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Antarctica: Overview of Geopolitical and Environmental Issues

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SUMMARY

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Antarctica: Overview of Geopolitical and Environmental Issues

Geopolitical and environmental developments are increasing international focus on Antarctica and the Southern Ocean. Stakeholders contend these developments may have political, economic, and security implications for the United States and the rest of the world. Geopolitical concerns center on the rising presence of China and Russia in the Antarctic and the integrity of the Antarctic Treaty System (ATS), which provides a framework for governing the region. Environmental issues, particularly those related to climate change, also are prominent in Antarctica, due to current and projected future rates of melting ice in the region, which cause some scientists to assert that Antarctica represents a significant source for global sea-level rise under future warming conditions. Much of the research on understanding and projecting rates of melting ice and its potential contribution to global sea-level rise relies on satellite data, as well as scientific work conducted in Antarctica. Most of the research done by U.S. scientists is overseen and funded by the National Science Foundation. Other environmental issues in Antarctica concern its ecosystems, biodiversity, and natural resources.

The Antarctic Treaty, the central part of the ATS, established the legal framework for Antarctica and guaranteed free access and research rights for the international community. The Antarctic Treaty was signed in 1959. There are 54 parties to the treaty; of these, 29 are *consultative parties*, which have the right to participate in decisionmaking. The consultative parties include the United States, Australia, Russia, and China, among others. In its preamble, the Antarctic Treaty states that "it is in the interest of all mankind that Antarctica shall continue to be used exclusively for peaceful purposes and shall not become the scene or object of international discord." The treaty also set aside all previous claims to land in Antarctica, essentially making it a common area for research activities.

Congressional interest in Antarctica stems to a large extent from geopolitical and environmental issues. Members introduced legislation in the 116th Congress that would have regulated expeditions and tourism activities in the region and addressed environmental emergencies (e.g., oil spills) in the Antarctic ecosystem that result from such activities. The former Trump Administration addressed security concerns in the region, issuing a presidential memorandum that called for a new fleet of polar security icebreakers to protect national interests in the Arctic and Antarctic regions. In the future, geopolitical, climate, and natural resources concerns in Antarctica might stimulate Congress to explore a number of questions related to the region, including what role Antarctica may play in the changing global order and its significance for sea-level rise.

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Introduction

Geopolitical and environmental developments are increasing international focus on Antarctica and the Southern Ocean. The interdisciplinary nature of various stakeholders concerned with Antarctica—including scientists, diplomats, defense personnel, members of the media, academics, and others in both domestic and international contexts—makes for a complex dynamic. Some of these stakeholders contend that current developments could have environmental, political, economic, and security implications for the United States and the rest of the world.[1]

For example, estimates of current and projected rates of melting ice sheets and glaciers in Antarctica cause some scientists to assert that the region represents one of the largest potential sources for global sea-level rise under future warming scenarios.[2] Sea-level rise can have significant effects on coastal cities and infrastructure in the United States and other parts of the world, absent human measures to mitigate or adapt to these effects, according to stakeholders.[3]

Geopolitical concerns center on the rising presence of China and Russia in the Antarctic and the integrity of the Antarctic Treaty System (ATS), which provides a framework for governing the region. Antarctica is not occupied or claimed by any country, and it is governed through the Antarctic Treaty. There have been few reports of incidents that conflict with the treaty; however, some stakeholders note there is potential for disagreements regarding the extraction and protection of natural resources in and around the continent (e.g., fisheries), the physical footprint of bases and access to them, and the nature of activities conducted by countries in the region.[4]

During the 116th Congress, the Trump Administration and some in Congress addressed U.S. interests in Antarctica in several ways. The Trump Administration issued a presidential memorandum stating that the United States requires a fleet of polar security icebreakers that are tested and deployable by FY2029 to protect national interests in the Arctic and Antarctic regions.[5] Some in the 116th Congress demonstrated interest in Antarctica through legislation under Title VII of the Securing American Leadership in Science and Technology Act of 2020 (H.R. 5685), which would have addressed, in part, expeditions and tourism in Antarctica and environmental emergencies in the Antarctic ecosystem that result from such activities. As of the publication of this report, there are no bills in the 117th Congress that specifically address Antarctica.

[1] Leah Feiger and Mara Wilson, "The Countries Taking Advantage of Antarctica During the Pandemic: While the West Has Scaled Back Operations in the Antarctic, Russia and China Have Pushed Ahead," *The Atlantic*, May 15, 2020. Hereinafter, Feiger and Wilson, "Countries Taking Advantage."

[2] This observation is based on the extent and thickness of land ice on Antarctica. Peter Fretwell et al., "Bedmap2: Improved Ice Bed, Surface, and Thickness Datasets for Antarctica," *The Cryosphere*, vol. 7 (2013), pp. 375-393; and Julius Garbe et.al., "The Hysteresis of the Antarctic Ice Sheet," *Nature*, vol. 585 (September 24, 2020), pp. 538-544. Hereinafter, Garbe, "Antarctic Ice Sheet."

[3] Michael Oppenheimer et al., "Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities," in *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*, IPCC, 2019. Hereinafter, Oppenheimer et al., IPCC Special Report Chapter 4, "Sea Level Rise."

[4] For example, see Jackson Gothe-Snape, "China Unchecked in Antarctica," *ABC News*, April 12, 2019. Hereinafter, Gothe-Snape, "China Unchecked."

[5] White House, Office of the Press Secretary, "Memorandum on Safeguarding U.S. National Interests in the Arctic and Antarctic Regions," presidential memorandum, June 9, 2020.

Geopolitical, climate, and natural resource concerns in Antarctica might stimulate Congress to explore a number of questions related to the region, including what role Antarctica may play in the changing global order and its potential to contribute to sea-level rise.

The United States and Antarctica

Scientific interest in the Antarctic began in the 1800s, with various countries sending exploratory expeditions. One of the first recorded sightings of Antarctica was by the American sealer Nathaniel Palmer on November 16, 1820.[6] The congressionally authorized Charles Wilkes expedition (1838-1842) was instrumental in establishing that Antarctica was a continent.[7] In 1898, members of a Belgian expedition were the first to winter in the Antarctic in their ship, frozen in ice.[8] The following year, a British expedition spent the winter on land.[9] In 1904, the United Kingdom set up a weather station in the South Orkney Islands that is still functioning.[10]

The U.S. presence in Antarctica and the Southern Ocean began with American whaling and sealing in the region in the early 1900s. In 1939, President Franklin D. Roosevelt appointed Admiral Richard Byrd to lead the U.S. Antarctic Service Expedition, which established scientific bases on the continent.[11] (These bases were evacuated in 1941.) Operation Highjump (1946-1947) and Operation Deep Freeze (1955-1957) subsequently reestablished a sizable American presence in Antarctica after World War II.[12]

Today, U.S. research on Antarctica is coordinated through the U.S. Antarctic Program (USAP), which is funded and managed by the National Science Foundation (NSF). The USAP has three stated research goals: "to understand the region and its ecosystems; to understand its effects on (and responses to) global processes such as climate; and to use the region as a platform to study the upper atmosphere and space." Approximately 3,000 Americans participate in USAP research activities annually.[13] USAP, through NSF, operates three stations in Antarctica—the McMurdo Station, the Amundsen-Scott Station, and the Palmer Station on the Antarctic Peninsula. (Overall, there are about 80 other stations operated by foreign countries in Antarctica.) USAP conducts research on: space weather, which informs global weather forecasting; ocean circulation patterns and carbon sequestration in oceans; astrophysics; and ice sheet dynamics and their implications for global sea-level rise.[14]

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[6] Cool Antarctica, "Human Impacts on Antarctica and Threats to the Environment—Whaling and Sealing," at https://www.coolantarctica.com/Antarctica%20fact%20file/science/threats_sealing_whaling.php.

[7] Gillen D'Arcy Wood, "The Forgotten American Explorer Who Discovered Huge Parts of Antarctica," *Smithsonian Magazine*, March 26, 2020.

[8] Cool Antarctica, "Adrien de Gerlach – Belgica Belgian Antarctic Expedition 1897-1899," at https://www.coolantarctica.com/Antarctica%20fact%20file/History/antarctic_whos_who_belgica.php.

[9] Cool Antarctica, "Carsten E. Borchgrevink – Southern Cross, British Antarctic Expedition 1898-1900," at https://www.coolantarctica.com/Antarctica%20fact%20file/History/antarctic_whos_who_southern_cross.php.

[10] Geoffrey N. Swinney, "The Scottish National Antarctic Expedition (1902-04) and the Founding of the Base Orcadas," *Scottish Geographical Journal*, vol. 123, no. 1, (March 2007), pp. 48-67. The Orcadas Base is operated by the Argentine government.

[11] "Byrd Antarctic Service Expedition," at http://www.south-pole.com.

[12] Scott Polar Research Institute, "United States Navy Antarctic Expeditions Operation Deep Freeze 1955-98," at https://www.spri.cam.ac.uk/picturelibrary/catalogue/usnaeodf1955-98/.

[13] National Science Foundation (NSF), "United States Antarctic Program," at https://www.nsf.gov/geo/opp/antarct/usap.jsp.

[14] Kelly Falkner and John Carlstrom, "Antarctica: U.S. Research and Diplomacy on the Southern Continent" (presentation, Wilson Center, Washington, DC, November 13, 2020), at https://www.wilsoncenter.org/event/antarctica-

Various other federal and military organizations contribute to U.S. involvement with Antarctica. U.S. policy on Antarctica is coordinated by the Department of State, which maintains ties with the Antarctic Treaty Secretariat, located in Buenos Aires, Argentina. U.S. Air National Guard crews provide air support for the Antarctic research bases, flying from Christchurch, New Zealand, and the U.S. Coast Guard operates icebreakers in Antarctica to support U.S. interests and activities.[15] The United States Coast Guard icebreaker Polar Star supports the USAP's mission on Antarctica by breaking ice to refuel and resupply McMurdo Station.[16]

Selected U.S. Laws Addressing Antarctica

Congress has passed a series of laws to conserve living resources and ecosystems on Antarctica, protect marine resources in waters surrounding Antarctica and the Southern Sea, and protect mineral resources.

The Antarctic Marine Living Resources Convention Act of 1984 (P.L. 98-623; 16 U.S.C. §§2431-2444) authorized the United States to carry out its obligations under the Antarctic Marine Living Resources Convention, including the implementation of measures to conserve marine resources and the promulgation of regulations to implement the act.

The Antarctic Protection Act of 1990 (P.L. 101-594; 16 U.S.C. §§2461-2466) aimed to strengthen the environmental protection of Antarctica; prohibit mineral extraction; and urge other nations to join the United States in an agreement to ban mineral resources extraction and in the conservation and protection of ecosystems in Antarctica. Specifically, Section 4 of the law states, "it is unlawful for any person to engage in, finance, or otherwise knowingly provide assistance to any Antarctic mineral resource activity." (Under the law, the term *person* means "any individual, corporation, partnership, trust, association, or any other entity existing or organized under the laws of the United States, or any officer, employee, agent, department, or other instrumentality of the Federal Government or of any State or political subdivision thereof.")

The Antarctic Science, Tourism, and Conservation Act of 1996 (P.L. 104-227; 16 U.S.C. §§2401-2413) made it illegal (unless a permit is issued) for U.S. citizens and scientific expeditions originating from the United States to take native fauna, enter Antarctic Specially Protected Areas, introduce species to Antarctica, introduce and discharge waste, and import certain items to the United States or export them to other countries. The law established a process for obtaining permits and set civil and criminal penalties for violations. Further, the law provided that environmental impact assessments of federal activities on the continent must be done.

Antarctic Treaty System

The ATS consists of the Antarctic Treaty and a collection of agreements and conventions made to regulate relations among countries associated with Antarctica. The core of the ATS is the Antarctic Treaty; the other agreements include the Protocol on Environmental Protection to the Antarctic Treaty, the Convention for the Conservation of Antarctic Seals, and the Convention on the Conservation of Antarctic Marine Living Resources.

Antarctic Treaty

The Antarctic Treaty established the legal framework for Antarctica and guaranteed free access and research rights for the international community. The treaty was signed in 1959 and entered

us-research-and-diplomacy-southern-continent. Hereinafter, Falkner, "Antarctica."

[15] William Woitrya, Commanding Officer of the U.S. Coast Guard Polar Star, "Antarctica: U.S. Research and Diplomacy on the Southern Continent" (presentation, Wilson Center, Washington, DC, November 13, 2020), at https://www.wilsoncenter.org/event/antarctica-us-research-and-diplomacy-southern-continent; Cool Antarctica, "The USA in Antarctica: The History and Activity of the Americans in the Antarctic," at https://www.coolantarctica.com/Antarctica%20fact%20file/activity_of_USA_in_antarctica.php.

[16] See CRS Report RL34391, *Coast Guard Polar Security Cutter (Polar Icebreaker) Program: Background and Issues for Congress*, by Ronald O'Rourke.

into force in 1961, following the advice and consent of the U.S. Senate.[17] The original treaty was signed by the 12 countries active in Antarctica at the time.[18] Currently, there are 54 parties to the Antarctic Treaty; of these, 29 are consultative parties, which have the right to participate in decisionmaking, and the rest are observers.[19] Countries that conduct research in Antarctica may apply to become consultative parties. Decisions under the treaty are made by consensus among the consultative parties.

Geopolitical issues contributed to the creation of the Antarctic Treaty. At the time of the treaty's negotiation, the United States was concerned with the Soviet Union's intentions in Antarctica,[20] and seven countries held territorial claims in the region: Argentina, Australia, Chile, France, New Zealand, Norway, and the United Kingdom. Some historians note that land-grabbing and tensions over competing claims led to the treaty's creation.[21] For example, when the treaty was signed in 1959, Australia had claimed 42% of the continent and the United Kingdom, Argentina, and Chile had overlapping claims in the Antarctic Peninsula. As part of treaty negotiations, all seven countries with territorial claims set aside but did not renounce their claims.[22] (See **Figure 1** for the location of historical territorial claims.) The United States has not made a territorial claim on the continent, though it "maintains a basis to claim territory in Antarctica."[23]

[17] The Antarctic Treaty, 402 U.N.T.S. 71, entered into force June 23, 1961. Also see Department of State, "Antarctic Treaty," at https://2009-2017.state.gov/t/avc/trty/193967.htm.

[18] The countries include Argentina, Australia, Belgium, Chile, France, Japan, New Zealand, Norway, South Africa, United Kingdom, United States, and the then-Soviet Union.

[19] For a list of parties to the treaty and their consultative status, see Secretariat of the Antarctic Treaty, "Parties," at https://www.ats.aq/devAS/Parties?lang=e.

[20] Doaa Abdel-Motaal, "High North and the Antarctic," *Handbook on Geopolitics and Security in the Arctic*, ed. Joachim Weber (Springer, 2020), pp. 363-378. Hereinafter, Abdel-Motaal, "High North and the Antarctic."Abdel-Motaal, "High North and the Antarctic."

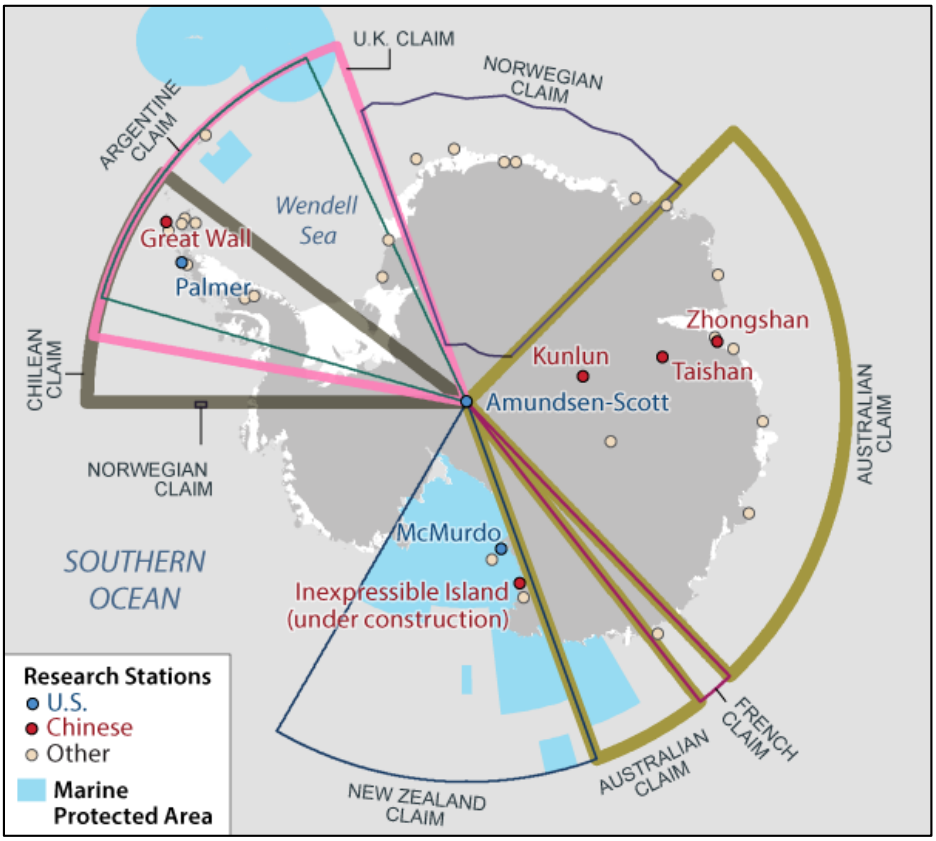
[21] Abdel-Motaal, "High North and the Antarctic."

[22] The Antarctic Treaty does not require parties to renounce previously asserted rights of or claims to territorial sovereignty in Antarctica. Article IV of the Treaty.

[23] Department of State, *Antarctic Region*, Office of Ocean and Polar Affairs, 2020, at https://www.state.gov/key-topics-office-of-ocean-and-polar-affairs/antarctic/. Hereinafter, State, "Antarctic Region."

Figure 1. Illustration of Antarctica with Historical Claims

(claims are not recognized under the Antarctic Treaty)



Sources: Illustration adapted by CRS from various sources, including Robert Keith Headland, "Territory and Claims in the Antarctic Treaty Region: A Disquisition on Historical and Recent Developments," *The Cartographic Journal*, vol. 57, no. 2 (2020), pp. 160-174; and Klaus Dodds and Alan D. Hemmings, "Polar Oceans: Sovereignty and the Contestation of Territorial and Resource Rights," in *The Earthscan Handbook of Ocean Resources and Management*, eds. Hance D. Smith, Juan L. Suárez de Vivero, and Tunday S. Agardy (Abingdon: Routledge, 2015), pp. 576-591.

Notes: Claims are illustrated by colored boundaries and are overlapping in some cases. Claims that border each other show two lines on the border. Under the Antarctic Treaty, countries set aside their claims without renouncing them. The United States has not made a claim in Antarctica and presently does not recognize foreign territorial claims in Antarctica. The section on the map not bracketed by a boundary has not been claimed. The white areas are ice shelves; the shaded areas are continental land.

The Antarctic Treaty provides the legal framework for the region south of 60º south latitude (Article VI). In its preamble, the treaty affirms that "it is in the interest of all mankind that Antarctica shall continue to be used exclusively for peaceful purposes and shall not become the scene or object of international discord."[24] Article I of the treaty states that Antarctica "shall be used for peaceful purposes only" and prohibits "any measures of a military nature." Article II states that the freedom of scientific investigation into Antarctica shall continue, and Article III stipulates that data from scientific investigations are to be shared and made freely available. The treaty, under Article IV, also provides that "no new claim, or enlargement of an existing claim, to

[24] Secretariat of the Antarctic Treaty, "The Antarctic Treaty," at https://www.ats.aq/e/antarctictreaty.html. (PDF of Antarctic Treaty text available for download at https://documents.ats.aq/ats/treaty_original.pdf.) Hereinafter, Secretariat of the Antarctic Treaty, "The Antarctic Treaty."

territorial sovereignty in Antarctica shall be asserted while the present Treaty is in force."[25] This article was a compromise for not eliminating claims altogether, according to some analysts.[26] Article V states that no nuclear explosions shall be conducted and no radioactive waste materials shall be disposed of in Antarctica.[27]

Articles VII and VIII of the Antarctic Treaty allow each party to designate observers to carry out inspections of other parties' facilities. Specifically, the treaty states that each observer "shall have complete freedom of access at any time to any or all areas of Antarctica."[28] This provision grants observers access to stations, installations and equipment, and all ships and aircraft, and it affords them the right to conduct aerial observations over any and all of Antarctica. Article IX states that in pursuit of cooperation, consultative meetings of active signatories are to be held periodically to review measures and objectives in pursuance of the treaty. Article X states that contracting parties shall ensure activities contrary to the treaty are not carried out. Article XI sets up a dispute resolution process, emphasizing that disputes are to be settled by peaceful means (such as arbitration, mediation, etc.) and not by force. Article XII provides a process for modifying the treaty, which can be done through a majority vote of consulting parties. The remaining articles provide details of ratification.[29]

Geopolitical Environment

Much has changed in global geopolitics since the Antarctic Treaty was signed in 1959. The Cold War context, during which the treaty was signed, has evolved into an era increasingly defined by the rise of China.[30] Some observers believe China's rise is altering the global geopolitical landscape and raising questions about the sustainability and future of long-standing international norms and power balances, with implications for every region of the world, including the polar regions. In addition, some believe pressure may mount to exploit the Antarctic region's resources and efforts to claim land and resources might ensue. Others argue that Chinese development (e.g., science stations, tourism) in Antarctica is proceeding peacefully under the ATS framework.[31]

China's Antarctic posture has increased dramatically since 1983, when it ratified the Antarctic Treaty.[32] China gained consultative status in 1985 and has since developed its presence on the continent through the construction of several research stations: Great Wall on King George Island (1985); Zhongshan on Larsmann Hill (1989); Kunlun on Dome A, near the center of East Antarctica (2009); and Taishan on Princess Elizabeth Land (2014). (See **Figure 1**.) Australia and China signed a bilateral memorandum of understanding deepening their Antarctic relationship

[25] Secretariat of the Antarctic Treaty, "The Antarctic Treaty."

[26] Gillian Triggs, "The Antarctic Treaty Regime: A Workable Compromise or a Purgatory of Ambiguity," *Case Western Reserve Journal of International Law*, vol. 17, no. 2 (1985), pp. 195-228.

[27] Secretariat of the Antarctic Treaty, "The Antarctic Treaty."

[28] Secretariat of the Antarctic Treaty, "The Antarctic Treaty."

[29] Secretariat of the Antarctic Treaty, "The Antarctic Treaty."

[30] For example, see Nengye Liu, "Defining the 'Rise' of China in Antarctica," *Australian Outlook* (blog), Australian Institute of International Affairs, January 24, 2019. Hereinafter, Liu, "Defining the 'Rise.'"

[31] Liu, "Defining the 'Rise."

[32] Andrew Erickson, "Capsule Review: *China as a Polar Great Power*," *Foreign Affairs*, vol. 97, no. 3 (May/June 2018); Anne-Marie Brady, *China as a Polar Great Power* (Cambridge: Cambridge University Press, 2017); David Fishman, "China's Advance into the Antarctic," *Lawfare* (blog), October 27, 2019. Hereinafter, Fishman, "China's Advance."

during President Xi Jinping's visit to Hobart, Australia, in 2014.[33] Key elements of the memorandum of understanding include China's commitment to use Australia as a gateway to Antarctica and the establishment of a joint committee to oversee cooperation.

In 2017, China released a report on its Antarctic activities, pledging more money for its own scientific research and reaffirming its stance against commercial resource extraction in the region.[34] China also hosted the 40th Antarctic Treaty meeting in Beijing in 2017. In addition, China discussed its plans to erect a fifth station on Inexpressible Island in Terra Nova Bay of the Ross Sea; the station is under construction and expected to be operational in 2022. China also has installed equipment in Antarctica related to its global satellite navigation system, Beidou.[35] The voyage of China's civilian icebreakers Xue Long and Xue Long 2 to the Southern Ocean in November 2019 reportedly was viewed in China as marking a new era of the country's Antarctic exploration.[36]

These recent activities, in addition to an increased fishing presence in the region, prompted some analysts to express concern that China is attempting to increase its influence in Antarctic governance regimes.[37] Some observers also posit that China's increasing presence could form the basis for a future territorial claim if the Antarctic Treaty is dissolved or modified.[38] Reporting from Australia has expressed concern over China's expanding presence in Antarctica and asserted that China is engaged in "undeclared military activities and mineral exploration."[39] Some observers counter this claim by noting that although the Antarctic Treaty prohibits military operations and mining on the continent, it allows scientific research, communications, and logistics, which could have military applications. They also contend there is no evidence that China eventually will overturn the Antarctic Treaty.[40]

Other countries with a presence in Antarctica also are increasing their footprints in the region through various activities.[41] Russia, for example, reportedly is exploring offshore oil and gas potential off the coast of Antarctica.[42] Russia's state-run geological survey Rosgeologia, surveyed

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[33] Australian Antarctic Program, *Australia and China Strengthen Antarctic Ties*, Australian Government, November 18, 2014, at https://www.antarctica.gov.au/news/2014/australia-and-china-strengthen-antarctic-ties/.

[34] Bai Tiantian, "China Releases 1st Antarctic Paper," *Global Times*, May 23, 2017.

[35] Pratol Jakhar, "How China's GPS Rival Beidou Is Plotting to Go Global," *BBC News*, September 20, 2018; Claire Young, "What Is China Up to in Antarctica?," *The Strategist*, September 20, 2018.

[36] Laura Zhou, "Chinese Icebreakers Set Sail for Antarctic Rendezvous That Will Herald 'New Era' of Polar Exploration," *South China Morning Post*, October 22, 2019.

[37] For example, see Gothe-Snape, "China Unchecked," and Nengye Liu, "What Does China's Fifth Research Station Mean for Antarctic Governance?" *The Diplomat*, June 28, 2018.

[38] Bryan Clark and Jesse Sloman, *Securing the Frontier: Challenges and Solutions for U.S. Polar Maritime Operations*, Center for Strategic and Budgetary Assessments, 2017, at https://csbaonline.org/uploads/documents/CSBA6303-Securing_the_Frontier_WEB.pdf. Hereinafter, Clark and Sloman, *Securing the Frontier*.

[39] Anne-Marie Brady, *China's Expanding Antarctic Interests: Implications for Australia*, Australian Strategic Policy Institute, August 2017.

[40] Nengye Liu, "The Rise of China and the Antarctic Treaty System?," *Australian Journal of Maritime & Ocean Affairs*, vol. 11, no. 2 (2019), pp. 120-131.

[41] As of May 2017, Russia reportedly had 46 ice breakers, plus 11 under construction and 4 planned. The United States had five icebreakers and three planned, and China had three icebreakers and one under construction. See "Major Icebreakers of the World," U.S. Coast Guard, at https://www.dco.uscg.mil/Portals/9/DCO%20Documents/Office%20of%20Waterways%20and%20Ocean%20Policy/20170501%20major%20icebreaker%20chart.pdf?ver=2017-06-08-091723-907, as referenced in Charlie Gao, "Russia's Icebreaker Fleet Is About to Get Bigger and More Dangerous," *The Buzz* (blog), *The National Interest*, September 30, 2019.

[42] In early 2020, Russia reportedly conducted its first seismic survey in Antarctica since the late 1990s. Feiger and

coastal areas off Antarctica's Queen Maud Land "to assess the offshore oil and gas potential of the area."[43] The ATS bans oil and gas exploration in and around Antarctica but allows for scientific research, which might include these activities.[44] Some analysts note that Russia's activities could be viewed as potentially destabilizing and might cause concern that Russia aims to claim oil and gas resources in the region when the ban on mineral extraction comes up for review in 2048. (See section on "Mineral Resources," below, for more information.)

Natural Environment

The continent of Antarctica has an area of 5.1 million square miles (13.2 million square kilometers), equal to approximately one-tenth of the Earth's land surface. Antarctica is surrounded by the Southern Ocean and covered in ice. It is the coldest, windiest, and driest continent on earth, receiving approximately 2 inches per year of precipitation averaged over the continent.[45] The glacial ice that covers more than 90% of the continent has accumulated over millions of years and averages 7,087 feet (2,160 meters) in thickness, making Antarctica the highest continent in the world.[46] The Antarctic Ice Sheet (see glossary of key terms in the report) is estimated to be about 6 million cubic miles; it contains 90% of the world's ice and 70% of the world's freshwater.[47] The Antarctic region is home to penguins, whales, seals, sea lions, mosses, algae, kelp, invertebrates, krill, and other marine communities.[48]

Climate Change and Air Temperatures

Antarctica's unique characteristics contribute to its susceptibility to the effects of climate change. Additionally, the volume of freshwater contained in its ice sheet makes it a potentially important contributor to rising sea levels in this century and after.

Climate research on the continent reveals complex interactions between oceanic and atmospheric circulation, the stratospheric ozone layer, annual snow levels, and long-term temperature trends. Studies report that some regions—including Western Antarctica and the Antarctic Peninsula—are experiencing potentially record high air temperatures, whereas other regions in Antarctica continue to show high variability and no significant trends in temperature over time.[49] For

Wilson, "Countries Taking Advantage."

[43] Robert Perkins and Rosemary Griffin, "Russia Stokes Political Tensions with Hunt for Antarctic Oil," S&P Global Platts, February 21, 2020, at https://www.spglobal.com/platts/en/market-insights/latest-news/oil/022120-russia-stokes-political-tensions-with-hunt-for-antarctic-oil. Hereinafter, Perkins and Griffin, "Russia Stokes Political Tensions."

[44] Perkins and Griffin, "Russia Stokes Political Tensions."

[45] Precipitation is not evenly distributed across the continent.

[46] NSF, Office of Polar Programs (OPP), "Ice Sheets," 2020, at https://www.nsf.gov/geo/opp/antarct/science/icesheet.jsp. Hereinafter, NSF, OPP, "Ice Sheets."

[47] NSF, OPP, "Ice Sheets."

[48] Australian Antarctic Program, "About Antarctica," April 30, 2019, at https://www.antarctica.gov.au/about-antarctica/.

[49] Kyle R. Clem et al., "Record Warming at the South Pole During the Past Three Decades," *Nature Climate Change*, vol. 10, (2020), pp. 762-770 (hereinafter, Clem et al., "Record Warming at South Pole"); M. K. Obryk et al., "Climate From the McMurdo Dry Valleys, Antarctica, 1986-2017: Surface Air Temperature Trends and Redefined Summer Season," *Journal of Geophysical Research: Atmospheres*, vol. 125, (2020) (hereinafter Obryk et al., "Climate from McMurdo Dry Valleys"); Turner et al., "Antarctic Temperature Variability and Change from Station Data," *International Journal of Climatology*, vol. 40, (2019), pp. 2986-3007 (hereinafter, Turner et al., "Antarctic Temperature Variability"); Wang et al., "Internal Variability in Multidecadal Trends of Surface Air Temperature over Antarctica in Austral Winter in Model Simulations," *Climate Dynamics*, vol. 55, (2020), pp. 2835-2847 (hereinafter, Wang et al.,

example, in February 2020, the Argentine research base Esperanza, located on the northern tip of the Antarctic Peninsula, reported a record high temperature of 65.1°F (18.4°C), topping the 2015 record of 63.5°F (17.5°C).[50] The Esperanza base has been recording temperatures since 1953.[51] Also in February 2020, a Brazilian research station on Seymour Island reported a high temperature of 69.3°F (20.75°C).[52] (Neither temperature has been verified by the World Meteorological Organization as a record high.[53]) Longer-term trends in surface air temperature however, vary across the continent. According to the 2019 Intergovernmental Panel on Climate Change (IPCC) *Special Report on the Ocean and Cryosphere in a Changing Climate* (hereinafter referred to as the IPCC Special Report):

> In contrast to the Arctic, the Antarctic continent has seen less uniform temperature changes over the past 30–50 years, with warming over parts of West Antarctica and no significant overall change over East Antarctica (Nicolas and Bromwich, 2014; Jones et al., 2016; Turner et al., 2016), though there is *low confidence* in these changes given the sparse *in situ* records and large interannual to interdecadal variability.[54]

Generally, researchers note the complexities of isolating the extent to which human-induced warming plays a role. Other factors influencing long-term surface air temperature trends include atmospheric circulation, ocean warming, albedo, and stratospheric ozone, among others.[55] Researchers note that increasing surface air temperatures may be due in part to warm tropical air moving over Antarctica because of natural variations in atmospheric circulation cycles.[56] They state that these observed trends are within the upper bounds of natural variability and note that increasingly warm tropical air, combined with climate variability and oscillations in the Western Pacific, highlight the complex nature of air temperature trends on the continent.[57] Rising temperatures can increase glacial melting, may destabilize portions of the ice sheet, and may affect the habitats of native flora and fauna on the continent.

"Internal Variability in Multidecadal Trends").

[50] World Meteorological Organization, "New Record for Antarctic Continent," February 14, 2020, at https://public.wmo.int/en/media/news/new-record-antarctic-continent-reported.

[51] World Meteorological Organization, "WMO Region VII (Antarctica mainland & adjoining islands): Highest Temperature," at https://wmo.asu.edu/content/antarctica-highest-temperature-continent.

[52] Jonathan Watts, "Antarctic Temperature Rises Above 20°C for the First Time on Record," *Guardian*, February 13, 2020, at https://www.theguardian.com/world/2020/feb/13/antarctic-temperature-rises-above-20c-first-time-record.

[53] World Meteorological Organization, "WMO Region VII (Antarctica mainland & adjoining islands): Highest Temperature," at https://wmo.asu.edu/content/antarctica-highest-temperature-continent.

[54] Meredith et al., "Polar Regions" in *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*, Intergovernmental Panel on Climate Change (IPCC), 2019, pg. 212, at https://www.ipcc.ch/srocc/chapter/chapter-3-2/. Hereinafter, Meredith et al., IPCC Special Report Chapter 3, "Polar Regions." For an explanation on the use of calibrated language to communicate confidence and likelihood in the IPCC Special Report see Abram et al., "Framing and Context of the Report" in IPCC, *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*, 2019, at https://www.ipcc.ch/srocc/chapter/chapter-1-framing-and-context-of-the-report/1-9approaches-taken-in-this-special-report/.

[55] For example, see Clem et al., "Record Warming at South Pole"; Obryk et al., "Climate from McMurdo Dry Valleys"; Turner et al., "Antarctic Temperature Variability"; Wang et al., "Internal Variability in Multidecadal Trends"; and Meredith et al., IPCC Special Report Chapter 3, "Polar Regions."

[56] Clem et al., "Record Warming at South Pole."

[57] Clem et al., "Record Warming at South Pole" and Chelsea Harvey, "Why Is the South Pole Warming So Quickly? It's Complicated," *E&E News*, June 30, 2020, at https://www.eenews.net/climatewire/2020/06/30/stories/1063477465.

Melting Ice

Antarctica holds substantial water resources in its ice sheet. As a result, some scientists assert that the continent represents a significant potential source for global sea-level rise under current and future warming conditions.[58]

When conducting research on polar ice, scientists measure both *sea ice extent*, comprised of frozen ocean water, and *ice sheet mass*, comprised of freshwater. The surface of the ocean around Antarctica freezes over in the winter and melts in the summer. The surface area of freezing ice over the ocean is *sea ice extent*. Ice sheets (grounded on land) gain mass largely through snowfall and lose mass through evaporation, iceberg calving, and melting.[59]

Table 1. Glossary of Key Terms

Ice Sheet	An *ice sheet* is a mass of glacial land ice (freshwater) extending more than 50,000 square kilometers (20,000 square miles). The two ice sheets on Earth today cover most of Greenland and Antarctica.
Ice Shelf	An *ice shelf* is a floating sheet of ice (freshwater) that forms where a glacier or ice flows into the sea. The shelf extends from the land and into the sea. Gravity drives the movement of ice from the land to the shelf. Ice shelves lose mass when chunks break off into the sea. The Antarctic Ice Sheet includes ice shelves that are an extension of the ice sheet. When ice shelves collapse or break off, they become icebergs and are no longer part of the ice sheet.
Sea Ice	*Sea ice* is frozen ocean water. It forms, grows, and melts in the ocean. For most of the year, sea ice typically is covered with snow. The area of sea ice in a region is measured as *sea ice extent*.
Glacier	A *glacier* is mass of ice (freshwater) that originates on land and shows some type of present or historical movement. A glacier can be part of an ice sheet.
Global Sea Level	*Global sea level* is the average height of the Earth's oceans, as measured by satellite altimetry relative to a calculated reference ellipsoid.
Relative Sea Level	*Relative sea level* refers to the elevation of sea level relative to the land surface from which it is measured. In many parts of the U.S. coastline and the coastlines of other countries, the elevation of the land surface is changing, due to a number of different causes. A change in relative sea level represents the combination of the change in land surface elevation and the change in global sea level.
Sea-Level-Rise Equivalent	*Sea-level-rise equivalent* is the change in global average sea level that would occur if a given amount of water or ice were added to or removed from the oceans.

Sources: CRS Report R44632, *Sea-Level Rise and U.S. Coasts: Science and Policy Considerations*, by Peter Folger and Nicole T. Carter; National Snow and Ice Data Center, "All About Sea Ice," April 3, 2020, at https://nsidc.org/cryosphere/seaice/index.html.

[58] Garbe, "Antarctic Ice Sheet."

[59] Michon Scott, "Antarctica Is Colder Than the Arctic, But It Is Still Losing Ice," National Oceanic and Atmospheric Administration (NOAA), March 12, 2019, at https://www.climate.gov/news-features/features/antarctica-colder-arctic-it%E2%80%99s-still-losing-ice. There are three methods to measure ice sheet mass: (1) the *mass budget/component method*, comparing melt outflow to snowfall accumulation; (2) the *volume change/geodetic method*, measuring changes in glacier elevation; and (3) the *gravimetric method*, detecting changes in the Earth's gravity field over the ice sheet to measure balance. These methods are largely calculated through indirect measurements made from satellites.

Changing Mass of the Antarctic Ice Sheet and Glaciers

In multiple studies, scientists have concluded that rates of ice loss from the land-based Antarctic Ice Sheet have increased in the early 21st century. The 2019 IPCC Special Report stated that Antarctica likely has cumulatively lost ice mass since widespread measurements began in 1992, with an increase in ice loss occurring around 2006.[60] Specifically, according to the 2019 IPCC Special Report, it is extremely likely that the 2012-2016 losses of ice mass in Antarctica were greater than those from 2002 to 2011 and likely were greater than those from 1992 to 2001. The IPCC Special Report characterized the contribution of the West Antarctic Ice Sheet to ice loss as follows: "Antarctic ice loss is dominated by acceleration, retreat and rapid thinning of major West Antarctic Ice Sheet (WAIS) outlet glaciers (*very high confidence*), driven by melting of ice shelves by warm ocean waters (*high confidence*)."[61]

Recent studies support that ice mass is largely decreasing in Western Antarctica and remaining steady or gaining in Eastern Antarctica, contributing to an aggregate loss of ice mass across the continent.[62] For example, using the component method,[63] researchers concluded that, between 1979 and 2017, the Antarctic Ice Sheet lost mass at an increasing rate overall, with most of the accelerated loss in West Antarctic.[64]

Ice mass loss in Western Antarctica is due, in part, to glacial retreat in the region.[65] In this region, ice mass loss is occurring in the Amundsen Sea Embayment (**Figure 2**), which includes glaciers such as the Pine Island and Thwaites Glaciers. Recent estimates indicate the Thwaites is losing around 50 billion tons of ice per year.[66] The International Thwaites Glacier Collaboration (ITGC), using NASA data, calculated that melting ice from this glacier alone is responsible for approximately 4% of annual global sea-level rise. The ITGC and others note the potential for a collapsing Thwaites to contribute significantly to global sea-level rise.[67]

The causes behind ice mass loss in Western Antarctica may be varied. Two studies mapped subglacial meltwater channels beneath the Thwaites Glacier and indicated these channels offer pathways for warm seawater to travel beneath the ice sheet and hasten melting.[68] The IPCC

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[60] Meredith et al., IPCC Special Report Chapter 3, "Polar Regions," p. 206.

[61] Meredith et al., IPCC Special Report Chapter 3, "Polar Regions," p. 206.

[62] Susheel Adusumilli et al., "Interannual Variations in Meltwater Input to the Southern Ocean from Antarctic Ice Shelves," *Nature Geoscience*, vol. 13 (September 2020), pp. 616-620; and Ben Smith et al., "Pervasive Ice Sheet Mass Loss Reflects Competing Ocean and Atmospheric Processes," *Science*, vol. 368, no. 6496 (April 30, 2020), pp. 1239-1242. Hereinafter, Smith et al., "Pervasive Ice Sheet Mass Loss."

[63] The component method compares accumulated snowfall in the interior of Antarctica with ice discharging at the grounding line (where the ice meets the ocean and detaches). See Eric Rignot, "Four Decades of Antarctic Ice Sheet Mass Balance from 1979–2017," *Proceedings of the National Academy of Sciences*, vol. 116, no. 4 (January 22, 2019), pp. 1095-1103. Hereinafter, Rignot, "Four Decades of Antarctic Ice."

[64] Rignot, "Four Decades of Antarctic Ice."

[65] *Glacial retreat* is when the terminus end of a glacier recedes or retreats due to ice melting or ablating more quickly than new glacial ice forming.

[66] Meredith et al., IPCC Special Report Chapter 3, "Polar Regions," p. 237; International Thwaites Glacier Collaboration, "Thwaites Glacier Facts," June 2020, at https://thwaitesglacier.org/sites/default/files/2020-09/ThwaitesGlacierFactsSheetJune2020_1.pdf.

[67] International Thwaites Glacier Collaboration, "Thwaites Glacier Facts," June 2020, at https://thwaitesglacier.org/sites/default/files/2020-09/ThwaitesGlacierFactsSheetJune2020_1.pdf; Jeff Tollefson, "First Look Under Imperiled Antarctic Glacier Finds Warm Water Coming from all Directions," *Nature*, vol. 578, (February 20, 2020), p. 500.

[68] Kelly A. Hogan et al., "Revealing the Former Bed of Thwaites Glacier Using Sea-Floor Bathymetry: Implications for Warm-Water Routing and Controls on Ice Flow and Buttressing," *The Cryosphere*, vol. 14 (September 9, 2020), pp. 2883-2908; Tom A. Jordan et al., "New Gravity-Derived Bathymetry for the Thwaites, Crosson, and Dotson Ice

Special Report also noted that recent Antarctic ice loss is being driven by sub-ice oceanic melting of ice shelves.[69] Scientists report that higher surface temperatures, changes in ocean heat content linked to atmospheric conditions in the Southern Hemisphere, and potential volcanic activity under glaciers in Antarctica can cause ice shelves to shrink and, in some cases, calve into the ocean.[70] Additionally, recent research indicates that structural weakening—such as open crevasses and fractures—of the Pine Island and Thwaites Glaciers may play a role in accelerating instability and eventual ice loss.[71]

Projections of future ice-sheet melting in Antarctica beyond 2100—including the potential for irreversible ice loss—carry uncertainty. (See **Figure 2** below.) The IPCC Special Report stated, "Evolution of the AIS [Antarctic Ice Sheet] beyond the end of the 21st century is characterized by deep uncertainty as ice sheet models lack realistic representations of some of the underlying physical processes";[72] the report also noted that "partitioning between natural and human drivers of atmospheric and ocean circulation changes remains very uncertain."[73] Some scientists contend that more bathymetric data around Antarctica would help them to understand the formation of ice shelves and model changes in the ice sheet over time.[74] Others note that better estimates of Antarctica's past contributions to sea-level rise from portions of its ice sheet, as well as more accurate models of ice-shelf and ocean interactions and the evolution of these interactions over time, would lower the uncertainty of projections of future ice-melting rates in Antarctica.[75] One study examined the potential "tipping points," or moments when ice losses become irreversible; its researchers concluded that "the Antarctic Ice Sheet exhibits a multitude of temperature thresholds beyond which ice loss is irreversible."[76] Another study highlighted the uncertainties surrounding predicting the location and timing of such tipping points but noted that certain parts of the Western Antarctic Ice Sheet may experience irreversible ice loss as a result of a warming climate.[77] The IPCC Special Report emphasized the potential for irreversible ice loss in the future but noted that observational data is lacking to support this claim. Specifically, the IPCC stated

> There is *limited evidence* and high agreement that recent Antarctic Ice Sheet (AIS) mass losses could be irreversible over decades to millennia. Rapid mass loss due to glacier flow acceleration in the Amundsen Sea Embayment (ASE) of West Antarctica and in Wilkes Land, East Antarctica, may indicate the beginning of Marine Ice Sheet Instability (MISI),

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Shelves Revealing Two Ice Shelf Populations," *The Cryosphere*, vol. 14 (September 9, 2020), pp. 2869-2882.

[69] Oppenheimer et al., IPCC Special Report Chapter 4, "Sea Level Rise," p. 346.

[70] David M. Holland, Keith W. Nicholls, and Aurora Basinski, "The Southern Ocean and Its Interaction with the Antarctic Ice Sheet," *Science*, vol. 367, no. 6484 (March 20, 2020), pp. 1326-1330; Johannes J. Furst et al., "The Safety Band of Antarctic Ice Shelves," *Nature Climate Change*, vol. 6 (2016), pp. 479-482; and Brice Loose et al., "Evidence of an Active Volcanic Heat Source Beneath the Pine Island Glacier," *Nature Communications*, vol. 9 (2018); Mattis Auger et al., "Southern Ocean In-situ Temperature Trends over 25 Years Emerge from Interannual Variability," *Nature Communications*, vol. 12, no. 514, (January, 21, 2021), pp. 1-9.

[71] Lhermitte et al., "Damage Accelerates Ice Shelf Instability and Mass Loss in Amundsen Sea Embayment," *Proceedings of the National Academies of Sciences*, vol. 117, no. 40, (October 6, 2020), pp. 24735-24741.

[72] Oppenheimer et al., IPCC Special Report Chapter 4, "Sea Level Rise," p. 324.

[73] Meredith et al., IPCC Special Report Chapter 3, "Polar Regions," p. 240.

[74] *Bathymetric data* is information about the depths and shapes of underwater terrain. Taryn L. Noble et al., "Antarctica in a Changing Climate," *Editors' Vox* (blog), EOS, November 12, 2020, at https://eos.org/editors-vox/antarctica-in-a-changing-climate. Hereinafter, Noble, "Antarctica Climate."

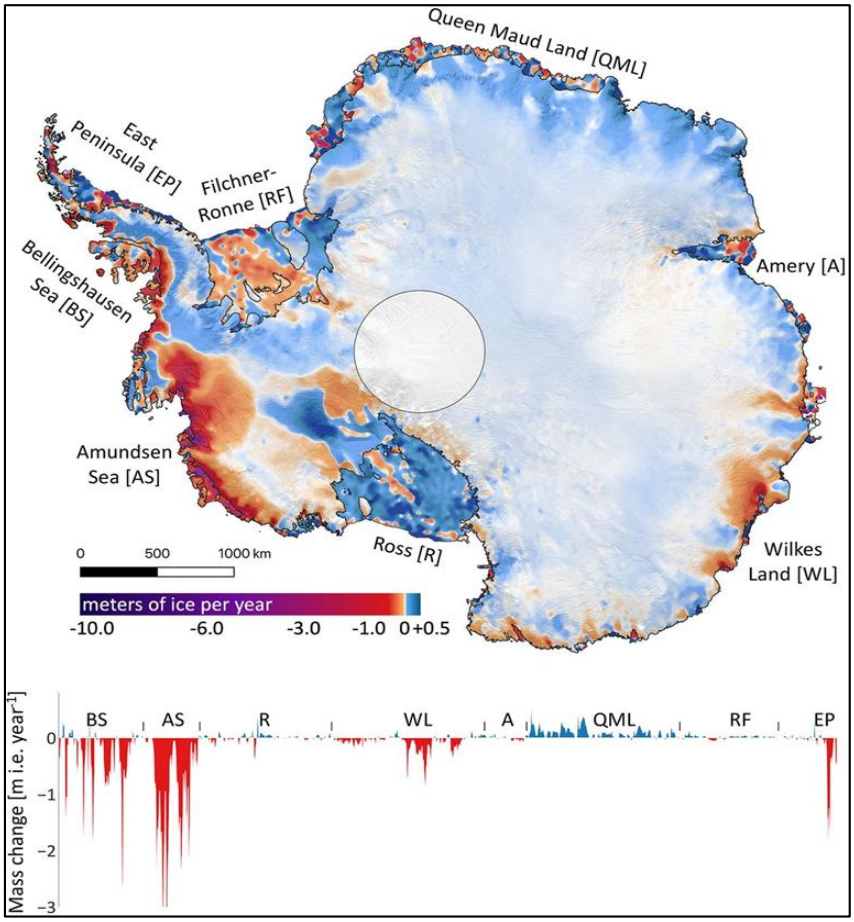
[75] Noble, "Antarctica Climate."

[76] Garbe, "Antarctic Ice Sheet."

[77] Frank Pattyn and Mathieu Morlighem, "The Uncertain Future of the Antarctic Ice Sheet," *Science*, vol. 367, no. 6484, (March 20, 2020), pp. 1331-1335, at https://science.sciencemag.org/content/367/6484/1331.

but observational data are not yet sufficient to determine whether these changes mark the beginning of irreversible retreat.[78]

Figure 2. Ice Mass Changes in Antarctica, 2003-2019



Source: Ben Smith et al., "Pervasive Ice Sheet Mass Loss Reflects Competing Ocean and Atmospheric Processes," *Science*, vol. 368, no. 6496 (April 30, 2020), pp. 1239-1242. (Used with permission.)

Note: Note the higher levels of change in the Amundsen Sea (AS) and the Bellingshausen Sea (BS), both in Western Antarctica.

Melting Ice and Sea-Level Rise

Melting ice from glaciers and ice sheets can contribute directly to global sea-level rise if the melting ice runs off land surfaces.[79] Ice shelves in Antarctica play a role in ice sheet dynamics. They buttress the outflow of melted grounded ice upstream and when they calve or disintegrate, they allow grounded ice and shelf ice to flow faster into the ocean. Grounded ice flowing into the ocean contributes to sea-level rise.[80] (Note that floating ice shelves are already in the water and do

[78] Meredith et al., IPCC Special Report Chapter 3, "Polar Regions," p. 206.

[79] For more information on sea-level rise, see CRS Report R44632, *Sea-Level Rise and U.S. Coasts: Science and Policy Considerations*, by Peter Folger and Nicole T. Carter. Melting sea ice does not contribute directly to sea-level rise.

[80] Oppenheimer et al., IPCC Special Report Chapter 4, "Sea Level Rise," p. 331.

not directly contribute to sea-level rise.) Ice shelves lose mass through calving and melting from below, especially when they are in contact with warmer ocean water.

The volume of ice contained within the Antarctic Ice Sheet is substantial; melting of portions of the ice sheet could contribute substantially to global sea-level rise over the centuries. Thus, the fate of this ice mass makes it a concern to countries that would be affected by sea-level rise.[81] (See textbox on Potential National Security Implications of Sea-Level Rise.) The IPCC Special Report stated

> Global mean sea level (GMSL) is rising, with acceleration in recent decades due to increasing rates of ice loss from the Greenland and Antarctic ice sheets (*very high confidence*), as well as continued glacier mass loss and ocean thermal expansion. Increases in tropical cyclone winds and rainfall, and increases in extreme waves, combined with relative sea level rise, exacerbate extreme sea level events and coastal hazards (*high confidence*).[82]

According to the 2019 IPCC Special Report, sea levels have risen at a rate of approximately 1-2 millimeters per year (mm/yr) in most regions over the past century.[83] However, rates of approximately 3-4 mm/yr were experienced recently (2006-2015). By the end of the century, these rates are projected to increase to 4-9 mm/yr under low-emissions scenarios (RCP2.6) and 10-20 mm/yr under high-emissions scenarios (RCP8.5).[84] According to the 2019 IPCC Special Report, uncertainty in climate change-driven future sea-level rise up to 2050 is relatively small; however, beyond 2050, uncertainty in sea-level rise increases substantially.[85]

Net loss of ice mass in Antarctica is contributing to global mean sea-level rise. From 1993 to 2015, the Antarctic Ice Sheet and peripheral glaciers contributed approximately 9% to the estimated average rate of annual sea-level rise.[86] From 2006 to 2015, however, the Antarctic Ice Sheet and peripheral glaciers contributed approximately 12% to the estimated average rate of annual sea-level rise, indicating an average annual increase in Antarctica's contribution to sea-level-rise equivalent.[87] The greatest present-day contribution to sea-level rise from Antarctica comes from grounded ice mass loss and the thinning of floating ice shelves, both in Western Antarctica; both sources allow more ice to flow from the interior to the ocean.[88]

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[81] Rignot, "Four Decades of Antarctic Ice."

[82] H.-O. Pörtner et al., "Summary for Policymakers," in *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*, IPCC, 2019, p. 10. Hereinafter, Pörtner et al., IPCC Special Report, "Summary."

[83] Oppenheimer et al., IPCC Special Report Chapter 4, "Sea Level Rise," p. 327.

[84] Oppenheimer et al., IPCC Special Report Chapter 4, "Sea Level Rise," p. 327. RCP 2.6 and RCP 8.5 are greenhouse-gas-emission scenarios used by the IPCC to calculate projections. According to the IPCC, "RCP2.6 represents a low greenhouse gas emissions, high mitigation future, that in CMIP5 simulations gives a two in three chance of limiting global warming to below 2ºC by 2100. By contrast, RCP8.5 is a high greenhouse gas emissions scenario in the absence of policies to combat climate change, leading to continued and sustained growth in atmospheric greenhouse gas concentrations." Taken from Pörtner et al., IPCC Special Report, "Summary," Box SPM.1.

[85] Oppenheimer et al., IPCC Special Report Chapter 4, "Sea Level Rise," p. 327.

[86] The percentage is derived from the observed global mean sea level from tidal gauges and altimetry provided in Table 4.1 in Oppenheimer et al., IPCC Special Report Chapter 4, "Sea Level Rise," p. 336.

[87] The percentage is derived from the observed global mean sea level from tidal gauges and altimetry provided in Table 4.1 in Oppenheimer et al., IPCC Special Report Chapter 4, "Sea Level Rise," p. 336.

[88] Smith et al., "Pervasive Ice Sheet Mass Loss."

The Greenland ice sheet currently contributes more to sea-level rise than the Antarctic Ice Sheet. Some scientists assert that the Antarctic Ice Sheet could contribute more to global sea-level rise by the end of century, due to the rate of projected ice mass loss discussed above.[89]

Some scientists have attempted to assess the potential future contribution to global sea-level rise from melting ice in Antarctica. Antarctica's contribution to global sea-level rise leading to 2100 and beyond is one of the more significant uncertainties in projections of sea-level rise under various climate change scenarios, in part due to uncertainties related to the timing and effects of ice sheet instability in Antarctica.[90] According to scientists, uncertainty related to ice sheet instability arises from limited observations; inadequate model representation of ice sheet processes; and a limited understanding of the interactions between the atmosphere, ocean, and ice sheets.[91] Although the 2019 IPCC Special Report used median estimates of Antarctica's contribution of 0.04 meters and 0.12 meters of sea-level rise (from a baseline of 1986 to 2005 levels) in 2100 as likely for low-emissions (RCP2.6) and high-emissions scenarios (RCP8.5), respectively,[92] an overview of different studies shows a wide variation for median estimates for Antarctica's contribution during this and the next century.[93]

Other studies refer to the geological record to estimate the potential for Antarctica to contribute to sea-level rise. For example, one study reports that ice sheets in Eastern Antarctica collapsed 400,000 years ago, when carbon dioxide levels in the atmosphere were 300 parts per million (ppm).[94] Current levels of carbon dioxide in the atmosphere are near 410 ppm, which leads some scientists to project greater levels of sea-level rise from ice melting in Antarctica than the collapse 400,000 years ago.[95]

Potential National Security Implications of Sea-Level Rise

Measuring and projecting the contribution to global sea-level rise from regions such as Antarctica is key to understanding how sea-level rise may affect coastal societies and raise national security concerns. Sea-level rise causes increased flooding (i.e., overall and due to storm events), coastal erosion for erodible coastlines, and increased salinity of groundwater resources in low-lying coastal areas. Approximately 600 million people live in coastal areas that are less than 10 meters above sea level, leading some scientists to claim that any level of sea-level rise could displace millions of people. Some policymakers assert that these effects could displace communities, alter infrastructure (e.g., ports), and be costly. These warnings are tempered by some studies that question whether sea-level rise would cause large-scale migrations and affect infrastructure in many coastal areas.

[89] Pörtner et al., IPCC Special Report, "Summary," B.1.2 and B.3.1.

[90] Pörtner et al., IPCC Special Report, "Summary," B.3.1 and Jonathan L. Bamber et al., "Ice Sheet Contributions to Future Sea-Level Rise from Structured Expert Judgement," *Proceedings of the National Academy of Sciences*, vol. 116, no. 23 (2019), pp. 11195-11200.

[91] Pörtner et al., IPCC Special Report, "Summary," A.3.3.

[92] Oppenheimer et al., IPCC Special Report Chapter 4, "Sea Level Rise," Table 4.4, p. 352. Estimated projections and their variability are based on expert elicitation.

[93] Oppenheimer et al., IPCC Special Report Chapter 4, "Sea Level Rise," Table 4.3, p. 351. Note that median or other estimates depend in part on the emissions and climate scenarios assumed; the RCPs in particular are not predictions or projections.

[94] Over long time scales, including during the current ice age, factors in addition to CO_2 concentrations in the atmosphere have at various time dominated influences on the climate system. See, for example, Christopher J. Campisano, "Milankovitch Cycles, Paleoclimatic Change, and Hominin Evolution | Learn Science at Scitable," *Nature Education*, 2012, at https://www.nature.com/scitable/knowledge/library/milankovitch-cycles-paleoclimatic-change-and-hominin-evolution-68244581/.

[95] T. Blackburn et al., "Ice Retreat in Wilkes Basin of East Antarctica During a Warm Interglacial," *Nature*, vol. 583 (July 22, 2020), pp. 554-559; and Douglas Fox, "Biggest Ice Sheet on Earth More Vulnerable to Melting Than Thought," *National Geographic*, July 22, 2020, at https://www.nationalgeographic.com/science/2020/07/east-antarctic-ice-sheet-more-vulnerable-to-melting-than-thought/.

Some policymakers argue that some coastal communities may adapt to sea-level rise rather than migrate elsewhere.

Potential sea-level rise effects could exacerbate other factors that could lead to various national security concerns. For example, the 2012 *Department of Homeland Security Climate Change Adaptation Roadmap* notes that "in U.S. coastal regions, rising sea levels, higher storm surge, and increased erosion could damage or destroy critical infrastructure," and the 2015 *National Security Strategy* states that "increased sea levels and storm surges threaten coastal regions, infrastructure, and property." Other government reports and studies have echoed these findings. For example, some experts contend the effects of sea-level rise are diverse and could range from altering the territorial integrity of nations to the exacerbating the effects of disasters for economies, cultures, and societies. Further, reports state that critical infrastructure, major military installations, and hurricane evacuation routes are increasingly vulnerable to impacts, such as higher sea levels, storm surges, and flooding exacerbated by climate change.

These effects are relevant for the United States and for other countries in the world. In his statement for the record before the Senate Select Committee on Intelligence in January 2019, President Trump's Director of National Intelligence, Daniel Coats, pointed out the following: "Extreme weather events, many worsened by accelerating sea level rise, will particularly affect urban coastal areas in South Asia, Southeast Asia, and the Western Hemisphere. Damage to communication, energy, and transportation infrastructure could affect low-lying military bases, inflict economic costs, and cause human displacement and loss of life."

Sources: Mathew E. Hauer et al., "Sea-Level Rise and Human Migration," *Nature Reviews: Earth and Environment*, vol. 1 (December 9, 2019), pp. 28-39; Dominic Kniveton, "Sea-Level Rise Impacts: Questioning Inevitable Migration," *Nature Climate Change*, vol. 7 (2017), pp. 548-549; "Findings from Select Federal Reports: The National Security Implications of a Changing Climate," White House, May 2015; Daniel Coats, Director of National Intelligence, in U.S. Congress, Senate Select Committee on Intelligence, *Worldwide Threat Assessment of the U.S, Intelligence Community*, statement for the record, January 29, 2019; Rob Jordan, "Bracing for Sea Level Rise to Boost National Security," Woods Institute for the Environment, Stanford University, June 26, 2018.

Sea Ice Extent

Sea ice extent is one of several ice-related metrics used to track climate change in polar regions. When sea ice melts, it does not add to the mass of ocean water and therefore does not contribute directly to sea-level rise. Scientists have measured sea ice extent in Antarctica using satellites since the 1970s (a period referred to as the *satellite era*). The 2019 IPCC Special Report concluded that "[i]t is very likely that Antarctic sea ice cover exhibits no significant trend over the period of satellite observations (1979–2018)."[96]

For most of the satellite era, the data show high year-to-year variability in the lowest daily sea ice extent of the year; scientists attribute this variability to a variety of potential drivers.[97] (See **Figure 3**.) However, since 2010, the variability has increased, with record high sea ice extent in 2012, 2013, and 2014 and record low sea ice extent in 2017 and 2018.[98] The 2020 minimum extent was below the 1981-2010 climatological average but above the record low recorded in 2017.[99] These data are based on the relatively short duration of satellite data available (approximately 40 years); consequently, the longer-term trends in sea ice extent are less certain.

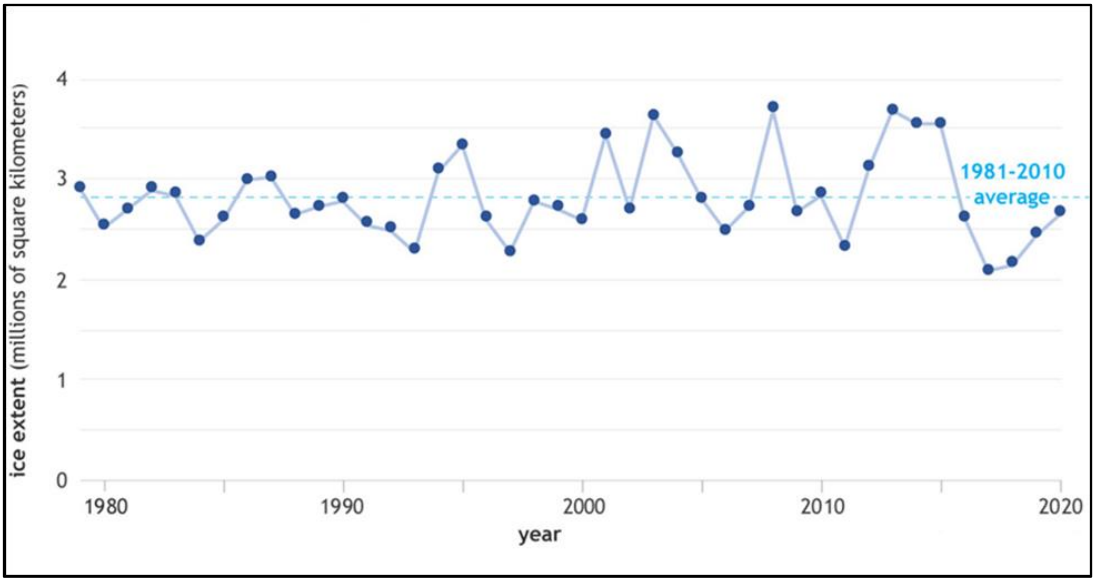
[96] Meredith et al., IPCC Special Report Chapter 3, "Polar Regions," pp. 205-206.

[97] Michon Scott, "Understanding Climate: Antarctic Sea Ice Extent," NOAA, April 28, 2020, at https://www.climate.gov/news-features/understanding-climate/understanding-climate-antarctic-sea-ice-extent. Hereinafter, Scott, "Antarctic Sea Ice Extent."

[98] Scott, "Antarctic Sea Ice Extent."

[99] Scott, "Antarctic Sea Ice Extent."

Figure 3. Antarctica's Lowest Daily Sea Ice Extent of the Year (1979-2020)



Source: National Oceanic and Atmospheric Administration (NOAA), "Understanding Climate: Antarctic Sea Ice Extent," April 28, 2020, at https://www.climate.gov/news-features/understanding-climate/understanding-climate-antarctic-sea-ice-extent.

Notes: Graph depicts each year's minimum sea ice extent since the start of the satellite record (1979). Extent is the total area where the ice concentration is 15% or higher. Data from the National Snow and Ice Data Center.

Biodiversity

Antarctica is experiencing habitat alteration, invasive species, pollution, and, according to some stakeholders, natural resources exploitation.[100] One study reports that although most of Antarctica can be considered wilderness (99.6%-100%),[101] pristine areas free from human influence comprise less than 32% of the continent.[102] Human- and climate-driven factors affect biodiversity and fisheries in the Antarctic region. For example, more than half of the 18 species of penguins globally are in decline, including four species in the subantarctic region.[103] King penguin populations are increasing in Antarctica, and Royal and Gentoo penguin species are stable.[104] (See **Figure 4** for the projected status of emperor penguin colonies and textbox on Emperor penguins for more discussion.)

[100] Hannah S. Wauchope, Justine D. Shaw, and Aleks Terauds, "A Snapshot of Biodiversity Protection in Antarctica," *Nature Communications*, vol. 10, no. 946 (2019), p. 946. Hereinafter, Wauchope et al., "Biodiversity Protection in Antarctica."

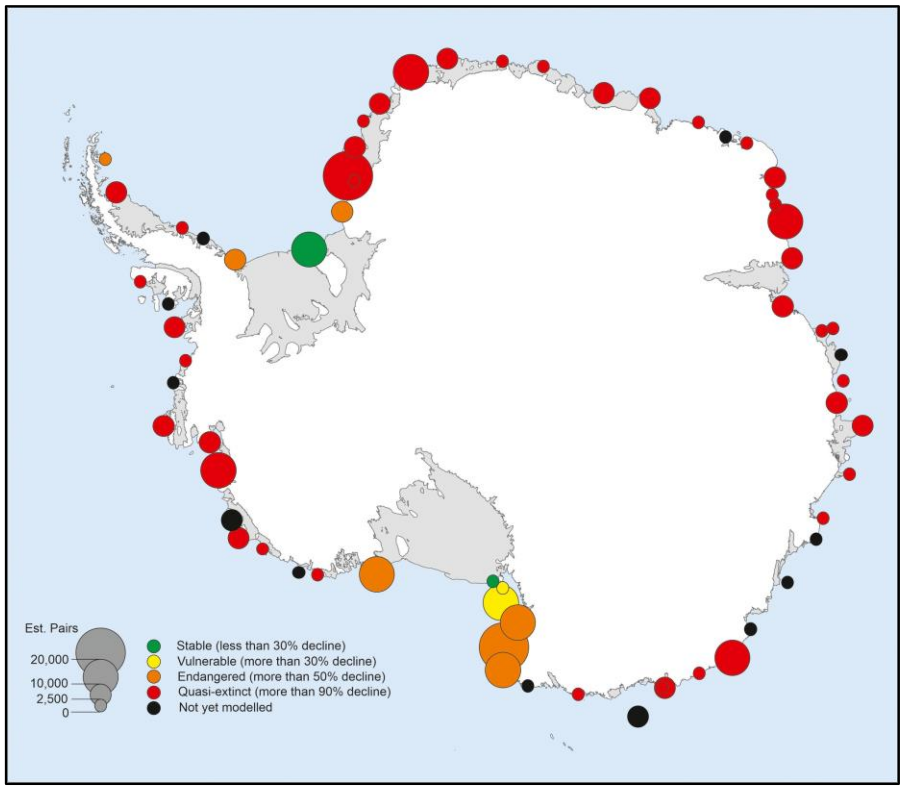
[101] This study used four definitions of wilderness to determine this figure. In general, the figure represents the percentage of the continent that has retained its intact, pristine natural ecosystems.

[102] Rachel I. Leihy et al., "Antarctica's Wilderness Fails to Capture Continent's Biodiversity," *Nature*, vol. 583 (July 15, 2020), pp. 567-571.

[103] P. D. Boersma et al., "Applying Science to Pressing Conservation Needs for Penguins," *Conservation Biology*, vol. 34, no. 1 (2019), pp. 103-112. Hereinafter, Boersma, "Applying Science for Penguins."

[104] Boersma, "Applying Science for Penguins."

Figure 4. Location of Current Emperor Penguin Colonies in Antarctica and Their Projected Vulnerability in 2100



Source: Peter T. Fretwell and Philip N. Thrathan, "Discovery of New Colonies by Sentinel2 Reveals Good and Bad News for Emperor Penguins," *Remote Sensing in Ecology and Conservation*, August 4, 2020, using data from Stéphanie Jenouvrier et al., "The Paris Agreement Objectives Will Likely Halt Future Declines of Emperor Penguins," *Global Change Biology*, vol. 26, no. 3 (November 7, 2019), pp. 1170-1184.

Emperor Penguins (*Aptenodytes forsteri*)

Emperor penguins spend their entire lives in the Antarctic and are adapted to cold temperatures. They depend on stable, landfast sea ice as breeding habitat and for colonies. They generally feed upon fish, krill, and cephalopods. Emperor penguins reside and seek their prey in polynyas (areas of open water or persistently loose sea ice). The penguins travel annually to the same breeding sites, which might take weeks to reach, and stay at these sites during their eggs' incubation periods, huddled to protect themselves from cold temperatures and winds.

The colonies' need for stable ice makes them vulnerable to altered wind regimes, rising temperatures, and reduced sea ice extent and persistence, according to several studies. Many studies project a large number of emperor penguin colonies will be gone by the next century, due to rising temperatures and ice loss. Some scientists estimate that with projected increases in temperature, all Antarctic colonies could decrease in size; for example, Stéphanie Jenouvrier and coauthors estimate 43 of the 54 existing colonies (80%) potentially decreasing by more than 90% by 2100.

Some scientists contend that lowering the effects of ice loss and rising temperatures can reduce threats to emperor penguins. Until this reduction occurs, however, some stakeholders advise protections for penguins at breeding sites and foraging locations. Further, some scientists recommend adding emperor penguins to a Specially Protected Species list in the Protocol on Environmental Protection to the Antarctic Treaty, one of the agreements that comprises the Antarctic Treaty System.

Sources: Peter T. Fretwell and Philip N. Thrathan, "Discovery of New Colonies by Sentinel2 Reveals Good and Bad News for Emperor Penguins," *Remote Sensing in Ecology and Conservation*, August 4, 2020; Stéphanie Jenouvrier et al., "The Paris Agreement Objectives Will Likely Halt Future Declines of Emperor Penguins," *Global Change Biology*, vol. 26, no. 3 (November 7, 2019), pp. 1170-1184; Philip N. Trathan et al., "The Emperor Penguin: Vulnerable to Projected Rates of Warming and Sea Ice Loss," *Biological Conservation*, vol. 241 (January 2020).

Protocol on Environmental Protection to the Antarctic Treaty

The ATS is composed of the Antarctic Treaty and several associated agreements. One of these agreements, the Protocol on Environmental Protection to the Antarctic Treaty (entered into force in 1998), addresses Antarctica's environment and biodiversity, among other issues.[105] The protocol designated Antarctica as a "natural reserve devoted to peace and science" and required the parties to "commit themselves to the comprehensive protection of the Antarctic environment and dependent and associated ecosystems."[106]

The Protocol on Environmental Protection to the Antarctic Treaty has six annexes. Annexes I-IV entered into force with the protocol, Annex V entered into force in 2002, and Annex VI has been adopted and is awaiting approval by the consultative parties before entering into force.[107] Annex I includes a requirement to conduct an environmental impact assessment before implementing an activity to assess the activity's impact to the environment. Annex II includes prohibitions on the intentional introduction of non-native species and regulations that address the disturbance of native species and ecosystems.[108] Annex II also contains an Appendix on Specially Protected Species. Species on this list are protected, with limited exceptions, compared with other species. A permit to kill or harm these species can be provided only if the action is for a scientifically compelling purpose and will not jeopardize the survival or recovery of that species or local population. The Ross seal and the fur seal (all species of the genus *Arctocephalus*) currently are the only species on this list. Annex III creates the principle that waste generation and disposal should be minimized on Antarctica and establishes a framework for cleaning waste sites. Annex IV prohibits the discharge of pollution, plastics, and other garbage from ships in the sea.[109]

Annex V to the Protocol provides for Antarctic Specially Protected Areas, which are designated to protect outstanding environmental, scientific, historic, aesthetic, or wilderness values; scientific research; or a combination of both.[110] Some scientists argue that actions to curb human impacts on biodiversity have been limited.[111] Although some scientists view the establishment of protected areas as promising, others warn that these areas will not be able to stem the decline of biodiversity.[112]

In the United States, the Antarctic Science, Tourism, and Conservation Act of 1996 (16 U.S.C. §§2401-2413; P.L. 104-227) codified in U.S. law the environmental standards set forth by the protocol.[113]

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[105] Scientific Committee on Antarctic Research, "The Antarctic Treaty System," at https://www.scar.org/policy/antarctic-treaty-system/.

[106] Australian Antarctic Program, "Protocol on Environmental Protection to the Antarctic Treaty (The Madrid Protocol)," at https://www.antarctica.gov.au/about-antarctica/law-and-treaty/the-madrid-protocol/.

[107] Secretariat of the Antarctic Treaty at https://www.ats.aq/e/protocol.html.

[108] "Annex II to the Protocol on Environmental Protection to the Antarctic Treaty: Conservation of Antarctic Fauna and Flora," at https://documents.ats.aq/cephandbook/Annex_II_e.pdf.

[109] A repository of the Annexes can be found at https://www.ats.aq/e/key-documents.html.

[110] "Annex V to the Protocol on Environmental Protection to the Antarctic Treaty: Area Protection and Management," at https://documents.ats.aq/cephandbook/Annex_V_e.pdf.

[111] Wauchope et al., "Biodiversity Protection in Antarctica," 2019.

[112] Justine D. Shaw et al., "Antarctica's Protected Areas Are Inadequate, Unrepresentative, and at Risk," *PLOS Biology*, vol. 12, no. 6 (June 17, 2014).

[113] This act amended P.L. 95-541 to include provisions from the Protocol on Environmental Protection to the Antarctic Treaty and Annexes I-V. Further, it required environmental impact assessments for all activities conducted by federal agencies (16 U.S.C. §2403a).

Fisheries

Some stakeholders and scientists are concerned about a number of factors that may diminish fish populations in the Southern Ocean. These factors include overfishing; climate-induced changes in oceans and sea ice; and illegal, unregulated, and unreported fishing in the Southern Ocean.[114] Further, a lack of data and monitoring would make it difficult to understand trends and quantify the effects of policies on fisheries. More than 20 countries fish in the Southern Ocean, including the United States, catching Antarctic krill and silverfish, among other species.

Antarctic Krill

Antarctic krill (*Euphausia superba*) are a key component of the Antarctic marine ecosystem, because they are food for hundreds of species, including whales, fish, invertebrates, and birds. Krill also contribute to the biogeochemical systems in the ocean and the carbon cycle. Krill feed on phytoplankton and excrete pellets containing carbon and other nutrients that are consumed by microorganisms. Approximately 70% of the global krill population resides in and around Antarctica. Krill live in swarms and have lifespans up to 10 years. They are dependent on sea ice, because they use it to shelter their larvae. The southwest Atlantic sector of the Southern Ocean is the focus of the Antarctic krill fishery. Antarctic krill accounts for 85% of the total fishery catch by weight in the Southern Ocean. The krill fishery in this sector has been increasing steadily from 2010 to 2019, according to reports. The fishery is regulated by the Commission for the Conservation of Antarctic Marine Living Resources, which sets catch limits. Some stakeholders are concerned that increased fishing, sea ice loss, and shifting populations of krill might lead to future declines.

There is debate and uncertainty regarding trends in krill population size in the southwest Atlantic sector over the last 50 years. Some studies report a decline in krill abundance after analyzing catch data, whereas other studies have reanalyzed the data and reported no conclusive evidence for a decline in krill. Some scientists note the global krill population is known for its boom and bust cycles, making it difficult to quantify population trends. Some studies project the distribution of krill is expected to shift southward, due to changes in the optimum areas for krill growth and recruitment. Populations are expected to shift away from areas with warming waters and move southward, closer to the Antarctic land mass, for greater sea ice coverage. According to some scientists, the highest potential loss of krill might be in areas where they are most consumed by other marine life and fished.

Efforts to conserve krill in addition to catch limits include the establishment Marine Protected Areas (MPAs), which could lead to restricted fishing zones for krill. Some countries favor MPAs because they restrict fishing and other activities to promote conservation; other countries assert MPAs are not necessary.

Sources: M. Meredith et al., "Polar Regions" in *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*, Intergovernmental Panel on Climate Change (IPCC), 2019, p. 231; Erik Stokstad, "Is the Fishing Industry Leaving Enough Food for Antarctica's Top Predators?," *Science Magazine*, January 15, 2019; Carolyn J. Hogg et al., "Protect the Antarctic Peninsula—Before It's Too Late," *Nature*, vol. 586, no. 7830 (October 22, 2020), pp. 496-499; Martin James Cox et al., "No Evidence for a Decline in the Density of Antarctic Krill *Euphausia superba* Dana, 1850, in the Southwest Atlantic Sector Between 1976 and 2016," *Journal of Crustacean Biology*, vol. 39, no. 3 (2019), pp. 323-327; and Simeon L. Hill et al., "Evidence for a Decline in the Population Density of Antarctic Krill *Euphausia superba* Dana, 1850 Still Stands. A Comment on Cox et al.," *Journal of Crustacean Biology*, vol. 39, no. 3 (2019), pp. 316-322.

Convention on the Conservation of Antarctic Marine Living Resources

Another associated agreement that is part of the ATS, the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), governs fishing in the Antarctic region. The agreement was signed by several countries, including the United States, in 1980 and entered into force in 1982. The CCAMLR was created in response to commercial interest in Antarctic krill resources and overexploitation of other marine resources in the Southern Ocean.[115] It applies to

[114] Antarctic and Southern Ocean Coalition, "Southern Ocean Fisheries," press release, 2020, at https://www.asoc.org/advocacy/wildlife-conservation/southern-ocean-fisheries.

[115] Erik Stokstad, "Is the Fishing Industry Leaving Enough Food for Antarctica's Top Predators?," *Science Magazine*,

all Antarctic populations of finfish, mollusks, crustaceans, and sea birds found south of the Antarctic Convergence.[116]

The CCAMLR set limits on fishing that some countries have challenged. Some stakeholders support fishing limits due to concerns about overfishing. These stakeholders suggest that better-designed marine reserves, increased planning for climate change in decision rules, and better research and monitoring under the CCAMLR are needed to improve the convention's effectiveness.[117] In response to these concerns, the CCAMLR proposed a series of Marine Protected Areas (MPAs) around Antarctica with the purpose of preserving the region's marine biodiversity and creating areas for overfished species (including krill) to recover. To date, two MPAs have been implemented, one in the South Orkney Islands in 2009 and one in the Ross Sea in 2016.[118] The Ross Sea MPA is one of the world's largest international MPAs, with an area of 193,000 square miles.[119] Some countries, such as China and Russia, oppose the expansion of MPAs in the Southern Ocean and greater restrictions on fisheries. These countries contend there should be specific, narrow criteria for closing fishing areas and argue that no-fishing zones are contrary to the CCAMLR.[120]

Pollution

Evidence of pollution is prevalent in parts of Antarctica with tourism and scientific activities. Pollution can have long-term, localized effects on marine organisms and wildlife. For example, studies have reported microplastic pollution in Antarctic surface waters and sediments and, more recently, in Antarctic sea ice.[121] Pollution also comes from shipping vessels due to accidents, oil spills, and waste discharges. In Antarctic waters, ships are prohibited from discharging noxious liquid substances and other chemicals that might harm the marine environment, oil, garbage, and other substances into the sea under Annex IV to the Protocol on Environmental Protection to the Antarctic Treaty.

In addition, some stakeholders are concerned about tourism and its environmental effects. Tourism in the Antarctic is conducted in accordance with the Protocol on Environmental Protection to the Antarctic Treaty, which has environmental regulations, a process for establishing and monitoring protected areas, and regulations on disposing waste.[122] A waste-management plan is required for each country, and waste is to be minimized and returned to the country of those

January 15, 2019.

[116] The area covered by the Convention for the Conservation of Antarctic Marine Living Resources consists of all waters bounded by the Antarctic Continent to the south and to the north by a line starting at latitude S 50°, longitude W 50°. See Convention for the Conservation of Antarctic Marine Living Resources, "Convention Area: Statistical Areas," at https://www.ccamlr.org/en/system/files/CCAMLR-Convention-Area-Map.pdf.

[117] PEW Charitable Trusts, *The Need for a Network of Marine Protected Areas in the Southern Ocean*, issue brief, October 7, 2020, at https://www.pewtrusts.org/en/research-and-analysis/issue-briefs/2020/10/the-need-for-a-network-of-marine-protected-areas-in-the-southern-ocean.

[118] NOAA Fisheries, "Marine Protected Area in Antarctica's Ross Sea," February 26, 2018, at https://www.fisheries.noaa.gov/national/international-affairs/marine-protected-area-antarcticas-ross-sea.

[119] See Commission for the Conservation of Antarctic Marine Living Resources at http://www.ccamlr.org.

[120] Feiger and Wilson, "Countries Taking Advantage."

[121] Catherine L. Waller et al., "Microplastics in the Antarctic Marine System: An Emerging Area of Research," *Science of the Total Environment*, vol. 598 (November 15, 2017), pp. 220-227; Anna Kelly et al., "Microplastic Contamination in East Antarctic Sea Ice," *Marine Pollution Bulletin*, vol. 154 (May 2020).

[122] Meredith et al., IPCC Special Report Chapter 3, "Polar Regions," p. 264.

generating the waste to the maximum extent possible.[123] The protocol also authorizes observers to inspect stations and report on any environmental issues;[124] these inspections are to be done in accordance with inspections carried out under Article VII of the Antarctic Treaty.

Mineral Resources

Although there are no known commercial quantities of minerals, oil, or petroleum in Antarctica, some scientists believe undocumented commercial quantities might exist on the continent.[125] Reporting the resource potential of Antarctica is challenging, due to the thick layer of ice covering the land. The Protocol on Environmental Protection to the Antarctic Treaty bans mineral extraction in and around Antarctica. Article VII of protocol states, "Any activity relating to mineral resources, other than scientific research, shall be prohibited." Article VII also states that after the protocol's 50-year term, the parties can convene to revisit the ban on mineral extraction. According to Article VII, mineral extraction could occur if there were a binding legal regime in place that included an agreed means for determining under which conditions extraction activities would be acceptable.

Some observers believe pressure will build from some countries for increased resource exploitation in Antarctica and the Southern Ocean. According to one source, "growing awareness of the impacts of climate change and suspicions that states are interested in the resource potential of the continent mean that scientific activities and political motives for being involved in Antarctic research are increasingly coming under global scrutiny."[126] In contrast to this perspective, no known extraction activities are taking place in Antarctica, although some stakeholders assert that various scientific activities conducted by China and Russia may lay the groundwork for future mineral extraction.[127]

Issues for Congress

Congress may consider its role in seeking to protect or promote U.S. strategic, economic, environmental, and scientific interests in Antarctica and the Southern Ocean.

Geopolitical Considerations

The Antarctic Treaty binds countries together in forming policies that govern the continent. Some have questioned how resilient the treaty will be to changes initiated by parties.[128] Congress may examine the treaty's resiliency to change and consider for what purposes the treaty could be challenged in the future. For example, some analysts contend that China is seeking new flexibility in implementation of the treaty.[129] These observers allege that several incidents over the last few

[123] The Protocol on Environmental Protection to the Antarctic Treaty, Annex III, Waste Disposal and Waste Management.

[124] Article 14 of the Protocol on Environmental Protection to the Antarctic Treaty.

[125] William Westermeyer et al., *Polar Prospects: A Minerals Treaty for Antarctica*, Office of Technology Assessment, OTA-0-428, September 1989, p. 94.

[126] Klaus Dodds and Mark Nuttall, *The Scramble for the Poles: Geopolitics of the Arctic and Antarctica* (Malden: Polity Publishers, 2016). Hereinafter, Dodds and Nuttall, *Scramble for the Poles*.

[127] Dodds and Nuttall, *Scramble for the Poles*.

[128] If a binding legal agreement among parties on mineral exploitation is reached as prescribed under Article 25.5 of the Protocol on Environmental Protection to the Antarctic Treaty, mineral extraction potentially could proceed.

[129] Ralph Espach and Nilanthi Samaranayake, "Antarctica Is the New Arctic: Security and Strategy in the Southern

years support this view: China built its latest research base on Antarctica without completing a required environmental impact assessment; China and Russia cooperated to delay the implementation of new MPAs that would protect fisheries; and China proposed the creation of a "Chinese management district" of approximately 20,000 square kilometers where foreigners were to be restricted (the proposal was rejected).[130] Congress might consider whether this reported progression of actions could be aimed at supporting Chinese territorial claims in Antarctica.

China has increased its presence in Antarctica in other ways. For example, China has increased krill fishing and expanded tourism in the region, and it is the only country to build research stations on the continent since 2000.[131] China currently has four research stations in Antarctica, with plans for a fifth station. Some stakeholders are concerned about China's increased presence and its implications for the ATS and for other nations. Congress might consider how expanding Chinese activities and presence in Antarctica could affect the expectations, strategies, and policies of countries with existing territorial claims in the region such as Australia, the United Kingdom, Argentina, and Chile. Further, Congress might consider how China could seek to alter the ATS to benefit its activities and presence in Antarctica.

Some stakeholders contend that receding sea ice levels will make Antarctica more accessible for longer periods of time and will provide an incentive for exploiting fisheries and other natural resources (e.g., oil and gas). Greater accessibility could increase the need for monitoring and regulatory enforcement of the Antarctic Treaty.[132] The United States, the Netherlands, and South Korea have complained about the difficulty of carrying out inspections of facilities and proposed the creation of a database on inspections to improve transparency.[133] More than a dozen stations, including Chinese and Russian ones, have yet to be inspected, according to some reports.[134] Congress might consider whether increased monitoring by the United States and other countries and improved transparency are necessary to adequately inspect facilities and monitor fishing and scientific activities. Congress also might consider whether expanding the U.S. Antarctic fleet would facilitate an increase in monitoring and match heightened presence by other countries. Lastly, some stakeholders note the Antarctic Treaty does not have a mechanism to sanction parties that violate the treaty; Congress may consider encouraging the Administration to work with other parties to enhance compliance mechanisms under the treaty and pursue infractions to the treaty through other international organizations, such as the United Nations.[135]

Ocean," *CNA InDepth*, March 17, 2020. Hereinafter, Espach and Samaranayake, "Antarctica Is the New Arctic."

[130] Anne Marie Brady, *China's Expanding Antarctic Interests: Implications for Australia*, Australian Strategic Policy Institute, August 2017, pp. 1-24, at https://s3-ap-southeast-2.amazonaws.com/ad-aspi/2017-08/SR109 Chinas expanding interests in Antarctica.pdf?LqDGafveA4ogNHB6K08cq86VoEzKQc; Preethi Amaresh, "China's Increasing Foothold in Antarctica," *On Research* (fall 2020), pp. 45-49; and Espach and Samaranayake, "Antarctica Is the New Arctic."

[131] Giulia Sciorati, *China's Polar Strategy Through the Looking Glass*, Istituto Per GLI Studi de Politica Internazionale, July 2019, at https://www.ispionline.it/it/pubblicazione/chinas-polar-strategy-through-looking-glass-23525.

[132] Clark and Sloman, *Securing the Frontier*, pp. 4-6.

[133] Feiger and Wilson, "Countries Taking Advantage."

[134] Feiger and Wilson, "Countries Taking Advantage." Also see the Inspections Database created by the Secretariat of the Antarctic Treaty at https://www.ats.aq/devAS/Ats/InspectionsDatabase?lang=e

[135] Fishman, "China's Advance."

Natural Resource Considerations

Some stakeholders are concerned about the extraction and preservation of natural resources in Antarctica, even though these issues are addressed in the ATS. Presently, mineral resource extraction in Antarctica is banned; however, some biological resources are declining, such as certain fisheries and some habitat. Further, some stakeholders speculate that towing icebergs from Antarctica to cities in South Africa and the Middle East to address freshwater issues could be proposed in the future.[136] Congress might consider options for U.S. roles in addressing the balance between protecting natural resources and allowing extractive uses in Antarctica as it relates to biodiversity, fishing, and minerals.

For example, Congress might consider new or enhanced approaches to improve the conservation of biodiversity in Antarctica through the ATS. Some scientists assert that the current approaches to conservation of biodiversity in Antarctica are inadequate, given the threats of climate-driven changes to the Antarctic environment as well as human activities on the continent.[137] Some stakeholders propose the creation of an integrated biodiversity strategy and action plan for Antarctica and the Southern Ocean under the ATS to provide a pathway for conserving biodiversity. Further, they suggest deploying tools and creating a plan for measuring and monitoring Antarctic biodiversity.[138] Some stakeholders might question the value of this approach and whether it would garner support from all consultative parties. These stakeholders might contend that increased protection could hinder the development of new stations.

In addition, Congress may consider issues related to Antarctic fisheries. Some stakeholders express concern that certain fisheries in Antarctica and the Southern Ocean are overexploited; they contend the Antarctic Treaty needs additional measures to protect these fisheries.[139] Further, scientists note that changes in climate and sea ice extent can affect fisheries and some contend that precautionary based ecosystem management[140] should be employed to counter these effects.[141] In contrast, some stakeholders contend the treaty overly restricts resource extraction and should be more lenient for sustainable extraction. For example, these stakeholders assert that fisheries in the Southern Ocean should have fewer fishing restrictions on species such as krill.[142] Congress may consider encouraging the Administration to press other consultative parties to ratify the creation of MPAs along the coast of Eastern Antarctica and in the Weddell Sea to improve conservation of marine resources. These MPAs would cover krill fishing grounds, according to scientists. The CCAMLR attempted to establish these MPAs in 2020; however, they were not implemented due to Chinese and Russian opposition to restrictions on fishing, among other resources.[143] Many scientists perceive an urgent need to create protected areas before

[136] Jeremy Berke, "An Engineering Firm Wants to Tow Ice Bergs Thousands of Milles from Antarctica to Quench the Driest Areas in the World—and It's Starting in Dubai," *Business Insider*, September 8, 2018, at https://www.businessinsider.com/engineering-firm-tow-icebergs-antarctica-for-water.

[137] Steven L. Chown et al., "Antarctica and the Strategic Plan for Biodiversity," *PLOS Biology*, vol. 15, no. 3 (March 28, 2017). Hereinafter, Chown et al., "Antarctica and the Strategic Plan."

[138] Chown et al., "Antarctica and the Strategic Plan."

[139] For example, see Elizabeth Grossman, "Scientists Consider Whether Krill Need to be Protected from Human Over-Hunting," *The World*, July 14, 2015.

[140] Precautionary based ecosystem management means taking management actions now to avert anticipated ecosystem issues in the future.

[141] Meredith et al., IPCC Special Report Chapter 3, "Polar Regions," pp. 262 and 276.

[142] Feiger and Wilson, "Countries Taking Advantage."

[143] Elizabeth Claire Alberts, "No Other Choice: Groups Push to Protect Vast Swaths of Antarctic Seas," Mongabay, October 19, 2020, at https://news.mongabay.com/2020/10/no-other-choice-groups-push-to-protect-vast-swaths-of-

climate change, fishing, and human activities such as tourism and research stations further affect the region.[144]

Antarctica may have undocumented commercial mineral resources, including oil, coal, and iron ore. Congress also may consider whether possible future efforts to increase natural resource extraction in Antarctica hold the potential for instigating future disagreements and conflicts in the region. Some stakeholders contend the United States and other countries should consider how to address portions of the Antarctic Treaty that affect mining if they are debated earlier than 2048, when several parts of the ATS will come up for possible renewal or modifications.[145] Some geologists counter this concern by noting that successfully extracting mineral deposits would require overcoming hazardous conditions and potentially mining through a thick ice sheet.[146] Further, transporting products over long stretches on the Southern Ocean might be treacherous and costly.

Melting Ice and Sea-Level Rise

Several studies report that melting ice in Antarctica is contributing to increases in annual average rates of global sea-level rise.[147] Several scientists, however, highlight the current scientific uncertainty of future melting rates in Antarctica and question how melting rates and subsequent sea-level rise will respond to future anthropogenic climate change.[148] The 2019 IPCC Special Report stated that there is a need to better understand polar glaciers, ice sheets, and their contributions to sea-level rise; specifically, longer and better quantifiable data are needed, along with a better attribution of natural versus anthropogenic drivers of change.[149] Scientists and policymakers also note that reducing scientific uncertainty and more precisely projecting Antarctica's contribution to sea-level rise could help society manage risks of sea-level rise.[150]

Scientific research on Antarctica, both through on-the-ground fieldwork in research stations and through remote satellite observations, may contribute to a better scientific understanding of the region. Improved scientific understanding of Antarctica could have implications for better understanding of global phenomena, such as global weather, ocean circulation, and the relationship between ice dynamics and sea-level rise. Congress might consider the level of U.S. support for research on ice dynamics in Antarctica. Congress also might consider if there is a sufficient level of scientific collaboration and sharing of scientific findings among countries doing research in Antarctica. Further, Congress may weigh the usefulness of developing a larger footprint (e.g., more scientific bases and infrastructure) in Antarctica to facilitate U.S. and collaborative research.

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antarctic-seas/.

[144] Carolyn J. Hogg et al., "Protect the Antarctic Peninsula—Before It's Too Late," *Nature*, vol. 586, no. 7830 (October 22, 2020), pp. 496-499.

[145] Espach and Samaranayake, "Antarctica is the New Arctic."

[146] Australian Antarctic Program, "Mining in Antarctica," October 27, 2020, at https://www.antarctica.gov.au/about-antarctica/geography-and-geology/geology/mining/.

[147] Meredith et al., IPCC Special Report Chapter 3, "Polar Regions," p. 276.

[148] For example, see Chii-Yun Tsai, Chris E. Forest, and David Pollard, "The Role of Internal Climate Variability in Projecting Antarctica's Contribution to Future Sea-Level Rise," *Climate Variability*, vol. 55 (July 18, 2020), pp. 1875-1892.

[149] Meredith et al., IPCC Special Report Chapter 3, "Polar Regions," p. 275.

[150] For example, see Kelly Falkner, "Antarctica."

Antarctica and COVID-19

The threat of the Coronavirus Disease 2019 (COVID-19) infiltrating research bases in Antarctica led several countries to reduce personnel in research bases and limit research activities in mid-2020. There were no recorded cases of the COVID-19 on Antarctica until December 2020, when the Chilean Army reported 36 cases at its Bernardo O'Higgins research station on the Antarctic Peninsula.[151] U.S. research station administrators note that bases do not have medical facilities to adequately address a full-scale outbreak of COVID-19.[152] To keep the virus from the continent, the United States, New Zealand, and the United Kingdom in June 2020 announced plans to partially cancel their summer (October 2020-March 2021) field research.[153] Other countries announced they would rely on remote equipment or limited staffing.[154] Some experts assert that activities by China and Russia are being maintained.[155]

Congress might consider how to ensure long-term research and continuous data collection are not interrupted by the COVID-19 pandemic, whether research and data collection were interrupted, and how limited staff might keep the work going. Further, Congress may address whether the United States should consider encouraging China, Russia, and other countries to share information collected during this period, especially given the reduced presence of the United States and other countries in Antarctica.

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[151] Isabella Kwai, "With First Positive Tests in Antarctica, No Continent is Untouched by the Virus," *New York Times*, December 22, 2020.

[152] Falkner, "Antarctica."

[153] Paul Voosen, "Coronavirus Forces United States, United Kingdom to Cancel Antarctic Field Research," *Science*, June 12, 2020.

[154] Di Minardi, "Antarctica is the Last Continent Without COVID-19. Scientists Want to Keep It That Way," *National Geographic*, August 7, 2020.

[155] Feiger and Wilson, "Countries Taking Advantage."

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