

Cracking the Code on Melting Glaciers

Deanna Conklin

College of DuPage

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Professor Vandana Patwardhan

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It's June 8<sup>th</sup>, 2009, a little girl and her family are on a trip visiting all the coastal towns of Alaska. The first town you stop in is Juneau. Where you can visit the ice glaciers, go dog sledding, shopping in local towns, and maybe even grab a bite of fresh-caught king crab from the Pacific Ocean. As we travel to our first destination to see the glaciers, you are greeted by a local tour guide who takes you around the glacier park explaining the ever-changing wonder behind the glaciers. Just as our tour was about to end, you hear this crackling sound, and you start to look around, asking yourself "Where is that sound coming from?". After a few minutes, your eyes then set upon an ice glacier where there was an enormous chunk of ice that broke off and fell into the surrounding water. Now, being only 10 years old at the time, the little girl didn't think much of "Why did part of the ice glacier break off? Does this have to do with global warming and or human-related activities? Or what happens to the arctic animals affected by the melting glaciers as their habitat is physically depreciating right before their eyes?" At the time the little girl didn't think of those questions, rather she was more fascinated and astonished at the glaciers decent. For she didn't know the devastating effects melting glaciers could have on the arctic animals living nearby, human life, and the surrounding environment.

Ice glaciers are essentially a large piece of ice floating both above and below a body of water that can extend for miles upon miles, occupying about 11% of the Earth's total land surface (**Britannica, 2021**). Glaciers can often be found on nearly every continent including Antarctica, Greenland, Africa, and both North & South America. However, in order for these glaciers to exist, there must be certain climatic conditions present in the surrounding environment. First, glaciers must be found above the snow line in regions where winters have a high amount of snowfall and cold temperatures, followed by cool, summer temperatures that are not too hot. These ideal conditions allow for the maximum amount of snowfall to accumulate in

winter, whilst slowing down the melting process in the summer overall aiding in the glacier's survival. Generally, if there is more snow accumulation within winter, there will be less melting or calving. Quite-similarly, if the snow on the glacier survives throughout the summer, then it creates a layer called a firn, which is a thickening mass of granular snow that has not yet been compressed into the glacier (**National Snow and Ice Data Center, 2021**). While their beauty is exquisite to look at, the main purpose that glaciers serve in today's environment is assisting the ocean currents flow and sustaining some of the largest rivers and lakes in the world. But what exactly happens when these glaciers stop growing and begin to melt? How does this affect the arctic animals that rely on glaciers as their natural habitat? Well, as a matter of fact many of our critical rivers and lakes dry up, ocean currents would stop circulating, therefore bringing massive storms among us. There wouldn't be any glacial residue left, meaning we wouldn't be able to provide fertile soil for growing crops, and lastly, there would be *no* freshwater left for humans, plants, or even the arctic animals to drink. As for the animals, they are losing their habitats right before their eyes left with no protection from other predators and hunters, struggling to find food sources, and are experiencing more interactions with humans, sometimes even leading to lethal outcomes.

“In the arctic, as sea ice melts, arctic wildlife like [the penguins and arctic foxes] are losing their home and polar bears are spending more time on land, causing higher rates of conflict between people.” (**Hancock, 2021**). The animals that are constantly being threatened of losing their habitats include both those that live on land and in the ocean. Some most common land animals include the polar bear, penguins, and arctic foxes VS. the ocean animals which include the Orca, Beluga Whale, and the Saimma Ringed Seal.

**Polar bears** are found in the arctic region who are “uniquely adapted to thrive on sea ice and are dependent on its platform for hunting seals, seasonal movements, summer refuge, traveling to ice or terrestrial refuge areas, finding mates, and breeding.” (Stirling & Deorcher, 2007). Due to the sea ice melting, the polar bears are forced to fast and spend more time on land until the sea ice freezes again in autumn. With global warming present, polar bears have a difficult time to adjusting their harvest rate when the ice is breaking up earlier and freezing later. “Ecological studies show evidence that polar bears [have been forced] to spend more time foraging for berries and seabird eggs, which are lower quality foods that require greater effort to obtain.” (Encyclopedia Britannica, 2022). Polar bears in general stalk and search for ringed seals, bearded seals, and other pinnipeds. Yet for polar bears, its not just the fact that they can’t find sources of food and not adapt well to the ever- changing environment, it’s their habitat loss that remains the most critical concern.

**Penguins** located in the southern hemisphere are highly vulnerable to changes in climate and ocean temperature including global warming. For their survival, penguins often compete with whales for krill, squid, and cuttlefish as their primary food sources. By being adapted for rapid locomotion in the water, they are able to get away from their competitors very fast. But if there isn’t glacial ice present and land predators begin to hunt the penguins on land, “[The Penguins won’t be able to ‘Toboggan’ on snow or ice, sliding on their belly as they propel themselves with their feet and flippers.” (Encyclopedia Britannica, 2022). Yet without glacial ice present their predators will be able to catch up to them very fast. Another point to be noted is, “Penguins forms colonies in May, lay their eggs in June, and don’t fledge chicks until the end of December, so they need that ice to stay in place during all that time, and has to be reliable.”

(Liao, 2019). Not even soon after the chicks hatch, the ice will start breaking before they have developed their waterproof coat, therefore decreasing the penguin survival rate overall.

**Arctic Foxes** can mainly be found in the arctic region on tundra or mountains near the sea. Arctic foxes feed on whatever animal or vegetable material is available and often follow polar bears who leave behind the remains of their kills. Their habitat is being threatened by means of “The treeline is moving further north as the tundra retreats - so they're increasingly crossing paths with their tundra dwelling relatives [The Red Foxes]. Red foxes are twice the size of Arctic foxes and not only compete for prey but can take their dens by killing or chasing them away.” (WWF, 2022). It’s not just the increased contact with the Red Foxes, but other predators involve polar bears, wolves, and humans for hunting their fur. Just like the polar bears and penguins, arctic foxes too use the sea ice to travel from continent to continent in search of food and other populations. “During winter, most arctic foxes do not migrate... but for the small proportion that do migrate, melting sea ice is an even bigger problem.” (Kieren, 2022). In essence, the melting glacial ice is like a double-edged sword for any arctic animal, both land and ocean habitats since they are unable to retrieve their food for survival and overall build dens as their homes.

Now onto our ocean animals, the **Orcas**, also known as Killer Whales, are essentially located in the Northern Pacific Ocean, North Atlantic Ocean, and also some within the Southern Hemisphere. Orcas normally steer clear of ice to avoid entrapment and suffocating, but with all the glacial ice melting, one might think this is better for them, right? Well, actually with the increase in melting glacial ice, they are starting the venture further into the Arctic, and swimming in the cold water becomes “difficult to navigate through ice-covered sea in that the

tall dorsal fins on their backs [prevents them from plowing] through the ice.” (Harvey & E&E News, 2021).

Next, we have **Beluga Whales**, who are home to the coastal waters of the Arctic Ocean,. They struggle with a variety of different factors affecting their oceanic habitat. Belugas detect and respond to the presence of ice breaking ships and offshore drilling from great distances. Yet these sounds often disrupt the Belugas behavior impairing their ability to communicate with other oceanic wildlife. Due to “Loss of sea ice and increased ocean temperatures this affects distribution, composition, and productivity of prey communities... and as weather patterns become more unpredictable and extreme due to climate change... other arctic whales will become more susceptible to ice entrapment.” (Reeves, 2009). As of right now, we don’t know how well the Beluga Whales adapt to the constantly changing environmental conditions. But what we do know is when the waters become warmer affecting the oceanic patterns of circulation, and nutrient input change, Beluga Whales begin to move to the Arctic where they weren’t present there before. If this happens, seals and other predators will directly compete with Belugas for food sources. In addition to this, Orcas may have a slightly more increased opportunity to prey on the Belugas. Either way both situations cause negative effects on the current Beluga populations.

Last but not least, we have the **Saimma Ringed Seal** who lives near “pack ice” which is also known as a large piece of floating ice driven together into a continuous mass. Saimma Ringed Seal don’t particularly have a problem with their food resource allocation seen as they feed on crustaceans, mollusks, and other kinds of fish. However, they are very similar to the Polar Bear’s habitat situation in that they both depend on the glacier ice and snowy surface in winter for traveling, building birthing dens with their mates, where they will raise their seal pups

and cubs, hunt/locate their food for survival overall. Yet as the ice decreases many will be forced to travel farther for food, spending more time on land leading the seal pups and polar bear cubs to fast for longer periods and experience an increased likelihood of encounters with humans from a young age.

As illustrated from above, we can see that because of our humanly actions, over time we have begun to strip away the homes of some among many other arctic animals. To date there isn't much relocation or rehoming solutions because we are unsure of how these animals will be able to adapt in new environments and their overall survival rate. For arctic animals in general who are affected by the glaciers melting, "Additional concerns arise from using model projections to estimate future population trends... because they cannot account for unknown but likely fluctuations in environmental conditions." (Stirling & Deorcher, 2007). Shockingly, yes that is true. There are not as accurate, up-to-date methods for tracking the populations of these arctic animals. Due to the lack of population records of these arctic animals, "Projections [have been inferred in relation to the] shifts in species distributional ranges under future climate change." (van Beest, et al., 2021). As a result of the lack of tracking methods used for populations of the arctic animals, they are beginning to wander away from their original habitats, just to search and hunt for food primarily. If we don't begin to keep track of the populations, let alone change our everyday humanly actions within the urban, industrial, and agricultural areas, the glaciers will melt further destroying and harshly affecting the home of many arctic animals, not just the ones mentioned here.

Now that we know which animals are *most* impacted by the glaciers melting, what exactly is causing the glaciers to melt? The central reason for glacier melt is global warming along with other various components factoring into the causation. The first major component is

1) human activity, followed by 2) warming of the oceans, and finally, 3) oil & gas drilling.

Human activity involves carbon emissions originating from businesses such as manufacturing plants and daily transportation. Now when businesses manufacture a product, they burn fossil fuels to produce everyday items. With this continuous production of goods and products, there is an increase in CO<sub>2</sub> getting trapped in the atmosphere overall raising the global temperature. The same effect goes for humans relying more on their own individual transportation to get to places, whether it's to go to Starbucks for a quick coffee, work, college, traveling, etc. Almost all of us today would agree we prefer to take our own time getting to our destination rather than taking public transportation, because it provides us personal freedom, convenience, and flexibility, a sense of privacy. However, the drawback to driving our own car to our final destination “accounts for 29% of all greenhouse gas emissions in the U.S... but when people ride together on rail systems such as subways and metros, they produce 76% fewer emissions per mile than the average vehicle.” (PSECU, 2019). In essence, “We are currently at a global surface temperature operating 0.81°C (1.46°F) above the 20<sup>th</sup> century average of 14.8°C (58.6°F).” (NOAA National Center for Environmental Information, 2021). If both CO<sub>2</sub> and the average global temperature continue to rise at their current rate, it won't be long before all of our glaciers will vanish 100%.

The second component that factors into the causation of melting glaciers is the warming of the oceans. “These large bodies of water absorb 90% of the Earth's total warmth, meaning that sea ice floating in the ocean is subject to higher temperatures and naturally melt as a result.” (Chen, 2020). We all know that as the temperature gets warmer during the summer months, the surface temperature of water warms up as well. But if we were to put this in a global perspective, not only does the increasing global temperature cause the glaciers to melt and begin to calve, but



“Continuous freshwater inputted from glacier melting leads to ocean freshening and sea-level rise.” (Pan et al., 2022). Freshening of the oceans doesn’t sound as positive impacting as it seems. The freshening of the water reduces the formation of sea floor, causing glacier retreat more rapidly after losing grip of the ocean floor, thus having a significant negative impact on the ocean’s role in regulating the global climate. As a result of all these events, the surface water density is actually reduced slowing down the ocean currents that carry warm water over various channels and ultimately stunting the growth of glaciers.

The third component that factors into the causation of melting of glaciers is the burning of fossil fuels & oil and gas drilling. Just like sunlight becoming trapped within Earth’s atmosphere warming up our oceans and bodies of water, when we burn fossil fuels, this creates a similar buildup of greenhouse gases in the environment. Not only does the environment experience long term effects, but it also contributes to our sea level rising about every 4 meters over the course of a few centuries (Carrington, 2015). As we continue to burn these fossil fuels as energy, we are increasing the risk of melting the glaciers that may soon be irreversible. As for oil and gas drilling, this process is used to extract petroleum oil hydrocarbons to the surface from the underground reservoirs beneath land and ocean floor(s) by using large drilling machines (Turgeon, A., & Morse, E., 2018). During the process of extraction, methane is released into the air at the same time producing an atmosphere that is more detrimental than CO<sub>2</sub>. Methane gas is one of many greenhouse gases that retains heat in the Earth’s atmosphere.

A study conducted by Christian Bogdal, a postdoctoral research fellow at the Swiss Federal Institute of Technology, Zürich, and colleagues in November 1<sup>st</sup>, 2009, found that glaciers are releasing toxic pollutants found in great basins where water is used for drinking and fishing purposes, and simultaneously being transmitted through the circulation of our

atmosphere. “The substances analyzed included 17 dioxins and furans, 18 polychlorinated biphenyls (PCBs), 10 synthetic musk compounds, DDT and two of its transformation products (DDE and DDD), 4 additional organochlorine pesticides (hexachlorobenzene, hexachlorocyclohexane, dieldrin, and heptachlor epoxide), and their transformation products, and polychlorinated naphthalene’s.” (Empa, 2009). These toxic pollutants have the ability to threaten animal life and their habitats, human health, and environment all deriving from urban, industrial, and agricultural areas. We don’t visually see these toxic pollutants because sometimes they are tasteless and odorless just like carbon monoxide, so we don’t actually know that we are breathing it in. “The evidence to date suggests the release of lead and mercury, concerns areas including the Arctic region, Antarctica, the Alps, the Himalayas, and the Caucasus, Andes, Rocky, Cascade, and Sierra Nevada Mountain ranges.” (Empa, 2009).

So, what can we do to further prevent these glaciers from melting and how does this affect the environment we live in? The actions we can take as humans to further prevent the glaciers from melting are 1) reducing our carbon footprint per individual, 2) drive less, and consider other modes of transportation, 3) replacing our combustion engines with hybrid engines to reduce carbon emissions, 4) and lastly, practicing ecotourism to prevent the “declining aesthetics or attractiveness of glaciers while some landscapes face the prospect of sustained decline or even full disappearance. This not only affects glacial cultural appreciation... but it increases the difficult in entering and experiencing glaciers. Some points of tourism even face the risk of glacial disaster.” (Wang, S.-J., & Zhou, L.-Y., 2019). All of these actions along many others will at least slow down the melting of the glaciers, but never halt it completely. Hence, we need to come together as a community in voicing actionable steps to undo our problems we created, while ignoring this issue will not change anything. We can tailor these

additional steps that need to be taken to each of the unique lifestyles we live to allow for the maximization of results. If anything, we can at least protect what's left of our magnificent glaciers from melting and preventing Earthly disasters to protect all living organisms.

By definition of Earthly disasters, we can 1) prevent constant changes in weather patterns, the ocean's water currents, and jet streams, and 2) slow the rise of the sea level. Glaciers often affect weather patterns by forming darker patches of the ocean creating warmer temperatures that disrupt the patterns of the ocean circulation causing heat to not be transported into the Northern Hemisphere. In turn, this transports more heat through extreme mid-latitudes extending to places in the southern border. "Think of it as two highways connecting to big cities... if one is shut down, the other one gets more traffic. [Likewise] in the atmosphere, the traffic is the daily weather. So, if the ocean heat transport slows or shuts down, the weather becomes more extreme." (University of Arizona, 2021). As for the rising sea levels, this creates a major risk for cities along any coastline and or continent because this is where the majority of glaciers are located. When glaciers melt, it not only causes the sea level to rise, but the very densely cold ice mixing with warm bodies of water will lead to an increase of coastal erosion which elevates a storm surge. Just like the game to tag the little girl used to play when she was in elementary school at recess where the little girl would chase her friends around the playground, and eventually caught up to her friend. Then it was her friends turn to try and tag the little girl. Quite similarly, this happens in our environment when the warm air and ocean temperatures circle around one another they eventually create hurricanes and typhoons, however as these weather outbreaks are more likely to occur, the glaciers will continue to melt away. We aren't the only breathing organism that are trying to live on Earth in such conditions that we have created as a result of our own actions. Which is why us as humans need to correct this issue of

melting glaciers sooner rather than later, or else we are going to be experiencing some traumatic changes in both our world and environment.

## References:

- About*. Alan Walker. (2022). Retrieved April 15, 2022, from <https://alanwalker.com/about/>
- Alan Walker - Different World feat. Sofia Carson, K-391 & Corsak (Lyric Video)*. (2018). *YouTube*. Retrieved April 15, 2022, from <https://youtu.be/m-PJmmvyP10>
- Britannica, T. Editors of Encyclopaedia (2021, April 29). glacier summary. Encyclopedia Britannica. <https://www.britannica.com/summary/glacier>
- Carrington, D. (2015, September 11). *Burning all fossil fuels will melt entire Antarctic ice-sheet, study shows*. The Guardian. Retrieved December 15, 2021, from <https://www.theguardian.com/environment/2015/sep/11/burning-all-fossil-fuels-will-melt-entire-antarctic-ice-sheet-study-shows>
- Chen, Alice. (2020, October 28). The Causes and Effects of Melting Glaciers. WorldAtlas. Retrieved December 15, 2021, from <https://www.worldatlas.com/articles/what-are-the-effects-of-melting-glaciers.html>
- Climate Science: Melting triggers more melting. (2012). *Nature*, 488(7412), 433. <https://doi-org.cod.idm.oclc.org/10.1038/488433d>
- Earth Reminder. (2020, December 27). *How to prevent glaciers from melting?* Earth Reminder. Retrieved December 15, 2021, from <https://www.earthreminder.com/how-to-prevent-glaciers-from-melting/>
- Encyclopædia Britannica. (n.d.). *Arctic fox*. Britannica Academic. Retrieved March 22, 2022, from <https://academic.eb.com/levels/collegiate/article/Arctic-fox/9308>
- Encyclopædia Britannica. (n.d.). *Polar bear*. Britannica Academic. Retrieved March 22, 2022, from <https://academic.eb.com/levels/collegiate/article/polar-bear/60587>
- Encyclopædia Britannica. (n.d.). *Penguin*. Britannica Academic. Retrieved March 22, 2022, from <https://academic.eb.com/levels/collegiate/article/penguin/105926>
- Encyclopædia Britannica. (n.d.). *Killer whale*. Britannica Academic. Retrieved March 22, 2022, from <https://academic.eb.com/levels/collegiate/article/killer-whale/45439>
- Encyclopædia Britannica. (n.d.). *Beluga*. Britannica Academic. Retrieved March 22, 2022, from <https://academic.eb.com/levels/collegiate/article/beluga/15328>
- Encyclopædia Britannica. (n.d.). *Ringed seal*. Britannica Academic. Retrieved March 22, 2022, from <https://academic.eb.com/levels/collegiate/article/ringed-seal/63722>

- Empa. (2009, October 21). Glacial Melting May Release Pollutants Into The Environment. *ScienceDaily*. Retrieved March 23, 2022 from [www.sciencedaily.com/releases/2009/10/091021100742.htm](http://www.sciencedaily.com/releases/2009/10/091021100742.htm)
- Hancock, L. (2021). *Why are glaciers and sea ice melting?* WWF. Retrieved December 15, 2021, from <https://www.worldwildlife.org/pages/why-are-glaciers-and-sea-ice-melting>
- Harvey, C., & E&E News. (2021, December 3). *As Arctic Sea Ice Melts, Killer Whales Are Moving In*. Scientific American. Retrieved March 23, 2022, from <https://www.scientificamerican.com/article/as-arctic-sea-ice-melts-killer-whales-are-moving-in/>
- Kieren. (2022, January 22). *Are Arctic Foxes Endangered? How Can We Help Them?* Polar Guidebook. Retrieved March 23, 2022, from <https://polarguidebook.com/are-arctic-foxes-endangered/>
- Liao, K. (2019, December 3). *Emperor Penguins Are Marching to Extinction at Current Emissions Levels*. Audubon. Retrieved March 23, 2022, from <https://www.audubon.org/news/emperor-penguins-are-marching-extinction-current-emissions-levels>
- Lupro, M. M. (2011). Inconvenient Truth, An. In C. W. Allin (Ed.), *Encyclopedia of Environmental Issues, Revised Edition*. Salem Press. <https://go.openathens.net/redirector/cod.edu?url=online.salempress.com>
- Murphy, R. P. (2009). Economics of global climate change. In S. I. Dutch (Ed.), *Encyclopedia of Global Warming*. Salem Press. <https://go.openathens.net/redirector/cod.edu?url=online.salempress.com>
- National Snow and Ice Data Center. (2021). *The Life of a Glacier*. The Life of a Glacier | National Snow and Ice Data Center. Retrieved December 15, 2021, from <https://nsidc.org/cryosphere/glaciers/life-glacier.html>
- National Snow and Ice Data Center. (2020, March 16). *Where are glaciers located?* National Snow and Ice Data Center. Retrieved December 15, 2021, from <https://nsidc.org/cryosphere/glaciers/questions/located.html>
- NOAA. (2021, February 26). *How does sea ice affect global climate?* National Ocean Service. Retrieved December 15, 2021, from <https://oceanservice.noaa.gov/facts/sea-ice-climate.html>
- NOAA National Centers for Environmental Information, State of the Climate: Global Climate Report for May 2021, published online June 2021, retrieved on December 15, 2021 from <https://www.ncdc.noaa.gov/sotc/global/202105>

- Oceanwide Expeditions. (2021). *All About Ice: Glaciers and Icebergs of the Arctic and Antarctica*. Oceanwide Expeditions. Retrieved December 15, 2021, from <https://oceanwide-expeditions.com/blog/majestic-glaciers-and-icebergs-of-the-arctic-and-antarctica>
- Pan, X. L., Li, B. F., & Watanabe, Y. W. (2022). Intense ocean freshening from melting glacier around the Antarctica during early twenty-first century. *Scientific Reports*, *12*, 383. <https://doi.org/https://doi.org/10.1038/s41598-021-04231-6>
- Reeves, R. (2009). *Beluga whales and climate change*. Retrieved March 23, 2022, from [https://www.iucn.org/sites/dev/files/import/downloads/fact\\_sheet\\_red\\_list\\_beluga\\_v2.pdf](https://www.iucn.org/sites/dev/files/import/downloads/fact_sheet_red_list_beluga_v2.pdf)
- Schiller, R. (2019, January 22). *Alan Walker on creating environmental track 'Different world': 'we are ruining earth faster than we can repair it'*. Billboard. Retrieved April 15, 2022, from <https://www.billboard.com/music/music-news/alan-walker-talks-different-world-song-8494309/>
- Stirling, I., & Derocher, A. (2007). *Melting Under Pressure*. Retrieved March 15, 2022, from [https://wwfeu.awsassets.panda.org/downloads/meltingunderpressure\\_1.pdf](https://wwfeu.awsassets.panda.org/downloads/meltingunderpressure_1.pdf)
- Trathan, P. N., Weinecke, B., Barbraud, C., Jenouvrier, S., Kooyman, G., Bohec, C. L., Ainley, D. G., Ancel, A., Zitterbart, D. P., Chown, S. L., LaRue, M., Cristofari, R., Younger, J., Clucas, G., Bost, C. A., Brown, J. A., Gillett, H. J., & Fretwell, P. T. (2019, October 8). *The emperor penguin- Vulnerable to projected rates of warming and sea ice loss*. ScienceDirect. Retrieved March 15, 2022, from <https://doi.org/10.1016/j.biocon.2019.108216>
- University of Arizona. (2021, October 20). Changing ocean currents are driving extreme winter weather. *ScienceDaily*. Retrieved December 15, 2021 from [www.sciencedaily.com/releases/2021/10/211020140042.html](http://www.sciencedaily.com/releases/2021/10/211020140042.html)
- Wang, S.-J., & Zhou, L.-Y. (2019, June 13). *Integrated Impacts of Climate Change on Glacier Tourism*. ScienceDirect. Retrieved March 18, 2022, from <https://www.sciencedirect.com/science/article/pii/S1674927818301096>
- What is ecotourism?* The International Ecotourism Society. (2022). Retrieved March 18, 2022, from <https://ecotourism.org/what-is-ecotourism/>
- WWF. (2022). *11 arctic species affected by climate change*. WWF. Retrieved March 18, 2022, from <https://www.wwf.org.uk/updates/11-arctic-species-affected-climate-change>
- van Beest FM, Beumer LT, Andersen AS, Hansson SV, Schmidt NM. *Rapid shifts in Arctic tundra species' distributions and inter-specific range overlap under future climate change*. *Divers Distrib*. 2021;00:1–13. <https://doi.org/10.1111/ddi.13362>