

# WHALE ECOSYSTEM SERVICES AND SOCIO-ECOLOGICAL CHANGE IN THE ARCTIC

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An aerial photograph of a glacier with numerous meltwater ponds of varying sizes. Two people are walking across the ice in the middle ground. The text is overlaid on a white rectangular box at the top and a semi-transparent grey box at the bottom.

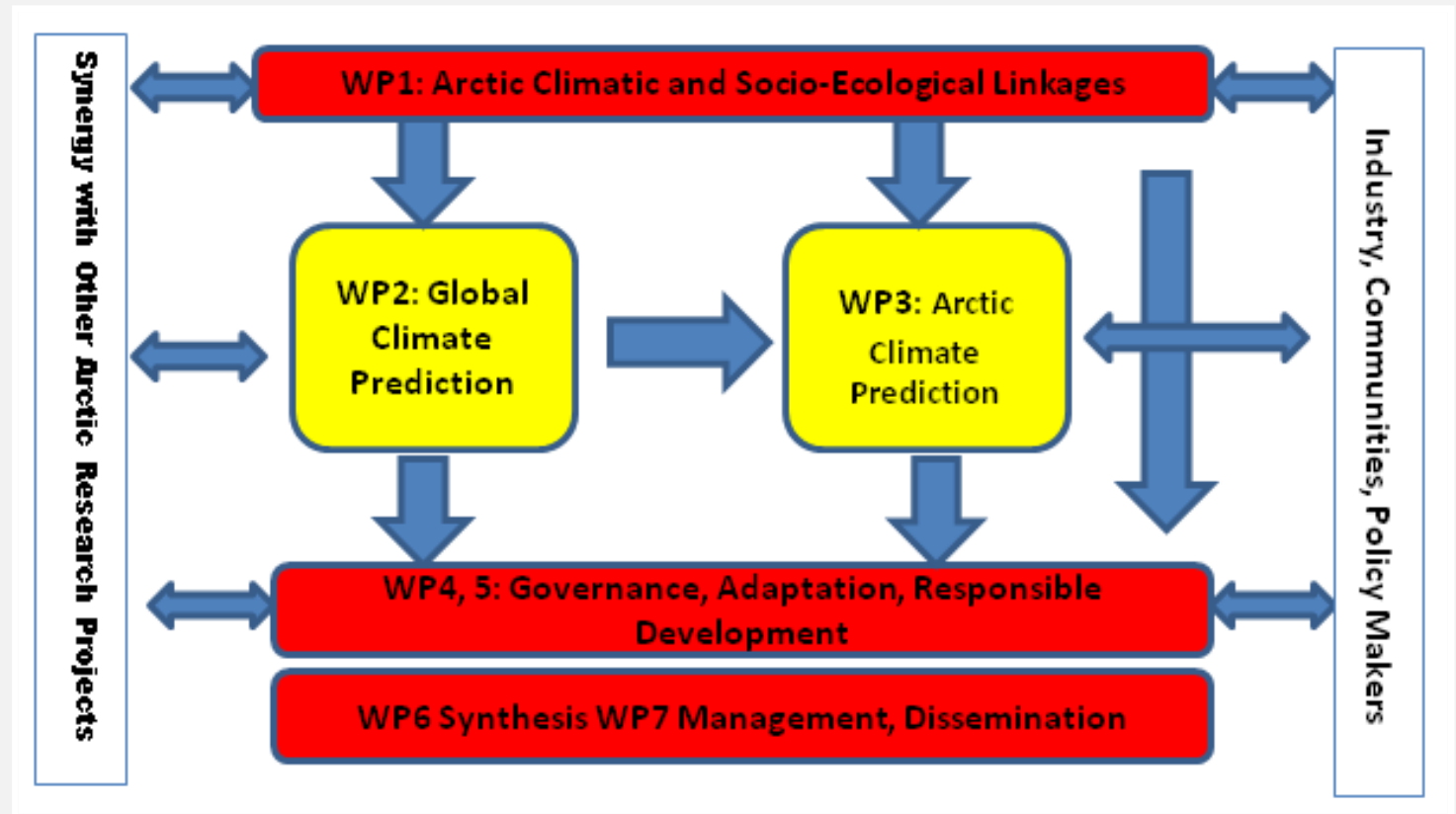
# THREE OVERARCHING ARCPATH OBJECTIVES

- (i) climate predictions
- (ii) increased understanding how climate change interacts with multiple societal factors
- (iii) combining improved regional climate predictions with enhanced understanding of environmental, societal and economic interactions to supply new knowledge on potential pathways to action

# ARCPATH - ARCTIC CLIMATE PREDICTIONS: PATHWAYS TO RESILIENT, SUSTAINABLE SOCIETIES



- ‘Responsible Development in the Arctic: Opportunities and Challenges’
- Arctic climate change predictions and what they mean for ecosystems and communities



# WHAT HAVE WE STUDIED?



Photo: National Geographic, 2009.

- ARCPATH Work Package 4 (WP4):

‘Climate, Socio-Ecological Systems, Cetaceans and Tourism’

Main study areas of WP4:

- impacts of increased marine tourism and marine traffic on marine mammals
- various ecosystem services (ES) are provided by marine mammals
- trade-offs between different whale ES
- **changing socio-ecological systems in the Arctic**
- sustainable management / governance of marine ecosystems



# ECOSYSTEM SERVICES OF WHALES

| <b>CICES Category</b>             | <b>Ecosystem Service</b>  |
|-----------------------------------|---|
| <b>Provisioning</b>               | Food products (meat, blubber, skin and intestines)<br>Whale bones, teeth and baleen<br>Oil based products deriving from blubber   |
| <b>Regulation and maintenance</b> | Enhanced primary production<br>Enhanced biodiversity and evolutionary potential<br>Nutrient cycling<br>Climate regulation   |
| <b>Cultural</b>                   | Tourism (whale watching)<br>Music and arts<br>Education<br>Spiritual enrichment<br>Community cohesiveness and cultural identity<br>Aesthetics<br>Associations linked to non-use value |

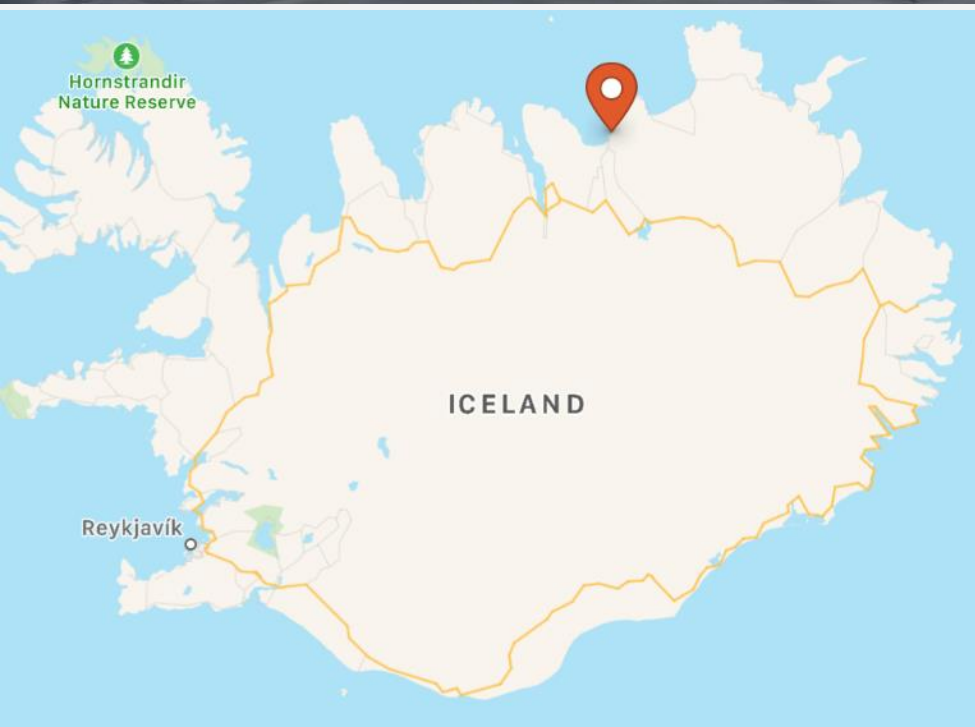
Sourced from Cook et al., 2019.





## CASE STUDY LOCATION I: HÚSAVÍK, SKJÁLFANDI BAY

- Medium-sized town with 2,323 inhabitants
- “Whale watching capital of Europe”
- Located near Skjálfandi Bay, Northeast Iceland
- Most common species: humpback, minke and blue whales, harbor porpoises
- Whale watching since 1990s
- 115,000 whale watching passengers in 2019 (364,000 in Iceland)



## CONNECTING THE DOTS – INTERDISCIPLINARY SYNTHESIS PAPER

- Literature review on climate change impacts on cetaceans – global focus
- Downscaled climate models to Skjálfandi Bay region
- Logs on whale sightings
- Statistical tests on links between SST and sightings
- Projections on changes to SST up to 2050 and beyond
- Adaptive planning may be necessary



# CLIMATE ANALYSIS

- Three IPCC scenarios of analysis over period 1981-2050 using EC-Earth3
  - SSP1-2.6 – low emissions
  - SSP2-4.5 – intermediate emission scenario
  - SSP3-7.0 – high emission scenario
- Analysis of changes to SST and wind speeds of more than 7 m/s and 10 m/s
- Model results compared to ERA-5 analysis





# HOW DO THE METHODS INTERRELATE?

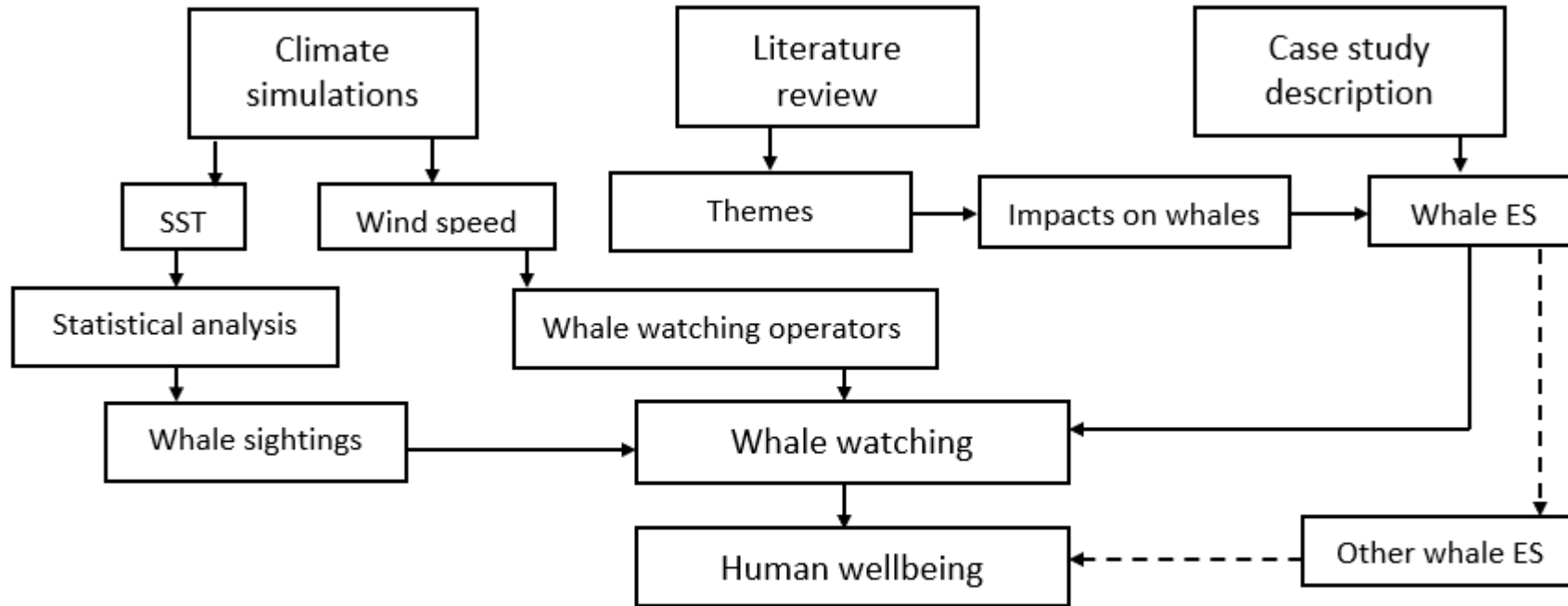


Figure 1. The research methods used in the study and how they relate to the study objectives.



# LITERATURE REVIEW FINDINGS

- Three main categories of impact:
  - 1) Changing distributions and migration
  - 2) Prey availability
  - 3) Sea-ice and ocean temperature



# WHALE SIGHTINGS – PAST DATA

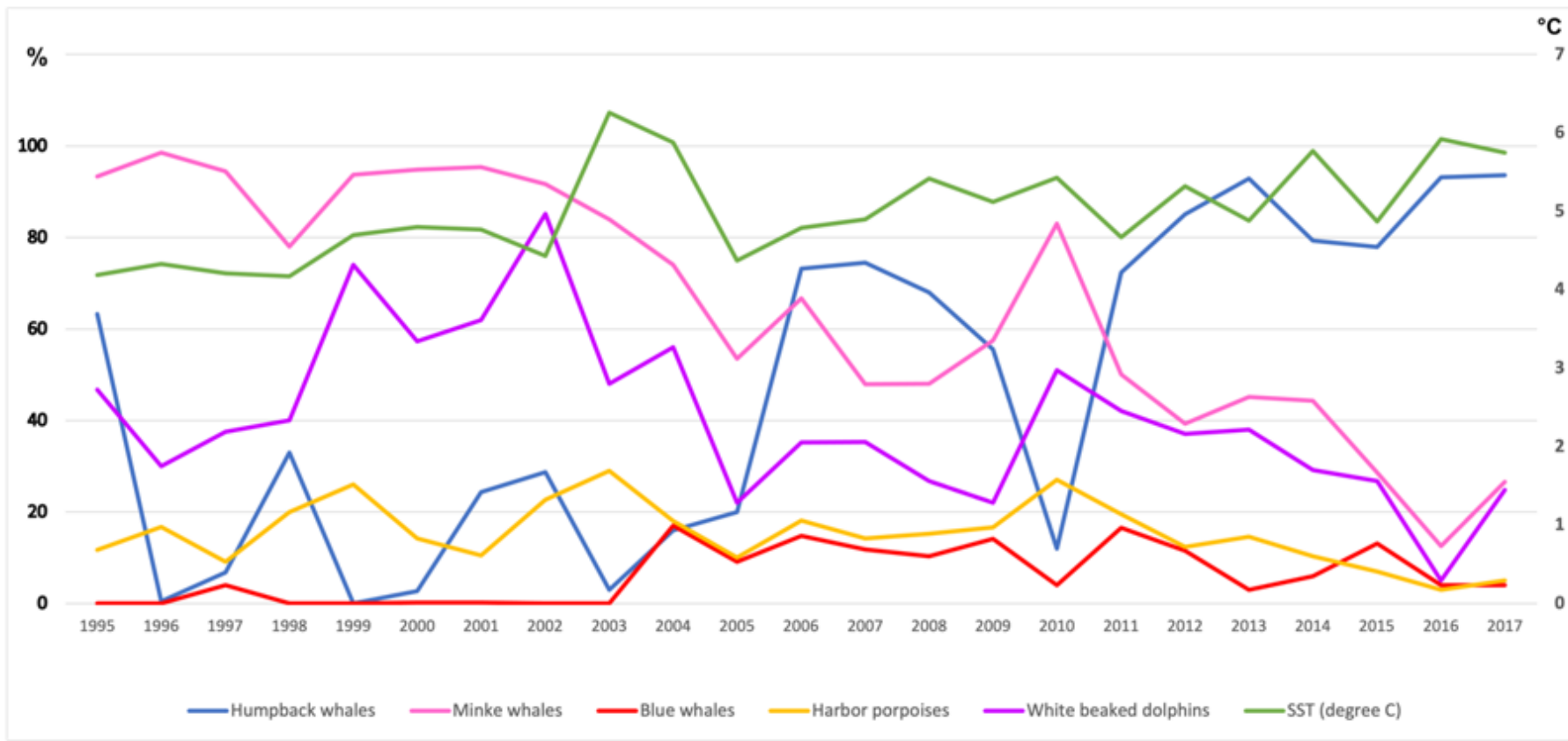


Figure 4. Whale sightings (% of whale watching trips; the % scale on the left y-axis) and SST in Skjálfandi Bay 1995-2017 (in green; the degree Celsius scale on the right y-axis).



# SST – PAST AND PROJECTIONS

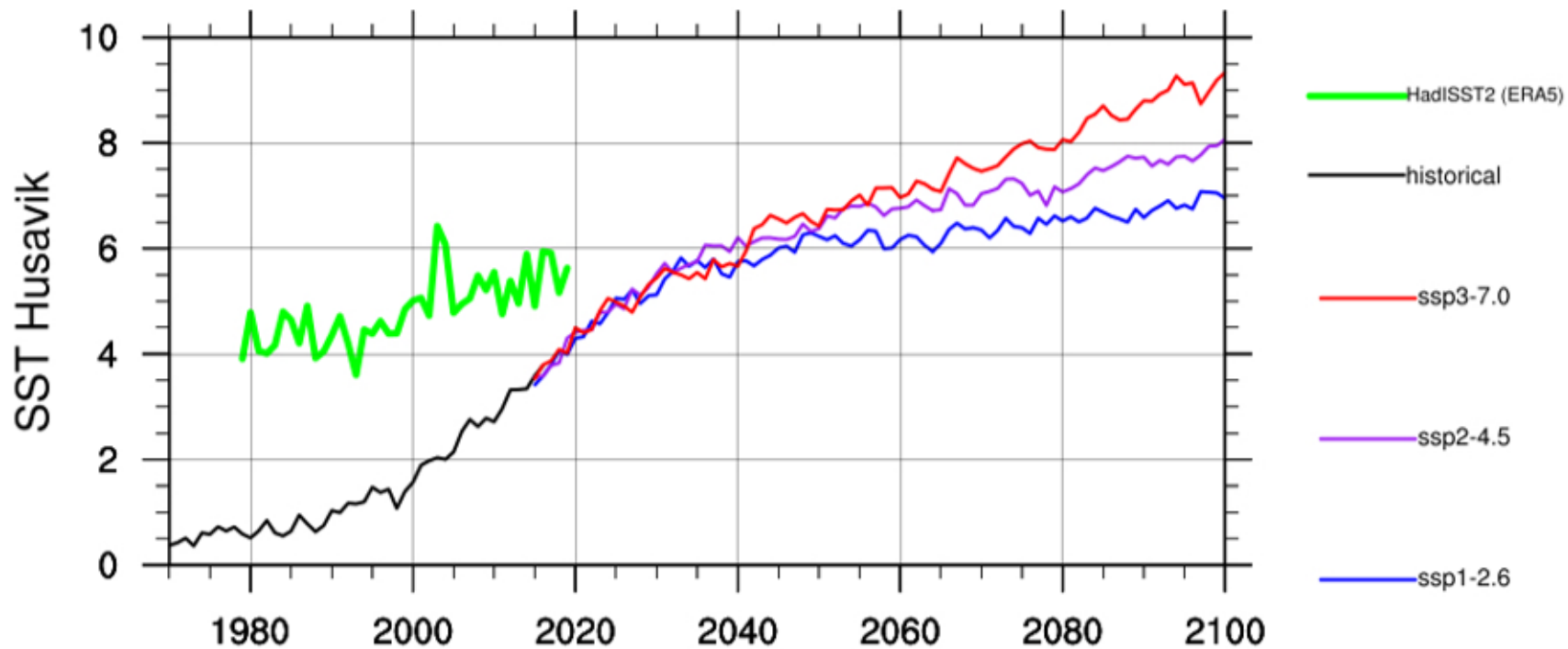


Figure 3. Projected sea surface temperatures (SST) in Skjálfandi Bay according to different climate change scenarios with respect to atmospheric temperature increases of 2.6°C (SSP1-2.6), 4.5°C (SSP2-4.5), and 7°C (SSP3-7.0).



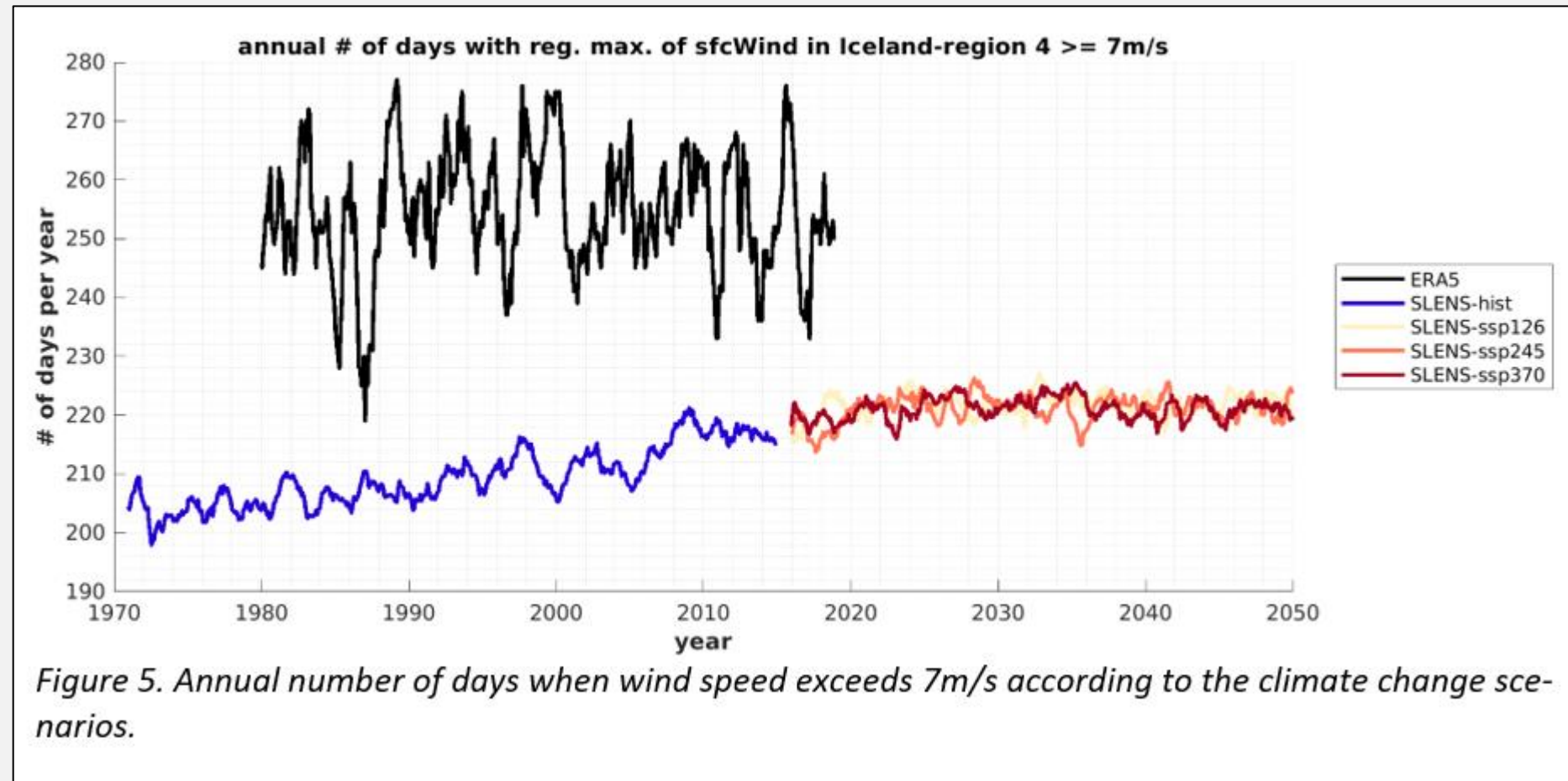
# STATISTICALLY SIGNIFICANT RELATIONSHIPS

- With no time lag, increased SST was found to be a statistically significant influence on declining sightings of minke whales (\*\*,  $p = 0.047$ ).
- Applying a time lag of one year, SST was found to be a statistically significant influence on the declining percentage sightings of minke whales (\*\*,  $p = 0.037$ ) and increased percentage sightings of blue whales (\*\*,  $p = 0.019$ ).
- Applying a time lag of two years, SST was found to be a statistically significant influence on the declining percentage sightings of minke whales (\*,  $p = 0.057$ ) and white-beaked dolphins (\*\*,  $p = 0.019$ ).

\*\*indicates significance at 5% level and \* indicates significance at 10% level.



# WINDY DAYS AND CLIMATE CHANGE



## IMPLICATIONS OF STUDY

- Uncertainty and ongoing socio-ecological change – increased SSTs a near-certainty over the next 3 decades
- Likely further northwards transition of minke whales and white-beaked dolphins
- Húsavík has already demonstrated adaptive capacity – fishing to whale watching
- Could the region further adapt if the whales disappeared?
- What might this mean for other whale ecosystem services?
- What about governance and the role and scope of the Skjálfandi Bay whale sanctuary?





**THANK YOU!**

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