EPICENTERS OF CLIMATE AND SECURITY: THE NEW GEOSTRATEGIC LANDSCAPE OF THE ANTHROPOCENE

June 2017

Edited by:
Caitlin E. Werrell and Francesco Femia

THE CENTER FOR CLIMATE AND SECURITY

Sponsored by:

skoll global threats fund

In partnership with:

Carnegie Mellon University
Civil and Environmental Engineering

SCHOOL OF GEOGRAPHY AND THE ENVIRONMENT
UNIVERSITY OF OXFORD

Energy Science Technology & Policy
Carnegie Mellon University
College of Engineering

ASP
American Security Project

Planetary Security INITIATIVE

Dire Straits: Strategically-Significant International Waterways in a Warming World

Adam H. Goldstein[1] and Constantine Samaras[2*]

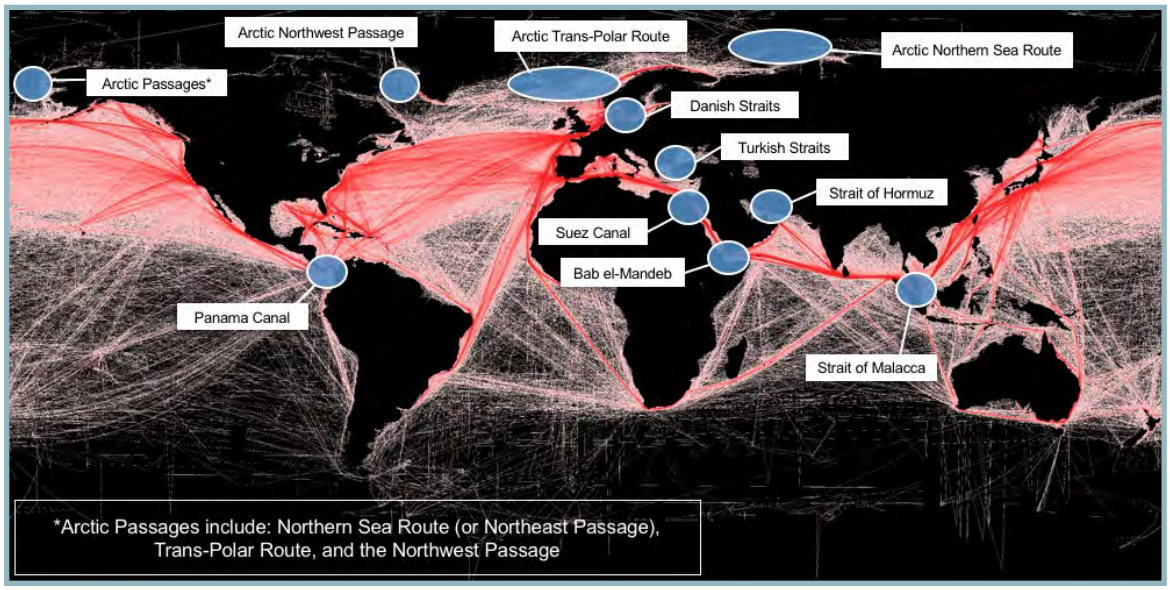
Introduction

While the oceans are vast, long-distance maritime traffic often flows through just a few passages due to confined geography and the desire to travel the shortest distance possible.[3] These marine chokepoints are critical to the continuous movement of goods around the world and are essential elements of the geostrategic landscape. These chokepoints include the Strait of Malacca (Malaysia), the Strait of Hormuz (Iran and the United Arab Emirates), the Suez Canal (Egypt), the Bab el-Mandeb Strait (between Yemen, Djibouti, and Eritrea), the Panama Canal, the Danish Straits, and the Turkish Straits.[4] Additionally, Arctic Ocean passages are likely to become important in the coming decades in a warming world due to climate change.

These maritime chokepoints may be viewed as a valuable and scarce natural resource, subject to increasing demand, finite supply, and few affordable alternatives (See Figure 1).[5] All greatly affect global trade dynamics through the capacity and size limitations they impose.[6] For instance, in 2013 the oil shipped through the Straits of Hormuz and Malacca alone represented a combined 36% of the total oil supplied globally, at 17 million and 15.2 million barrels per day, respectively.[7]

Each of these critically important passages face a dynamic host of challenges. Iran temporarily closed the Strait of Hormuz to maritime traffic through the use of mines as recently as the 1980s,[8] and it has recently increased the frequency of its "provocations" (as defined by the U.S. Central Command).[9] While instances of piracy in the Gulf of Aden (which connects to the Red Sea via the Bab el-Mandeb Strait) have declined precipitously since the mid-2000s, the Strait of Malacca and the surrounding waters

FIGURE 1



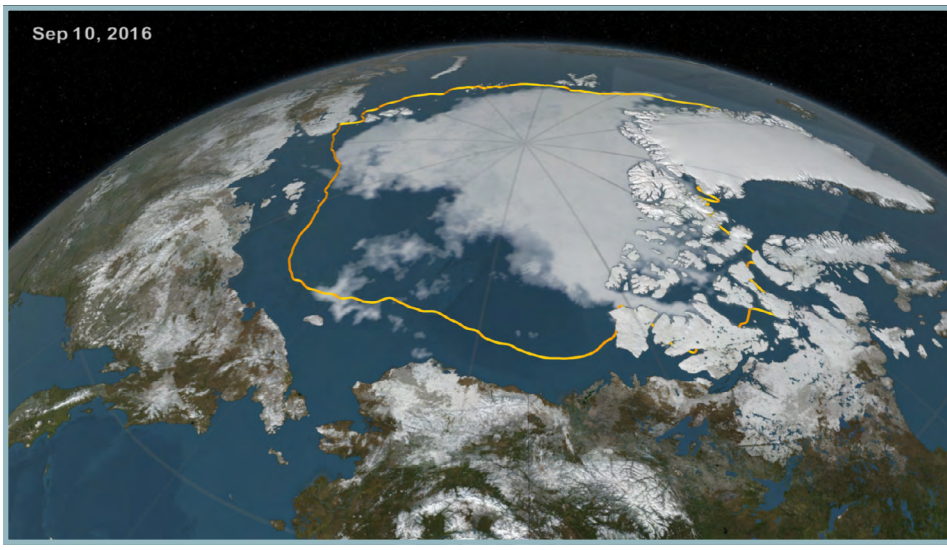
of Southeast Asia have experienced an almost 84% increase in the number of actual and attempted acts of piracy from 2011-2015, rising from 80 to 147 documented incidents, respectively.[10] The October 2016 guided missile attack by Houthi rebels on a UAE vessel near the Bab el-Mandeb Strait underscores the ongoing threat concerns surrounding strategically important maritime straits.[11] **All of these challenges are likely to grow in importance as the effects of global climate change alter the geophysical patterns undergirding national economies and patterns of life across significant segments of the world.** The impacts of climate change are likely to accelerate challenges in many of the regions with maritime chokepoints, and it is important to understand the range of impacts and plan for resiliency.

The 2014 U.S. Department of Defense Quadrennial Defense Review (QDR) described climate change as a "threat multiplier that will aggravate stressors abroad, such as poverty, environmental degradation, political instability, and social tensions – conditions that can enable terrorist activity and other forms of violence."[12] The National Intelligence Council's January 2017 Global Trends: Paradox of Progress report framed global climate change as a long-term force that will shift temperature, precipitation, and extreme weather event patterns in many regions, affecting agriculture and water supplies and accelerating pressure on fragile and failing states. Sea-level rise, coastal extreme events, and localized air pollution will also affect population patterns and infrastructure investment decisions. Climate change impacts are magnified by the increasing concentration of humans in climate-vulnerable locations, such as water-stressed, coastal, and urban areas. Combined, all of these factors will increase stress on social, economic, political, and security systems in many areas surrounding maritime chokepoints, as well as induce both geopolitical competition and cooperation.[13]

Maritime Straits with Potentially Major Climate Change Impacts

Some maritime straits will be directly affected by climate change through impacts to operations and availability. The Panama Canal is a major trading artery linking the Atlantic and Pacific Oceans, and the U.S. East Coast and Asia in particular. In June 2016, the Panama Canal Authority dedicated the "Third Set of Locks" project, which included deepening and widening the canal's channels. The expansion effectively doubles the overall capacity of the canal while also increasing the size limit for vessels utilizing the canal (from 5,000 to 12,500 Twenty Foot Equivalent Units (TEUs)). However, this newly expanded capacity is sensitive to the water levels in Panama's Gatun Lake, which are affected by El Niño meteorological events and may be affected by climate change.[14] The Panamanian National Environmental Authority (ANAM) in a 2013 application for funding identified the recent history and potential future risks associated with increased precipitation during the wet season and decreased precipitation during the dry season, especially during El Niño Southern Oscillation.[15] One recent study projected the Panama Canal region could experience increased rainfall and runoff from May to December (i.e. the wet season).[16] Climate-induced precipitation changes could result in changes in the expected shipping capacity of the expanded Panama Canal, both during droughts and flood events. However, additional understanding is needed to project climate impacts on the local scale, where relatively small (on the global scale) changes in precipitation and evaporation can have significant impacts. Inter-seasonal precipitation (i.e. wet season vs. dry season) is also an important area for future study as scientists and engineers assess climate change impacts on the Panama Canal watershed.

While future impacts in Panama are uncertain, scientists have observed significant impacts in the Arctic.[17] Perhaps no other shipping region will be affected by climate change more than the Arctic. Since World War II, the Arctic Ocean has been a major geopolitical theater of interest for the U.S. Bordered by the U.S., Canada, Russia, Greenland/Denmark, and Norway,[18] the ice-choked ocean was viewed as strategically important during the Cold War due to the regions surrounding it, rather than shipping or mineral wealth located on or under it. However, Arctic summer sea ice is diminishing rapidly and not rebounding as much as it used to in the winter months.[19] While the research community continues to investigate time frames and specific impacts, the 2014 National Climate Assessment assessed that summer Arctic Ocean sea ice is expected to "virtually disappear" by the middle of the century. This trend is expected to increase access for marine shipping, offshore mineral development and coastal erosion, and to significantly alter marine ecosystems.[20] Indeed, the burning of the petroleum products shipped through existing marine chokepoints is contributing to the change that is opening up a new waterway in the Arctic. [21]



Seasonal availability of the Northeast Passage (or Northern Sea Route) following Russia and Norway's coastline, the North Pole route passing through the center of the Arctic Ocean, and the Northwest Passage (tracking close to the U.S. and Canada's coastline) are expected to significantly expand the demand for Arctic Ocean maritime shipping.[22] These routes are thousands of nautical miles shorter than current routes and can offer substantial time and fuel savings for commercial shippers. A Northern Sea Route can save as much as two weeks on Asia to Europe routes (compared to present-day shipping via the Suez Canal), and also shorten routes from Europe to the U.S. West Coast.[23, 24]Among the Arctic passages, the Northern Sea Route is projected to be the most accessible shipping option in the near-term, with the trans-polar route becoming increasingly viable in the longer-term.[25]

In addition to its utility as a transport corridor, the Arctic Ocean contains vast mineral and resource wealth. As the Arctic warms, increases in access is likely to be unevenly distributed across the Arctic nations – Russia is projected to have the greatest percentage increase in access to its exclusive economic zone by late century.[26] According to the U.S. Geological Survey, the "Arctic continental shelves may constitute the geographically largest unexplored prospective area for petroleum remaining on Earth."[27] Increasing utilization of the Arctic Ocean as a result of global climate change may further strain international relations with Russia[28], while also increasing demands on border nations' emergency services and militaries due to increased shipping traffic in highly remote and more ice-prone waters. For example, increasing commercial utilization of the Arctic Ocean during the summer is likely to place new demands on the U.S. Coast Guard and Navy. In the past, ice and equipment failures had little impact on commercial vessels because there were few of them in the Arctic Ocean. However, when equipment fails or conditions unexpectedly worsen, as they inevitably will, it will often fall to the U.S. Coast Guard and Navy to provide aid. Both services have limited icebreaker capacity and a limited infrastructure in the Arctic region from which to project operational capability.[29]

Throughout most of the 19th Century the British and Russian empires engaged in "The Great Game," a diplomatic and political contest for influence and resources in Central and Southern Asia. A new Great Game may be about to unfold in the Arctic Ocean,

as vast mineral wealth and strategic trade routes are unlocked, potentially reshaping global trade between the eastern and western hemispheres. While some climate change impacts may not be apparent until the future, some are clearly already under way. An 820-foot (250m) cruise ship, the Crystal Serenity, traversed the Northwest Passage in the summer of 2016, opening the door for increased activity in the immediate future.[30] Existing ocean policy institutions are highly fragmented, with differentiated mandates for numerous separate international bodies managing human activity in international waters. A strategic approach to this complicated nexus of issues and actors is required.[31]

Maritime Straits with More Diffuse Climate Change Impacts

Many other regions with maritime straits will experience indirect effects from climate change. Climate and weather patterns have affected states throughout history, although the impacts have often only been recognized in retrospect. They exert pressures on a nation's economic, political, and social fabric. In 2016, the Office of the Director of National Intelligence assessed that climate change is likely to impact U.S. national security over the next 20 years through six major pathways:

> "Threats to the stability of countries;
> Heightened social and political tensions;
> Adverse effects on food prices and availability;
> Increased risks to human health;
> Negative impacts on investments and economic competitiveness; [and]
> Potential climate discontinuities and secondary surprises."[32]

These six pathways are likely to result in diverse impacts across the major maritime straits of the world. Regional stability threatening the free movement of energy commodities through the Strait of Hormuz is a perennial concern, given the narrow size of the passage, the potential for disruption, and the strait's importance to the global energy industry. In addition, the Danish Straits and Turkish Straits are increasingly important to Russian energy exports. Changes in geopolitical alliances, global oil demand trends, and Russian contributions to regional tensions could affect energy flows, investment, and security.

Yet the challenges aren't limited solely to energy transit routes, as disruptions to connected energy, food, and water systems can cascade across regions. Populations around global maritime straits, and in coastal states around the world, depend on access to the maritime commons for food and trade. Food supplies have also become more globalized -- many regions have increased their reliance on importing or exporting food, and the volume of agricultural exports has increased by 60 percent from 2000 to 2012.[33] Embedded in the growing amounts of food exports are non-renewable groundwater resources used in countries for irrigation.[34]

Divergent precipitation patterns are expected in many regions, whereby precipitation rates in already wet regions are expected to increase while precipitation rates in already dry regions are expected to decrease. Much of this decline in precipitation is expected to occur over the Middle East, northern Africa, western Central Asia, southern Africa, southern Europe, and the U.S. Southwest. For instance, between 80 and 90 percent of existing food supply in Gulf Cooperation Council states is imported,[35] and precipitation over Algeria, Saudi Arabia, and Iran is expected to decline by 2050.[36] This is likely to increase the scale and importance of food imports via maritime shipping, utilizing the Suez Canal, the Bab el-Mandeb Strait, and Strait of Hormuz. Twenty percent of the existing food imports to Gulf states originate in the Black Sea region, which is also threatened by rising temperatures and variability in precipitation. For food to travel from the Black Sea region to the Gulf, ships have to travel through the Turkish Straits, the Suez Canal, Bab el-Mandeb, and potentially the Straits of Hormuz.[37] Thus, challenges in one region can affect energy and food flows in other regions.

In addition, the degraded health of ocean ecosystems, rising water temperatures, and increasing population could lead to increased competition and degraded stability. The impacts of climate change are likely to stress both freshwater resources and freshwater fisheries,[38] resulting in a greater reliance on ocean fisheries that are also shifting geographically because of warming waters.[39] Changes in the productivity and geography of some ocean species and agricultural products could accelerate food security challenges in existing vulnerable states.[40] These issues are further exacerbated by overfishing and illegal fishing,[41] such as the challenges faced by fishermen in West Africa due to fishing by Chinese distant-water fishing vessels.[42] In the increasingly contested areas of South China Sea, fishing disputes between China and Vietnam have sometimes resulted in violence,[43] and shifting fish stocks could be a catalyst for further incidents. As waters warm and ocean traffic continues to increase, these trends may also place increasing stress on already fragile nation states across the world.

Finally, climate change impacts will stress the performance and integrity of the coastal infrastructure that enables trade and disaster response. The Intergovernmental Panel on Climate Change has assessed with high confidence that coastal infrastructure (e.g. railroads, ports, airports, roads, power and water supply, storm and sewage water management, etc.) are highly sensitive to a host of climatic and extreme weather events associated with climate change. Increased storm surges and precipitation events, on top of increased global mean sea levels, put additional infrastructure assets at risk of temporary or permanent flooding. Many industrial facilities and networks are periodically retrofitted in their original design location, meaning that siting locations made decades or even a century ago will continue to have an impact well into the future.[44]

While these direct impacts are more likely to be felt at the coast compared to the deep shipping channel, land-side facilities at ports and supporting facilities are facing major investments under climate change. For example, underinvestment and weather-related vulnerability threaten road and rail infrastructure in Russia and Ukraine, which are critical in moving agricultural products to ports.[45] Responding to disasters and extreme weather events will also require reliable access to coastal support facilities, which need to be resilient to the increasing impacts from climate change. An example of this effect is already occurring at Naval Station Norfolk, the world's largest naval station. Decades-old piers are being partially submerged every few months, requiring the utility conduits built into the piers to be shut off. This disrupts operations on the vessels docked at these piers, delaying maintenance work and potentially impairing operational readiness.[46] It is critical that investments in military and civilian coastal infrastructure maintain critical capabilities to respond to emergencies as conditions evolve[47], both for the U.S. and the international community.

Path Forward

The continuous and open flow of energy, food, and other goods through maritime straits is essential to improving economic opportunities and stability, and hence is in the interest of the global community. Many of the existing chokepoints will be stressed under the impacts of climate change, as well as with changes in trade demands, patterns, and alliances. It is important to further analyze and understand how maritime chokepoints, and the regions surrounding them, will be stressed under climate change. Policies and programs that strengthen state resilience to disruption will become increasingly important in regions with maritime straits. A growing and urbanizing population will increasingly rely on the maritime commons for food and trade, and initiatives that support food security in fragile states will be critical to stability. Equally important are the efforts to continue to diversify the sources and fuels used for energy to increase the resiliency of national economies to an oil price shock due to tensions at marine chokepoints. Also, because of the interconnected food, water, energy, and trade systems, disasters in one region can have global cascading impacts. Hence nations must enhance adaptive capacity to respond to disasters, which includes investing in resilient coastal infrastructure to maintain critical capabilities.

Global marine chokepoints have been critical geographies throughout history. The changing geostrategic landscape of the future and the role of climate in accelerating those changes means that these straits will likely remain key points of interest and power. The global community can reduce tensions in these chokepoints by undertaking investments and initiatives that increase resiliency to disruptions to food, energy, and water systems in a warming world.

Acknowledgements

All statements reflect our own views and not necessarily the opinions of any organization. We are grateful to Caitlin Werrell and Francesco Femia for helpful comments.

Notes

1 Graduate Research Assistant, Energy, Science, and Technology Policy Program, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15123 USA.

2 Assistant Professor, Department of Civil and Environmental Engineering, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15123 USA.
* Corresponding Author. Email: csamaras@cmu.edu Phone: +1.412.268.1658

3 Adapted from Grolltech. (2012, March 19). Shipping Routes. Accessed November 30, 2016, from https://commons.wikimedia.org/wiki/File:Shipping_routes_red_black.png.
This file is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license; it is free to share and remix with attribution and share alike.
The underlying research presented in the graphic was performed by: Halpern, B.S., et al. 2008. A Global Map of Human Impact on Marine Ecosystems. Science 319(5865):948-952. http://dx.doi.org/10.1126/science.1149345

4 Charles Emmerson and Paul Stevens. *Maritime choke points and the global energy system: charting a way forward.* Chatham House, 2012. Accessed at https://www.chathamhouse.org/sites/files/chathamhouse/public/Research/Energy%2C%20Environment%20and%20Development/bp0112_emmerson_stevens.pdf

5 Donna J. Nincic, "Sea Lane Security and U.S. Maritime Trade: Chokepoints as Scarce Resources", in *Globalization and Maritime Power*. Washington, D.C.: National Defense University Press, 2002, accessed at https://www.files.ethz.ch/isn/110803/fulltext.pdf

6 Jean-Paul Rodrigue, Claude Comtois, and Brian Slack. *The geography of transport systems*. New York: Routledge, accessed at https://people.hofstra.edu/geotrans/eng/ch1en/appl1en/ch1a2en.html

7 U.S. Energy Information Administration. *World Oil Transit Chokepoints*. November 10, 2014. Retrieved November 21, 2016, accessed at https://www.eia.gov/beta/international/analysis_includes/special_topics/World_Oil_Transit_Chokepoints/wotc.pdf

8 Ronald O'Rourke, "The Tanker War", U.S. Naval Institute Proceedings Magazine, 1988. Retrieved November 21, 2016, accessed at http://www.usni.org/magazines/proceedings/1988-05/tanker-war

9 David Brunnstrom, "Close encounters with Iran show need for rules of behaviour -U.S. Navy." Reuters. September 12, 2016. Retrieved November 21, 2016, accessed at http://uk.reuters.com/article/uk-usa-iran-navy-idUKKCN11I1VE

10 Table 1, ICC International Maritime Bureau. (2016). *Piracy and Armed Robbery Against Ships – 2015 Annual Report*. Retrieved November 21, 2016, accessed at http://www.hellenicshippingnews.com/wp-content/uploads/2016/02/2015-Annual-IMB-Piracy-Report-ABRIDGED.pdf

11 Sam LaGrone, "Officials: 3 U.S. Warships Off Yemen Following Attack on UAE Ship." *U.S. Naval Institute*. October 4, 2016. Retrieved November 21, 2016, accessed at https://news.usni.org/2016/10/04/official-3-u-s-warships-off-yemen-following-attack-uae-ship

12 Page 8, U.S. Department of Defense. (2014). *The 2014 Quadrennial Defense Review*. Accessed November 21, 2016, from http://archive.defense.gov/pubs/2014_Quadrennial_Defense_Review.pdf

13 Pages 21-22, National Intelligence Council. (2017). *Global Trends: Paradox of progress: A publication of the National Intelligence Council*. Retrieved January 16, 2017, from https://www.dni.gov/files/images/globalTrends/documents/GT-Main-Report.pdf

14 United Nations Office for Disaster Risk Reduction. (2016, June 28). *Easing impact of drought on the Panama Canal*. Retrieved November 22, 2016, accessed at https://www.unisdr.org/archive/49408

15 Panama National Environmental Authority. (2013, April). *Enhancing Resilience to Climate Change and Climate Variability in the Central Pacific Region of Panama*. Retrieved November 22, 2016, accessed at http://www.miambiente.gob.pa/images/stories/BibliotecaVirtualImg/CambioClimatico/Propuesta_de_Panama_al_FA_en.pdf

16 Panama National Environmental Authority. (2013, April). *Enhancing Resilience to Climate Change and Climate Variability in the Central Pacific Region of Panama*. Retrieved November 22, 2016, accessed at http://www.miambiente.gob.pa/images/stories/BibliotecaVirtualImg/CambioClimatico/Propuesta_de_Panama_al_FA_en.pdf

17 Jose Fábrega, Tosiyuki Nakaegawa, Reinhardt Pinzón, Keisuke Nakayama, and Osamu Arakawa. "Hydroclimate projections for Panama in the late 21st Century." *Hydrological Research Letters* 7, no. 2 (2013): 23-29.

18 Jeff Tollefson, "Huge Arctic report ups estimates of sea-level rise", *Nature*. April 28, 2017, accessed at http://www.nature.com/news/huge-arctic-report-ups-estimates-of-sea-level-rise-1.21911

19 NASA Goddard's Scientific Visualization Studio/C. Starr. (2016, September 15). *Arctic Sea Ice Annual Minimum Ties Second Lowest on Record.* Retrieved November 30, 2016, accessed at https://www.nasa.gov/feature/goddard/2016/arctic-sea-ice-annual-minimum-ties-second-lowest-on-record

20 NASA, "Arctic Sea Ice Annual Minimum Ties Second Lowest on Record." September 15, 2016. Accessed at https://www.nasa.gov/feature/goddard/2016/arctic-sea-ice-annual-minimum-ties-second-lowest-on-record

21 Page 517, F.S. Chapin III, S. F. Trainor, P. Cochran, H. Huntington, C. Markon, M. McCammon, A. D. McGuire, and M. Serreze, 2014: Ch. 22: Alaska. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 514-536. doi:10.7930/J00Z7150. Accessed at http://nca2014.globalchange.gov/report/regions/alaska

22 J. Walsh, D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, J. Willis, D. Anderson, S. Doney, R. Feely, P. Hennon, V. Kharin, T. Knutson, F. Landerer, T. Lenton, J. Kennedy, and R. Somerville, 2014: Ch. 2: *Our Changing Climate*.
Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 19-67. doi:10.7930/J0KW5CXT.

23 Laurence C. Smith and Scott R. Stephenson. "New Trans-Arctic shipping routes navigable by midcentury." *Proceedings of the National Academy of Sciences* 110, no. 13 (2013): E1191-E1195

24 Costas Paris and Joanne Chiu. (2015, October 29). "Chinese Shipping Group Cosco Planning Regular Trans-Arctic Sailings." Wall Street Journal. Accessed at http://www.wsj.com/articles/chinese-shipper-cosco-to-schedule-regular-trans-arctic-sailings-1446133485

25 Borgerson, Scott G. "Arctic meltdown: the economic and security implications of global warming." *Foreign affairs* (2008): 63-77.

26 Scott R. Stephenson, Laurence C. Smith, Lawson W. Brigham, and John A. Agnew. "Projected 21st-century changes to Arctic marine access." Climatic Change 118, no. 3-4 (2013): 885-899.

27 Scott Stephenson, et al, "Projected 21st-century changes to Arctic marine access." Climatic Change 118, no. 3-4 (2013): 885-899.

28 U.S. Geological Survey. (2008). Circum-Arctic Resource Appraisal: Estimates of Undiscovered Oil and Gas North of the Arctic Circle. Retrieved November 21, 2016, accessed at http://pubs.usgs.gov/fs/2008/3049/

29 Scott Waldman. (2016, October 19). Arctic ice melt strains U.S.-Russia relations. Accessed October 26, 2016, at http://www.eenews.net/stories/1060044495

30 Page 7, National Research Council. Committee on National Security Implications of Climate Change for U.S. Naval Forces. "National security implications of climate change for U.S. naval forces," 2011. Retrieved from https://www.nap.edu/catalog/12914/national-security-implications-of-climate-change-for-us-naval-forces

31 Crystal Cruises. (2016, August 30). Crystal Serenity Becomes Largest Luxury Cruise Ship to Enter Fabled Northwest Passage. Retrieved November 21, 2016, accessed at http://www.businesswire.com/news/home/20160830006511/en/Crystal-Serenity-Largest-Luxury-Cruise-Ship-Enter

32 Pew Charitable Trusts. (2016, August 17). Mapping Governance Gaps on the High Seas. Retrieved November 22, 2016, accessed at http://www.pewtrusts.org/en/research-and-analysis/issue-briefs/2016/08/mapping-governance-gaps-on-the-high-seas

33 Page 3, National Intelligence Council. (2016, September 21). *Implications for US National Security of Anticipated Climate Change*. Retrieved November 21, 2016, accessed at https://www.dni.gov/files/documents/Newsroom/Reports and Pubs/Implications_for_US_National_Security_of_Anticipated_Climate_Change.pdf

34 FAO. 2016. *The State of Agricultural Commodity Markets 2015-2016*. Rome. 89 pp. http://www.fao.org/3/a-i5090e.pdf

35 Carole Dalin, Yoshihide Wada, Thomas Kastner, and Michael J. Puma. "Groundwater depletion embedded in international food trade." *Nature* 543, no. 7647 (2017): 700-704.

36 FAO. 2016. *The State of Agricultural Commodity Markets 2015-2016*. Rome. 89 pp. http://www.fao.org/3/a-i5090e.pdf.

37 Page IV, National Intelligence Council. (2012). *Global trends 2030: Alternative worlds: A publication of the National Intelligence Council*. Retrieved November 21, 2016, accessed at https://globaltrends2030.files.wordpress.com/2012/11/global-trends-2030-november2012.pdf

38 FAO. 2016. *The State of Agricultural Commodity Markets 2015-2016*. Rome. 89 pp. http://www.fao.org/3/a-i5090e.pdf

39 Keith M. Brander, "Global fish production and climate change." *Proceedings of the National Academy of Sciences* 104, no. 50 (2007): 19709-19714.

40 William Cheung, WL, Reg Watson, and Daniel Pauly. "Signature of ocean warming in global fisheries catch." *Nature* 497, no. 7449 (2013): 365-368.

41 Tim Wheeler, and Joachim Von Braun. "Climate change impacts on global food security." *Science* 341, no. 6145 (2013): 508-513.

42 Alkaly Doumbouya, Ousmane Tagbe Camara, Josephus Mamie, Jeremias Francisco Intchama, Abdoulie Jarra, Salifu Ceesay, Assane Guèye et al. "Assessing the effectiveness of Monitoring Control and Surveillance of illegal fishing: the case of West Africa." *Frontiers in Marine Science* 4 (2017): 50.

43 Andrew Jacobs, "China's Appetite Pushes Fisheries to the Brink." The New York Times, April 30, 2017. Accessed at https://www.nytimes.com/2017/04/30/world/asia/chinas-appetite-pushes-fisheries-to-the-brink.html?_r=0

44 Marcus DuBois King, "Climate Change and Vietnamese Fisheries: Opportunities for Conflict Prevention." Center for Climate and Security, Washington, DC. 2015.

45 Page 383, P.P. Wong, I.J. Losada, J.-P. Gattuso, J. Hinkel, A. Khattabi, K.L. McInnes, Y. Saito, and A. Sallenger, 2014: Coastal systems and low-lying areas. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 361-409. Accessed at http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap5_FINAL.pdf

46 FAO. 2016. *The State of Agricultural Commodity Markets 2015-2016*. Rome. 89 pp. http://www.fao.org/3/a-i5090e.pdf

47 U.S. Army Engineer Research and Development Center (ERDC). (2014). Risk Quantification for Sustaining Coastal Military Installation Assets and Mission Capabilities (RC-1701). Retrieved November 30, 2016, accessed at https://www.serdp-estcp.org/Program-Areas/Resource-Conservation-and-Resiliency/Infrastructure-Resiliency/Vulnerability-and-Impact-Assessment/RC-1701/RC-1701/(language)/eng-US, and Beeler, C. (2016, June 23). What it might take to protect the world's biggest naval base from rising seas. Retrieved November 22, 2016, accessed at http://www.pri.org/stories/2016-06-23/what-it-might-take-protect-worlds-biggest-naval-base-rising-seas

48 Constantine Samaras, "U.S. Military Basing Considerations during a Rebalance to Asia: Maintaining Capabilities under Climate Change Impacts." In, *The U.S. Asia-Pacific Rebalance, National Security and Climate Change*, C. Werrell and F. Femia (eds.), Center for Climate and Security, Washington, DC. 2015.