Climate Change 2022
Impacts, Adaptation and Vulnerability

Dr. Kirstin K. Holsman
NOAA AFSC
Lead Author IPCC Working Group II (Chp. 14, CCP6)
Outline for today

• Part 1: Key WGI findings
• Part 2: Key WGII findings
• Part 3: Relevant findings for Alaska Fisheries
  • Key sections for fisheries
  • Key recommendations for adaptation
• Part 4: WGIII findings relative to 1.5 ºC target
How to access the most recent (CMIP6) climate projections

- PSL Climate Change portal (explore plots from CMIP6; similar to IPCC Atlas): [https://psl.noaa.gov/ipcc/cmip6/](https://psl.noaa.gov/ipcc/cmip6/)
- ACLIM data portal: explore high res projections for the EBS including krill: [https://data.pmel.noaa.gov/aclim/las/UI.html](https://data.pmel.noaa.gov/aclim/las/UI.html)
- *Future: EBS Climate Change dashboard (via ACLIM3)*
Climate Change

Causes
Drivers

WG I
Aug 2021

Impacts
Adaptation

WG II
Feb 2022

Mitigation

WG III
Apr 2022
A.1 It is unequivocal that human influence has warmed the atmosphere, ocean and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred.

A.2 The scale of recent changes across the climate system as a whole – and the present state of many aspects of the climate system – are unprecedented over many centuries to many thousands of years.

A.3 Human-induced climate change is already affecting many weather and climate extremes in every region across the globe. Evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones, and, in particular, their attribution to human influence, has strengthened since AR5.
Climate change has already warmed the planet

“The likely range of total human-caused global surface temperature increase from 1850–1900 to 2010–2019 is 0.8°C to 1.3°C, with a best estimate of 1.07°C.”

IPCC 2021 6th Assessment Report, WG 1, SPM

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IPCC 2021 6th Assessment Report, WG 1, SPM

Recent Global Mean Warming is:

- Warmest period in more than 100,000 years
- Unprecedented warming in more than 2,000 years
- CO2 concentrations in 2019 were higher than any time in at least 2 million years.
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IPCC 2021 6th Assessment Report, WG 1, SPM

Warming trends that match observations are seen in historical model runs that include human induced GHG emissions.

Warming is not seen in “control” runs that don’t have human induced GHG emissions.
Near linear relationship between temperature & CO$_2$ emissions

Every tonne of CO$_2$ emissions adds to global warming

Global surface temperature increase since 1850–1900 (°C) as a function of cumulative CO$_2$ emissions (GtCO$_2$)

The near-linear relationship between the cumulative CO$_2$ emissions and global warming for five illustrative scenarios until year 2050

Figures from the IPCC AR6 WGI Summary for Policymakers:
Near linear relationship between temperature & CO₂ emissions

Every tonne of CO₂ emissions adds to global warming

<table>
<thead>
<tr>
<th>CO₂ Emissions</th>
<th>Global Mean Warming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Historical global warming</td>
<td></td>
</tr>
<tr>
<td>Cumulative CO₂ emissions since 1850</td>
<td></td>
</tr>
<tr>
<td>Global surface temperature increase since 1850-1900 (°C) as a function of cumulative CO₂ emissions (GtCO₂)</td>
<td></td>
</tr>
</tbody>
</table>

Low carbon mitigation scenario

High carbon mitigation (low emissions) scenario

Climate change is expected to continue to impact AK Ecosystems & Fisheries

Low CO₂ mitigation scenario

High CO₂ mitigation scenarios

“plausible descriptions of how the future may evolve with respect to a range of variables…they are not meant to be policy prescriptive, (i.e. no likelihood or preference is attached to any of the individual scenarios of the set)”

van Vuuren et al. 2011

Climate change is expected to continue to impact AK Ecosystems & Fisheries

**Figures from the IPCC AR6 WGI Summary for Policymakers:**


**Low CO₂ mitigation scenario**

Sea Ice will continue to decline, more so under scenarios with high global warming and low CO₂ mitigation.

**High CO₂ mitigation scenarios**

Warming will continue and is greater in scenarios with low CO₂ mitigation.
Climate change is expected to continue to impact AK Ecosystems & Fisheries

WGI TECHNICAL SUMMARY

“In AR6, combining the larger estimate of global warming to date and the assessed climate response to all considered scenarios, the central estimate of crossing 1.5°C of global warming (for a 20-year period) occurs in the early 2030s, ten years earlier than the midpoint of the likely range assessed in the SR1.5, assuming no major volcanic eruption.

Warming in the Arctic is 2-3 x global average

1.07°C of “Global mean warming” = Warming of 2-3°C in the Arctic

“Arctic Amplification”

a) Annual mean temperature change (°C)
at 1 °C global warming

Warming at 1 °C affects all continents and is generally larger over land than over the oceans in both observations and models. Across most regions, observed and simulated patterns are consistent.
High Emissions (SSP585)
End of Century Change in Sea Surface Temperature (°C)
High Emissions (SSP585)

End of Century Change in Bottom Temperature (°C)
More acidification

Lower dissolved oxygen

Increased precipitation

Winds from the SW

https://psl.noaa.gov/ipcc/cmip6/
The science is clear. Any further delay in concerted global action will miss a brief and rapidly closing window to secure a liveable future. This report offers solutions to the world.
Growing scientific knowledge gives us our best understanding yet.

- 270 Authors
- 67 Countries
- 675 Contributing authors
- 43% Developing countries
- 57% Developed countries
- 41% Women / 59% Men
- More than 34,000 scientific papers
- 62,418 Review comments
New understanding of interconnections

Consider coupled climate-ecological-social systems

The risk propeller shows that risk emerges from the overlap of:

- Climate hazard(s)
- Vulnerability
- Exposure

...of human systems, ecosystems and their biodiversity
Global warming has caused dangerous and widespread disruption in nature…
...and climate change is affecting the lives of billions of people, despite efforts to adapt.
Action on adaptation has increased but progress is uneven and we are not adapting fast enough.
Every small increase in warming will result in increased risks.
Nature’s crucial services at risk in a warming world

Pollination

Coastal protection

Tourism / recreation

Food source

Health

Water filtration

Clean air

Climate regulation
Fisheries and Alaska
CCP6 : Polar Regions
Chapter 3: Oceans
Chapter 5: Food and Fibre
Chapter 14: North America
Long-term loss and degradation of marine ecosystems compromises the ocean’s role in cultural, recreational, and intrinsic values important for human identity and well-being.
Example Impacts & Risks

- Shifting distributions & altered access
- Shifts in trophic pathways & size spectra
- Phenological mismatches & changes in productivity

- Reductions in fishery & subsistence resources
- Future risk to food & nutritional security
- Geopolitical, survey, stock boundary challenges
- Increased interactions between protected species & fisheries (e.g., pot fisheries)
- Compound multiple climate impacts (MHW, HABs, and low DO) & non-climate pressures (e.g., pollution, shipping)

- Increasing fishery emergencies & economic losses
- Reduced confidence in management
- Supply chain disruption (e.g., ports)
- Changes in safety & security
- Changes in markets & demand (interactions with agriculture)
Climate change has already caused: US Fishery impacts

“Nationwide, 84.5% of fishery disasters were either partially or entirely attributed to extreme environmental events.”

<table>
<thead>
<tr>
<th>Cause</th>
<th>Alaska</th>
<th>Greater Atlantic</th>
<th>Pacific Islands</th>
<th>Southeast</th>
<th>West Coast</th>
<th>To be determined</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthropogenic</td>
<td>$82,000,000</td>
<td>$132,996,669</td>
<td>$30,940,000</td>
<td>$7,600,000</td>
<td>$253,536,669</td>
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<td></td>
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<tr>
<td>Environmental</td>
<td>$174,292,189</td>
<td>$41,572,622</td>
<td>$505,938,343</td>
<td>$170,723,211</td>
<td>$893,666,365</td>
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<tr>
<td>Combination of Both</td>
<td>$75,588,349</td>
<td>$36,600,000</td>
<td>$37,098,200</td>
<td>$281,802,589</td>
<td>$431,089,138</td>
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<tr>
<td>To be determined</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$414,103,069</td>
<td>$414,103,069</td>
</tr>
<tr>
<td>Total</td>
<td>$331,880,538</td>
<td>$211,169,291</td>
<td>$1,140,000</td>
<td>$460,125,800</td>
<td>$1,992,395,241</td>
<td></td>
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</tr>
</tbody>
</table>

Contractions of the polar climate zones lead to distribution shifts and changes in food webs, induce declines in many species (medium confidence) with impacts on subsistence harvests and commercial fisheries, and threaten global dependence on polar regions for substantial marine food production (high confidence).
Projected Impacts: Arctic

Warming to date

https://interactive-atlas.ipcc.ch/
Example Impacts & Risks

**Disappearing sea ice**

Winter ice cover in the Bering Sea has diminished faster than scientists expected. The record for the least amount of ice since 1850 was set in 2018, and 2019 came close to breaking that record.

https://www.seattletimes.com/seattle-news/as-bering-sea-ice-melts-nature-is-changing-on-a-massive-scale-and-alaska-crab-pots-are-pulling-up-cod/
Example Impacts & Risks

How sea ice helps sustain Bering Sea snow crab

Snow crab typically dwell in a bottom layer of cold water that provides protection from predators. That cold pool shrank drastically during recent warming.

1. **Sea ice**
   - As ice freezes, it sheds a dense layer of cold, briny seawater.

2. **Ice algae**
   - Algae grows on the part of the ice that hangs just below the surface.
   - By the summer, the dense layer of briny water, along with ice melt, forms a cold pool on the sea bottom where snow crab are found.

3. **Snow crab** (Chionoecetes opilio)
   - The cold pool was greatly diminished during the warm years of 2018 and 2019 when sea ice was at record lows. That enabled cod, which avoid the cold pool, as well as other predators, to eat more crab.

**Source:** Aug. 23, 2019, presentation by Janet Duffy-Anderson, NOAA/Alaska Fisheries Science Center

**MARK NOWLIN / THE SEATTLE TIMES**
Projected Impacts

Declines in benthic biomass projected for most regions

High CO₂ Mitigation
Less warming
(SSP1 2.6)

Low CO₂ Mitigation
High warming
(SSP5 8.5)
Projected Impacts

Declines in fish biomass projected for most regions

Adaptation planning needed to minimize impacts
There are options we can take to reduce the risks to people and nature.
Adaptation can reduce risks if coupled with CO₂ Mitigation

Urgent need for:

“Implementation of adaptive management that is closely linked to monitoring, research, and low cost and inclusive public participation”
Ocean adaptation

IPCC AR6 WGII
Figure 3.23
Key Aspects of Fisheries Adaptation

- Inclusive, participatory, & equitable decision making
- Responsive & flexible management
- Ecosystem Based Management
- Diversity in harvest options & livelihoods
- Ecological redundancy & high biodiversity
- Preserve ecosystem function & climate refugia
- Climate change planning & preparation
- Increased foresight & climate informed advice
- Monitoring & rapid response
- Emergency response
To avoid mounting losses, urgent action is required to adapt to climate change.

There are limits to adaptation

At the same time, it is essential to make rapid, deep cuts in greenhouse gas emissions to keep the maximum number of adaptation options open.
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Drivers

WG I

Aug 2021

Impacts
Adaptation

WGII

Feb 2022

Mitigation

WGIII

Apr 2022
Global net anthropogenic emissions have continued to rise across all major groups of greenhouse gases.

2019 total net anthropogenic GHG emissions
- 34% Energy Supply
- 24% Industry
- 22% Agriculture, forestry & land use
- 15% Transport
- 6% Buildings
C.1 Global GHG emissions are projected to peak between 2020 and at the latest before 2025 in global modelled pathways that limit warming to 1.5°C (>50%) with no or limited overshoot and in those that limit warming to 2°C (>67%) and assume immediate action...

...Without a strengthening of policies beyond those that are implemented by the end of 2020, GHG emissions are projected to rise beyond 2025, leading to a median global warming of 3.2 [2.2 to 3.5] °C by 2100.

C.3 All global modelled pathways that limit warming to 1.5°C (>50%) with no or limited overshoot, and those that limit warming to 2°C (>67%), involve rapid and deep, and in most cases, immediate GHG emission reductions in all sectors.
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**WGIII SPM**

Range of action to remain below 1.5 °C GMW (2020-2025; emissions must peak now to limit warming to 1.5 °C )

**WGI TECHNICAL SUMMARY**

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Overall, the latest studies on the net economic implications of decarbonisation – which also account for avoided climate damages – point to overall benefit from the transition.

- Prof Valentina Bosetti

If people are provided with opportunities to make choices supported by policies, infrastructure and technologies, there is an untapped mitigation potential to bring down global emissions by between 40 and 70% by 2050 compared to a baseline scenario.

- Prof Joyashree Roy

The evidence is clear: there are now mitigation options available in all sectors that could together halve global greenhouse gas emissions by 2030.

- Dr Céline Guivarch

This is solvable!