CONSEQUENCE OF CLIMATE CHANGE ON FISHERIES AND AQUATIC SYSTEM

Abstract

This chapter delves into the intricate web of interactions shaping aquatic ecosystems, focusing on the dynamic processes that drive physical, chemical, and biological changes within these environments. Exploring the ever-shifting balance between abiotic and biotic components, we examine the influence of physical factors such as temperature rise, sea level rise. Concurrently, the chapter scrutinizes chemical alterations, addressing issues like ocean acidification, increased salinity. Biological transformations, encompassing the diverse life forms from microorganisms to macrofauna, are intricately woven into this narrative, elucidating the interconnectedness of species and their adaptation to changing environmental conditions. Ocean acidification poses a threat to marine life. The consequences extend to human communities relying on aquatic resources, highlighting the urgent need for adaptive strategies and global cooperation to mitigate the adverse effects of climate change on aquatic ecosystems. Through a holistic lens, this chapter aims to enhance our understanding of the multifaceted nature of aquatic ecosystems, fostering insights crucial for effective conservation and management strategies.

Keywords: ocean acidification; temperature rise, sea level rise

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I. INTRODUCTION

The Intergovernmental Panel on Climate Change1 (IPCC) has been regularly disseminating information on climate change and its economic and political ramifications since 1988. These updates provide a thorough synopsis of the generally recognised body of knowledge regarding the causes, effects, and science of climate change. This chapter provides a thorough description of how climate change is affecting oceans, lakes, rivers, and other aquatic systems, with a focus on how it will affect fisheries and aquaculture as well as other aquatic food production. The recent scientific literature and fifth IPCC Assessment Report (AR5) were used to compile the data. This chapter mainly focuses on explaining the underlying drivers of climate change and their resulting biophysical changes in aquatic ecosystems. Subsequent chapters go into greater detail about the consequences of these food production systems on climate change.

II. OBSERVED CHANGES IN THE CLIMATE SYSTEM

The IPCC AR5 firmly established the undeniable warming of the climate system and highlighted the unprecedented nature of many observed changes from 1950 onwards, surpassing conditions seen in earlier decades to millennia. This conclusion was drawn from rigorous data analysis, acknowledging potential uncertainties stemming from knowledge gaps and data limitations. Since the middle of the nineteenth century, the average surface temperature of the Earth has grown by more than 0.8 °C, and it is currently warming at a rate of more than 0.1 °C every decade (Hansen et al., 2010). Even though data dependability and degree of accuracy differ between continents, heat waves are increasingly often lately (Hartmann et al., 2013). The rise in the atmospheric level of GHGs including methane CH4, CO2, and nitrogen dioxide NO2 is thought to be the main cause of this warming. GHGs are in charge of sustaining life on Earth by acting as a heat blanket surrounding the planet (IPCC, 2014). Since the industrial revolution, GHG emissions have grown exponentially, resulting in the highest atmospheric levels of these gases in the past 800 000 years. For instance, atmospheric CO2 levels rose from 278 ppm in the middle of the eighteenth century to approximately 400 ppm now (Ciais et al., 2013). The IPCC AR5 also came to the conclusion that the main cause of the warming that has been noticed since the middle of the 20th century is very likely human activity, notably the coupling of GHG emissions with petrol and oil burning, deforestation, and intensive agriculture. Only 1% of the extra heat brought on by human-caused climate change is kept in the atmosphere; 93% of it has been absorbed by the world's oceans. The ocean plays a vital role in the Earth's climate regulation, absorbing the last three to four percent of heat through the melting of ice and snow, effectively acting as a vast heat buffer. Even small alterations in the heat balance between the ocean and atmosphere can substantially influence global air temperatures (Reid, 2016). Furthermore, owing to its significant thermal capacity, the ocean has sequestered approximately 25 percent of anthropogenic CO2 emissions (Le Quéré et al., 2018), further emphasizing its importance in mitigating climate change.

Due to changes in precipitation, temperature, and climatic conditions, climate warming has a substantial impact on the hydrological cycle, influencing the amount, quality, and seasonal patterns of water resources. Aquatic habitats are further impacted by snow and ice melting. Permafrost is thawing in high-latitude regions, and glaciers are retreating in high-elevation places, both of which have an effect on downstream water resources (IPCC, 2014).

The worldwide ocean conveyor belt in marine systems may also be affected by the melting of the Arctic sea ice (Liu et al., 2017).

Fish is a crucial source of sustenance for underprivileged and vulnerable communities, serving as a major traded food item and employing many men and women. The fish trade significantly contributes to the economic growth of developing nations, aiding in foreign debt payments, government funding, and enhancing national food security through diversified diets. Climate changes, particularly on a medium (decadal) scale, have historically influenced fisheries and their management. Looking ahead, the continued warming of the atmosphere and ocean, rising sea levels, ocean acidification, and potential circulation pattern changes will impact fisheries, categorizing the effects as physical, chemical, and biological changes.

III. PHYSICAL CHANGES

1. **Water Surface Temperature Rise:** The control of the world's climate is greatly influenced by the oceans. Due to their heat capacity being around 1000 times greater than that of the atmosphere, they are able to absorb a sizeable portion of the heat that is emitted globally. Such variations in ocean temperature have the potential to alter the regional aquatic habitats' dynamics. Fish migration patterns may shift as a result of changes in ocean dynamics, and landings may decline, particularly in coastal fisheries.

2. **Sea Level Rise:** During the 20th century, global sea levels increased by 10 to 20 cm primarily due to thermal expansion, and the Intergovernmental Panel on Climate Change projects a further rise of 9 to 88 cm by 2100. This sea level increase could impact estuarine habitats, wetlands, and submerged vegetation along coastlines, affecting species that rely on these areas for recruitment and reproduction. Additionally, rising sea levels may pose increased risks to sea ports, fishing facilities, and fish storage facilities located near the coast, as they become more vulnerable to tidal and storm inundation

IV. CHEMICAL CHANGES

1. **Increasing Water Salinity:** Water salinity alter climate change in a number of ways. Oceans near the poles have become fresher while those in the tropics have become more salinized. It is expected that anthropogenic climate change would cause an increase in the salinity of several freshwater environments. By impairing the organisms' capacity for osmoregulation, such physical alterations will have a detrimental effect on the population of both plankton and larger prey fish species. Salinity is regarded as one of the most crucial factors affecting how long species survive in estuarine ecosystems. It can either directly affect the creatures or indirectly affect them by damaging their habitat, especially their breeding and rearing grounds.

2. **Ocean Acidification:** The majority of anthropogenic CO2 emissions may be able to be absorbed by oceans. In water, CO2 dissolves and irreversibly changes into carbonic acid. The world's oceans are becoming much more acidic as a result of this chemical process. Ocean habitats are negatively impacted by seawater's increased acidity due to dissolved CO2. Modifications in predator or prey abundance, impacts on biological ecosystems like coral reefs, and adjustments to nutrient recycling are examples of indirect effects.

Ocean acidification, a long-term decrease in ocean pH mainly due to the uptake of atmospheric CO2, is primarily caused by human activities and termed anthropogenic ocean acidification. Increased atmospheric CO2 concentrations lead to ocean CO2 absorption, lowering water pH, mineral saturation, and increasing pCO2 near the ocean surface. The decline in ocean surface water pH by an average of 0.1 since the industrial era began represents a 26 percent rise in acidity. Coastal waters exhibit more variable pH and higher pCO2 levels, exacerbated by lower salinity from ice melt or excessive precipitation. Regional variations in surface water acidification exist, with Arctic waters acidifying faster due to their higher CO2 absorption capacity in cold water. Corrosive conditions events have become more frequent and intense in the California Current. According to future forecasts, there will be widespread pH drops, which will be most noticeable in warmer low- and mid-latitude regions.

3. Biological Changes

- **Changes in Primary Productivity:** Ocean acidification has increased since the dawn of the industrial period, with the pH of the ocean's surface dropping. In addition to effects of changes in production, climate-induced changes in the distribution and phenology of fish larvae and their prey can also have an impact on recruitment and production of fish stocks.
- **Primary Production:** The marine food web's foundational mechanism, phytoplankton production regulates the food and energy accessible to higher trophic levels and, ultimately, to fish. Global marine primary production forecasts due to climate change are questionable, with models predicting both rises and decreases of up to 20 percent by 2100 (Taucher and Oschiles, 2011). (Bopp *et al*., 2013). This is due in part to the fact that changes in light, temperature, and nutrients are integrated by primary production, but it is also a result of the lack of clarity over how sensitive tropical ocean primary production is to climate change (Michelutti et al., 2005).
- **Changes in Fish Distribution:** Fish distribution changes are among the most often observed ecological concerns of marine species. The latitudinal and depth ranges of fish species are hypothesised to change in response to environmental changes, such as shifting water temperatures. Fish migration patterns may shift as a result of changes in ocean dynamics, and landings may decline, particularly in coastal fisheries. Since marine fisheries are a significant source of food, vary in the overall quantity or geographic distribution of fish that are accessible for catching could have an impact on food security.

V. CONCLUSION

The chapter gives background information and defines the context for the next chapters. The quantity of evidence currently available on the effects of climate change is quite limited, and many of the theories and presumptions are still up for debate given that aquatic systems make up more than two-thirds of the surface of the Earth. Oceans do, however, serve a critical role in controlling the climate, absorbing heat, and reducing the elevated CO2 levels brought on by human activities. The capacity of the ocean to absorb CO2 will decrease in the future, as predicted by models Aquatic system have a close relationship to climate since they can both affect atmospheric processes that are relevant to climate and serve as indicators of climate change. Due of the numerous anthropogenic impacts that freshwater systems are exposed to, the IPCC judged them to be among the most imperilled on the world. As a result of hydropower infrastructure, irrigation water consumption, and agricultural land use, water bodies are fragmented, flow regimes are changed, and floodplains and wetlands are gradually cut off from the rivers that support them. These stresses are anticipated to remain dominant as human demand for water resources increases, along with urbanisation and agricultural growth, in addition to climate change (Settele *et al*., 2014). Both short-term occurrences like extreme weather and medium- to long-term changes like lake levels or river flow are likely to have an impact on fishing and farming activities.

REFERENCES

[1] Settele, J., Scholes, R., Betts, R., Bunn, S., Leadley, P., Nepstad, D., Overpeck, J.T. & Taboada, M.A. 2014. Terrestrial and inland water systems. In C.B. Field, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee et al., eds. Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, USA, Cambridge University Press. pp. 271–359. (also available at http://www.ipcc.ch/pdf/ assessment-report/ar5/wg2/WGIIAR5-Chap4_FINAL.pdf) .

[2] Ciais, P., Sabine, C., Bala, G., Bopp, L., Brovkin, V., Canadell, J., Chhabra, A. et al. 2013. Carbon and other biogeochemical cycles. In T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex & P.M. Midgley, eds. Climate change 2013: The physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, pp. 465–570. Cambridge, UK and New York, USA, Cambridge University Press. (also available at http://www.ipcc.ch/ pdf/assessment-report/ar5/wg1/WG1AR5_Chapter06_FINAL.pdf).

[3] Gattuso, J.-P., Magnan, A., Billé, R., Cheung, W.W.L., Howes, E.L., Joos, F., Allemand, D. et al. 2015. Contrasting futures for ocean and society from different anthropogenic CO2 emissions scenarios. Science, 349(6243): aac4722. (also available at https://doi. org/10.1126/science.aac4722).

[4] IPCC. 2014. Climate change 2014: Synthesis report. Contribution of Working Groups I, II and III to the Fifth Assessment Report on the Intergovernmental Panel on Climate Change. Core writing team, R.K. Pachauri & L.A. Meyer, eds. Geneva, Intergovernmental Panel on Climate Change. 151 pp. (also available at http://www.ipcc.ch/report/ar5/syr/).

[5] Michelutti, N., Wolfe, A.P., Vinebrooke, R.D., Rivard, B. & Briner, J.P. 2005. Recent primary production increases in arctic lakes. Geophysical Research Letters, 32(19): L19715. (also available at https://doi.org/10.1029/2005GL023693).

[6] Kwiatkowski, L., Bopp, L., Aumont, O., Ciais, P., Cox, P.M., Laufkötter, C., Li, Y. & Séférian, R. 2017. Emergent constraints on projections of declining primary production in the tropical oceans. Nature Climate Change, 17: 355–359. (also available at https://doi. org/10.1038/NCLIMATE3265).

[7] Taucher, J. & Oschlies, A. 2011. Can we predict the direction of marine primary production change under global warming? Geophysical Research Letters, 38(2): L02603. (also available at https://doi.org/10.1029/2010GL045934).

[8] Bopp, L., Resplandy, L., Orr, J.C., Doney, S.C., Dunne, J.P., Gehlen, M., Halloran, P. et al. 2013. Multiple stressors of ocean ecosystems in the 21st century: projections with CMIP5 models. Biogeosciences, 10(10): 6225–6245. (also available at https://doi. org/10.5194/bg-10-6225-2013).

[9] Harris, K.E., DeGrandpre, M.D. & Hales, B. 2013. Aragonite saturation state dynamics in a coastal upwelling zone. Geophysical Research Letters, 40(11): 2720–2725. (also available at https://doi.org/10.1002/grl.50460).

[10] Jewett, L. & Romanou, A. 2017. Ocean acidification and other ocean changes. In D.J. Wuebbles, D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart & T.K. Maycock, eds. Climate Science Special Report: Fourth National Climate Assessment, Volume I, pp. 364–392. Washington, DC, USA, U.S. Global Change Research Program. (also available at https://doi.org/10.7930/J0QV3JQB).

[11] Pörtner, H.-O., Karl, D.M., Boyd, P.W., Cheung, W.W.L., Lluch-Cota, S.E., Nojiri, Y., Schmidt, D.N. & Zavialov, P.O. 2014. Ocean systems. In C.B. Field, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee et al., eds. Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York,

USA, Cambridge University Press. pp. 411–484. (also available at http://www.ipcc.ch/pdf/ assessment-report/ar5/wg2/WGIIAR5-Chap6_FINAL.pdf).

[12] Liu, W., Xie, S.P., Liu, Z. & Zhu, J. 2017. Overlooked possibility of a collapsed Atlantic meridional overturning circulation in warming climate. Science Advances, 3(1): e1601666 [online]. [Cited 25 May 2018]. https://doi.org/10.1126/sciadv.1601666.

[13] Hartmann, D.L., Klein Tank, A.M.G., Rusticucci, M., Alexander, L.V., Brönnimann, S., Charabi, Y., Dentener, F.J. et al. 2013. Observations: atmosphere and surface. In T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex & P.M. Midgley, eds. Climate change 2013: The physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, pp. 159–254. Cambridge, UK and New York, USA, Cambridge University Press. (also available at http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/ WG1AR5_Chapter02_FINAL.pdf).

[14] Henson, S.A., Beaulieu, C., Ilyina, T., John, J.G., Long, M., Séférian, R., Tjiputra, J. & Sarmiento, J.L. 2017. Rapid emergence of climate change in environmental drivers of marine ecosystems. Nature Communications, 8: art: 14682 [online]. [Cited 24 May 2018]. https://doi.org/10.1038/ncomms14682.

[15] Reid, P.C. 2016. Ocean warming: setting the scene. In D. Laffoley and J.M. Baxter, eds. Explaining ocean warming: causes, scale, effects and consequences, pp. 17–45. Gland, Switzerland, IUCN. (also available at https://portals.iucn.org/library/sites/library/files/ documents/2016-046_0.pdf).

