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Full Length Research Paper

Review Work on the Impact of Climate Change on Fish and Fisheries

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This review work stated that climate changes are recognized as the foremost environmental problem of the twenty-first century and subject of considerable debate and controversy. Alteration between two different periods of time is the major courses of climate change occurred in a specific area. Both natural and anthropogenic activities are affecting the habitat of fish earth's temperature and it's climatic. Additionally climate change is the cusses of fishing mortality, loss of habitat, pollution, disturbance and introducing new species. This review assessed that there is increasing concern over the consequences of climate change for fisheries production and the state of marine ecosystems. Changes in distribution, species composition and habitats will require changes in fishing practices and aquaculture operations, as well as in the location of landing, farming and processing facilities. Most marine and aquatic animals are cold-blooded and their metabolic rates are strongly affected by external environmental conditions (particularly temperature). This result investigated that changed environmental conditions are likely introduced new animal-transmitted diseases and redistributed some existing diseases which are affecting economic resources and human population. The wide range of adaptation potential and mitigation options for fisheries in response to climate change is implementing adaptation and mitigation pathways for communities dependent on fisheries maintain research and monitoring efforts that make sound policy, technology and investment choices.

Keywords: Adaptation, climate change, fish, fisheries, mitigation

INTRODUCTION

World is undergoing an extinction crisis and rapid loss of biodiversity due to accelerated climate change (FAO, 2012). Climate change has been recognized as the foremost environmental problem of the twenty-first century and lead to adverse and irreversible impacts on the earth and the ecosystems (Mohanty et al., 2010b). Climate change is widely accepted that unavoidable consequence of 200 years of greenhouse gas emissions from fossil fuel, transport, industry, deforestation and intensive agriculture (IPCC, 2007).

Fish provide essential nutrition and income to an ever-growing number of people around the world, especially where other food and employment resources are limited. Many fishers and aqua culturists are poor and ill-prepared to adapt to change, making them vulnerable to impacts on fish resources (World fish center, 2007). There is increasing concern over the consequences of climate change for fisheries production and the state of marine ecosystems. Climate change is an additional pressure on top of the many (fishing mortality, loss of habitat, pollution, disturbance, introduced species) which fish stocks already experience. This means that the impact of climate change must be evaluated in the context of other anthropogenic pressures, which often have greater and more immediate effects (Brander, 2010). The precise and localized impacts of climate change on fisheries are, however, still poorly understood. This is because "the inherent unpredictability of climate change and the links that entwine fishery and aquaculture livelihoods with other livelihood strategies and economic sectors make unraveling the exact mechanisms of climate impacts hugely complex"(Williams, 2010). Therefore the object-tive of this paper was to review the impacts of

climate change on fish and fisheries.

Causes of climate change

Climate change occurs when the climate of a specific area or planet is altered between two different periods of time. This usually occurs when something changes the total amount of the sun's energy absorbed by the earth's atmosphere and surface. It also happens when something changes the amount of heat energy from the earth's surface and atmosphere that escapes to space over an extended period of time (www.thegreatwarming.com). There are both natural processes and anthropogenic activities affecting the earth's temperature and resultants climate change. The steep increases in the global anthropogenic greenhouse gas (GHG) emissions over the decades are major contributors to the global warming (Mohanty et al., 2010b).

Natural processes and its effect on the earth's temperature

Sun is the primary source of energy on earth. Though the sun's output is nearly constant, small changes over an extended period of time can lead to climate change. The earth's climate changes are in response to many natural processes like orbital forcing (variations in its orbit around the Sun), volcanic eruptions, and atmospheric greenhouse gas concentrations. Changes in atmospheric concentrations of greenhouse gases and aerosols, land-cover and solar radiation alter the energy balance of the climate system and causes warming or cooling of the earth's atmosphere. Volcanic eruptions emit many gases and one of the most important of these is sulfur dioxide (SO2) which forms sulfate aerosol (SO4) in the atmosphere (Mohanty et al., 2010b). Sulfate aerosols, which enter the atmosphere naturally during volcanic eruptions, are tiny airborne particles that reflect sunlight back to space. Industrial activity has recently increased their concentration in the atmosphere primarily through the burning of fossil fuels containing sulfur (IPCC, 2007).

The impact of climate change on fish and fisheries

There is broad concern around the world about fisheries and aquaculture due to the effects of future climate changes. This concern arises significant variation in fisheries production of catches of Peruvian anchovies varied from < 100,000 tones to > 13 million tons between 1970 and 2004 as a result of changes in ENSO (Brander, 2007). According to Brander (2010) who reported that climate change is affecting on the distribution, species composition, seasonality and production in marine and freshwater systems. Fish has been an important part of the human diet in almost all countries of the world. It is highly nutritious and provides vital nutrients absent in typical starchy staples which dominate poor people's diets (FAO, 2005). Fish provides about 20 % of animal protein intake and is one of the cheapest sources of animal proteins as far as availability and affordability is concerned (Thorpe et al., 2006). While it serves as a health food for the affluent world due to the fish oils rich in polyunsaturated fatty acids (PUFAs), for the people in the other extreme of the nutrition scale, fish is a health food due to its proteins, oils, vitamins and minerals and associated with the consumption of small indigenous fishes (Mohanty et al., 2010a).

An increase in air temperature due to global warming will translate directly into warmer water temperatures for most streams and rivers, thereby altering fundamental ecological processes and species distributions. The life processes of many aquatic organisms are temperature-dependent. Warmer water can increase growth rates and stimulate ecosystem production. However, higher water temperatures will also increase the rate of microbial activity and thus the rate of decomposition of organic material, which may result in less food availability. In either case, warmer water holds less dissolved oxygen, so water quality will be reduced for organisms such as invertebrates and fish that have a high oxygen demand (Poff, 2002). Reduced availability of food is even forcing aquatic species to develop longer growing periods. Reduced thermal movement of the water also affects water quality by allowing Pollutants to accumulate in upper layers of the water and has led to increased levels of mercury and other contaminants in fish. In some areas local extinctions of freshwater and diadromous species are occurring (Brander, 2010).

Physiological effects of climate change on fish

All fresh water fishes are ectoderms that cannot regulate their body temperature through physiological means. These fishes do thermo regulate behaviorally, moving between thermally heterogeneous microhabitats to select the most advantageous temperature for their current physiological state (Ficke, 2005). Most marine and aquatic animals are cold-blooded (poikilotherms) and therefore their metabolic rates are strongly affected by external environmental conditions, in particular temperature (FAO, 2009). Some pollutants are toxic, having a direct effect on the metabolism of aquatic organism. Very few pollutants are, however, toxic to all species. More common are indirect effects – addition of pollutants altering the physical or chemical environment to the detriment of organisms (Frid and Dobson, 2002). Metabolic processes are simply chemical reactions with in an organism's body, whose rate increases with temperature. Therefore, as toxins operate chemically by

Table1: General effects of increased temperature on parasite life cycles, their hosts and transmission processes

Effects on parasites	Effects on hosts	Effects on transmission
Faster embryonic development and hatching	Altered feeding	Earlier reproduction in spring
Faster rates of development and maturation	Altered behavior	More generations per year
Decreased longevity of larvae and adults	Altered range	Prolonged transmission in the fall
Increased mortality of all stages	Altered ecology Reduced host resistance	Prolonged transmission year round

interfering with metabolic process, higher temperature increases toxicity (Frid and Dobson, 2002).

Many macro physiological studies have found that organisms transferred into conditions different from those to which they have been adapted, function poorly compared with related organisms previously adapted to these new conditions (Osovitz and Hofmann, 2007). When fish are exposed to conditions warmer than those to which they have been adapted their physiologies are incapable of supplying the increased tissue demand for oxygen over extended periods. This restricts the exposure of whole-animal tolerances to temperature extremes (Pörtner and Knust, 2007). The fish immune system responds optimally at normal summer temperatures for each species. Gradual increase in water temperature increase the speed at which the fish immune system responds up to a species dependent temperature threshold. Sudden temperature increase (heat waves) adversely affects the ability of the fish immune system to respond (Peeler et al., 2010).

Changes in fish distribution

Individual fish actively select and rapidly change living areas based on suitable temperatures, oxygen concentrations, and food availability. Cold-water fish will actively avoid temperatures that exceed their preferred temperature by 2 to 5°C (3.6 to 9°F) and seek out refuge areas of cooler water such as groundwater or seepage areas and headwater streams (shuter, 2003). Boundaries of the zoogeographic range of species are determined in part by the interaction of thermal tolerance and behavior of the fish with local climate. The potential effects of climate warming on such boundaries include expansion, contraction, or shift of species ranges. For freshwater fish, physic al constraints such as drainage patterns, waterfalls, and land-locked areas play a large role in determining the location of zoogeographic boundaries, and in the rate at which a species may respond to the release of a climate-determined boundary (shuter, 2003). In general, warm-water species are being displaced towards the poles and are experiencing changes in the size and productivity of their habitats (FAO, 2009)

Impact of climate change on aquatic animals for parasites and infectious diseases

Shifting environmental conditions will likely introduce new animal-transmitted diseases and redistribute some existing diseases, affecting key economic resources and some human populations (Mohanty et al., 2010b). The general effects of increased temperature on parasites include, rapid growth and maturation, earlier onset of spring maturation, increased parasite mortality, increased number of generations per year, increased rates of parasitism and disease, earlier and prolonged transmission, the possibility of continuous, year-round transmission (Marcogliese, 2008) Table 1. Many diseases display greater virulence at higher temperatures that might be the result of reduced resistance of the host due to stress or increased expression of virulence factors/ increased transmission of the vectors. Such disease and parasites includes: Red sore disease/ bacterium Aeromonashydrophila, Black spot disease/ trematode larvae (metacercariae), and Ciguatera fish poisoning (CFP) caused by bioaccumulation of algal toxins (Mohanty et al., 2010b).

Potential impacts of climate change on fisheries

Climate change, in particular, rising temperatures, can have both direct and indirect effects on global fish production. With increased global temperature, the spatial distribution of fish stocks might change due to the migration of fishes from one region to another in search of suitable conditions (Mohanty et al., 2010b). Climate change may directly affect fishery production along many pathways. Fish reproduction, growth and migration patterns are all affected by temperature, rainfall and hydrology. Climate change is likely to adversely affect both the fresh water and marine fisheries (Chowdhury, 2010). Fishes in warmer waters are expected to have a smaller maximum body size and smaller size at first maturity. Fishes with smaller bodies that live in warmer environments are likely to suffer higher natural mortality rates. These are important factors that determine population dynamics and productivity (Sumaila et al., 2011). Due to dependence on fish protein in diets,

Table 2: Changes in climate will have impacts on fish ecology and consequences for fisheries

Impact on Fish Ecology	Consequence for Fisheries
• Change in overall fish production in a particular aquatic ecosystem	• Change in sustainable harvests for all fish population in the ecosystem
• Chang in relative productivity of individual fish population in a particular aquatic ecosystem	• Change in the relative levels of exploitation that can be sustainably directed against the fish populations of the ecosystem
• Large scale shifts in geographic distribution of species	• Change in mixture of species that can be sustainably harvested within a specific geographic area • Change in location of profitable fishing grounds
• Small scale shifts in the special distribution of members of a specific population	• Change in sustainable harvest for the population; • Change in efficiency of fishing gear, leading to change in sustainable levels of fishing effort

limited alternative sources of food and employment, and small weak economies many African countries are highly vulnerable to the effects of climate change on fisheries and aquaculture, socially and economically as well as ecologically (World Fish Center, 2009b). Inland fisheries will be strongly affected by changes in rainfall and increased temperatures; some such changes are already evident. Coral damage, particularly in east Africa, will affect reef fisheries and could result in increased Ciguatera poisoning (IPCC, 2007).Climate-driven changes in fish populations and communities will produce a variety of impacts on existing fisheries (Shuter, 2003).

Socio-economic impact

In 2006, fisheries and aquaculture produced a total of 143.6 million tons of fish, 81.9 million tons from marine capture fisheries, 10.1 million tons from inland capture fisheries, 31.6 million tons from inland aquaculture and 20.1 million tons from marine aquaculture. China is by far the largest producer of fish, producing 51.5 million tons of fish in 2006, 17.1 million tons from capture fisheries and 34.4 million tons from aquaculture. The livelihoods of 520 million people depend on fisheries and aquaculture, 98% of them live in developing countries (Williams, 2010). The economic consequences of climate change on fisheries might manifest themselves through changes in the price and value of catches, fishing costs, fishers' incomes, earnings to fishing companies, discount rates and economic rent (that is, the surplus after all costs, including 'normal' profits, have been covered), as well as throughout the global economy (Sumailaet al., 2011). Changes in distribution, species composition and habitats will require changes in fishing practices and aquaculture operations, as well as in the location of landing, farming and processing facilities (FAO, 2009). The implications of climate change affect the four dimensions of food security such as the availability, the stability, the access and utilization of aquatic products (FAO, 2009).

Adaptation and mitigation options

Adaptation to climate change is defined in the climate change literature as an adjustment in ecological, social or economic systems, in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change, or take advantage of new opportunities. There is a wide range of potential adaptation options for fisheries (Mohanty et al., 2010b). In a changing world, both industry and communities will need to adapt past practices to maintain the benefits from fisheries, and to take advantage of new opportunities emerging from altered resources. One of the keys to successful adaptation will be diversification – the more options that industry and communities have to produce, process and distribute fish, the greater the chance that some of them may be favored, or not affected, by climate change (Bell et al., 2009). The capacity to adapt to climate change is determined partly by material resources and also by networks, technologies and appropriate governance structures. Improved governance, innovative technologies and more responsible practices can generate increased and sustainable benefits from fisheries (Mohanty et al., 2010b). At a more practical level, technology needs to be developed, adapted or implemented to reduce wastage and increase the value added to catches to balance the impact of decreasing catches on food security and livelihoods. Improved refrigeration and postharvest handling and processing can reduce losses due to deterioration of fish quality (Williams, 2010).

In general options to increase adaptability includes through improved fisheries and aquaculture management, diversification of livelihoods, capacity building on improved forecasting, disaster risk management, awareness raising on climate change impacts, promotion of general education and policy, legal and implementation framework (FAO, 2009). Mitigation is human intervention to reduce the

anthropogenic forcing of the climate system, including strategies to reduce greenhouse gas sources and emissions and enhance greenhouse gas sinks (IPCC, 2007). In many instances, climate change mitigation could be complementary to and reinforce existing efforts to improve fisheries and aquaculture sustainability (e.g. reducing fishing effort and fleet capacity in order to reduce energy consumption and carbon emissions and reducing fishmeal reliance in aquaculture) (FAO, 2009).

CONCLUSION AND RECOMMENDATIONS

Climate change causes a significant impact on fish and fisheries. The grown concern of climate change affect the fish and fisheries by causing precipitation, evaporation, runoff, change in the availability of water, change in temperature and increase the frequency of extreme events such as flooding and storm surge. All of these impacts are affecting the physiology, life cycle, distribution and the wellbeing of the fishes. Fisheries are also vulnerable to these impacts; change in fishing practice, sustainable harvest and relative level of exploitation, efficiency of fishing gear, fishing practice and affect the production of fish. Therefore, based on these facts, the following recommendations are forwarded:-

• Implementing adaptation and mitigation pathways for communities dependent on fisheries.
• Aquaculture and aquatic ecosystems is need special attention from planners and policy-makers.
• Monitoring research should be conducted to maintain the endangered resources.
• Revised policy, better technology and investment choices should be considered to reduce the emissions polluted gas in to atmospheric environment

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