ISSN: 2754-4958

Journal of Aquaculture & Livestock Production

Review Article

Open Access

Climate Variabilities and its Impact on Aquatic Systems

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ABSTRACT

Fish population variability and fisheries activities are closely linked to weather and climate dynamics. An investigation was made of the climatic changes and its impact on aquatic systems. Various factors i.e. temperature, rainfall, ocean acidification and dissolved oxygen were observed. Analysis of these factors showed some significant correlations.

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Received: September 23, 2022; **Accepted:** October 07, 2022; **Published:** October 20, 2022

Keywords: CO_2, pH, GHGs, NO_2, CH_4

Introduction

The warming of the climate system is pronounced. The amounts of snow and ice have diminished and sea level has risen due to the warming of atmosphere and ocean.The increase in the atmospheric concentration of carbon dioxide (CO_2) and other greenhouse gases (GHGs) due to the uptake of additional energy in the climate system. Climate is also changing in many regions which is affecting precipitation and melting of snow and ice, altering hydrological systems and affecting water resources in terms of quantity and quality.Temperature of water bodies is increasing across the globe, which results in more pronounced stratification of the water column, with more dramatic consequences for freshwater systems than for oceans because of their shallowness and lower buffering capacity. The absorption of increasing amounts of anthropogenic CO_2 by the oceans results in acidification of waters, with potentially detrimental impacts on shell-forming aquatic life; water acidity has increased by 26 percent since the industrial revolution and this trend will continue, especially in warmer low- and mid-latitudes. Climate change also affects communities and livelihoods in fisheries and aquaculture, and therefore efforts to adapt to and mitigate climate change must be humancentric. At the global level, the Earth's average surface temperature has increased by more than 0.8 °C since the middle of the nineteenth century, and is now warming at a rate of more than 0.1°C every decade (Hansen et al., 2010). Heat waves are more frequent now, even though the reliability of data and level of certainty vary across continents (Hartmann et al., 2013). The largest contribution to this warming is believed to be from the increase in atmospheric concentration of GHGs, such as CO_2, methane CH_4 and nitrogen dioxide NO2. GHGs act like a thermal blanket around the planet and are responsible for allowing life on Earth to exist (IPCC, 2014). The exponential increase in the emission of GHGs since the industrial revolution has resulted in atmospheric concentrations of these gases that are unprecedented in the last 800 000 years. The IPCC AR5 has also concluded that it is extremely likely that humans have been the dominant cause of the observed warming since the mid-twentieth century, through the association of GHGs emissions with gas and oil combustion, deforestation, and intensive agriculture.

Impacts on Aquatic System

The warming of the climate has significant implications for the hydrological cycle. Changing precipitation, temperature and climatic patterns and the melting of snow and ice affect the quantity, quality and seasonality of water resources, leading to inevitable changes in aquatic ecosystems.

In the twentieth century, global river discharges have not demonstrated changes that can be associated with global warming. However, as most large rivers have been impacted by human influences such as dam construction, water abstraction and regulation, it is difficult to be conclusive.

Due to anthropogenic forcing, upper ocean warming (above 700 m) occur that has been observed since the 1960s (Cheng et al., 2017) and the surface waters warming by an average of 0.7 °C per century globally from 1900 to 2016 (Huang et al., 2015). Ocean temperature trends over this period vary in different regions but are positive over most of the globe, although the warming is more prominent in the Northern Hemisphere, especially the North Atlantic. The upper ocean (0 m to 700 m) accounts for about 64 percent of the additional anthropogenic energy accumulated in oceans and seas. Upper ocean warming is expected to continue in the twenty-first century, especially in the tropical and Northern Hemisphere subtropical regions, whereas in deep waters the warming is expected to be more pronounced in the Southern Ocean. The trend in sea surface temperature already exceeds the range in natural seasonal variability in the subtropical areas and in the Arctic (Henson et al., 2017). For freshwater systems, an increase of water temperature is expected to occur in most areas, as a result of an increase of air temperature. This is linked to the relatively shallow nature of surface freshwaters and their susceptibility to atmospheric temperature change. There is a high confidence that rising water temperatures will lead to shifts in freshwater species' distributions and exacerbate existing problems in water quality, especially in those systems experiencing high anthropogenic loading of nutrients (IPCC, 2014).

Dissolved oxygen is an important component of aquatic systems. Changes in its concentrations have major impacts on the global carbon and nitrogen cycles (IPCC, 2014). The average dissolved oxygen concentration in the ocean varies significantly, ranging from super-saturated Antarctic waters to zero in coastal sediments where oxygen consumption is in excess of supply over sufficient periods of time. A large variety of such systems exist, including the so-called oxygen minimum zones (OMZs) in the open ocean, coastal upwelling zones, deep basins of semi-enclosed seas, deep fjords, and other areas with restricted circulation but the discovery of widespread decreases in oxygen concentrations in coastal waters since the 1960s, and the expansion of the tropical OMZs in recent decades (IPCC, 2014) has raised concerns. GHG-driven global warming is the likely ultimate cause of this ongoing deoxygenation in many parts of the open ocean (Breitburg et al., 2018). Ocean warming, which reduces the solubility of oxygen in water, is estimated to account for approximately 15 percent of current total global oxygen loss and more than 50 percent of the oxygen loss in the upper 1000 m of the ocean. Intensified stratification is estimated to account for the remaining 85 percent of global ocean oxygen loss by reducing ventilation. Oxygen influences biological and biogeochemical processes at their most fundamental level, but the impacts are very dependent on widely varying oxygen tolerances of different species and taxonomic groups. In particular, the presence and expansion of low oxygen in the water column reduces vertical migration depths for some species (e.g. tunas and billfishes), compressing vertical habitat and potentially shoaling distributions of fishery species and their prey.

In the recent past, sea level has increased by an average of 3.1 mm/year as a result of climatic and non-climatic factors (Dangendorf et al., 2017). The rate of increase shows a high variability across regions, with values up to three times the global average in the Western Pacific or null or negative values in the Eastern Pacific. Sea level has already risen by a global mean of 0.19 m over the period 1901 to 2010.

1) Ocean acidification refers to a reduction in the pH of the ocean over an extended period (typically decades or longer) caused primarily by the uptake of atmospheric CO_2. It can also be caused by other chemical additions to or subtractions from the ocean. Anthropogenic ocean acidification refers to the component of pH reduction that is caused by human activity. As atmospheric CO2 concentrations increase, the oceans absorb more CO_2. This causes an increase in the partial pressure of CO_2 (pCO_2) at the ocean surface and a decrease in water pH and in the saturation state of mineral.forms of calcium carbonate ($CaCO_3$), referred to as Ωar4 , which is important for all shell-forming aquatic life (Pörtner et al., 2014). Since the beginning of the industrial era, oceanic uptake of CO_2 has resulted in increasing acidification of the ocean; the pH of ocean surface water has decreased by an average of 0.1, corresponding to a 26 percent increase in acidity (IPCC, 2014; Jewett and Romanou, 2017). Variability in coastal pH, pCO_2 and Ωar is higher in coastal waters than in the open ocean. Lower salinity (resulting from ice melt and/or excess precipitation) exacerbates water acidification by diluting the concentration of substances acting as buffers. There are regional variations in the rate of acidification of surface waters: acidification is already 50 percent higher in the Northern Atlantic than in the subtropical Atlantic, and Arctic waters are acidifying faster than the global average because cold water can absorb more CO_2. In the California Current, corrosive conditions events (in terms of Ωar state) have increased in frequency, severity, duration and spatial extent (Harris, DeGranpre and Hales, 2013). While oceanic pH is subject to natural variability, especially near sources of freshwater input like rivers and heavily tidal environments, observed trends in global ocean pH already exceed the range in natural seasonal variability over most of the oceans (Henson et al., 2017), and are expected to exceed it further in coming years (Gattuso et al., 2015). The volume of undersaturated waters (where Ωar is less than 1), which are corrosive to calcium carbonate shells and skeletons, are forecast to increase by 10 percent to 20 percent depending on the scenario considered. Future projections show that this decrease in pH will occur throughout the world oceans, with the largest decreases in surface waters occurring in the warmer low- and mid-latitudes. However, it is the already low Ωar waters in the high latitudes and in the upwelling regions that are expected to become aragonite unsaturated first.unclear. Ocean acidification research is still in the early stages of development and so far, mainly short-term responses in laboratory conditions have been investigated and provide information only on the sensitivity of organisms to a single stressor (McElhany,, 2017). There is an emerging trend of scientific research that explores long-term responses and adaptive capacity of marine organisms (Munday, 2017), as well as the impact of combinations of stressors, such as temperature and acidification, or oxygen content and acidification (Gobler and Baumann, 2018). This will yield more insight into likely impacts.

Primary production: Phytoplankton production is the process at the base of the marine food web, controlling the energy and food available to higher tropic levels and ultimately to fish. Earth system model projections of global marine primary production as a result of climate change are uncertain, with models projecting both increases (Taucher and Oschiles, 2011) and declines of up to 20 percent by 2100 (Bopp et al., 2013). This is partly because primary production is an integrator of changes in light, temperature and nutrients, but also because of the uncertainty in the sensitivity of tropical ocean primary production to climate change [1-7].

Conclusion

From the findings of this study it can be stated that aquatic systems represent more than two-thirds of the Earth surface. Oceans play a critical role in climate regulation and in absorbing heat and the increased amounts of CO_2 resulting from anthropogenic activities (mining, release of industrial waste, fertilizers etc.). Freshwater systems are also strongly connected to climate, as they may influence climate-related atmospheric processes and also be indicators of climate change. Various activities like hydropower infrastructure, water use for irrigation and agricultural land-use result in the water bodies fragmentation, modificatios and a progressive disconnection of floodplains and wetlands from the riivers that sustain them. It is expected that these stressors will continue to dominate as human demand for water resources grows, together with urbanization and agriculture expansion (Settele et al., 2014), in addition to climate change. Species productivity and fish growth are already changing with consequences for fishing and farming yields, as a result of shifts in the distribution of fish, alteration oflarval transport or thermal tolerance of farmed fish. Operations of fishing and farming activities are also expected to be affected, whether by short-term events such as extreme weather events or medium to long-term changes such as lake levels or river flow that could affect the safety and working conditions of fishers and fish farmers. Food control procedures will undergo major reshaping to protect consumers from potential increase in contaminants and toxin levels resulting from changes in water conditions.

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