

## Earth & Space

# Cascading effects of a marine heatwave impact dolphin survival and reproduction

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### ABSTRACT

*Extreme climatic events associated with climate change pose a serious threat to ecosystems around the world. A marine heatwave in 2011 causes drastic losses of seagrass and fish stocks in Shark Bay, Western Australia, with cascading effects on long-term survival and reproduction of the resident bottlenose dolphin population.*



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Extreme weather events such as droughts, heavy rainfalls or extreme temperature fluctuations are occurring more frequently around the globe associated with global climate change. In early 2011, the western Australian coastline was hit by an unprecedented marine heatwave, which turned the coastal waters into a hot tub. In the World Heritage Area of Shark Bay – located about 800 km North of Perth – temperatures rose to more than 4 Degrees Celsius above long-term averages for several weeks with devastating consequences for the bay's entire ecosystem. The high temperatures caused a catastrophic die-off of over a third of the seagrass meadows, mass mortalities of fish and invertebrates as well as health declines in the herbivorous green turtles feeding on the seagrass.

While many studies reported on the consequences of the heatwave on species on the lower levels of the food web, we were interested whether the heatwave's dramatic effects on the ecosystem also impacted species feeding at higher trophic levels, namely the resident population of Indo-pacific bottlenose dolphins. In particular, we investigated any potential effects of the heatwave on dolphin survival as well as female reproduction.

To estimate survival rates, we used sightings data of several hundred dolphins collected over 11 years from before (2007-2010) and after the heatwave (2011-2017). Dolphins can be individually identified based on markings on their dorsal fins, which allows

estimation of their numbers and survival rates in different time periods. We additionally used long-term records on the number of calves born each year to estimate rates of female reproduction over time.

We found that survival rates, on average, plummeted by 12% after the heatwave for several years. Interestingly, dolphins that use marine sponges as foraging tools were less impacted compared to those that do not, showing only 6% reduction in survival. Some dolphins wear sponges as protective gloves over their beaks during foraging to find prey buried in the sand, which allows them to access an alternative foraging niche that other dolphins do not have access to. This technique is learned from mothers, so only dolphins born to a mother with the tool using knowledge also acquire this technique. Besides long-term reductions in survival, we also found significant declines in the number of calves born in the years following the heatwave.

Lower overall survival and reproductive rates indicate that the heatwave did not only affect species on lower trophic levels but had cascading effects through to top order predators. The loss of such large volumes of seagrass during the heatwave and a lack of recovery in the years following are most likely responsible for driving the long-term reductions in dolphin survival, since seagrass beds are an important driver of the Shark Bay ecosystem, providing breeding grounds and shelter for various prey species. Lower reproductive rates after a major ecological disturbance are unsurprising - a decline in food availability is expected to primarily affect the

most vulnerable members of a population, such as young individuals or pregnant or lactating females. The drivers of the reduced reproductive rates in the Shark Bay dolphins, however, are unknown and we can only speculate about potential reasons: Mass mortalities of fish may also have decreased prey availability for large sharks, leading to increased predation on dolphin calves. In fact, over 70% of the Shark Bay dolphins carry scars from such attacks, indicating just how frequent predation attempts by sharks are. Due to their small body size and lack of mobility, dolphin calves constitute relatively easy prey. Alternatively, lower food availability may have led to increased rates of abortions or mortality of neonates, when both the mother's as well as the offspring's diet could not be sustained at the same time. Or, females may have simply not fallen pregnant in the first place by suppressed ovulation or delayed sexual maturity, trying to preserve their energy, as has been observed in other marine mammals in times of lower food availability.

Long-lived species such as dolphins or great apes are likely to experience environmental fluctuations throughout their lifetime and therefore usually show great ability to adapt to changing conditions. The drastic negative impacts of the heatwave on the dolphin population, however, indicates that extreme weather events may be too sudden and disruptive for even behaviourally flexible species to adapt. These results are concerning, since extreme weather events are expected to occur with increased frequency due to global climate change, posing a threat to various ecosystems around the world.