Analyzing Climate Impacts on Current & Future Antarctic Penguin Populations

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Abstract

As global climate change continues to intensify worldwide, important indicator species, such as penguins, have been greatly affected in their ability to adapt and maintain population numbers long-term. It is unclear how pervasive these effects will be in the future, given that much of climate change is anthropogenic, and human activity can greatly vary in the future. This thesis aims to quantitatively break down historical trends based on species differences and their specific correlations to sea ice extent and temperature changes. Data from the Mapping Application for Penguin Populations and Projected Dynamics (MAPPPD) was taken to track Adélie, Chinstrap, Gentoo, and Emperor penguin populations on shared research sites from 1979 to 2018. It was determined that during this period in the analyzed regions, Adélie, Chinstrap, and Emperor penguins have declined by approximately 88.70%, 96.20%, and 9.59% respectively, while Gentoos have increased by about 43.66%. These trends were then plotted on maps using ArcGIS to provide a visualization of the population shifts. Next, climate data for Antarctic temperature anomalies and sea ice extent was taken across the same time frame. Finally, a linear regression analysis was performed and a Pearson correlation coefficient was calculated to quantify the association between these climate factors and the trends shown. It was determined that there is a statistically significant relationship between sea ice extent and Adélie penguins, as well as a statistically significant relationship between temperature anomalies and Adélies and Chinstraps.

Background

- Around half of the 18 penguin species are currently in decline
- Existing literature: Adélie and Chinstrap penguin populations have declined more than 50% during the last 30 years
- Sea ice concentration: ideal conditions around 5-10% for various migratory species such as Adélies
- Current international political climate can affect these populations – current GHG emissions would cause Emperors to be reduced by 80% before 2100

Methods

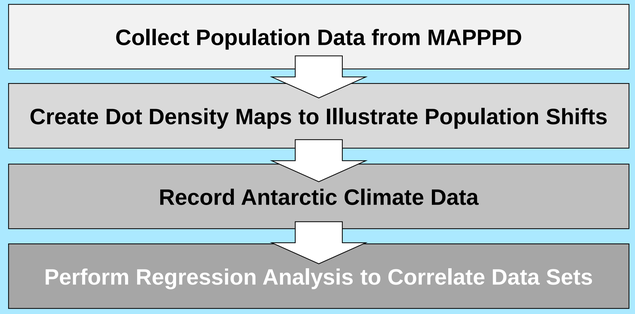

Fig. 1: General overview of the research methodology.

Results

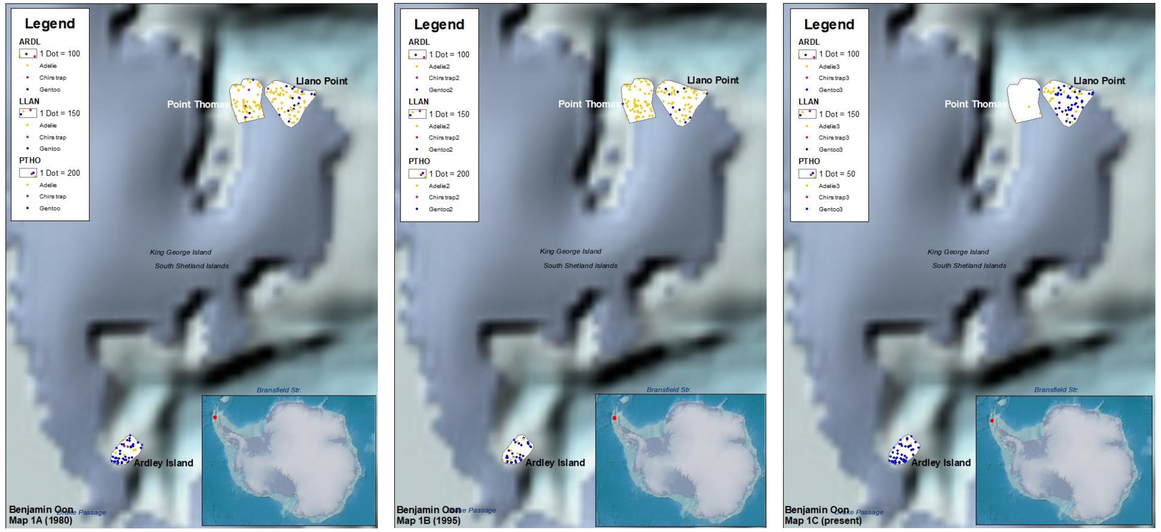

Fig. 2, 3, 4 (above): Maps of Ardley Island, Llano Point, and Port Thomas tracking population shifts for Adélie, Gentoo, and Chinstrap penguins over a roughly 40 year time span. Inset map indicates the location of these sites within Antarctica.

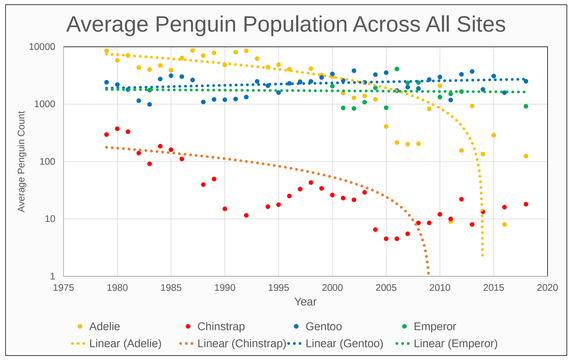

Fig. 5: Graph of arithmetic mean of the penguin species across the examined sites from 1979-2018.

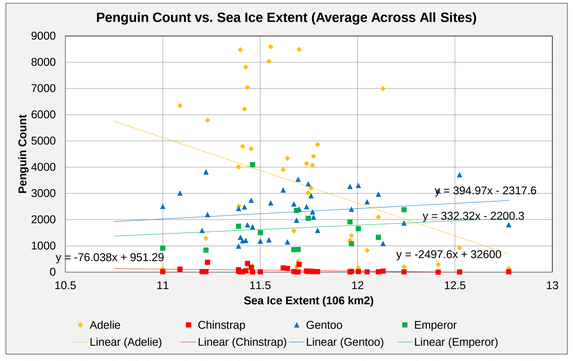

Fig. 7: Graph of the relationship between penguin populations and sea ice extent, using linear regression.

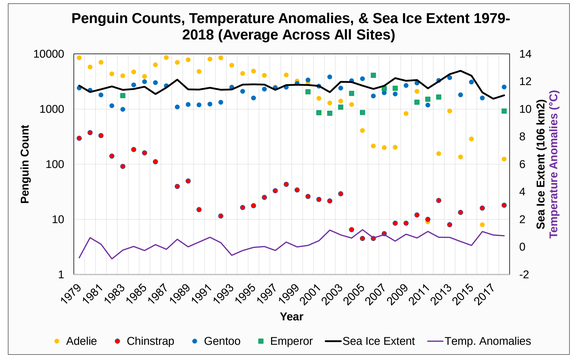

Fig. 6: Complete graph of all the penguin population species in comparison to the trend lines for Sea Ice Extent and Temperature Anomalies.

Correlations

		Sea Ice Extent	Temperature Anomalies
Adelie	Pearson Correlation	-.338*	-.569**
	Sig. (2-tailed)	.036	.000
	N	39	39
Chinstrap	Pearson Correlation	-.322	-.386*
	Sig. (2-tailed)	.056	.020
	N	36	36
Gentoo	Pearson Correlation	.190	.168
	Sig. (2-tailed)	.245	.305
	N	39	39
Emperor	Pearson Correlation	.132	-.296
	Sig. (2-tailed)	.652	.304
	N	14	14

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Fig. 8: Table of the Pearson correlation coefficient and p-value statistics to determine the relationship between climate factors and species shifts.

Analysis

- The coastal species of penguins that lay eggs and build nests underwent different changes in their populations over this time span.
  - Adélie penguins: decreased by 88.70%
  - Chinstrap penguins: decreased by 96.20%
  - Gentoo penguins: increased by 43.66%
- Meanwhile, Emperor penguins decreased their population numbers by about 9.59%
- It is unclear how migration patterns impacted these results.
- Sea ice extent is not a strong predictor of future penguin population aside from Adélies, where there is actually a negative correlation between sea ice extent and Adélie counts. Temperature deviations from the annual mean are a stronger, but not universal, predictor.

Conclusion

This thesis corroborates existing research that Adélie and Chinstrap penguins have been steadily declining over the past four decades. Gentoo penguins, meanwhile, have been able to adapt to more temperate climates due to their migratory habits, and have thus seen an increase in population numbers. Emperor penguins seem to have unclear correlations with temperature changes and sea ice extent, but have been slowly declining nonetheless.

Future Work

- Determine potential impacts of migration on population shifts and if those have any correlation with these climate factors.
- Continue to supply regular, constant data to reduce the frequency of gaps that currently exist, and also consider monitoring other climate factors such as sea level rise and greenhouse gas concentrations.
- Analyze the impact of legislation on the international scale and if various protocols can help lessen the impact of climate change.

References

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