

Impact of Global Temperature Variation on Fishery Sector: A Comprehensive Review

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Abstract

Aquaculture production dependence on the natural environment raised concerns about its susceptibility to climate change.

Many aquaculture species are impacted both directly and indirectly by the rising water temperature brought on by global warming. One of the main abiotic variables influencing the development and survival of aquatic life. Their productivity, health, and performance are generally negatively impacted by extreme temperature that beyond their thermal threshold. Therefore, the goal of this study is to provide a thorough and in-depth analysis of the effects on anthropogenic temperature increases on the general physiology aspect The effects of fluctuating water temperatures on aquatic ecosystems are also discussed, including the uptake of heavy metals and pesticides, aquatic parasites, pathogen-associated disease outbreaks. A few freshwater, euryhaline, and marine species, as well as cold-water and warm-water species, have been selected to offer examples of how rising water temperatures will affect global trends in aquaculture production. This will give a more comprehensive understanding of how various aquaculture species react to temperature changes above their thermal threshold.

Keywords: Aquaculture, Health, Threshold, Physiology and MicroRNA.

INTRODUCTION

Around 50% of the animal protein consumed by humans comes from aquaculture, the industry with the greatest rate of growth in food production worldwide (Fazio, 2019). The Food and Agriculture Organization (FAO) projects that by 2030, aquaculture production would account for 53% of total production (FAO, 2020). However, the current global trends of aquaculture production are

threatened by climate change. Anthropogenic global warming is already changing our environment with devastating consequences (Reid *et al.*, 2019). Although its implication has been previously focused on terrestrial organisms, less attention has been given to its effect on aquaculture species. Ectothermic creatures, such as fish, experience variations in body temperature in response to variations in the surrounding temperature (Alfonso *et al.*, 2021). Since temperature has a direct impact on aquatic species' immunology, metabolic rate,

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and oxygen requirement, it is the primary driver of their development and survival. In addition to increasing oxygen consumption and causing metabolic changes in the ambient temperature above the organism's thermal threshold will also lower feed intake (FI) and impair immunity (Reid *et al.*, 2019; Alfonso *et al.*, 2021). This is due to the fact that rising water temperatures have an adverse effect on oxygen availability and solubility, which impairs aerobic metabolism. Southern Europe is one of the area predicted to experience the most extreme global warming, with air temperatures in the Iberian Peninsula ranging from 4 to 7 °C by 2100, according to the Intergovernmental Panel on Climate Change report (IPCC 2001). More precisely, the models of climate change have projected that tropical ocean temperature will rise by 3 °C over the next century (Campos *et al.*, 2019). Therefore, animals that live in these warm places will experience higher water temperatures on a larger scale as heatwaves become more intense, frequent, and prolonged. The ocean has absorbed more than 90% of the energy in the climate system, which has led to a 0.11 °C increase in temperature over the first decade (1971–2010). Furthermore, temperature rises predicted by end-of-century prediction models range from 2.73 ± 0.72 °C (RCP 8.5) to (mean \pm SD) 0.71 ± 0.45 °C (Representative Concentration Pathway [RCP] 4.5). According to Howes *et al.* (2015), some end-of-century estimates (RCP 8.5) indicate significant temperature increases of more than 4 °C in the Tropics, Arctic, and North Pacific areas. Given that a significant portion of aquaculture production is centred in deltas, rivers are of particular portion. According to Van Vliet *et al.* (2013), the IPCC Special Report on Emission Scenarios B1 A2 scenario predicts that global average river temperatures will rise by 0.8 to 1.6 °C by the end of the century compared to 1971–2000, with the highest warming predicted for Europe, the United States, eastern China, some parts of Southern Africa, and Australia. As a result, tropical species are predicted to be more vulnerable to warming than subtropical and temperate species because of their smaller thermal range and survival near their thermal limits. Therefore, the goal of this paper is to provide a thorough and in-depth analysis of how anthropogenic temperature increases affect the gut and skin microbiome of aquaculture species as well as their general animal physiology, growth, survival, reproduction, immunity, digestive enzyme activity, differential expression of microRNAs, and genes linked to apoptosis (Mugwanya *et al.*, 2022). Likewise, the impacts of increasing water temperatures on

aquatic ecosystems with regards to pathogens and aquatic parasites, toxicity, and uptake of heavy metals and pesticides as well as vaccine efficacy are presented. To provide examples of how increasing water temperatures will impact the global trends of aquaculture production, a couple of fresh water, euryhaline, and marine species, as well as cold-water and warm water species, have been chosen to give a broader perspective on how different aquaculture species respond to temperature fluctuations.

Marine Species vs Freshwater Species: Impact of Fluctuating Water Temperatures

In the past 50 years, a continuous trend in warming in the large part of the world's oceans has been observed although regional differences such as cooling have also been identified. Therefore, previously reported 1 °C increase in the sea-surface temperature in the Arctic basin over the past 20 years. According to Frost *et al.* (2012), reported increasing sea-surface temperatures in the tropical Pacific accompanied by increasing precipitation. In general, climate change will negatively impact the production of marine species in comparison to freshwater species. This is because increasing temperatures not only lower the concentration of dissolved oxygen but also reduce the water salinity. The latter is a result of increased precipitation in warming regions which negatively affect stock distribution, reproductive capacity, growth, and survival of marine species. Moreover, water pollution persists the production of freshwater species will be affected. Marine, euryhaline, and freshwater species discussed in this review are Atlantic cod (*Gadus morhua*), Yellowtail kingfish (*Seriola lalandi*), turbot (*Scophthalmus maximus*), Shrimp (*Litopenaeus vannamei*, *Penaeus monodon*, *Palaemonetes* spp., *Palaemon peringueyi*, *Palaemon elegans*), olive flounder (*Paralichthys olivaceus*) Mozambique tilapia (*Oreochromis mossambicus*) and trout (*Oncorhynchus mykiss*, *Oncorhynchus clarkii*, *Salmo trutta*, *Salmo gairdneri*, *Salvelinus confluentus*, *Salvelinus fontinalis*), carp (*Cyprinus carpio*, *Ctenopharyngodon idellus*, *Hippelates nobilis*, *Hypophthalmichthys molitrix*, *Hypseleotris klunzingeri*, *Labeo rohita*), salmon (*Salmo salar*, *Oncorhynchus nerka*, *Oncorhynchus kisutch*, *Oncorhynchus gorbuscha*, *Oncorhynchus tshawytscha*), Nile tilapia (*Oreochromis niloticus*, *Oreochromis niloticus* GIFT), catfish (*Silurus meridionalis*, *Clarias batrachus*, *Horabagrus brachysoma*, *Ictalurus punctatus*, *Ompok bimaculatus*, *Pangasianodon hypophthalmus*), respectively (Mugwanya *et al.*, 2022).

Cold water Species vs Warm-Water Species: Impact of Fluctuating Water Temperatures

It is obvious that cold water aquaculture species will be more impacted than warm-water species since temperature swings more in line with the rising temperature trend. The biodiversity of some areas will change due to their historically colder climates, which could have an impact on the distribution and number of native species. Threatened by non-indigenous aquatic species' bio-invasion, which is taking over the ecosystem as a result of warming water temperatures. The distribution and survival of cold-water species that have previously called these habitats home is being impacted. According to Singh (2015), the survival of cold-water species in India Himalayan area would be impacted both directly and indirectly by climate change, including changes in temperature and rainfall patterns. However, because some environmental factors are expected to be retained that support the species' continued survival, McKelvey and Buotte (2018) have predicted that some temperature-sensitive salmonid species, like Bull trout (*Salvelinus confluentus*), will continue to inhabit the Northern Rockies. However, because stream temperatures are expected to rise to around 2.4°C by the middle of the century, cold-water species including salmon, charrs, steelhead, whitefish, and trout will generally suffer in the Northwest and Northern Rockies.

Impact on Metabolic Rate, Oxygen Consumption and Demand

The metabolic rate increases with the temperature of the water. Hyperthermal stress, on the other hand, causes the metabolic energy needed for growth and reproduction to be reallocated to the restoration of physiological equilibrium (Islam *et al.*, 2021). The fish cease feeding during this phase until the temperature reaches its ideal thermal range again. Research on how raising the temperature of the water affects metabolic rate. The synthesis of ATP to support the metabolic changes is impacted by high temperatures because they reduce the solubility and availability of oxygen (hypoxia). Similarly, when fish are exposed to high water temperatures, their oxygen demand rises, leading to elevated respiration rates and decreased feed intake in low dissolved oxygen (DO) environments. In the previous study by, Oliva-Teles *et al.* (1990) examined how temperature affected the use of endogenous energy stores in the embryonic development of diploid and triploid rainbow trout and found a direct relationship

between temperature, oxygen consumption, and ammonia excretion. All developmental stages were increased oxygen use at high water temperatures and vice versa, with eggs showing the largest temperature impact on respiratory metabolism. In addition, Hogue and Pegg (2009) found that two Asian carp species (*H. nobilis* and *H. molitrix*) at the juvenile and adult stages consumed more oxygen as the water temperature rose. A relationship was showed between oxygen usage and body mass. An earlier study by Lee *et al.* (2003) on adult salmon stocks (*O. nerka* and *O. kisutch*) collected from a variety of field and lab settings, oxygen consumption arose as water temperature rises until the species reaches its maximum thermal limit, beyond which it falls. Therefore, the decline over time at high water temperatures over their thermal threshold, this was connected with the critical swimming speeds of both species. According to earlier research, hypoxia brought on by specific conditions, like warm water, impairs fish aerobic swimming ability by reducing their aerobic metabolic scope (Domenici *et al.*, 2013). Therefore, it is not shocking that salmon dropped under these circumstances. Because of their susceptibility to the combined impacts of hypoxia and rising water temperatures, salmonid farming requires careful temperature monitoring. Burggren *et al.* (2019) found that the Nile tilapia which is higher partial pressure of oxygen (pO₂) resistant and temperature tolerant, increased oxygen consumption as water temperature rose across all fish embryonic stages. No behavioural alterations were seen in this line, even at extremely low DO levels and extreme temperatures of up to 35 °C. Zeng *et al.* (2018) looked at how temperature acclimation affected the juvenile Southern catfish post-exercise oxygen consumption following vigorous activity (MO₂) and resting oxygen consumption rate (MO₂). While MO₂ peak first rose with rising water temperatures before plateauing, the scientists found that MO₂ rest grew linearly with rising water temperatures. Lower energy usage efficiency during swimming and the post-exercise recovery process resulted in a delayed recovery time. Research on Atlantic cod and turbot has revealed that as temperatures rise, their oxygen demand rises.

CONCLUSION

Despite the catastrophic effects on aquatic ecosystems, research on how climate change affects aquaculture and fisheries management is still in its early stages. The diminishing water quality brought

on by global warming will have an influence on both freshwater and marine species, with the latter being more severely impacted. Depending on the organism's upper thermal limit, freshwater species may be able to tolerate the shifting hazardous environment. Similarly, species found in warm and cold water will probably react to rising water temperatures in different ways.

CONFLICT OF INTEREST

There is no competing of interest between author.

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