing coastal communities, especially in SE Asia and S Pacific to resort to criminality including piracy in busy shipping lanes.	Rising sea levels because of deglaciation making ports unusable could significantly disrupt the loading/unloading of cargoes altering the trading routes for commercial shipping.	Rising sea levels because of deglaciation making ports unusable could significantly disrupt the loading/unloading of cargoes altering the trading routes for commercial shipping.
Resource Management	Arctic nation mineral and fossil fuel prospecting causes UNCLOS boundary dispute.	Exploitative IUU fishing/resumption of whaling under the guise of scientific experimentation.	Sea surface temperature increases will alter the migratory routes of pelagic fish potentially from one nation's EEZ to another, possibly causing frictions and tensions.	States commence exploitation of resources before or after failure of AT negotiations causes tensions between Treaty and signatory nations.	Exploitation of natural resources by remote control and autonomous technologies could raise levels of acquisition significantly by those nations with access and capability.	With rising sea levels, the high-altitude Antarctic continent offers good opportunities for valuable resources extraction. However, competing demands could lead to tensions.

Smuggling, Trafficking, Mass Maritime Migration & Stowaways	Access to new ports along the Arctic Ocean coastline provide opportunities for smuggling of contraband, trafficking of illegal items including people and stowaways.	The trafficking of IUU caught fish species from the Southern Ocean to markets may increase as overfished species become extinct or are unprofitable to fish.	Potential for national/commercial entities to smuggle restricted valuable	Trafficking of IUU fished (fish, Krill, whales) from Antarctic region to support nations who have lost other fish resources due to altered currents/fish migratory routes due to climate change	With alteration of global climate, populations start to move north into Arctic lands to live in cooler climate. Lack of infrastructure and lack of resources increases tensions within and between communities.	With alteration of global climate, some people decide to occupy the Antarctic continent but lack of resources (water, food, firewood, materials to construct shelters) causes tensions between groups.
Terrorism	Climate activism/terrorism against ships transiting NEP/NWP and tourism, or fossil fuel platforms for ideological/ political objectives. Potential for indigenous groups to initiate activism and minor acts of terrorism to support their cause exploiting their innate knowledge and expertise of the Arctic.	Climate activism/terrorism against cruise ships visiting Antarctic waters for ideological/ political objectives. Possible NGO activity against nations/vessels believed to be transgressing international agreements.	Ideological and State sponsored terrorism to hamper ship movements through Berring Straits.	Activist attacks and disruptions to cruise ships visiting Antarctic regions disrupting the fragile flora and fauna.	Lack of government action to manage climate change and consequences lead to the forming of vigil ante groups that start to disrupt established Arctic communities and ignite conflict.	Tensions between groups on the Antarctic continent leads to large scale confrontations.
Disasters	As NEP/NWP are exploited, the possibility of accidents increases with possibility of death, destruction and significant pollution of Arctic waters.	Exploitation of Antarctic cruising results in major vessel collision with another vessel, land or iceberg causing an unprecedented death toll highlighting isolation and vulnerability of ships in region.	Tensions rise across the Arctic region, triggering the deployment of forces, increasing the likelihood of accidents leading to the use of weapons disrupting the fragile eco system.	Antarctic Treaty fails to be renegotiated, and nations start to exploit resources at sea and on the Antarctic continent taking advantage of isolation to hide their activities.	Significant warming of the Arctic results in sea ice totally disappearing during the summer, leading to all polar shipping lanes becoming viable, resulting in ships transiting uncharted waters increasing likelihood of accidents.	Significant warming of Antarctic results vast expanses of Antarctic continent losing ice coverage and major icebergs floating into southern shipping lanes.

Oceanography	Increase in sea surface temperatures alters eco system of Arctic Ocean attracting more fishing boats and maritime traffic into increasingly shipping lanes.	Increase in sea temperatures alters bathymetry and meteorology of Southern Ocean causing stronger currents, rougher more treacherous seas making use of scientific/survey vessels in Antarctic less tenable resulting in fewer nations continuing with their scientific stations on Antarctic continent.	Increase in sea temperatures and rising acidity in the northern hemisphere begins to alter the routes of migratory fish, causes some species to go extinct causing an unstoppable deterioration of the marine eco system. Sea food in the northern hemisphere is no longer a reliable source of protein for humans.	Increase in sea temperatures and rising acidity in the southern hemisphere begins to alter the routes of migratory fish, causes some species to go extinct causing an unstoppable deterioration of the marine eco system. Sea food in the southern hemisphere is no longer a reliable source of protein for humans.	Long periods of increased radiant heat during the Arctic summer completely alters the nature of the Arctic Ocean, which becomes bereft of sea life and a lack of marine predators (sea mammals) completely upsets the eco system and altering the oceans' ability to absorb carbon and produce oxygen.	Long periods of increased radiant heat during the Antarctic summer completely alters the nature of the Southern Ocean, which becomes bereft of sea life and a lack of marine predators (sea mammals) completely upsets the eco system and altering the oceans' ability to absorb carbon and produce oxygen.

Table 6: Arctic/Antarctic Maritime Security Projections.

Conclusion:

Together the polar regions cover almost 11 million square miles which is around one-fifth of the earth's surface. Along with the depths of the oceans they are the least explored and understood areas of the globe. The ends of the earth experience climatic extremes, enduring months of 24-hours sunlight and total darkness with corresponding swings in temperatures of more than 50°C during Earth's orbit of the sun. Polar amplification, along with a depleted ozone layer exacerbate climatic variations and the impact of intense solar energy. These factors make the poles disproportionately influential to the meteorology, oceanography and therefore climatic stability of the plant. The extremes of the polar climate and logistical challenges for humans operating in these regions, along with the perpetual movement of the magnetic poles and limited satellite coverage make the regions politically and commercially easy to ignore.

Whilst it may be a cliché, these two regions are literally and figuratively *polar opposites;* the Arctic is ocean surrounded by land, whereas the Antarctic is a land mass surrounded by ocean. From a maritime security perspective, the contrasts are stark, the Arctic is contested, the Antarctic is uncontested, until 2048. The raw material reserves in the Arctic are already causing fractures amongst the members of the Arctic Council. The frigid waters in both polar regions are rich in seafood raising another point of potential friction between nations. The Arctic landmasses can support diverse flora and fauna including habituated terrestrial mammals and has supported around 4 thousand years of human habitation. The Antarctic region only supports migratory fish, mammals and birds feeding on seasonal gluts of invertebrates and the associated eco system. Unsupported human existence in the Antarctic continent is impossible.

The political, economic, social, technological, legal and environmental factors of both polar regions are varied, challenging and unique, posing potentially inflammatory scenarios that could lead to unanticipated tensions. The "out of sight, out of mind" nature of the poles along with unfamiliarity about their inherent physical complexity could easily lead to irrational reactions between competing nations in a scramble for territory, resources and assets.

Climatic hostility has been the two polar regions greatest protection from human exploitation since whaling and sealing lost their commercial appeal in the mid twentieth century. But as the global balance of power shifts and technological advances in AI and robotics manifest themselves along with a changing global climate we move into an unprecedented period when human presence in these harsh sub-zero temperatures is likely to lose its significance. The protection against extreme weather conditions and concerns about humans freezing to death in polar climes may be overtaken by the capabilities of devises with systems and technologies that can endure what humans can't, significantly reducing the logistical challenge and inherent costs, exploiting legal loopholes in agreements written before any of these technologies had been imagined let alone invented. It is likely, these exponential technological advances will take the accumulation of scientific knowledge and understanding to unforeseen levels, potentially providing the pathway to commercial exploitation of these two regions to unparalleled heights.

Whilst the two polar regions are very different in so many ways, they could both easily act as a catalyst to international frictions on political, economic, social, technological, legal and environmental levels. Ignoring their integral climatic influence could be catastrophic for coastal states unless climate change is arrested.

Ignorance and complacency about the polar regions and their unchallengeable natural influence on the globe is our greatest enemy. We need to be more proactive in our understanding of the polar regions, and their importance to the globe otherwise we may be unable to prevent an unstoppable global phenomenon. We ignore these regions at our peril.

Photograph 3: An Iceberg about to eclipse the setting sun in the Southern Ocean.

Photographs: All photographs provided by the author.

Diagrams:

1. Movement of the North Magnetic Pole 1900-2020 Source: The three norths align over Great Britain | Blog | OS (ordnancesurvey.co.uk)
2. Observed south dip poles during 1903–2000 are yellow squares. IGRF-12 Modelled pole locations from 1590 to 2020 are circles progressing from blue to yellow. Source South pole historical map - South magnetic pole - Wikipedia

Maps:

1. www.researchgate.net
2. www.articportal.org
3. AADC Map Catalogue 13576 Commonwealth of Australia.
4. Mapping Solutions, Lawson Bingham, USAARC Anchorage 2006
5. www.antarctica.fandom.com

Tables:

1. Ongoing Arctic Circle Territorial Conflicts https://theowp.org/crisis_index/arctic-circle-territorial-conflicts/
2. Comparison of distance and time of using conventional southern routes versus northern polar routes (distances and time/distance calculations conducted on www.ports.com
3. A selection of factors that would assist with the cost benefit analysis of using the northern polar routes (authors work).
4. Rumsfeld's four quadrant matrix applied to the environmental impacts of climate change (authors work).
5. Natural and humanity imposed polar opposites (authors work).
6. Arctic/Antarctic Maritime Security Projections (authors work).

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[1] https://en.wikipedia.org/wiki/Earth%27s_magnetic_field
[2] 365° divided by 24 equals 15°.
[3] These average temperatures are very conservative, as the poles represent around 20% of the earth's surface, and temperatures vary significantly across both regions, where the lowest and highest temperatures far exceed the medians.
[4] The Ozone layer of gas (O_3) in the atmosphere of the planet absorbs 97-99 percent of the sun's harmful medium frequency ultraviolet light.
[5] Permafrost is soil or water that is continuously frozen for more than two years. Some land has been frozen for over 700,000 years and some permafrost is as deep as 1,500m.
[6] Calf/Calving: process by which ice breaks off a glacier's terminus; usually the term is reserved for tidewater glaciers or glaciers that end in lakes, but it can refer to ice that falls from hanging glaciers. https://nsidc.org/learn/cryosphere-glossary
[7] Significant floating ice definitions, Iceberg: a piece of ice that has broken off from the end of a glacier that terminates in water. Bergy Bit: large chunk of glacier ice (a very small iceberg) floating in the sea; bergy bits are usually less than 5 meters (15 feet) in size and are generally spawned from disintegrating icebergs. Growler an iceberg less than 2 meters (6.6 feet) across that floats with less than 1 meter (3.3 feet) showing above water; smaller than a bergy bit. Brash Ice: accumulation of floating ice made up of fragments not more than 2 meters (6.6 feet) across, the wreckage of other forms of ice. https://nsidc.org/learn/cryosphere-glossary
[8] National Geographic, Ocean: An illustrated Atlas, 2008
[9] A23a: Tracking the world's biggest iceberg as it drifts towards oblivion https://www.bbc.co.uk/news/resources/idt-f4de435a-d215-4a7c-86e9-9b838701c993
[10] https://yaleclimateconnections.org/2022/02/what-the-latest-science-says-about-antarctica-and-sea-level-rise/
[11] The Arctic, Klaus Dodds & Jamie Woodward, 2021
[12] Geographical miles are the same distance as nautical miles 2,000 yards/,
[13] Peary's party comprised six men, including Matthew Hanson and four Inuit men, Ootah, Seeglo, Egingwah and Ooqueah.
[14] The Worst Journey in the World, Apsley Cherry-Garrard, 1922, p327
[15] Ibid Scott's route
[16] The Lives of Nansen and Amundsen, Hans Olav Thyvold , 2018, p150
[17] The Arctic Ocean is the smallest ocean covering 8.7 million square kilometres.
[18] Kowalik, Z. & Proshutinsky, A. Y. The Arctic Ocean Tides. The Polar Oceans and Their Role in Shaping the Global Environment 1, 137–158 (American Geophysical Union (AGU), 1994).
[19] National Geographic Ocean Illustrated Atlas p254
[20] Baleen plates have replaced teeth in Mysticises whales, they are stiff and act as a sieve, allowing whales to take vast volumes of water and small plankton into their enormous mouths, the water is then pushed out but the small creatures, captured by the Baleen plates remain and are consumed.
[21] The 1996 Ottawa Declaration saw the formation of the Arctic Council. The Council includes the Arctic states of Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden, and America. The Arctic Council was designed to increase cooperation, coordination, and diplomacy among the Arctic States with the involvement of indigenous communities and other Arctic inhabitants. The Arctic Council has performed studies on climate change's effects in the Arctic.
[22] https://arctic-council.org/about/states/
[23] Bernaerts' Guide to the 1982 United Nations Convention of the Law of the Sea p112
[24] Ibid
[25] Ibid
[26] Ibid Art 56, p170
[27] Ibid Art 59 p171
[28] National Geographic, The New Cold War Sep 2019
[29] World's Most Capable Icebreakers: Russia's New Arktika Class - https://www.usni.org/magazines/proceedings/2022/may/worlds-most-capable-icebreakers-russias-new-arktika-class
[30] USCG Polar Star, the US Icebreaker was commissioned in 1974.
[31] WSW – West by Southwest,
[32] Capt James Cook, The Journals Monday 18th January 1773, 65° 52'S, 39° 35'E
[33] The Antarctic, Klaus Dodds p57
[34] Ibid
[35] Shipping in Arctic Waters, Østreng, Jørgensen-Dahl, Wergelend, Eger, Lothe, Fløistad, Mejlænder-Larsen, 2013, pxxiv
[36] Ibid

[37] Ibid
[38] Authors italics.
[39] VN Leskin and BN Porfiriev, "The Russian Arctic: The logic and paradoxes of change," Stud. Russ. Econ. Dev. 30, 594-605 (2019)
[40] Transport Infrastructure of the Russian Arctic: Specific Features and Development Prospects, Serova and Serova 2020, Luzin Institute for Economic Studies, Federal Research Centre of Kola Science Centre, Russian Academy of Sciences
[41] https://www.imo.org/en/OurWork/Safety/Pages/polar-code.aspx
[42] Both Suez Canal and Panama Canal charge ships transiting the canals for their use.
[43] Marine Insurance comprises; Hull & Machinery which covers the material aspects of the vessel; Protection and Indemnity (P&I) covers ship owners, charterers against third party liability linked to the operation of the ship; Cargo insurance for the cargo.
[44] https://chnl.no/news/main-results-of-nsr-transit-navigation-in-2024/
[45] Rosatom, the Russian State Atomic Energy Corporation reported a figure of 3.08 tons of cargo transiting the NSR during the year.
[46] Ibid
[47] Ibid
[48] Shipping in Arctic Waters, Østreng, Jørgensen-Dahl, Wergelend, Eger, Lothe, Fløistad, Mejlænder-Larsen, 2013, p142
[49] Cruise Lines International Association (CLIA) State of the Cruise Industry Report April 2024
[50] Ibid
[51] https://www.aeco.no/
[52] https://iaato.org/
[53] The global population in 1950 was around 2.6 billion, by 2050, the global population is estimated to be around 9 billion, a 350% increase.
[54] https://www.arcticcentre.org/EN/arcticregion/Arctic-Indigenous-Peoples
[55] https://arctic-council.org/about/permanent-participants/
[56] Antarctic Convergence is a hydrological boundary that separates the northward flowing cold Antarctic waters from the warmer waters of the great oceans. The Antarctic waters normally sink below the warmer waters but where there are upwellings of cold Antarctic waters rich in Krill and are very high in marine productivity. The line is dynamic that fluctuates by up to 0.5 of a degree of latitude. As the Arctic is surrounded by land is does not have a maritime convergence line but it does have a terrestrial tree line marking a climatic zone.
[57] In accordance with IAATO, only 100 people are allowed to step ashore at any one location at a time, meaning that many of the larger cruise ship passengers only view the environment from the ship.
[58] Many of the early Antarctic expeditions including Amundsen, Mawson, Scott and Shackleton included the dogs as part of their rations as the loads on the sledges required less animals to pull the loads.
[59] Many quantum computing technologies operate at 0.1Kelvin/-273°C
[60] As most communication satellites orbit above the populated areas of the planet, the space above the poles is less cluttered, therefore a satellite in a polar orbit would have less lunar traffic to deal with.
[61] The temperature in outer space is generally 2.73 Kelvin (-270.42°C/-454.75°F) https://www.scienceabc.com/nature/universe/what-is-the-temperature-of-space
[62] USA is not a signatory of UNCLOS.
[63] https://arctic-council.org/explore/work/cooperation/
[64] Aleut International Association (AIA), Arctic Athabaskan Council (AAC), Gwichín Council International (GCI), Inuit Circumpolar Council (ICC), Russian Association of Indigenous Peoples of the North (RAIPON), Saami Council
[65] https://arctic-council.org/about/permanent-participants/
[66] https://arctic-council.org/explore/work/cooperation/
[67] https://www.ats.aq/index_e.html
[68] Argentina, Australia, Belgium, Chile, France, New Zealand, Norway, Poland, USSR (Russia), South Africa, UK and USA.
[69] LawTeacher. November 2013. Antarctic Treaty System: Strengths and Weaknesses. [online]. Available from: https://www.lawteacher.net/free-law-essays/international-law/antarctic-treaty-system-8363.php?vref=1 [Accessed 22 August 2024].
[70] Convention of Antarctic Flora and Fauna (1964), Convention for the Conservation of Antarctic Seals (1972), Convention for the conservation of Antarctic Marine Living Resources (1982), Convention on the Regulation of Antarctic Mineral Resources Activities (1988), Protocol on Environmental Protection to the Antarctic Treaty (1991).

[71] As an example since 1963, Australia has undertaken just 10 inspections of facilities in Antarctica, mostly coastal stations and just one of the inland seasonal Station Taishan, run by China in 2019/20. However, no party has ever inspected the inland Chinese station Kunlun on Dome Argus. Ice Panda: Navigating China's hybrid Antarctic Agenda, Dr Elizabeth Buchanan, ASPI, August 2024
[72] LawTeacher. November 2013. Antarctic Treaty System: Strengths and Weaknesses. [online]. Available from: https://www.lawteacher.net/free-law-essays/international-law/antarctic-treaty-system-8363.php?vref=1 [Accessed 22 August 2024].
[73] https://www.ipcc.ch/srocc/
[74] https://www.theuncertaintyproject.org/tools/rumsfeld-matrix
[75] The Anarchic Sea, Dave Sloggett, p37
[76] In a survey conducted by two international shipping associations, BIMCO and the International Chamber of Shipping in 2015 they identified the top seafarer supplying nations, all of which use the same word for "safety" and "security": including China 安全 (Ānquán), Philippines "seguridad" (Spanish), Russian "безопасность", and India "सुरक्षा". The two largest ship owning countries also use the same word for "safety" and "security": Greece – ασφάλεια (asfaleia) and China.
[77] Oxford English Dictionary
[78] Oxford English Dictionary
[79] These ports and airfields are in various states of serviceability but there are aspirations, with Chinese financial support, to reinvigorate the network.
[80] Artic policies and strategies for Arctic States, Indigenous Peoples and non-Arctic States are listed at https://arcticportal.org/arctic-governance/arctic-policies-database
[81] National Geographic September 2019.
[82] Ibid
[83] Ibid
[84] The concept of transhipment ports is they act as hub ports for ships to visit to exchange containers. In this case, the delivery of laden containers from China, by specialist ice strengthened ships using the NEP and the collection of containers with European products and/or empty boxes.
[85] United Nations Conference on Trade and development Maritime Transport Review 2024, p38
[86] The "coolest" place for astronomy, Chinese Embassy, Canberra website
[8787] Ice Panda: Navigating China's hybrid Antarctic Agenda, Dr Elizabeth Buchanan, ASPI, August 2024
[88] Ibid
[89] https://www.seashepherd.org.au/our-campaigns/antarctica-defense/
[90] Arctic Council and Antarctic Treaty.
[91] https://iwc.int/management-and-conservation/whaling/commercial
[92] https://iwc.int/table_objection
[93] Paul Watson: Sea Shepherd eco-warrior fighting to stop whaling and seal hunts. The Telegraph 17 Apr 09.
[94] https://www.seashepherd.org.au/who-we-are/our-mission/