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CLIMATE CHANGE AND HUMAN HEALTH

Environmental and Ecological Effects of Climate Change on Venomous Marine and Amphibious Species in the Wilderness

Robert K. Needleman, MD; Isabelle P. Neylan; Timothy B. Erickson, MD, FACEP, FACMT, FAACT

From the Department of Emergency Medicine, Cook County Hospital, Chicago, IL (Dr Needleman); the Institute of Marine Sciences, University of North Carolina Chapel Hill, Morehead City, NC (Ms Neylan); and the Department of Emergency Medicine, Division of Medical Toxicology, Brigham and Women's Hospital, Harvard Medical School, Harvard Humanitarian Initiative, Boston, MA (Dr Erickson).

Introduction—Recent analyses of data show a warming trend in global average air and sea surface ocean temperatures. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, the sea level has risen, and the concentrations of greenhouse gases have increased. This article will focus on climate change and projected effects on venomous marine and amphibious creatures with the potential impact on human health.

Methods—Retrospective analysis of environmental, ecological, and medical literature with a focus on climate change, toxinology, and future modeling specific to venomous aquatic and amphibious creatures. Species included venomous jellyfish, poisonous fish, crown-of-thorns starfish, sea snakes, and toxic frogs.

Results—In several projected scenarios, rising temperatures, weather extremes, and shifts in seasons will increase poisonous population numbers, particularly with certain marine creatures like jellyfish and crown-of-thorns starfish. Habitat expansions by lionfish and sea snakes are projected to occur. These phenomena, along with increases in human populations and coastal development will likely increase human−animal encounters. Other species, particularly amphibious toxic frogs, are declining rapidly due to their sensitivity to any temperature change or subtle alterations in the stability of their environment. If temperatures continue to rise to record levels over the next decades, it is predicted that the populations of these once plentiful and critically important animals to the aquatic ecosystem will decline and their geographic distributions will shrink.

Conclusion—Review of the literature investigating the effect and forecasts of climate change on venomous marine and amphibious creatures has demonstrated that temperature extremes and changes to climatic norms will likely have a dramatic effect on these toxicological organisms. The effects of climate change on these species through temperature alteration and rising coastal waters will influence each species differently and in turn potentially affect commercial industries, travel, tourism, and human health.

Keywords: jellyfish, lionfish, stingrays, crown-of-thorns starfish, sea snakes, amphibians, poison dart frogs, envenomation, toxinology

Introduction

Recent analyses of data show a clear warming trend in global average air and ocean temperatures.[1] The past 4 years (2014–2017) have been the warmest on record since 1880. Each of the last 3 decades has been successively warmer at the Earth's surface than any preceding decade since 1850. In the Northern Hemisphere, 1983 to 2012 was likely the warmest 30-year period of the last 1400 years. The global average of combined land and ocean surface temperature data as calculated by a linear trend, show a warming of 0.9°C (±0.2°C) over a period 1880 to 2012, when multiple independently produced data points exist.[2]

The surface 300 m of the world's oceans has warmed by 9.3°C since the mid-1950s.[3] Climate models project

Corresponding author: Dr. Robert K. Needleman, MD, Department of Emergency Medicine, Cook County Hospital, Chicago, IL 60612; e-mail: Robert.k.Needleman@gmail.com.

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that global warming due to human influences will be 0.1 to 0.2°C per decade for the next 2 decades, and that sea surface temperatures (SSTs) will rise nearly everywhere.[4,5]

Due to such temperature increases, glaciers have diminished and the mean sea level has risen. Over the period 1901 to 2010, global mean sea level rose by 0.19 m, which is higher than the mean rate estimated for the previous 2 millennia.[2] Rising coastal waters, however, do not necessarily equate to more marine habitat. Certain environments, such as marshes, mangroves, and other biogenic shoreline habitats, will experience "habitat squeeze" due to rising sea levels and continued human development in these areas. This degradation and loss of habitat may decrease native venomous aquatic species. Conversely, these creatures may begin to appear in new areas where they were not previously described.

By the end of this century, it is predicted that over 50% of the world's population will be living within 100 km of a coastline. With increasing population and coastal development, more humans are venturing into aquatic environments for recreational activities, vacations, tropical destinations, and coastal living.[6] As a result, the opportunity for humans to encounter venomous marine life that inhabit reefs and shallow marine waters increases.[7] Additionally, the risk and the spectrum of marine envenomation are often unknown to nonindigenous travelers. As reported in 1 study, returning travelers in recent years were more likely to encounter coral-related injuries and experience marine envenomation from jellyfish and stonefish. This was followed in frequency by starfish, stingrays and lionfish.[8]

This article will uniquely focus on climate change and its affect upon toxinology (the scientific discipline dealing with microbial, plant, and animal venoms, poisons, and toxins) specific to venomous marine and amphibious creatures. To our knowledge, a review of this kind does not exist in the literature apart from species-specific investigations. The effects of climate change on these species will potentially affect commercial industries, travel, tourism, and human health. Our objectives are to describe i) how climate change affects the species' habitat, ii) how species are responding, and then iii) discuss the effects upon human health.

Methods

A search of Web of Science core database collection including MEDLINE, Biological Abstracts, and SciELO Citation index to include citations since 1970 with identified keywords was undertaken. Keywords included the following: climate change, anthropogenic climate change, climate, global warming, temperature change, environmental change, envenomation, venomous, distribution, jellyfish, box jellyfish, Portuguese man o' war, sea nettle, Irukandji venomous fish, stingrays, lionfish, scorpion fish, stonefish, crown-of-thorns, sea snakes, sea kraits, blue-ringed octopus, puffer fish, porcupine fish, poison dart frogs, and poison arrow frogs, (common and scientific names were used for species). Each keyword was used independently and, when appropriate, in combination with additional keyword(s) to identify relevant articles. The coauthors screened titles and abstracts of all articles identified by the search. Eligibility criteria included peer reviewed, published studies. In particular, we analyzed multiple "ecological niche model" studies that project future species distribution given a set of climatic predictor variables, which were relevant to the topic.

Results

JELLYFISH

Coelenterates (phylum Cnidaria) include sea anemones, corals, and jellyfish, whose stings are the most common marine envenomation. Although most species are typically found in temperate and tropical waters,[7] jellyfish encounters also occur in colder marine regions such as Scandinavia.[8] Of the roughly 10,000 jellyfish species, there are approximately 100 that comprise the majority of human envenomations.[9] The sea nettle (*Chrysaora quinquecirrha*), for example, is widely distributed in temperate and tropical waters and is known to sting humans. The Portuguese man o' war (*Physalia physalis*) (not a true jellyfish but a hydroid colony) is one of the largest Coelenterates with tentacles that can reach up to 30 m in length. The deadliest and most venomous of coelenterates is the box jellyfish or sea wasp of Australia.[10,11] Another Australian jellyfish, *Carukia barnesi*, also produces a devastating envenomation known as Irukandji syndrome.[12,13] Studies have found that climate change will not only affect jellyfish in their native environments but may also lead to invasion into new areas.

Recent evidence is accumulating that jellyfish populations have increased in many regions of the world.[14,15] These populations, however, undergo large, worldwide oscillations with approximately 20-year periodicity, including a well-documented rise in the 1970s[16] and again in the 1990s in addition to smaller cyclical oscillations.[17] Their unpredictable reproductive and lifecycles can lead to blooms with spatial and temporal variability in abundance, making populations difficult to estimate. One recent study represents the first rigorous demonstration that jellyfish populations are increasing in coastal ecosystems worldwide, although it may be too early to conclude definitively (Figure 1).[15] Other time-