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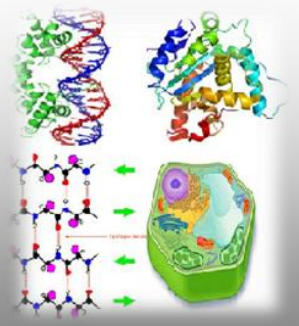

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RESEARCH PAPER

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Review on the Impact of Climate Change on Aquatic Biodiversity

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ABSTRACT
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. There is a broad body of evidence that climatic fluctuations are playing an important role changing aquatic biodiversity distributions and abundances, which is discernible against the background of trends in abundance due to diversity. The objective of this paper is to review the impacts of climate change on aquatic biodiversity and its relevant restoration measures. The effects of increased atmospheric CO2 concentrations-such as changes in ocean chemistry-will adversely affect the physical and biological characteristics of coastal systems, modifying their ecosystem structure and functioning. As a result, coastal nations face losses of marine biodiversity, fisheries, and shorelines. Coral reefs, which are among the most bio diverse ecosystems on Earth, are highly sensitive to increases in sea surface temperature. These impacts will add to the stress already resulting from local anthropogenic effects; combined, they represent an unprecedented challenge to the global biosphere. The review attempted to clarify that atmospheric carbon dioxide emissions concentrations have subsequent impacts on marine environment by driving rapid distribution shifts in marine ecosystems. It suggests ongoing programs worldwide will act as lookouts to recognize the marine ecosystems changes that may happen as a result of rising sea level. Building stronger relationships between organizations and governments and financial institutions to respond mechanisms. Many existing natural resource plans should already contain provisions for updates and revisions, which could provide a mechanism for incorporating information about climate-change effects and adaptation strategies for aquatic biodiversity
Keywords: Aquatic Biodiversity, Adaptation Measures, Climate Change, Species Extinctions and Food Web.

INTRODUCTION
Background
The diversity of life on earth is dramatically affected by human alterations of ecosystems (Antril and Power, 2004). Biodiversity is continually transformed by a changing climate. Now days, a new type of climate change, brought about by human activities, is being added to this natural variability, threatening to accelerate the loss of biodiversity already under stress due to other human stresses. Approximately 70% of the earth's surface is covered by water. Climate change is already changing the distribution and abundance of aquatic ecosystem (Klyashtorin, 1998).

Climate change can result in significant changes in the variables and processes that affect water quality and freshwater biodiversity. These include: physical changes such as increased water temperature, reduced river and lake ice cover, more stable vertical stratification and less mixing of water of deep-water lakes, and changes in water discharge, affecting water level and retention time; chemical changes, such as increased nutrient concentrations and changing water color and decreased oxygen content biological changes, including northwards migration of species and alteration of habitats, affecting the structure and functioning of freshwater ecosystems (Houghton et al, 2001).
Without proper action against anthropogenic greenhouse effects the intergovernmental panel on climate change (IPCC) predicts increase s in global average surface temperature of 1.4 to 5.8 for the year 2100 (Houghton et al, 2001). However regional climate changes are harder to predict as small spatial fluctuation in climate patterns have far-reaching consequence for regional climate. Ecological response to recent climate change has been demonstrated across different natural system (Walther et al, 2002). Long time series analysis of physical and biological characteristic of fresh water ecosystem has shown that climate change affects winter concentration of nitrate nitrogen (George et al, 2004). However, differences in lake morphometry and site specifically result in differences in the relative effect of climate change on water quality and aquatic biodiversity (Germen and Adrian 2001; George et al, 2004). Because of their smaller volume and absence of stratification in summer shallow water bodies are less influenced by meteorological condition s in the preceding winter than deeper water bodies and respond more directly to the prevailing weather condition (Germen and Adrian, 2001). The important of morphometry and site specify added to the strong deviation s of local climate change from global climate, imply that specific prediction on the effects of climate change can only be made with specific type of ecosystem and specific region in mind. Several parameters of climate change are relevant to those ecosystem changes in temperatures, ice cover, wind and precipitation. Second effects of climate change may include changes in nutrient loading residence time and water level and biological changes including north wards migration of species and alteration of habitats, affects the structures and functioning of water ecosystem changes in these variable lead to impacts on all water aquatic biodiversity and on their good s and services (Kaman et al, 2010 and (IPPC, 2007).
Climate change is having widespread impacts across multiple scales of biodiversity including genes, species, communities, and ecosystems (Parmesan, 2006; and Bellard, 2012). Biological responses to climate change vary widely among species and populations; some responses are positive, leading to increased growth rates or range expansions, while others are negative, resulting in localized or widespread declines (Miller-Rushing, 2011). Many species have already shifted their geographical ranges, generally pole ward, towards higher elevations, or to deeper depths in marine environments (Nye, 2010). Species have altered the temporal patterns of seasonal migrations and other life cycle events (phonology), showed changes in population demographics (Doak and Morris, 2010).These shifts will likely bring about new assemblages of species (Williams and Jackson, 2007), cause novel interspecific interactions (Suttle and others, 2007), and in worst case scenarios result in some extinctions (Butchart and others, 2010; Barnosky and others, 2011).Climate change is altering the a biotic conditions that influence biological systems and processes (Table 1); biological responses to climate change depend on a number of factors, including the rate, magnitude, and character of the change, ecological sensitivity, and adaptive capacity to environmental change. The combination of these factors is affecting all levels of biodiversity, such that the distribution, organization, and interactions among biota are shifting over spatial and temporal scales (Walther, 2010).

Objective

To review the impacts of climate change on aquatic biodiversity and their relevant restoration measures.

Review of the Related Literature

General Concept and Definition of Climate Change

Climate is an ancient Creek word, meaning inclination and later has been scientifically defined by different literatures as prevailing weather conditions of a region, as temperature, air pressure, humidity, precipitation, sunshine, rainfall, snow, winds, turbidity, ice storm, clouds and sleet, averaged over a long period.

There is a difference between weather and climate, is that, weather is what conditions of atmosphere are over a short period of time and climate is how the atmosphere behaves over relatively long period of time. The climate has behaved over periods of time, led to a clear phenomena termed as climate change. Climate change is a change in the statistical distribution of weather patterns when that change lasts for an extended period of time (i.e., decades to millions of years). Some use the term "climate change" refers to "all forms of climatic inconstancy, regardless of their statistical nature (or physical causes)" (Mitchell et al. 1966). Also, the Intergovernmental Panel on Climate Change (IPCC) defines climate change broadly as "any change in climate over time whether due to natural variability or as a result of human activity." In contrast, the United Nation's Framework Convention on Climate Change (UNFCCC) defines climate change as "a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere, and is in addition to natural climate variability over comparable time periods". BACC has decided to essentially follow the IPCC-definition, and to add explicitly anthropogenic" to the term "climate change" when human causes are attributable, and to refer to "climate variability" when referring to variations not related to anthropogenic influence.

Table 1. Overview of physical changes associated with climate change and examples of the potential ecological consequences associated with these changes.

Observed or projected physical change	Examples of potential impacts on biodiversity
Increased ambient temperature	Species and population range shifts and/or changes in phenology leading to alteration or loss of biotic interactions
Changes in annual and seasonal precipitation	Changes in community composition
Increased frequency of extreme events	Mortality resulting from flooding after storms or drought events; damage or mortality resulting from deep freezes or heat waves
Changes to hydrologic regimes	Reduced stream flow affecting population persistence and community composition
Changes to fire regimes	Changes in community composition
Ocean acidification	Change in water chemistry affecting calcification rates of marine organisms
Sea level rise	Habitat loss and fragmentation affecting population persistence
Increases in ocean stratification	Reduced productivity of pelagic ecosystems
Changes in coastal upwelling	Changes in productivity of coastal ecosystems and fisheries

Source: Walther, 2010

Shifts in precipitation and temperature can also affect food availability and indirectly lead to changes in body size. In Arctic environments, female polar bear (*Ursus maritimus*) reproductive success (decreased litter mass, and numbers of yearlings) has been linked to changes in body size and/or body condition following years with lower availability of optimal sea ice habitat (Rode and others, 2010).Therefore, analyzing the impact of climate change and anthropogenic activities on livelihood of fishing community is important in order to formulate focused and targeted interventions to sustain the life of the lakes and reservoir by maximizing its usability. Thus, the aim of this review is to identify climate change impacts on the aquatic biodiversity and to identify major its restoration measures.

The Main Source of Climate Change

There are both natural and human sources of climate change. Natural sources include decomposition, ocean release and respiration. Human sources come from activities like cement production, deforestation as well as the burning of fossil fuels like coal, oil and natural gas.

Due to human activities, the atmospheric concentration of carbon dioxide has been rising extensively since the industrial revolution and has now reached dangerous levels not seen in the last 3 million years (M. Lomas, 2011). Climate change poses new challenges to the sustainability of fisheries and aquaculture systems, and has serious implications on the 520 million people who depend on fishery for their livelihoods and on the nearly 3 billion people who use fish as an important source of animal protein (Dereje Tewabe, 2011).

Anthropogenic Source of Climate Change

Fossil fuel Combustion

Since the industrial Revolution, human sources of carbon dioxide emissions have been growing. Human activities such as the burning of oil, coal and gas, as well as deforestation are the primary cause of the increased carbon dioxide concentrations in the atmosphere 87% of all human-produced carbon dioxide emissions come from the burning of fossil fuels like coal, natural gas and oil. The remainder results from the clearing of forests and other land use changes 9%, as well as some industrial processes such as cement manufacturing 4% (I. House G. Marland,2012).The largest human source of carbon dioxide emissions is from the combustion of fossil fuels. Burning these fuels releases energy which is most commonly turned into heat, electricity or power for transportation. Some examples of where they are used are in power plants, cars, planes and industrial facilities. In 2011, fossil fuel use created 33.2 billion tons of carbon dioxide emissions worldwide (J. Schwinger, 2012)).

Industrial sector

The industrial sector is the man-made source carbon dioxide emissions. This sector produced 20% of fossil fuel related carbon dioxide emissions in. (The industrial sector consists of manufacturing, construction, mining, and agriculture. Manufacturing is the largest of the 4 and can be broken down into 5 main categories: paper, food, petroleum refineries, chemicals, and metal/mineral products. This is because many manufacturing facilities directly use fossil fuels to create heat and steam needed at various stages of production. For example, factories in the cement industry have to heat up limestone to 1450°C to turn it into cement, which is done by burning fossil fuels to create the required heat (Lequéré, 2012).

Natural cause of Climate Change

Apart from being created by human activities, carbon dioxide is also released into the atmosphere by natural processes. The Earth's oceans, soil, plants, animals and volcanoes are all natural sources of climate change. The largest natural source of climate change is from ocean-atmosphere exchange. This produces 42.84% of natural climate change. The oceans contain dissolved carbon dioxide, which is released into the air at the sea surface (Denman, K.L., G. Brasseur, 2007). A minor amount climate change is created by volcanic eruptions, which accounts for 0.03% of natural emissions. Volcanic eruptions release magma, ash, dust and gases from deep below the Earth's surface. One of the gases released is carbon dioxide. Annually this process creates about 0.15 to 0.26 billion tones of carbon dioxide emissions (Gerlach, Terry, 2011).The most common volcanic gases are water vapor, carbon dioxide, and sulfur dioxide. Volcanic activity will cause magma to absorb these gases, while passing through the Earth's mantle and crust. During eruptions, the gases are then released into the atmosphere (Brasseur, 2007).

The Climate Change indicators

Increased Sea level

Changes in sea level have had major impacts on the abundance and particularly the distribution of both marine and terrestrial diversity. Sea level will rise as climate changes pushes planetary temperature higher. This occurs due to the thermal expansion of ocean water, the melting of glaciers, and changes to the distribution of ice sheets. The expected increase in sea level is approximately 9 - 29 cm over the next 40 years or 28 - 29 cm by 2090 (Church et al., 2001; IPPC 2001). According to Nichols and colleagues (1999), sea level rise could cause the loss of up to 22% of the world's coastal west lands by 2080. Combined with other human impacts, this number is likely to climb to a loss of 70% of the world's coastal wetlands by the end of the 21st century.

Sea temperature increases

Significant increase in heat content has not been distributed evenly. Sea temperature in turn influences of the marine environment. Due to its direct effects on the density of seawater, changes in global temperatures can play directly upon the rates and directions of ocean water movement.

Climate Change Impacts on Aquatic Biodiversity

Species and habitat dynamics in the face of climate change a/re complex and have many aspects. Increased temperatures and CO2 concentrations will have an effect on different processes such as photosynthesis, respiration and decomposition and generally speed up these processes. Climate-induced changes in ice cover period, thermal stratification and nutrient availability and longer growing seasons affect species composition and food web structures (Ficetola et al, 2009). Water temperature is one of the parameters that determine the overall health of aquatic ecosystems. Most aquatic organisms (e.g. salmon fish) have a specific range of temperatures that they can tolerate, which determines their spatial distribution long a river or on a regional scale. Climate change could lead to the extinction of some aquatic species or at least could modify their distribution in a river system or move their distribution northwards several indications of climate impact on the functioning and biodiversity of freshwater ecosystems have already been observed, such as northward movement, phonology changes and invasive alien species (Bady et al, .2007).

Enhanced harmful algal blooms in lakes resulting from climate change may counteract nutrient load reduction measures and also require a revision of classification systems for ecological status assessment. The inclusion of additional nutrient load reduction measures in river basin management plans may be needed to obtain good ecological status, as required by the Water Framework Directive. Public health may be threatened and the use of lakes for drinking water and recreation may be reduced (Daufresne et al, .2007).

On the Fish populations

Coastal fisheries are critical resources for hundreds of millions of people. Many scientists now point to the dramatic over exploitation of fisheries and the subsequent decline in fish stocks as the major factor in ecosystem change over the past two centuries (Jackson et al., 2001). Recent evidence has revealed that oceanographic and climatic variability may play dominant role in fish stocks (Klyashtorein, 1998; Babcock Hollowed et al., 2001; Attrill and Power, 2002). The relationship between climate variability and fish stocks is probably complex. In some cases, indirect changes may affect conditions and crucial changes in the life history of the fish species. The most widespread effects of climate occur on the primary and secondary production in marine ecosystems. Climate change is predicted to drive species ranges toward the colder waters (Parmesan & Yohe, 2003) potentially resulting in widespread extinctions where dispersal capabilities are limited or suitable habitat is unavailable (Thomas *et al.*, 2004). For fishes, climate change may strongly influence distribution and abundance (Wood & McDonald, 1997) through changes in growth, survival, reproduction, or responses to changes at other atrophic levels. Further temperature rises are likely to have profound impacts on commercial fisheries through continued shifts in distribution and alteration in community interactions. Extremes in environmental factors, such as elevated water temperature, low dissolved oxygen, changes in salinity and pH, can have deleterious effects on fishes (Moyle & Cech, 2004). Suboptimal environmental conditions can decrease foraging, growth, and fecundity, alter metamorphosis, and affect endocrine homeostasis and migratory behavior (Barton & Barton, 1987; Donaldson, 1990; Pörtners *et al.*, 2001). The tropical and subtropical corals are expected to be among the worst affected, with implications for the stability and longevity of the reefs that they build and the organisms that depend on them. Other calcifying organisms that may be affected are components of the phytoplankton and the zooplankton, and are a major food source for fish and other animals.

Effects on Sea Grass Beds

Sea grasses are aquatic flowering plants that grow in the soft or sandy bottoms of estuaries and along the coastal margins of tropical, temperate and sub-arctic marine waters (Hartog, 1970; McRoy & Helfferich, 1977). Sea grasses form extremely complex ecosystems that are highly productive, faunally rich and ecologically important. The plants filter suspended sediments, and nutrients from coastal waters, stabilize sediments, dissipate wave energy, and remove carbon dioxide from the ocean-atmosphere system which could play some role in the amelioration of climate change impacts (Creed *et al.*, 2003). Sea grasses are subjected to nutrient pollution mainly from land-based sources, particularly sewage and grey water (Juman, 2005). Increased sediment loading as a result of deforestation, urbanization and agricultural activities has caused major damage to beds. Coupled with the slight increase in temperature, these chemical changes

Will increase the biomass of sea grasses, and thus, the detritus-based atrophic level (Harley, 2006). Regimes and sediment transport will impact sea grass beds Millennium Ecosystem Assessment (2005).

Effects on Food Web Structure and Dynamics

The impacts of climate change on the structure and dynamics of aquatic food webs remain poorly understood. To date, many of the insights as to how arctic food webs will respond (directly or indirectly) to climate change effects have been obtained from either descriptive studies or a select few manipulative/experimental studies where ecosystem-level or food web manipulations were conducted and response variables measured (Moran & Bjorndal, 2007). Other recent studies of arctic systems have identified the structural and functional importance of the microbial freshwater food web. Furthermore, diatom community structure was highly correlated with DOC gradients in Siberian and subarctic Quebec lakes. Hence, related changes in the phytoplankton component of the food web probably will also force through the ecosystem. Increasing temperature has the potential to alter the physiological rates (e.g., growth, respiration) of individuals, and the vital rates and resulting dynamics of populations. Studies by Beisner et al., 2008, which investigated the influence of increasing temperature and food chain length on plankton predator–prey dynamics, showed that the predator–prey system is destabilized at higher temperatures (i.e., the macro zooplankton herbivore Daphnia pulex always became extinct), irrespective of the complexity of the food web (i.e., whether a two- or three-level food web was involved). Long-term studies of Topic Lake, Alaska, project that rising temperatures are likely to eliminate lake trout (Salvelinusnamaycush) populations in this lake, with concomitant impacts on the food web (Moran & Bjorndal, 2007).

SUMMARY AND CONCLUSION

Climate change is projected to affect runoff, water levels, river and lake-ice, and thermal regimes, causing significant alterations to: biogeochemical processes, including carbon dynamics; aquatic biodiversity and adaptive capacities; aquatic food web structure and dynamics and corresponding levels of primary and secondary production; and, the range, distribution and habitat quality/quantity of aquatic mammals and cold water species, potential genetic adaptation, birds, sea grass bed, risk increased cyan bacterial blooms, coastal pelagic and fish species sea turtle and waterfowl. Climate change will also produce probable changes in quality and quantity of aquatic habitat for aquatic mammals and waterfowl. Some projected effects at the individual, population and community levels include: altered migration routes and timing; a possible increase in the incidence of mortality and decreased growth and productivity from disease and/or parasites; and, probable changes in habitat suitability and timing of availability, very likely leading to altered reproductive success. In general, endorses for this problem moving animals, plants, and other organisms from sites that are becoming unsuitable due to global climate change to other sites where conditions are thought to be more favorable for their continued existence.

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