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Effects of temperature variations on fish in lakes

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ABSTRACT

Most aquatic organisms are cold-blooded as they are unable to internally regulate their body temperature. Therefore, temperature exerts a major influence on the biological activity and growth of aquatic organisms. Fish, insects, zooplankton, phytoplankton and other aquatic species all have chosen temperature ranges. As temperatures get too far above or below this preferred range, the number of individuals of the species decreases until finally there are few, or none. A thriving trout (fresh water fish) fishery in ponds or shallow lakes is rarely seen because the water is too warm throughout the ice-free season. Temperature is also important because of its influence on water chemistry. The rate of chemical reactions generally increases at higher temperature, which in turn affects biological activity. An important example of the effects of temperature on water chemistry is its impact on oxygen. Warm water holds less dissolved oxygen that cool water, so it may be saturated with oxygen but still not contain enough for survival of aquatic life. Some compounds are also more toxic to aquatic life at higher temperatures. Changes in temperature affect aquatic life as it determines which organisms will thrive and which will diminish in numbers and size. For each organism there is a thermal death point. Also there is a range of temperature of that produces optimal abundance. The effects of temperature upon life of a cold blooded are profound. These animals have coped with temperature problems in different ways. Not only the organism survival, but growth and reproduction of each organism have critical temperature ranges. Each organism must be favored by the proper temperature if the individual or their populations are going to survive.

Key words: cold-blooded, dissolved oxygen, thermal death point

INTRODUCTION

Temperature influences enzymatic reactions through hormonal and nervous control to digestion, from respiration and osmoregulation to all aspects of an organism's performance and behaviour. High and low temperatures that are lethal to individual organism of a species determines the distribution and abundance its populations. However, more often the distribution and abundance of populations is determined by less than lethal temperatures interacting with other environmental factors that either tend to favor or not to favor reproduction and growth. Increased water temperature is an important consideration when toxic substances are present in water. Many substances (i.e. cyanides, phenol, xylene, zinc) exhibit increased toxicity at elevated temperatures. These toxicities and other physiological interactions are also influenced by temperature acclimation or history of the species. In relation to the survival of individual organisms, the upper and lower lethal temperatures define the total temperature gradient. Within this temperature gradient the species can function at or near optimum. In this range, growth and reproduction temperature requirements are met and the species will be found in greatest abundance. Outside the optimum range, there are zones of physiological stress. In these zones, organisms become infrequent because activities are limited more by temperatures that produce discomfort or stress. The period of time an organism can live under physiological stress is a function of how far the temperature is from the lethal level. Since they constitute a large part of our planet and have rich biodiversity, lakes are aquatic ecosystems that are affected by the process of change caused by global warming. A temperature increase of only a few degrees does not only cause an increase in the temperature of large water masses such as oceans, seas, lakes and ponds but it also causes hydrological events that cause a change in the physical and chemical characteristics of water. Water temperature is the most important environmental parameter that affects the life cycle, physiology and behaviors of aquatic living beings. Therefore, to what extent the aqua bodies will be affected by global warming on a worldwide scale, how global warming will affect the distribution of species, the relationship between global warming and biodiversity and the impact of climate change on water resources which can renew themselves but are limited are topics that need to be considered carefully.

HUMAN ACTIVITIES AND TEMPERATURE VARIATIONS

Human activities such as burning coal, natural gas and oil have caused global warming, a phenomenon that has caused temperatures across the world to increase over the past 50 years. Global warming and climate change have caused a decrease in lake waters, an increase in the sea level and changes in streams and precipitation models and have started to show negative impacts on all aquatic organisms from plankton to mammals. Global warming is the process in which the earth's temperature and the temperature on the atmosphere layers that are close to earth rise artificially as a result of the intense increase in some gases that occur in consequence of various human activities. Oceans, rivers and lakes are mostly affected by the process of change caused by global warming since they constitute a large portion of our planet and have rich biodiversity. The most obvious reason for temperature change in lakes is the change in seasonal air temperature. The surface layers are warm during the day and cool at night. In deeper lakes (greater than 5 m for small lakes and 10 m for larger ones) during summer, the water separates into layers of distinctly different density due to differences in temperature. Thermal changes almost always occur as a result of discharge of municipal or industrial effluents in lakes. In urban areas, runoff that flows over hot asphalt and concrete pavement before entering a lake will be artificially heated and could cause lake warming, although in most cases this impact is too small to be measured. Consequently, direct, measurable thermal pollution is not common. In running waters, particularly small urban streams, elevated temperatures from road and parking lot runoff can be a serious problem for populations of cool or cold-water fish already stressed from the other contaminants in urban runoff. Water temperature fluctuations in streams may be further worsened by cutting down trees (deforestation), which provide shade and by absorbing more heat from sunlight. Most changes in water temperature as a result of land use activity generally trend upward. Most other activities generally raise the temperature of receiving waters. The way that temperatures vary in lakes over seasons depends on where they are located. In warm climates the surface may never get so cold. But, in climates that have a cold winter, temperature stratifications and turning do occur. Today, almost all climatologists have agreed on that the climate change results from the increase in the greenhouse gas emissions in the atmosphere and this comes as a consequence of various human activities. The carbon dioxide has the largest share among greenhouse gases in terms of contribution in global warming and climate change. Greenhouse gases that cause greenhouse effect are carbon dioxide, chlorofluorocarbon gases, methane, nitrous oxides, ozone and water vapor. Since carbon dioxide largely permeates the short wave rays coming directly from the sun but traps the long wave rays radiated back from the earth, it is a greenhouse gas with a very important role in the warming of the lower parts of the atmosphere. It has been calculated that in the event that the CO2 density is doubled, the global temperature will rise by 3 degree Celsius. This result gives an idea about how high the impact level of carbon dioxide on global warming is. The effects on wildlife have been extreme, especially for fish populations. Global warming heats the water in lakes, rivers and even oceans. As water temperatures warm, fish populations that are already at risk due to pollution, over fishing and the loss of habitats due to development endure new problems and challenges.

SIGNIFICANCE

Temperature exerts a major influence on biological activity and growth on organisms that can live in rivers and lakes as they have a preferred temperature range. Higher temperatures also decrease the maximum amount of oxygen that can be dissolved in the water, leading to oxygen stress if the water is receiving high loads of organic matter. As temperatures get too far above or below this preferred range, the number of individuals of the species decreases until finally there are none. Temperature is also important because of its influence on water chemistry as the rate of chemical reactions generally increases at higher temperature. Water, particularly groundwater, with higher temperatures can dissolve more minerals from the rocks it is in and will therefore have a higher electrical conductivity. It is the opposite when considering a gas, such as oxygen, dissolved in the water. Warm water holds less dissolved oxygen than cool water and may not contain enough dissolved oxygen for the survival of different species of aquatic life. Some compounds are also more toxic to aquatic life at higher temperatures. Water temperature is considered an important water-quality measurement. After all, temperature is not a chemical and it doesn't have physical properties. In natural environments, temperature is not too much of a concern for aquatic life, since the animals and plants in the water have evolved to best survive in that environment. It is when the temperature of a water body changes, either by a natural event or by a human-induced event that the fish start to worry. The heated water can be a shock to the aquatic life in the stream and can, thus, harm the water quality of the stream. Those temperature changes stabilize the water column in lakes, especially in the tropics where, unlike in temperate regions, winter cooling and mixing is absent. The increased stability decreased circulation, hampering the re-supply of nutrients from the deep water to the surface waters of the lake where they help algae grow. The algae, which form food chain, ultimately feed the commercially important fish. Many lakes experience a "turning" of its water layers when the seasons change. In summer, the top of the lake becomes warmer than the lower layers. Since warm water is less dense that colder water, it stays on top of the lake surface. But, in winter some lake surfaces can get very cold. When this happens, the surface water becomes more dense than the deeper water with a more constant year-round temperature (which is now warmer than the surface), and the lake "turns", when the colder surface water sinks to the lake bottom and the hot one takes its place. Because the layers don't mix, they develop different physical and chemical characteristics. Dissolved oxygen concentration, pH, nutrient concentrations, and species of aquatic life in the upper layer can be quite different from those in the lower layer. It is almost like having two separate lakes. The most profound difference is usually seen in the oxygen profile since the bottom layer is now isolated from the major source of oxygen to the lake - the atmosphere. When the surface water cools again in the fall to about the same temperature as the lower water, the stratification is lost and the wind can turbulently mix the two water masses together because their densities are so similar. A similar process also may occur during the spring as colder surface waters warm to the temperature of bottom waters and the lake mixes. Because light deceases exponentially with depth in the water column, the sun can heat a greater proportion of the water in a shallow lake than in a deep lake and so a shallow lake can warm up faster and to a higher temperature. Lake temperature also is affected by the size and temperature of inflows (e.g., a stream flow) and by how quickly water flushes through the lake. It has been established that higher temperatures diminish the solubility of dissolved oxygen and availability. Elevated temperatures increase the metabolism, respiration and oxygen demand of fish and other aquatic life, approximately doubling the respiration for a 10°C rise in temperature. Hence the demand for oxygen is increased under conditions where oxygen supply is lowered. Study shows that the solubility of many toxic substances is increased as well as intensified as the temperature rises. Higher temperatures militate against desirable fish life by favouring the growth of sewage fungus and the putrification of sludge deposits present in the aqua body system.Even with adequate dissolved oxygen, there is a maximum temperature that each species of fish or other organism can tolerate. Higher temperatures produce death. Temperature increase that occurs in the atmosphere does not only cause an increase in the temperature of large water masses such as oceans, seas, lakes, and ponds but it also causes change in the physical and chemical characteristics of water. The maximum temperatures that adult fish can tolerate vary with the species of fish, prior accommodation, oxygen availability and the synergistic effects of other pollutants. The impact of global warming on lakes comes out as the increase in water temperature and regression of lakes. It is known that the Aral Sea in Asia, , Yellow River in China, Owens Lake in Northern America, Chad Lake in Africa, Ganges River in India and Platte Lake in Central Europe have lost large portions of their waters due to global warming and a lot more are under threat.

IMPACT ON FISH

Goldfish, Bass and Carp are relatively tolerant of high temperatures, whereas Trout and Salmon are more sensitive. These temperatures, however, apply to adult fish. For spawning and hatching of eggs, much lower temperatures are required. Many species produce only above or below certain temperatures. This is the main distinction between the cold-water and warm-water fishes. Cold-water fishes may begin breeding at very low temperatures – only a few degrees above freezing for salmon, trout, and grayling. Whereas many warm water species start to breed only at much higher temperatures and so are successful only in places where high temperatures are available long enough for breeding and early development. Trout eggs will not hatch over 14.4° C. Chinook Salmon eggs fare well at 16° C., but suffer mortalities at 18° C. Rocky Mountain Whitefish eggs are affected at 20-21° C. It is apparent therefore, that many fish are unable to complete their life cycles unless the temperatures at the time of their spawning and hatching are 10-15° C. below the median tolerance limit. As stated earlier, fish have optimum temperatures for rates of growth and reproduction. If the temperature of a reach of stream is raised by 5-10° C., it is probable that cold water fish will avoid this reach and that they will be replaced by warm water fish. Thus, without any direct visible mortality, the character of the fish and supporting aquatic life will change. It will also change because the temperature impacts successful spawning and hatching of eggs. Sudden changes in temperature are believed to be deleterious to fish life with abrupt changes of 5° C. or greater likely to be harmful. Rainbow trout could not stand a temperature shock of 11° C. above an acclimation temperature of 12° C., but could tolerate an 8° C. shock above an acclimation temperature of 10° C. Increased temperatures can stimulate the decomposition of sludge, formation of sludge gas, multiplication of saprophytic bacteria and fungi and in the consumption of oxygen by decomposition processes thus affecting the aesthetic value of a water resource. As waters warm, the body temperature of cold-blooded fish rise and their metabolism increase to maintain this temperature. Warm water causes them to need more food and oxygen to survive. Problems occur when increased temperatures cause a decrease in the amount of oxygen that is available to fish. Fish may not get enough oxygen to support their needs. As the waters continue to warm, lethally low oxygen levels may cause the deaths of many fish. Fish in warm water reach sexual maturity more quickly than those in cold water, but 90 percent of warm water fish develop smaller bodies than their cold water counterparts. The result is reproductive problems and fewer offspring. Grass carp ovulate less often in warm water, while guppies produce fewer offspring. Salmon, catfish and sturgeon need temperatures to drop below a certain level in order to produce. If water temperatures continue to rise, the numbers and diversity of fish will decrease. When water temperatures rise, fish seek out cooler waters. They may move into deeper, far-off waters, leaving animals that rely on them for food with nothing to eat. Fish in the Gulf of Alaska move to deep water when the temperature rises, but in 1993 this caused the deaths of 120,000 seabirds that could not reach their prey. New fish populations that are used to warm water will arrive and take over the areas formerly inhabited by cool water fish. It is estimated that warm water species will become 14 times more prevalent than cooler water species if lake temperatures increase by just two degrees Celsius. New species will compete with struggling native fish for food and space. Overall, this could lead to less diverse fish populations. Major changes will be likely to occur in the species composition, seasonality and production of planktonic communities and their food web interactions with consequent changes in water quality. An increase or decrease in freshwater flows will also affect aqua bodies by altering salinity, sediment inputs and nutrient loadings. Increased thermal stratification may lead to oxygen deficiency, loss of habitats, biodiversity and distribution of species, and impact whole ecosystems. The impacts that global warming has created and will probably create on aquatic ecosystem can be listed as increase in water temperature and drying of the lakes, increase in the extinction of species and increase in the distribution areas of ailment vectors. Since the breaking of the nourishment chain in nature once will lead to incredible results, the extinction of some species will directly affect the other species. Temperature of lake water comes the first in the list of most determinant factors since it is essential for the reproduction of fish species and the formation of an ideal living environment. In pre adolescence stages called larva and juvenile, fish are quite susceptive to changes in the water temperature. A fish population can be tolerant of temperature changes in the area where it is distributed in a certain time interval. If these changes are within a certain temperature boundary and slow, it generally causes migration of fish. Temperature takes important physiological phenomena such as feeding, respiration, osmo regulation, growth and reproduction under control. If the individuals of population can not adjust themselves according to the sudden and strong changes in temperature, one or some of their metabolism activities may deteriorate and mass deaths may occur. Another effect of climate change is the decrease in the pH level of the lake water through increasing atmospheric CO2. A study was carried out to find the effects of high and low pH on spawns and larva and it was observed that 99% of the hatching process of eggs was in the high pH level environment while 39.5% was in the low pH level environment; and that 85% of the spawns bore normal juveniles in the high pH level environment while only 1.2% of the spawns bore normal juveniles in the low pH level environment.

CONCLUSION

Study shows that continued global warming and increasing water temperatures will cause 18 to 38 percent of trout and salmon to disappear from their current habitats in the next 80 years. A total of 17 percent of trout and salmon habitats will be lost by 2030 and 42 percent by 2090. In the larger picture, if global warming continues, it will affect wildlife and humans alike, compromising the global food supply, especially in undeveloped countries that rely on fish as a food source. In order to keep water temperatures from increasing two degrees Celsius, industrialized countries must cut their carbon dioxide emissions by 60 to 80 percent. Switching to clean as opposed to coal-burning power will also help cut carbon dioxide emissions, 37 percent of which are caused by electricity. It has been calculated that in the event that the CO2 density is doubled, the global temperature will rise by 3 degree Celsius. For this reason, among the precautions to be taken against global warming, decreasing of the carbon dioxide emission comes first and studies are being carried out for this purpose on an international level. Global warming and climate change which have caused the ecological systems, bio diversity and human life to confront the biggest problem of history have started to show their impacts on all living beings in the aquatic ecosystem from plankton to mammals. The studies that have been conducted indicate that the deterioration in the climate caused by global warming will continue to the future even if precautions are taken today. Just as the climate changes that we observe today are the results of phenomena that have piled up through years, the effects of the precautions to be taken that may be considered positive will require nearly the same amount of time. Since we do not have the chance to reverse the global warming and climate change phenomena, the only thing that needs to be done is to minimize the foreseen harms in the future. To this end, mankind needs to understand the global warming problem and cooperate on an international level.

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