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<b>SHORT COMMUNICATION ON CLIMATE CHANGE AND ITS IMPACT ON FISHERIES AND MARINE ECOSYSTEMS IN THE GFCM AREA (CAMILLERI M. AND DE YOUNG C.)</b>

\* Available only in English

## **Background**

1. Climate change and its impact on fisheries and marine ecosystems in the GFCM Area is an issue which merits due attention and has been brought up in recent meetings of both the Scientific Advisory Committee (SAC) and the Commission. The Transversal Session of the Sub-Committees held in Malaga on 30<sup>th</sup> December 2009 agreed on the need to step-up activities on this topic on a Region-wide scale.
2. The SAC is in the best position to promote the integration of climate change considerations into scientific monitoring and assessments of fisheries resources in the Region. In addition, it is evident from the information available that there are important socio-economic implications of climate change on fishing communities in the Mediterranean and Black Sea which the SAC may wish to address through its subsidiary bodies and the support of regional projects. The development of a regional policy to face the challenges of impacts of climate change on fisheries and to implement adaptation strategies over the coming decades should also be given due consideration.
3. The purpose of this information document is to present a summary of the current knowledge on the impacts of climate change on fisheries and marine ecosystems in general, as well as on the impacts identified so far in the Mediterranean basin through sub-regional initiatives. It is also intended to serve as a working document for SAC in developing a programme of work to address the subject.

## SHORT COMMUNICATION ON CLIMATE CHANGE AND ITS IMPACT ON FISHERIES AND MARINE ECOSYSTEMS IN THE GFCM AREA

Camilleri M. and De Young C.

### 1. INTRODUCTION

The concerns about direct and indirect impacts of climate change on the physical marine environment, marine ecosystems, living marine resources and the livelihoods of people who exploit them are shared globally. With a forecasted significant increase in sea surface temperature, changes in salinity and sea level rise over the next century, the Mediterranean and Black Sea fisheries and aquaculture industries are also particularly vulnerable to climate change. Dealing with impacts of climate change adds complexity to the challenges being faced to manage fisheries in a sustainable manner in the Mediterranean and Black Sea. Apart from the direct effects on the distribution and population dynamics of commercial fish species, climate change is also expected to contribute to changes in the Large Marine Ecosystems' biota creating competition between indigenous and exotic or newly established species, subsequently affecting fisheries in the region.

### 2. CURRENT KNOWLEDGE ON IMPACTS OF CLIMATE CHANGE ON FISHERIES

During the last few years, the GFCM Secretariat has closely followed the work carried out by FAO Fisheries and Aquaculture Department (FI), particularly through its internal working group on Climate Change. Noteworthy progress on the subject was registered by the Expert Workshop on Climate Change Implications for Fisheries and Aquaculture (FAO Fisheries Report 870) held in April 2008, specifically convened by FI to respond to the request made by the FAO Committee on Fisheries (COFI) to address the subject and to provide inputs to the FAO High-Level Conference on World Food Security. The Workshop collated the best available knowledge and reviewed key issues, from the physical changes, the impacts on aquatic resources and ecosystems and how these ecological impacts translate into human dimensions of coping and adapting within fisheries and aquaculture. It also evaluated policy options, mitigation, impact reduction means and the building of adaptive capacity to climate change. Three technical papers formed the basis of the technical discussions and have been recently published (FAO Fisheries and Aquaculture Technical Paper 530).<sup>1</sup>

#### *Physical and biological impacts*

In terms of physical and biological impacts, climate change is modifying the distribution of marine and freshwater species. In general, warm-water species are being displaced towards the poles and are experiencing changes in the size and productivity of their habitats. In a warmed world, ecosystem productivity is likely to be reduced in the lower latitudes (i.e. most tropical and subtropical oceans, seas and lakes) and increased in the higher latitudes. Increased temperatures will also affect fish physiological processes resulting in both positive and negative effects on fisheries and aquaculture systems.

Climate change is already affecting the seasonality of particular biological processes, altering marine and freshwater food webs, with unpredictable consequences for fish production. Increased risks of species invasions and spreading of vector-borne diseases provide additional concerns.

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<sup>1</sup> In addition, the FAO, along with the other members of the Global Partnership on Climate, Fisheries and Aquaculture (PaCFA), has published a policy brief entitled "Fisheries and aquaculture in our changing climate" available on the Partnership's website ([WWW.CLIMATEFISH.ORG](http://www.climatefish.org)). Another recent document identifying the role of the oceans as natural carbon sinks is the UNEP/IOC/FAO/IUCN/CSIC *Blue Carbon. A Rapid Response Assessment* ([HTTP://WWW.GRIDA.NO/PUBLICATIONS/RR/BLUE-CARBON/](http://www.grida.no/publications/rr/blue-carbon/)).

Differential warming between land and oceans and between polar and tropical regions will affect the intensity, frequency and seasonality of climate patterns (e.g. El Niño) and extreme weather events (e.g. floods, droughts, storms); affecting the stability of marine and freshwater resources adapted to or affected by these.

Sea level rise, glacier melting, ocean acidification and changes in precipitation, groundwater and river flows will significantly affect coral reefs, wetlands, rivers, lakes and estuaries; requiring adaptive measures to exploit opportunities and minimise impacts on fisheries and aquaculture systems.

### *Impacts on livelihoods*

Fisheries-dependent economies, coastal communities and fisherfolk are expected to experience the effects of climate change in a variety of ways. These include: displacement and migration of human populations; effects on coastal communities and infrastructure due to sea level rise; and changes in the frequency, distribution or intensity of tropical storms.

The vulnerability of fisheries and fishing communities depends on their exposure and sensitivity to change, but also on the ability of individuals or systems to anticipate and adapt. This adaptive capacity relies on various assets and can be constrained by culture or marginalization. Vulnerability varies between countries and communities, and between demographic groups within society. Generally, poorer and less empowered countries and individuals are more vulnerable to the effects of climate, and the vulnerability of fisheries is likely to be higher where they already suffer from overexploitation or overcapacity.

Fisheries are dynamic social-ecological systems and are already experiencing rapid change in markets, exploitation and governance, ensuring a constantly developing context for future climate-related impacts. These existing socioeconomic trends and the direct and indirect effects of climate change may interact with, amplify or even overwhelm biophysical effects on fish ecology. The variety of different impact mechanisms, complex interactions between social, ecological and economic systems, and the possibility of sudden and surprising changes make future effects of climate change on fisheries difficult to predict.

### *Adaptation to change*

Adaptation to climate change includes reactive or anticipatory actions by individuals or public institutions. These range from abandoning fisheries altogether for alternative occupations, to developing insurance and warning systems and changing fishing operations. Governance of fisheries affects the range of adaptation options available and will need the flexibility to account for changes in stock distribution and abundance. Governance aimed towards equitable and sustainable fisheries, accepting inherent uncertainty, and based on an ecosystem approach, as currently advocated, is thought to generally improve the adaptive capacity of fisheries.

### *Mitigation potentials*

The primary mitigation route for the sector lies in its energy consumption, through fuel and raw material use and through - as with the other food sectors - management of distribution, packaging and other supply chain components. In the fisheries sector, there are many examples of multiple-win measures that can reduce or sequester emissions, enhance adaptation and contribute to food security, rural livelihoods, poverty reduction and environmental services.

For example, fuel efficiency for the sector as a whole can be improved by good fisheries management – current over-capacity and excess effort lead to lower catches per unit effort and, therefore, lower fuel efficiency; this is compounded by the fact that competition for increasingly limited resources can create incentives to increase engine power. There may also be important interactions for the sector with respect to aquatic environmental services (e.g. maintaining the quality and function of coral reefs, mangroves, inland watersheds) and potential carbon sequestration and other nutrient management options needing further research and development.

### **3. IDENTIFYING AND ADDRESSING THE IMPACTS OF CLIMATE CHANGE IN THE GFCM AREA**

Although there is increasing interest within the scientific community to conduct research and to develop forecasting models on the impact of climate change on Mediterranean and Black Sea marine ecosystems, the direct effects on fisheries and options for adaptation have hardly been addressed at the regional level.<sup>2</sup> Considering the knowledge available at global level and the results of studies carried out in other regions of the world, there is an evident requirement to integrate climate change considerations into scientific monitoring and assessments of fisheries resources in the Region. There is equally a growing need to understand and address the socio-economic implications of climate change on fishing communities, especially those linked with the predominant artisanal fisheries, and to develop a holistic adaptation policy to help confront the threats and to take advantage of any opportunities which lie ahead.

#### *Southern and eastern Mediterranean Fisheries*

As part of the recent workshop, “Adapting to climate change: the Ecosystem Approach to Fisheries and Aquaculture in the Near East and North Africa Region”<sup>3</sup>, a first review of the climate change implications for the southern and eastern Mediterranean fisheries and aquaculture<sup>4</sup> is now available. The following text is extracted from this review.

#### *Expected rise in temperature*

The Mediterranean, especially its Southern and Eastern rims, is likely to be more affected by climate change than most other regions of the globe in the 21st century. The temperature increases in the Mediterranean are likely to be above 2°C and, because of the ecological and socioeconomic characteristics of the areas, the impact will be more marked than in many other regions of the world. The Mediterranean has thus been qualified as the “hot spot for climate change” (Giorgi, 2002). According to the IPCC (2007), the most vulnerable areas of the Mediterranean are the North African ones bordering on the desert areas, the major deltas (Nile for example), the coastal zones as well as socially vulnerable areas and those with rapid demographic growth. The impacts of the rise in temperature, drop in rainfall, increase in number and intensity of extreme events, as well as of a possible rise in sea level, could thus overlap and exacerbate the pressures due to anthropogenic activities that are already exerted on the natural environment.

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<sup>2</sup> However, relevant information may be gleaned through research on Mediterranean climate and hydrology and its impacts on the aquatic ecosystems, such as Gambaiani et al. (2009) and Greenpeace (2009). Oguz and Gilbert (2007) analyzed the impacts of climate variability and fishing on pelagic fisheries in the Black Sea.

<sup>3</sup> Organized by the FAO and The WorldFish Center in Abbassa, Egypt from 10-12 November 2009.

<sup>4</sup> This review by Malika Bel Hassen-Abid will be available through the publication of the proceedings from the November, 2009 workshop.

*Impacts on water resources in the southern and eastern Mediterranean*

One measure of national water resource stress is the ratio of water used to water available, and countries using more than 20% of their total annual water supply are generally held to be exposed to water stress. Using this measure, all countries around the Mediterranean are expected see an increase in water stress. The sole exception can be Egypt where river runoff from the Nile may actually increase due to floods in the Central African Nile springs. Some countries have conducted studies to understand the impact of such changes on their countries. The Algerian Government estimates that a 1°C rise in mean annual temperature would lead to decreases in precipitation by 15% and in influx of surface waters by 30%. Subsequently, water demand would exceed available water resources by 800 million m<sup>3</sup> (Government of Algeria, 2001). The Lebanon Government estimates that by 2050, climate change would be responsible for nearly doubling the water shortage to 350 million m<sup>3</sup> of water (Khawli, 1999).

*Impacts on sea level rise in the southern and eastern Mediterranean*

Model projections of regional sea level patterns show very little agreement. For the Mediterranean, the values range from 1 to 2cm of regional sea level rise per 1 cm of global sea level rise (IPCC, 2001). This is due to the low tidal range in the Mediterranean combined with the limited potential for wetland migration. The Southern Mediterranean seems to be the most vulnerable region where flooding impacts can occur particularly in deltaic countries (such as Egypt). Fisheries communities located in delta will be particularly vulnerable to sea level rise and the associated risks of flooding, saline intrusion and coastal erosion.

*Impacts on biodiversity in the southern and eastern Mediterranean*

Climate change over the past 30 years has produced numerous shifts in the distributions and abundances of species. Increased temperatures will also affect fish physiological processes and the seasonality of particular biological processes altering marine and freshwater food webs, with unpredictable consequences for fish production. This will result in both positive and negative effects on fisheries and aquaculture systems in terms of production and marketing costs, and changes in the prices for fishery and aquaculture products. The impacts of climate change on the Mediterranean environment will relate particularly to marine biological diversity (animal and plant), via a displacement northwards and in altitude of certain species, extinction of less mobile or more climate sensitive species, and emergence of new species; fishing yields are expected to drop as a result of the accumulated conditions related to temperature, rainfall, and the behaviour of animal and plant species.

The future impacts of climate change on fisheries and aquaculture are still poorly understood. The key to minimizing negative impacts and maximizing opportunities will be understanding and promoting the wide range of creative adaptive and their interactions with existing policy, legal and management frameworks.

The report concludes that the sub-region appears as the most threatened region in the world by climatic change. To minimise the negative impacts of such change on fisheries and aquaculture systems, adaptive measures are required although the countries have limited level of services, technological and economical resources, which are likely to result in very restricted adaptation capabilities to environmental and climate changes. The adaptive capacities of fisheries and aquaculture production systems could be increased by applying existing good governance and management principles and approaches. Such approaches include the ecosystem approaches to fisheries and aquaculture, which includes practices of adaptive and precautionary management based on appropriate social, economic, political and institutional incentives.

### *Northwestern Mediterranean Fisheries*

A 2005 WWF study<sup>5</sup> briefly reviewed the expected impacts of climate change on the northwestern Mediterranean fisheries and the following text is extracted from this review.

#### *Expected rise in temperatures*

Global warming may force some cold water species such as hake and poor cod to disperse and shift their distribution ranges, or may alter their ability to survive, and thereby disrupting existing ecosystems. In contrast, termophilic species such as dusky grouper (*Epinephelus marginatus*), round sardinella (*Sardinella aurita*) and the ornate wrasse (*Thalassoma pavo*), benefit from warmer water temperatures and are expanding their distribution to areas where they could not live otherwise. The observed warming of western Mediterranean waters may have already contributed to the changes in the recruitment pattern of the dusky grouper, which now recruits regularly on the northwesternmost coasts (while it seems it never did before due to relative historic cold conditions in the area).

The increase in water temperatures may reduce water mixing and upwelling of nutrients because water stratification would be enhanced, thus affecting negatively phytoplankton and zooplankton productivity. This would finally impact adversely on fish populations whose adults (e.g. sardines and anchovies) or larvae (most of fishes and invertebrates) feed on plankton.

The temperature change will probably mean an increase in the frequency of extreme events such as droughts, floods and storms that would have a negative impact on coastal habitats such as estuaries and seagrass meadows, thus affecting fish productivity in these areas. These impacts could be attenuated, however, by the fact that Mediterranean biota is somewhat adapted to common high seasonal and interannual variability in hydrographic variables (e.g. torrential rainfall).

#### *Impacts on sea level rise in the northwestern Mediterranean*

The rise in global-mean sea-level due to warming will erode essential fish habitats such as deltaic areas and coastal lagoons (e.g. the Rhône and Ebre deltas and the coastal lagoons and saltmarshes of the southeast of France) that are important for breeding, feeding or resting of many fish species (e.g. anchovy, eel and many sparids). Erosion of these key habitats for fish production will be exacerbated by the decrease of riverine sediments flowing into the NW Mediterranean due to local reversion of agricultural land to forest, as well as planned river diversion and dam construction (e.g. Ebre River). In addition, most lowland coastal areas are subject to a degree of slow tectonic subsidence that will also accentuate the predicted sea-level rise. Salt-water intrusion due to sea-level rise and decreasing riverine sediments will cause increased salinity in these areas, thus limiting the life of many species in these environments.

#### *Other biophysical impacts in the northwestern Mediterranean*

Changes in all climate and oceanographic parameters such as evaporation, precipitation, salinity, river runoffs, current and wind patterns and strengths, etc., will necessarily accompany changes in global-mean temperature. At present, however, our capability for predicting these changes is limited and we must resort to the use of scenarios that must be interpreted cautiously. One of the parameters that could show large fluctuations that will affect fish populations is river runoff, which depends, to some extent, on precipitations. Some projections show that there will not be major precipitation changes whilst other projections predict a general decrease of precipitation and river runoff.

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<sup>5</sup> Impact of Climate Change on NW Mediterranean Fisheries. I. Palomera and J. Lloret. In: Global warming and the world's fisheries - case studies. 2005. WWF Publications. Available at [assets.panda.org/downloads/medwwfcanviclimaticeng.doc](http://assets.panda.org/downloads/medwwfcanviclimaticeng.doc)

Although local rainfall has not shown any important trend, large variability in runoff of some rivers has been observed in the last decades owing to water use for human activities (e.g. decreasing trend of Ebre River runoff). Any further decrease of freshwater from the rivers due to climatic changes will reduce the amount of nutrients available to phytoplankton, which will finally adversely affect zooplankton productivity and hence fish populations, as mentioned before. In many coastal Mediterranean areas, river discharges are the only source of nutrients in surface waters during spring and early summer, i.e. the periods in which many marine species spawn.

Assuming that the entire Mediterranean region will experience a decrease in precipitation and an increase in evaporation, then salinity would continue to rise, which could upset the ecology of the coastal areas. A rise in both the salinity and temperature of the sea will result in a decrease of oxygen solubility and increases organic matter decomposition. This may enhance the oxygen depletion in some coastal, shallow areas (e.g. bays), which may negatively affect benthic species. Global warming may also induce changes in currents that may cause subsequent changes in the migratory habits of some exploited fish species such as tuna.

Everything points to the hypothesis that the climate change would first affect coastal fisheries, especially in deltaic areas (e.g. Ebre's delta) and coastal lagoons (e.g. southeast of France). These areas are very sensible to the expected changes in temperature and salinity, the decrease of river runoff, erosion, rise of the sea level, etc. and thus the effects on natural resources inhabiting there would occur very fast.

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