CONCISE NOTES ON THE ARCTIC

R. K. Headland, Scott Polar Research Institute, Cambridge. Revised February 2022

The Arctic is essentially an ocean (the smallest of the 5 oceans), Greenland, the northern extremities of 3 continents (Asia, Europe, and North America) and several archipelagos. The boundaries are not distinct but are best defined by a combination of the tree-line and the southern limit of continuous permafrost on land, and the average extent of winter pack ice at sea.

The Arctic Ocean includes the Barents Sea, Kara Sea, Laptev Sea, East Siberian Sea, Chukchi Sea, Beaufort Sea, and Lincoln Sea. It receives a large, although seasonably very variable, fresh-water influx from many of the world's greatest rivers, especially those draining Siberia. Its surface area is $14{\cdot}5 \times 10^6$ km^2 of which a summer minimum of 50% is permanently covered by *pack ice*; this increases to 85% in winter. Currently the quantity of sea-ice is diminishing. The mean ice thickness is 2·5 m; the usual duration of a floe is 3 years before it melts or escapes from the Arctic Ocean. At the North Pole ice may drift as much as 20 km daily. The greatest oceanic depth is 5608 m, Molloy Deep (78°N, 02°W) and the depth at the *North Pole* is 4302 m (the floating ice averages 1·5 m thick). Its submarine topography is complex with several ridges, trenches, abysses, deep and shallow plains. The average depth is 1800 m, thus it is the shallowest of the oceans. Siberia has an extensive continental shelf while that off North America is narrow and drops abruptly. The remote Northern Pole of Inaccessibility (85·80°N, 176·15°W) is 1010 km from the nearest coastal points. The North Magnetic Pole was at 86·107°N, 153·37°W in 2015, about 670 km from the nearest land and moving about 45 km WNW annually; it was first reached in 1831 when much farther south.

Greenland, with a surface area of $2{\cdot}8 \times 10^6$ km^2, has the only Arctic *ice sheet* which has an area of $1{\cdot}8 \times 10^6$ km^2, maximum elevation of 3238 m (73°N, 40°W), and a volume of $2{\cdot}5 \times 10^6$ km^3 which is 9% of the ice on Earth. The greatest ice depth measured is 3350 m (72°N, 40°W) and mean depth 1200 m. Bedrock is depressed to a maximum depth of 450 m below sea level in some places. Greenland also has the highest peak in the Arctic; Gunnbjørns Fjæld at 3693 m (68·9°N, 29·9°W, first climbed on 18 August 1935). The many Arctic ice caps are of minor size; no large ice shelves exist. The most northern land on Earth is Odâq Ø, or a small shingle bank in its vicinity (83·7°N, 30·7°W), off Greenland.

The Arctic has had a peripheral *indigenous population* for many millennia. These include tribes of Inuit and other Eskimo, Lapp or Saami, Samoyed, and Chukchi. Abandoned Eskimo settlements have been found beyond 80°N in Greenland and Ellesmere Island, which were occupied during warmer epochs. About 80% of the present population of the Arctic immigrated during the 20th century during which urbanization began, nomads settled, and several major population centres were established. *Exploration* of the continental coasts was largely complete almost two centuries ago but many of the islands were charted subsequently. Most of the extreme north regions of the Canadian Arctic archipelago and Greenland were mapped by 1900. The last major discovery of land on Earth was Severnaya Zemlya in 1913, and the last of the smaller islands was identified in 1947. The *North Pole* was first seen on 12 May 1926, from an airship expedition led by Roald Amundsen; first reached by aircraft on 23 April 1948, by a submarine on 3 August 1958, over the pack-ice surface on 19 April 1968, and by icebreaker on 17 August 1977. To date 139 surface voyages have reached it.

Sealers, *whalers*, *hunters*, and *trappers* have been active in the Arctic for millennia. Extraction of metals, hydrocarbons, and other *minerals* is currently a major economic activity. Many air and some sea routes cross Arctic regions. *Tourism* is minor but increasing. Russia maintains the *Northern Sea Route* (Northeast Passage) for much of the year with icebreakers, some atomic powered; thousands of commercial transits have been made. In contrast the *Northwest Passage* is not a commercial waterway; only 290 transits have ever been made and only 8 of these were commercial.

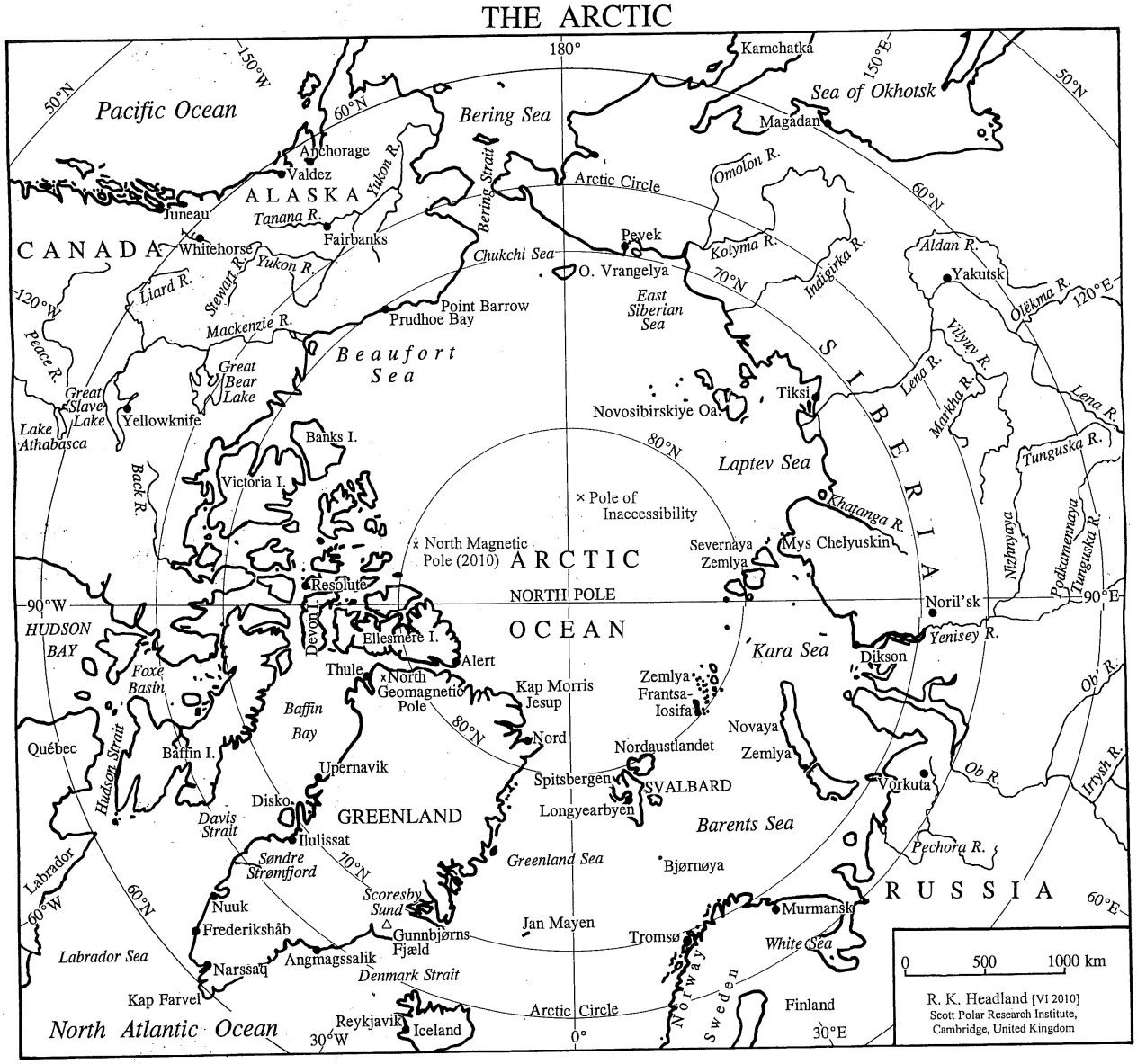
Several countries conduct research and maintain meteorological observatories and other stations around the Arctic Ocean, on the continents and islands. Drift stations have been deployed on ice floes which circulate around the ocean. A large number of Russian stations were closed from the early 1990s. Several *military stations* are maintained, both offensive and defensive, although numbers of Russian ones decreased after 1990 several are currently being re-established. Likewise Canada is increasing its Arctic military capability. *Novaya Zemlya* was the principal Arctic nuclear bomb testing site for the Soviet Union, with 132 detonations from 1955 to 1990; its vicinity has also been used for disposal of radioactive waste. The United States used sites in Alaska for testing 3 nuclear explosions and 4 nuclear bombs, in a crashed aircraft, spread contamination near Thule, Greenland, in January 1968.

The Arctic *climate* is extreme but the low elevation and proximity of the sea ameliorate it compared with that of the Antarctic. Winds may be severe and precipitation, mainly snow, is generally abundant. The record Arctic minimum temperature is -71·2°C, from Oymyakon, Siberia (63·3°N, 143·2°E), 26 January 1924. Exceptional optical phenomena, such as the *Aurora Borealis,* may be prominent.

Arctic *flora* and *fauna* are closely related to those of surrounding continents but have adapted to the harsh climate. *Polar Bears*, Ringed Seals, and several birds have been found at the North Pole. Migratory birds occupy breeding sites in immense numbers during the brief summer. Barely 5000 years ago Mammoths were present.

Most of the Arctic is ocean thus unrestricted nationally as 'high seas'. The *Spitsbergen Treaty* (1920) allows access to the Norwegian Svalbard archipelago by the 46 signatory countries. Eight countries govern territory north of the Arctic Circle (66·5°N): Canada, Denmark (for Greenland), Finland, Iceland, Norway, Russia, Sweden, and United States. The few instances of sovereignty disputes have generally been solved without military intervention. Territorial waters, in conformity with the United Nations Law of the Sea Convention, are currently under active negotiation. Coordination of *scientific research* between the 8 Arctic states, and 15 other countries involved, is largely through the International Arctic Sciences Committee (founded in 1990), with a Secretariat in Akureyri, Iceland.

THE ARCTIC


Pacific Ocean
Bering Sea
Sea of Okhotsk
Kamchatka
Magadan
Anchorage
Valdez
ALASKA
Juneau
Yukon R.
Bering Strait
Arctic Circle
Omolon R.
Tanana R.
Fairbanks
CANADA
Whitehorse
Yukon R.
Chukchi Sea
Pevek
Kolyma R.
Aldan R.
Yakutsk
Liard R.
Stewart R.
O. Vrangelya
Indigirka R.
Olekma R.
Point Barrow
Prudhoe Bay
East Siberian Sea
Mackenzie R.
Peace R.
Beaufort Sea
Great Bear Lake
Great Slave Lake
Yellowknife
Lake Athabasca
Novosibirskiye Oa.
Tiksi
Lena R.
Vilyuy R.
Markha R.
SIBERIA
Banks I.
Laptev Sea
Tunguska R.
Victoria I.
Back R.
× Pole of Inaccessibility
Khatanga R.
× North Magnetic Pole (2010)
ARCTIC
Severnaya Zemlya
Mys Chelyuskin
Nizhnyaya Tunguska R.
Podkamennaya Tunguska R.
Resolute
NORTH POLE
Noril'sk
90°W
90°E
HUDSON BAY
Devon I.
Ellesmere I.
OCEAN
Yenisey R.
Kara Sea
Dikson
Alert
Thule
Foxe Basin
× North Geomagnetic Pole
Kap Morris Jesup
Zemlya Frantsa-Iosifa
Ob' R.
Baffin Bay
Québec
Baffin I.
Hudson Strait
Nord
Nordaustlandet
Novaya Zemlya
Upernavik
Spitsbergen
SVALBARD
Vorkuta
Ob R.
Irtysh R.
Disko
GREENLAND
Longyearbyen
Davis Strait
Barents Sea
Ilulissat
Pechora R.
Labrador
Greenland Sea
Bjørnøya
Søndre Strømfjord
Scoresby Sund
RUSSIA
Murmansk
Nuuk
Jan Mayen
Gunnbjørns Fjæld
Tromsø
Frederikshåb
White Sea
Labrador Sea
Angmagssalik
Narssaq
Denmark Strait
Kap Farvel
Arctic Circle
Finland
North Atlantic Ocean
Reykjavik
Iceland
Norway
Sweden
180°
150°W
150°E
120°W
120°E
90°W
90°E
60°W
60°E
30°W
30°E
0°
50°N
60°N
70°N
80°N
0
500
1000 km
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CONCISE NOTES ON THE ANTARCTIC

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The Antarctic includes the continent of *Antarctica* (the fifth largest), the surrounding *Southern Ocean*, and the 19 *peri-Antarctic islands*. The limit of the Southern Ocean is the *Antarctic Convergence* or Polar Front, which is subject to seasonal variation and large gyres. Antarctica is the most isolated of the 7 continents, separate by 900 km from South America, the closest one. It is the only continent entirely isolated by abyssal deeps. Its coasts are about 51% glacier or ice wall, 44% floating ice shelf, and 5% rock or beach.

Antarctica is 99·7% covered by a permanent *ice sheet* and has a surface area of 13·94 x 10^6 km^2, including several massive ice-shelves. It includes sub-continents of Greater Antarctica (10·38 x 10^6 km^2) and Lesser Antarctica (3·56 x 10^6 km^2), separated by the Trans-antarctic Mountains. The *South Pole* is 2835 m above sea level (its 'pressure altitude' is about 3350 m), about 2757 m of which is ice. The ice surface at the pole flows about 10 m annually. The mean ice thickness is 2034 m; maximum measured depth is 4776 m (69·9°S, 135·2°E). The ice sheet has a maximum elevation of 4231 m (Dome Alpha, 81°S, 75°E) and a volume of about 26·9 x 10^6 km^3 which is 90% of that on Earth. Much of the bedrock is depressed below sea level by the weight of ice; the greatest depression is 2870 m at Byrd Glacier (80·3°S, 159·0°W). More than 170 sub-glacial lakes have been discovered deep under the ice sheet. Ice features account for the majority of the coast. Many peri-Antarctic islands have ice caps; these are of insignificant size compared with the ice sheet. Several ice-shelves have recently calved and diminished greatly. This may leave massive tabular icebergs drifting as they disrupt for several years in the Southern Ocean.

Antarctica's highest peak is Mount Vinson at 4892 m (78·6°S, 85·4°W, first climbed on 17 December 1966); at least 33 other peaks, and an ice dome, exceed 4000 m. The remotest spot is the Southern Pole of Inaccessibility (83·8°S, 65·8°E), 1330 km from the nearest coastal points (first reached in 1958). In 2016 the *South Magnetic Pole* was at 64·3°S, 136·7°E, some 50 km off the Terre Adélie coast; it was inland in 1909 when first reached. The average surface elevation of Antarctica is 2300 m, the highest of any continent.

The *Southern Ocean* includes the Scotia Sea, Weddell Sea, Amundsen Sea, Bellingshausen Sea, and Ross Sea. Its surface area is 31·8 x 10^6 km^2, about 8·8% of the world oceans. As well as the peri-Antarctic islands there are many seamounts, also causing upwellings of nutrient-rich waters. Much of the ocean is covered by *pack ice* which has an average winter maximum area of 20 x 10^6 km^2 (63% of the Southern Ocean). At the height of summer this decreases to 2·4 x 10^6 km^2 (8% of the ocean). The mean thickness of the ice is 1·2 m; the usual duration of a floe is 1 year as the majority drift north during summer. Massive tabular icebergs, calved from the ice shelves, are a distinctive feature of the ocean. Its greatest measured depth is 8365 m (Meteor Deep, 56°S, 26°W).

The *first lands* seen in the Antarctic were several of the peri-Antarctic islands. Mainland Antarctica was first sighted in 27 January 1820 and the first landing was probably in late 1820. It was not until 1899 that a winter was spent on the continent and continuous presence began in 1944. The *South Pole* was reached on 14 December 1911 by an expedition led by Roald Amundsen. *Sealers*, mainly during the 19th century, and *whalers* during the 20th century were major exploiters of Southern Ocean biological resources. The latter established land stations on several peri-Antarctic islands. Currently *fishing* and *tourism* are the only commercial operations; research is the principal activity. Unlike in the Arctic neither mineral extraction nor commercial transport routes exist in the Antarctic. Many economic minerals undoubtedly occur but none has yet been exploited.

During the 2018 austral winter 46 research *stations* were open in Antarctic regions (26 on Antarctica, all but 3 on coasts) recording meteorological data and involved in other scientific research. These were operated by 20 countries. The winter population of the Antarctic is about 1100, at least thrice as many are present during the brief summer. Most stations are relieved by icebreakers and other ships. Only 6 inter-continental landing strips are maintained.

The Antarctic *climate* is the most severe on Earth. Winds often become blizzards and Earth's minimum air temperature of -93·2°C was recorded by remote sensors at 81·8°S, 159·3°E, August 2013. The continent is essentially a frigid desert because there is very little precipitation from the cold dry atmosphere - and virtually all this is snow. In many areas sublimation exceeds melting in ablating glaciers, and humidifies the air. Exceptional optical phenomena, especially the *Aurora Australis,* may be prominent.

Terrestrial *flora* and *fauna* are highly endemic. They are characterized by few species which may occur in very isolated concentrations. A few lichens and algae survive on the most remote nunataks. Marine organisms are, on the contrary, abundant in local situations and include many species of whales, seals, and commercial fish. The peri-Antarctic islands are particularly important breeding sites for *penguins* and other sea-birds, and seals. No indigenous humans have existed; although a small number of children have been born on continental Antarctica (the first was in 1978), and on several peri-Antarctic islands.

The terrestrial part of the Antarctic south of 60°S is subject to the *Antarctic Treaty* of 1959, which, currently, has 53 signatory countries (over 80% of the Earth's population). A Secretariat opened in Buenos Aires in 2004. The treaty puts the 7 original sovereign claims (Argentina, Australia, Britain, Chile, France, New Zealand, and Norway, some overlap) in abeyance, and its subsequent instruments regulate most activities in its region. The Convention on the Conservation of Antarctic Marine Living Resources, with a headquarters in Hobart, regulates Southern Ocean exploitation. Current *military deployments* in the Treaty region are mainly to provide transport for, supplies and personnel to a proportion of stations, and for hydrographic survey. Neither testing of nuclear weapons nor disposal of radioactive waste has been reported within the Treaty region (although nuclear explosions and military operations have occurred in other parts of the Antarctic). *Scientific research* is coordinated internationally by the Scientific Committee on Antarctic Research (founded in 1958), with membership of 39 countries, a Secretariat in Cambridge, and various specialised groups.

THE ANTARCTIC