PAME I-2020: Agenda item 4.2

PAME Project to develop two factsheets on Marine Protected Areas under change

Working Bibliography

Note: The below sources represent a work-in-progress, both in terms of adding additional sources and providing summary snapshots of publications.

Climate Drivers

Sea Surface Temperature

- AMAP, 2019. AMAP Climate Change Update 2019: An Update to Key Findings of Snow, Water, Ice and Permafrost in the Arctic (SWIPA) 2017. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. 12 pp.
    - Sea-surface temperatures are increasing over much of the Arctic Ocean
        - August sea-surface temperatures in the Chukchi Sea, between Siberia and Alaska, rose at a rate of 0.7°C per decade from 1982–2017

- Timmermans, M. -L., and C. Ladd, 2018: Sea Surface Temperature [in Arctic Report Card 2018], https://www.arctic.noaa.gov/Report-Card.
    - August mean sea surface temperatures (SSTs) show statistically significant warming trends for 1982-2018 in most regions of the Arctic Ocean that are ice-free in August (source)
        - Mean August SSTs from 1982-2018 show warming trends over much of the Arctic Ocean -- linear warming trends of up to +1° C decade-1 are observed

- IPCC, 2019: Summary for Policymakers. In: *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* [H.- O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.)]. In press.
    - The Arctic ocean has continued to warm in recent years
    - Over large sectors of the seasonally ice-free Arctic, summer upper mixed layer temperatures increased at around 0.5°C per decade during 1982-2017, primarily associated with increased absorbed solar radiation accompanying sea ice loss, and the inflow of ocean heat from lower latitude increased since the 2000s

Air Temperature

- Overland, J.E., et al, 2018: Surface Air Temperature [in Arctic Report Card 2018], https://www.arctic.noaa.gov/Report-Card.
    - The Arctic continued it long-term warming trend in 2018, warming at twice the rate relative to the rest of the globe with Arctic air temperatures for the past five years (2014-18) exceeding all previous records since 1900.

- Conservation of Arctic Flora and Fauna (CAFF). 2013. Arctic Biodiversity Assessment: Report for Policy Makers. CAFF, Akureyri, Iceland.
    - Summer temperatures in the Arctic during recent decades have been warmer than at any time in the past 2000 years
        - The region is warming twice as fast as the rest of the planet

        - Within this century, temperatures in the Arctic are projected to increase by several degrees above the 1980-2000 average

- AMAP, 2019. AMAP Climate Change Update 2019: An Update to Key Findings of Snow, Water, Ice and Permafrost in the Arctic (SWIPA) 2017. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. 12 pp.
    - Observed and projected annual average warming in the Arctic continues to be more than twice the global mean, with higher increases in winter
        - From 1971–2017, Arctic annual surface air temperatures rose 2.4 times faster than the Northern Hemisphere average.
        - Arctic annual surface air temperatures in 2014, 2015, 2016, 2017, and 2018 exceeded those of any year since 1900
        - The annual average Arctic surface air temperature rose by 2.7°C from 1971 to 2017, with a 3.1°C increase during the cold season and a 1.8°C increase during the warm season.

- IPCC, 2019: Summary for Policymakers. In: *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* [H.- O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.)]. In press.
    - Arctic surface air temperature has likely increased by more than double the global average over the last two decades, with feedbacks from loss of sea ice and snow cover contributing to the amplified warming.
    - For each of the last five years (2014-2018), Arctic annual surface air temperature exceeded that of any year since 1900.
    - During the winters (January-March) of 2016 and 2018, surface temperatures in the central Arctic were 6°C above the 1981-2010 average, contributing to unprecedented regional sea ice absence.

Sea Ice Change

- AMAP, 2019. AMAP Climate Change Update 2019: An Update to Key Findings of Snow, Water, Ice and Permafrost in the Arctic (SWIPA) 2017. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. 12 pp.
    - Arctic winter sea ice maximums in 2015, 2016, 2017, and 2018 were at record low levels, and the 12 lowest minimum extents in the satellite record have all occurred in the last 12 years.
        - The volume of Arctic sea ice present in the month of September has declined by 75 percent since 1979
    - Sea ice has gone through a transition from mostly thick multi-year sea ice to younger and thinner seasonal sea ice
    - If global warming is stabilized at 1.5°C, the probability of an ice-free summer occurring in any given year would be roughly 2 percent; at 2°C, the probability would rise to 19–34 percent
        - Some models suggest the Arctic Ocean could be seasonally ice-free within the next few decades

- IPCC, 2019: Summary for Policymakers. In: *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* [H.- O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.)]. In press.

- It is very likely that Arctic sea ice extent continues to decline in all months of the year; the strongest reductions in September (-12.8 ± 2.3% per decade; 1979-2018) are likely unprecedented in at least 1000 years.
- It is virtually certain that Arctic sea ice has thinned, concurrent with a shift to younger ice: since 1979, the areal proportion of thick ice at least 5 years old has declined by approximately 90%.
- It is very likely that approximately half the observed sea ice loss is attributable to increased atmospheric greenhouse gas concentrations.
- It is very likely that projected Arctic warming will result in continued loss of sea ice and snow on land, and reductions in the mass of glaciers.
    - Important differences in the trajectories of loss emerge from 2050 onwards, depending on mitigation measures taken. For stabilised global warming of 1.5°C, an approximately 1% chance of a given September being sea ice free at the end of century is projected; for stabilised warming at a 2°C increase, this rises to 10-35%.

- Perovich, D., et al, 2018: Sea Ice [in Arctic Report Card 2018], https://www.arctic.noaa.gov/Report-Card.
    - Arctic sea ice in 2018 remained younger, thinner, and covered less area than in the past.
    - Observations of Arctic sea ice extent have shown decreasing trends in all months and virtually all regions
        - The 2018 sea ice cover winter maximum was 7.3% below the 1981-2010 average and was the second lowest maximum extent recorded.
            - The past four years (2015-18) have the four lowest maximums in the satellite record.
        - The 2018 sea ice cover minimum was 26% less than the 1981-2010 average minimum ice extent
            - The 12 lowest extents in the satellite record have occurred in the last 12 years.
    - The oldest ice (>4 years old) continues to make up a small fraction of the Arctic ice pack in March, when the sea ice extent has been at its maximum in most years of the satellite record.
        - In 1985, the oldest ice comprised 16% of the ice pack, whereas in March of 2018 old ice only constituted 0.9% of the ice pack.
            - Therefore, the oldest ice extent declined from 2.54 million km2 in March 1985 to 0.13 million km2 in March 2018, representing a 95% reduction.
        - First-year ice now dominates the ice cover, comprising ~77% of the March 2018 ice pack compared to about 55% in the 1980s.
    - The sea ice thickness increase from October 2017 through April 2018 was less than normal, resulting in a relative decline in mean thicknesses over the winter.
        - The total volume gain amounted to only 7.31 thousand km3 compared to the 2010-18 average of 7.73 thousand km3
    - In the Bering Sea, winter sea ice extent reached a record low for virtually the entire 2017-2018 ice season. During two weeks in February, typically the height of winter, the Bering Sea lost significant ice cover, about ~215,000 km2, dropping from ~59% to only ~26% of normal (relative to the 1979-2016 median).

Ocean Acidification

- Conservation of Arctic Flora and Fauna (CAFF). 2013. Arctic Biodiversity Assessment: Report for Policy Makers. CAFF, Akureyri, Iceland.
    - The increased carbon dioxide concentrations in the atmosphere are also leading to acidification of ocean waters worldwide, especially in colder Arctic waters that can dissolve more carbon dioxide

- IPCC, 2019: Summary for Policymakers. In: *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* [H.- O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.)]. In press.
    - The Arctic Ocean is continuing to remove carbon dioxide from the atmosphere and to acidify.
    - In the Arctic Ocean, the area corrosive to organisms that form shells and skeletons using the mineral aragonite expanded between the 1990s and 2010, with instances of extreme aragonite undersaturation.

Ocean Circulation

- IPCC, 2019: Summary for Policymakers. In: *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* [H.- O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.)]. In press.
    - Freshwater release from Greenland has the potential to modulate/inhibit the formation of water masses that represent the headwaters of the Atlantic Meridional Overturning Circulation
        - there is medium confidence that the AMOC has weakened over the historical era but there is insufficient evidence to quantify a likely range of the magnitude of the change

Extreme Weather

- AMAP, 2019. AMAP Climate Change Update 2019: An Update to Key Findings of Snow, Water, Ice and Permafrost in the Arctic (SWIPA) 2017. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. 12 pp.
    - Annual precipitation appears to be increasing in the Arctic, by an estimated 1.5–2.0 percent per decade, with the strongest increase occurring during the October–May cold season
    - Some regions such as Scandinavia and the Baltic Sea basin are seeing less precipitation falling as snow and more as rain
- IPCC, 2019: Summary for Policymakers. In: *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* [H.- O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.)]. In press.
    - There is high confidence that marine heatwaves will increase in frequency, duration, spatial extent and intensity in all ocean basins under future global warming, mainly because of an increase in mean ocean temperature.
        - The largest increases in the probability of MHWs will occur in the tropical ocean and the Arctic Ocean

Sea Level Rise

- AMAP, 2019. AMAP Climate Change Update 2019: An Update to Key Findings of Snow, Water, Ice and Permafrost in the Arctic (SWIPA) 2017. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. 12 pp.
    - Arctic glaciers, led by the Greenland Ice Sheet, are the largest land-ice contributors to global sea level rise
        - Even if the Paris Agreement is successful, they will continue to lose mass over the course of this century

- IPCC, 2019: Summary for Policymakers. In: *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* [H.- O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.)]. In press.
    - Contribution from the Greenland Ice Sheet to sea level rise over 2012–2016 (0.68 [0.64 to 0.72] mm yr–1) was similar to the contribution over 2002–2011 (0.73 [0.67 to 0.79] mm yr–1) and extremely likely greater than over 1992–2001 (0.02 [0.21 to 0.25] mm yr–1).
        - Summer melting of the Greenland Ice Sheet has increased since the 1990s to a level unprecedented over at least the last 350 years, and two-to-fivefold the pre-industrial level
        - The Greenland Ice Sheet is currently losing mass at roughly twice the pace of the Antarctic Ice Sheet. From 2005-2016 GIS was the largest terrestrial contributor to global sea level rise.
        - Mass loss from Arctic glaciers (-212 ± 29 Gt yr-1) during 2006-2015 contributed to sea level rise at a similar rate (0.6 ± 0.1 mm yr-1) to the Greenland Ice Sheet

Additional resources to be used and cited (In process to review for key information)

- AMAP, 2018. Adaptation Actions for a Changing Arctic: Perspectives from the Baffin Bay/Davis Strait Region. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. 354 pp.
- AMAP, 2017. Adaptation Actions for a Changing Arctic (AACA) - Baffin Bay / Davis Strait Region Overview report. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. 24 pp.
- AMAP, 2017. Adaptation Actions for a Changing Arctic: Perspectives from the Bering-Chukchi-Beaufort Region. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. 255 pp.
- AMAP, 2017. Adaptation Actions for a Changing Arctic (AACA) - Bering/Chukchi/Beaufort Region Overview report. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. 24 pp.
- AMAP, 2017. Adaptation Actions for a Changing Arctic: Perspectives from the Barents Area. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. 267 pp.
- AMAP, 2017. Adaptation Actions for a Changing Arctic (AACA) - Barents Area Overview report. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. 24 pp.
- AMAP, 2019. Arctic Ocean Acidification Assessment 2018: Summary for Policy-Makers. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. 16 pp.
- AMAP, 2018. AMAP Assessment 2018: Arctic Ocean Acidification. Arctic Monitoring and Assessment Programme (AMAP), Tromsø, Norway. 187 pp.

- AMAP, 2014. Arctic Ocean Acidification 2013: An Overview. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. 27 pp.
- AMAP, 2013. AMAP Assessment 2013: Arctic Ocean Acidification. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. 99 pp.
- AMAP, CAFF, and SDWG, 2013. Identification of Arctic marine areas of heightened ecological and cultural significance: Arctic Marine Shipping Assessment (AMSA) IIc. Oslo. 114 pp.
- CAFF. 2013. Arctic Biodiversity Assessment. CAFF, Akureyri, Iceland.
- CAFF. 2017. State of the Arctic Marine Biodiversity Report. Conservation of Arctic Flora and Fauna International Secretariat, Akureyri, Iceland. 978-9935-431-63-9