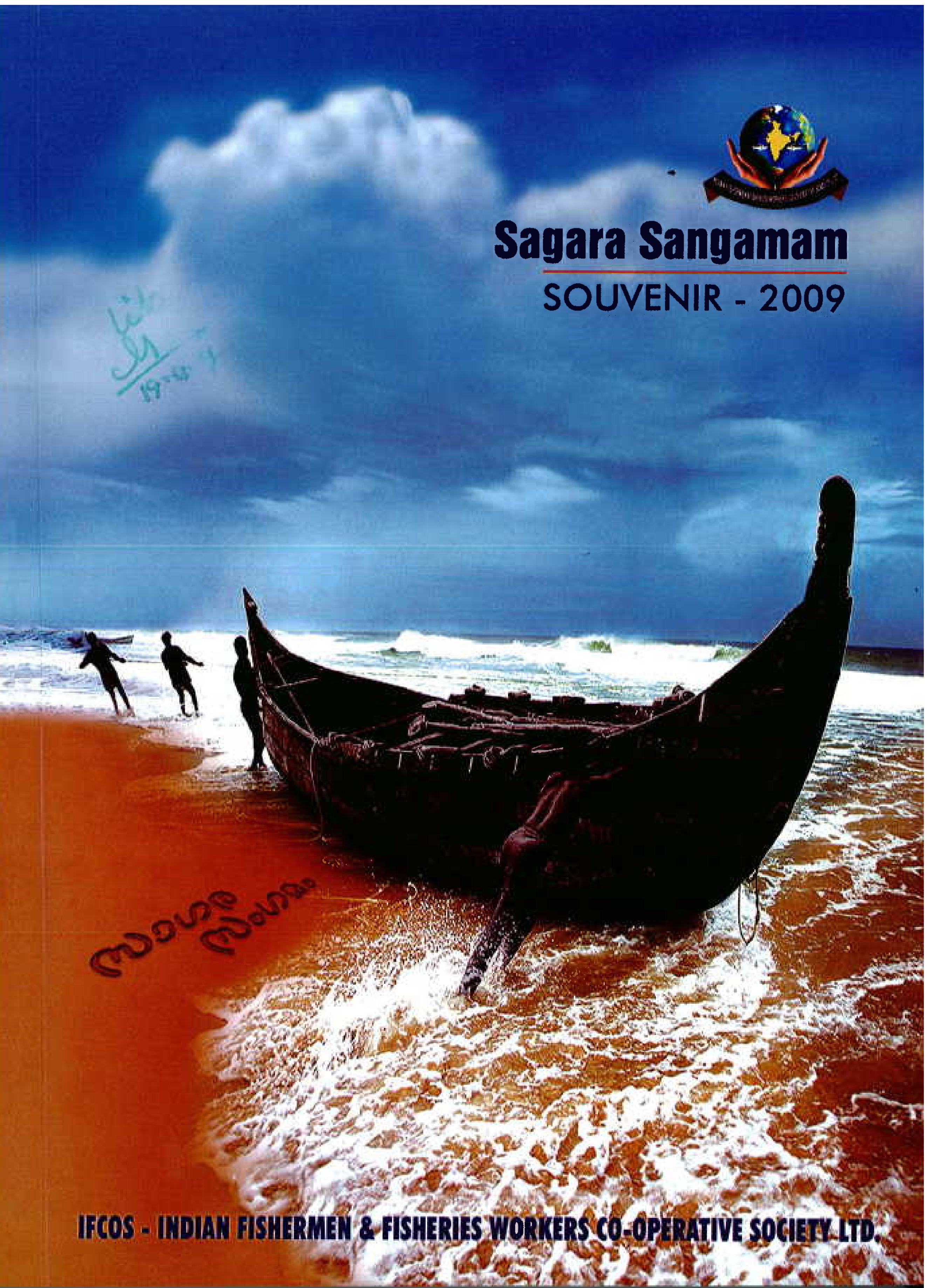

Sagara Sangamam

SOUVENIR - 2009

IFCOS - INDIAN FISHERMEN & FISHERIES WORKERS CO-OPERATIVE SOCIETY LTD.

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CLIMATE CHANGE, MARINE ECOSYSTEMS & FISHERIES

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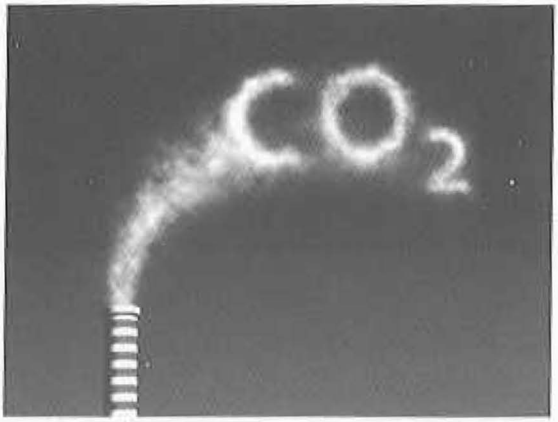
Climate is the weather of a place averaged over a length of time. Weather and climate have profound influence on life on earth. They are part of the daily experience of human beings and are essential for health, food production and well-being. Statistically significant variations of the mean state of the climate, typically persisting for decades or longer, are referred to as "climate change". Climate varies in time; from season-to-season, year-to-year, and decade-to-decade and also it varies from place-to-place, depending on latitude, distance to the sea, vegetation, presence or absence of mountains etc. For example, a thousand years ago, northern latitudes were warmer than they are today. Within the past 1,200 years, the period between A.D. 950 and 1250 was mild. The years from A.D. 1400 to 1850 were cool. Since then, global average temperatures generally have risen.

Causes of climate change

Many natural processes influence a region's climate. Natural events such as change in ocean circulation, volcanic eruptions, activity on the sun's surface etc alter the earth's climate. The changes we have seen over recent years and those, which are predicted over the next 80 years, are thought to be mainly as a result of human activities/induced. Human activities like burning of fossil fuels and clearing of forests increase the amount of carbon dioxide in the atmosphere. Changes in carbon dioxide concentration in the atmosphere may cause short-term and long-term

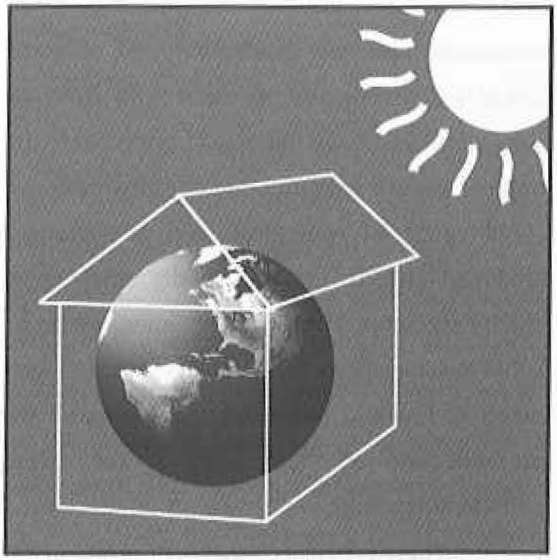


variations in the climate. One prediction is that by the year 2050, the amount of carbon dioxide in the atmosphere will have doubled from the preindustrial level. If this increase happens then the earth's surface temperature might rise between 1.5 and 4.5° C by 2100. Atmospheric concentration of methane is increased due to activities like livestock and paddy farming, land use and wetland changes, fully-vented septic systems etc that enhance the fermentation process. Since the mid-1800's, methane concentration has risen by about 150 per cent. Refrigeration systems, fire suppression system and manufacturing process emit fluorocarbons and higher nitrous oxide concentrations in atmosphere are because of overuse of fertilizers. Water vapour, carbon dioxide, methane, fluorocarbon and nitrous oxide are greenhouse gases (GHGs); they trap heat and increase the atmospheric temperature (greenhouse effect/global warming). The GHG are very important when we talk about climate change as they keep the earth warm. Global warming could change rainfall patterns, melt enough polar ice to raise the sea level, increase the severity of tropical storms, flooding, and lead to shifts in plant and animal populations.

Impact on marine ecosystems

Since life began on earth, changes in the global climate have affected the distribution of organisms as well as their interactions. However, human-induced increases in atmospheric concentrations of greenhouse gases are expected to cause much more rapid changes in the earth's climate. The immense area and the modest extent of our knowledge of the open ocean hamper predictions of how ocean systems will respond to climate change. The predicted changes may have a significant effect on coastal ecosystems, especially estuaries and coral reefs, which are relatively shallow and currently under stress because of human population growth and coastal developments.

Significant environmental factors that affect the structure and function of estuarine and marine systems, and are expected to be part of global climate change include temperature, sea-level rise,



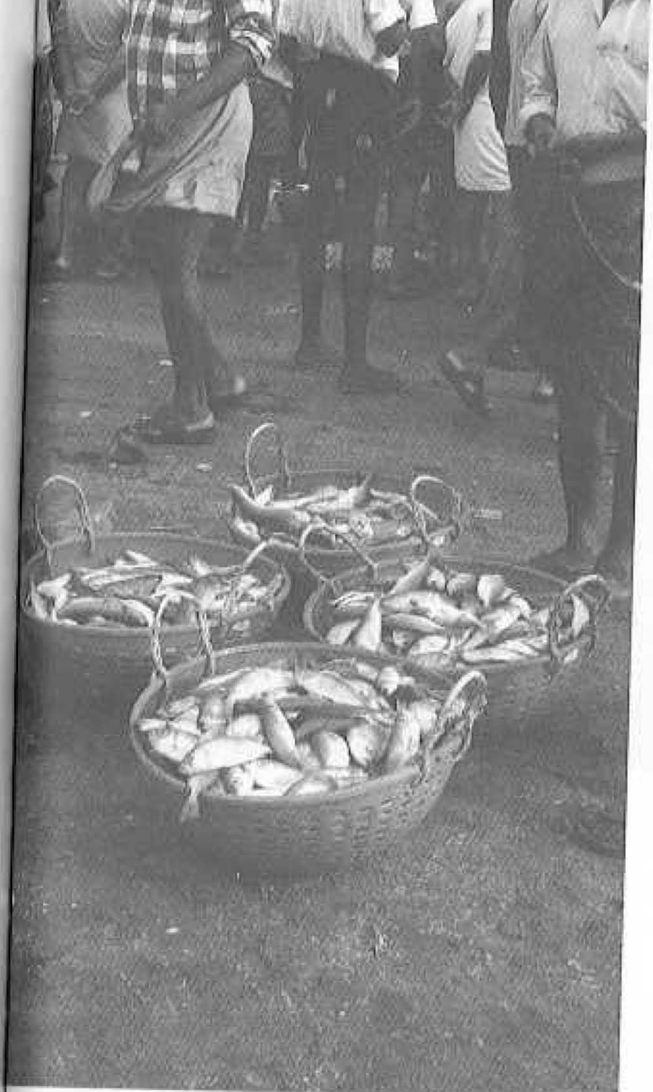
the availability of water and associated nutrients from precipitation and runoff from land, wind patterns, and storms. Temperature, in particular, affects dissolved oxygen concentrations in water, and plays a direct role in sea-level rise and in major patterns of coastal and oceanic circulation. Temperature can influence changes in species interactions (e.g., predator-prey, parasite-host, competition for resources). Changes in distribution patterns would change the mix of predators, prey, parasites, and competitors in an ecosystem that could alter the functions of the ecosystem and the productivity of selected fisheries. Predation pressure in marine ecosystems generally increases from poles to the tropics. Hence warming due to climate change could cause an ecological shift to increased predation if it led to greater diversity and numbers among predators. Higher temperatures would be lethal to some species at the southern end of their range and would allow others to expand the northern end of their range if they were sufficiently mobile.

There is evidence that marine organisms and ecosystems are resilient to environmental change. The biological components of marine systems are tightly coupled to physical factors, allowing them to respond quickly to rapid environmental change and thus rendering them ecologically adaptable. Some species also have wide genetic variability throughout their range, which may allow for adaptation to climate change.

Some believe that marine systems experience fewer extinctions of species compared to terrestrial systems because large numbers of marine species have wide geographic temperature ranges as well as greater capacity to migrate to new habitats through their larvae that drift in the water column. Others counter that not all marine species have drifting larvae, and that many larvae are short-lived or remain relatively close to the parental population before becoming juveniles.

Impact on fisheries

Fish populations are embedded in ecosystems where they perform their roles as consumers and prey of other organisms, including



larger fishes. Climate change will have economic consequences, both benign and disadvantageous. One reason could be that the effects of global warming on fish stocks and their migrations are extremely difficult to predict. There are two main uncertainties in the causal chain from global warming to the fisheries. First, the impact on ocean temperature and currents is uncertain, not just in magnitude but possibly also with respect to direction. Second, even if we knew the change in temperature and ocean currents we would not necessarily know the effect on abundance and migrations of fish stocks. Nevertheless, it appears that little research has been done on the possible consequences of climate change for fisheries.

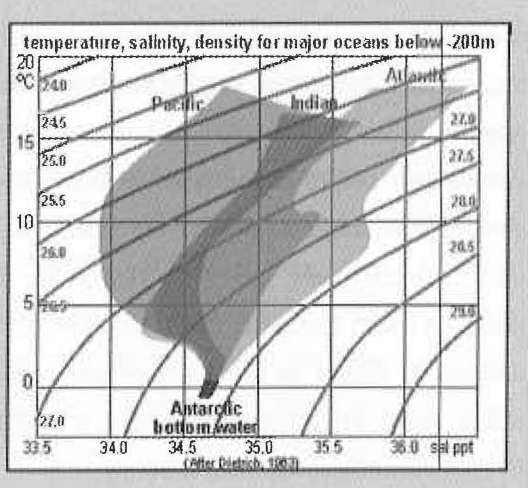
Most fish species have a fairly narrow range of optimum temperatures related to both their basic metabolism and the availability of food organisms that have their own optimum temperature ranges. Depending on the species, the area it occupies may expand, shrink, or be relocated with changes in ocean conditions.

For fishes, climate change may strongly influence distribution and abundance through changes in growth, survival, reproduction, or responses to changes at other trophic levels. Changing sea temperature and current flows will likely bring increases, decreases and shifts in the distribution of marine fish stocks, with some areas benefiting while others lose. These changes may have impacts on the nature and value of commercial fisheries. Species-specific responses are likely to vary according to rates of population turnover. Fish species with more rapid turnover of generations may show the most rapid demographic responses to temperature changes, resulting in stronger distributional responses to warming. The North Sea has warmed by an average of 0.6° C in 40 years between 1962 and 2001. Water temperatures become colder with increasing latitude in the southern North Sea but become slightly warmer with increasing latitudes in the north. This temperature pattern explains the movement of the Norway pout (*Trisopterus esmarkii*). Its distribution was centered in the

northern North Sea, and its southern movement brought it into cooler waters. Most species that showed climate-related latitudinal changes also shifted in depth, because the North Sea depths are positively correlated with latitude. The cuckoo ray (*Leucoraja naeus*) moved deeper with warming but did not change latitude, suggesting that they may respond to climatic variation through local movements into pockets of deeper waters. The boundaries of fishes also moved significantly with warming. Boundaries moved over distances ranging from 119 to 816 km. In the case of bib (*Trisopterus luscus*), the northern boundary shifted by 342 km from 1978 to 2001. Shifting species have faster life histories than do non-shifting species, with significantly smaller body sizes, faster maturation, and smaller sizes at maturity.

There is strong evidence that the catches of cod in the North Sea are influenced by variations in temperature, with lower temperatures leading to increased catches and vice versa. In contrast, the recruitment of Northeast Arctic cod was found to respond favorably to rises in temperature in the Norwegian Sea. The catches from this stock also respond favorably to rises in temperature, with a longer time lag. There is some indication that the catches of mackerel in the Norwegian Sea increase with rising temperature in that area. Capelins, an important prey fish of cod, spend most of its time in the colder waters north of Iceland, returning to the warmer waters to spawn. One major result of these phenomena was that cod spawned in large numbers in the north and east of Iceland, as well as in the more traditional south and west. This is an example of fish expanding (not shifting) their range when the ocean water warms. A second major result was that there was a migration of cod larvae to Greenland, which matured and led to a spawning population and an active cod fishery there. With the cooling trend of the late 1960s, cod no longer spawned off Greenland, and ultimately the cod larvae migration from Iceland ceased. The Greenland cod fishery also ended.

In the northeastern North Atlantic, including the North Sea, the Nordic Seas and the Barents Sea, the mean temperature is expected to increase by 1–3° C over the next 50 years.



Highest temperature changes are expected to occur in the northernmost part of the region. Moreover, the model scenarios predict ice-free summers in the Arctic basin in 50 years. Changes in ocean climate will substantially impact the marine ecosystems of the region. The change will impact abundance and distributions of fish species as well as abundance and distributions of key plankton species. Generally, a northward shift in distribution of all species is expected, and an increased biomass production of the Arctic and Arcto-boreal regions. In the North Sea, however, the present fish species is found to decline, but new species will invade from the south. The area will be dominated by pelagic species such as herring and mackerel in the northern part and possibly anchovy and sardine in the southern part.

In the Barents Sea and the Norwegian Sea, both the herring stock and the cod stock will most likely benefit from the warming. The abundances will increase and the distributions will expand, resulting in more availability for the Russian fishing fleet. The presently relatively unimportant Atlantic cod spawning areas along the Finnmark coast will become more important. New species are likely to appear. For example, Atlantic mackerel might be available in the Barents Sea. Capelin will probably move eastwards, and find new spawning areas.

Most radical changes will occur in high-latitude regions. The Arctic climate is changing almost twice as fast as the rate of climatic change at lower latitudes. Global climate models indicate that global warming induced by the greenhouse effect will be most acute in polar regions, most likely resulting in changes in the extent of sea ice, increased thawing of permafrost, and melting of polar ice masses, with profound societal impacts around the globe.

Reports of Intergovernmental Panel on Climate Change suggest the following changes in future decades as a result of global warming and corresponding climatic and ocean-ecological change:

1. Atmospheric and ocean-water warming in Arctic and sub-Arctic regions: According to the IPCC the greatest temperature increases over the last 35 years have occurred in the Arctic and sub-Arctic regions. In parts of these regions the warming has been extreme—as much as 3.9–5.6 °C. Projecting this trend two to three decades into the future, such warming may prompt rapid disruption, alteration, or collapse of various marine-ecological systems as they are unable to adapt as fast as the change is taking place.

2. A drop in aggregate fish production, as the foregoing marine ecosystems are not able to adapt as fast as the environmental changes are taking place.

3. Fisheries scientists may be unable to provide credible assessment advice for preventing major fishery collapses as the climate moves farther from its historic baseline. Widespread stock collapses may be the unavoidable result of poorly informed science and management, as well as the disappearance of many fish species in regions where they have long been plentiful.

4. A rise in sea level above the current level, with persistent coastal flooding in many regions and permanent inundation in others, causing not only radical marine-ecological change, but also requiring costly relocation of shore-side fisheries facilities.

5. An increase in the frequency and intensity of storms in certain coastal regions, causing widespread destruction to property, economic disruption, and loss of human life.

The changes in ocean climate showed dramatic effects on abundance and migrations of fish stocks. One such is the disappearance of the California sardine, and another is the collapse of the Atlanto-Scandinavian herring stocks. Similarly in the Indian Seas, trend has been noticed on the distribution of the oil sardine *Sardinella longiceps* and the Indian mackerel *Rastrelliger kanagurta* as a consequence of seawater warming. These small pelagics, which were predominant along the southwest coast of India, have extended (not shifted) their northern boundary up to Gujarat in the northwest coast and West Bengal in the northeast coast. The Indian mackerel is noticed to descend to depths to avoid higher sea surface temperatures. These are a few strategies adopted by fishes to mitigate seawater warming.

The migratory patterns of tuna are closely governed by ocean processes that create a conjunction between suitable physical habitat (in terms of temperatures and adequate oxygen) and adequate food sources. The tunas are constantly swimming in search of food—in some circumstances needing to consume as much as 15% of their body weight per day. As a result, the areas of tuna concentration are by no means casual, and migration takes place according to hydrological routes: in which each species finds the optimum environment for survival in every stage of its existence. As they are so energy-consuming, they are dependent on ocean processes and features which promote the aggregation of the prey resources which they must find within finite time periods, or die. Climate plays a large role in determining short-term, seasonal and multi-year patterns of variability in the location and productivity of these optimal tuna habitat zones.

Tropical tunas, including skipjack (*Katsuwonus pelamis)*, yellowfin (*Thunnus albacares*) and bigeye (*Thunnus obesus*) tend to be fast growing and relatively short lived. **Climate variability has demonstrable impacts on the abundance, concentration, location, and catchability of tropical tuna stocks. Climatic variability drives seasonal changes in the location of the most productive fishing grounds. There is evidence that operators of modern tuna fleets are actively using the available information on climatic/ oceanographic impacts** on tuna stocks to guide their harvesting operations. The effects of changed fish migrations and distribution caused by climate variability and climate change are likely to be most difficult to deal with for highly migratory species, such as the tuna.

Higher inland water temperatures may reduce the availability of wild fish stocks by harming water quality, worsening dry season mortality, bringing new predators and pathogens, and changing the abundance of food available to fishery species. In Lake Tanganyika, which supplies 25-90% of animal protein for the countries that surround it, warmer temperatures reduced the mixing of surface and deep-water layers in the last century, limiting the nutrients available to plankton and thereby cutting, by an estimated 30%, the yield in fish that feed on them.

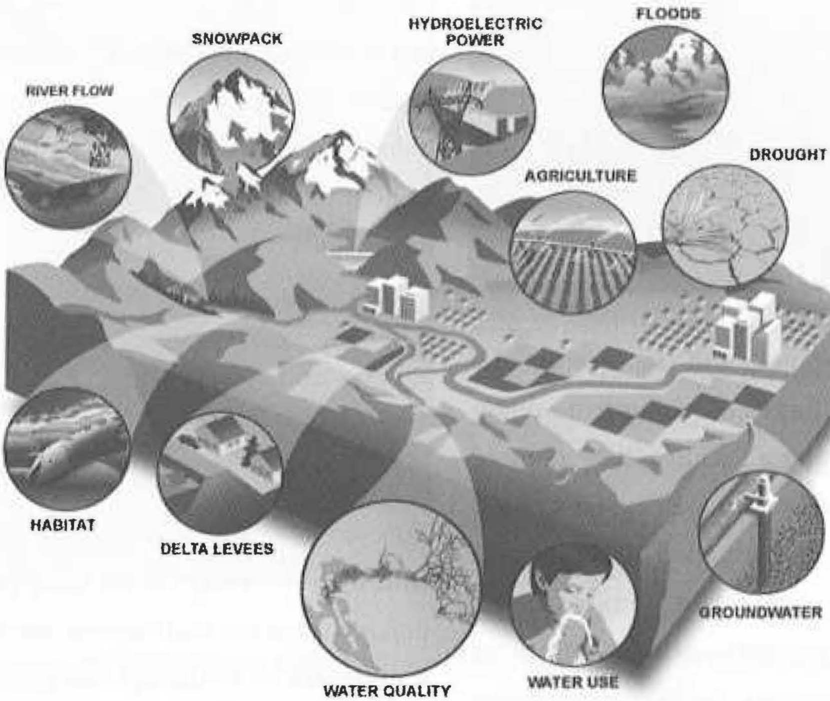
Drivers	Effects	Implications
Change in sea surface temperature	Algal blooms increase, less dissolved oxygen, parasites increase, invasion of predators, longer growing seasons, shift in location and size, damage to coral reefs.	Infestation of diseases, speciescompositionchanges, increased production, migration, loss of species, recruitment decreases.
Sea level rise	Loss of land, salt-water infusion, changes to estuary, loss of coastal ecosystem and mangroves.	Loss of fresh water species, area reduction for aquaculture, fresh water availability decrease, species shift/ composition, distribution changes, reduced recruitment and stock.
Increase in frequency of storms	Turbulent water, salinity changes	Loss of stock, catch decreases, risk to fishers, cost of maintainance increase, damages to vessels, nets etc.
ElNino-Southern oscillation	Location and timing of ocean current changes, upwelling alters food supply, coral bleaching.	Productivity decrease.
Drought	Salinity changes	Loss of stock, fisher folk migration

Other factors

The mean sea level (MSL) has increased at the rate of 0.705 mm, 1.086 mm and 3.772 mm per year in the Arabian Sea, Bay of Bengal and Andaman Sea, respectively during 1992-2005. Higher sea levels may make groundwater more saline, harming freshwater fisheries, aquaculture and agriculture, and limiting industrial and domestic water uses. Increased inland groundwater salinity has been observed in Bangladesh in recent decades. Sea-level rise might drown reefs that are near their lower depth limit by decreasing available light.

Increases in precipitation can lower salinity and increase sediment discharge and deposition near river mouths, sometimes leading to mass mortalities on nearby coral reefs. Tropical cyclones may limit reef development, but healthy coral reefs tend to recover from the damage caused by cyclones.

These initial results emphasize the need for finding answers to several questions. What will be the influence of rising seawater temperature on the bombayduck, whose northern boundary is landlocked? The distribution and migration of oceanic tunas, which are influenced by thermocline, may be strongly influenced. The sex of sea turtles is critically determined by the soil temperature at which the embryo develops. Temperature above 28° C produces only females. How the turtles would adopt to this crisis? Will there be species succession of phytoplankton with the domination of temperature tolerant species? Is the massive intrusion of pufferfish and medusae into the Indian coastal waters in recent years a fall out of climate change?



Mitigation

From the observations of increases in global average air and ocean temperature, it is now evident that warming of the climate system is unequivocal. Climate change could exacerbate tensions and trigger conflicts across the world by worsening food, water, and land

resources shortages and increasing the environmental refugees, according to the report "Climate Change as a Security Risk" released by U.N. Environment Programme on Climate Change in Bali in December, 2007. Because climate change might do much harm, controlling it depends on the efforts of governments, scientists, business and industry, agriculture, environmental organizations and individuals. No single person or nation owns the earth's global resources, that is, its oceans and atmosphere. Hence, the people of the world must work together to reduce greenhouse gas emission and warming of the earth.

All countries will be affected by climate change, but those in the forefront are poor nations, especially small island states and developing economies where hundreds of millions of people live in low-level deltas. It might cause a substantial loss to India's GDP too. Climate change has become central to global development politics. The main objective of all climate change conferences is to finding out ways in reducing the anthropogenic GHG emissions to tackle rising temperature. Developing countries with booming economies and a growing contribution to climate change must accept flexible and fair commitments to reduce GHG emission. The important option is to limit the amount of greenhouse gases each nation emits.

There are real and affordable ways to deal with climate change. Already, business in many parts of the world are demanding clear public policies on climate change, regardless of what form they might take regulation, emission caps and efficiency guidelines. We need a new ethic by which every human being realizes the importance of the challenge we are facing and starts to take action through changes in life style and attitude. The least controversial way to reduce such emissions would be to use gains in efficiency to decrease the use of energy. For example, manufacturers would adopt more efficient processes to produce goods. Makers of electrical equipment would introduce more efficient motors, light bulbs, and other devices. Scientists and engineers are also researching

ways to generate electricity more cheaply from renewable energy sources such as the wind and sun, causing little or no emission. From an overall perspective, to create the necessary carbon space for the poor, countries must evolve policies and measures to reduce the carbon emissions of the rich. People can save electricity by buying more efficient light bulbs and home appliances. For example, compact fluorescent light bulbs use only 25 per cent as much electricity as traditional incandescent bulbs. People can also conserve by using appliances less often, by turning off appliances and lights when not in use, and by setting home thermostats at or below 20° C in winter and at or above 26° C in summer. Buildings with specially treated windows and good insulation need far less electricity to heat or cool than buildings without such materials.

Even if global emission stabilizes and if the temperature increase is kept below 2°C, because of the delayed response of ocean warming, the impact of the already warmed atmosphere and surface is inevitable. Hence, along with the strategies of mitigation to reduce greenhouse gas emissions, measures of adaptation to the effects need to be implemented to secure the lives of vulnerable populations, especially along the coastlines.

GHG emission by fisheries sector is meager when compared to other sectors. Emission is from fishing by mechanized and motorized boats, and from processing plants. By increasing the fuel efficiency of fishing boats, emission can be reduced. Fisheries sector can adopt the following mitigation measures to climate change: (i) impact assessment of climate change on distribution and species diversity of fisheries resources; (ii) assessment on production and economic value of commercially important fish in the changed scenario; (iii) identify genes for thermal tolerance; (iv) evaluate sensitive biological processes such as growth, maturity and spawning and the adaptive capacity of important fish groups with reference to climate change; (v) identify adaptive fishing and post-harvest practices to sustain production and quality; (vi) quantify GHG emissions from fisheries sector; (vii) quantify the carbon sequestration potential of fresh water, brackish water and marine ecosystems; (viii) identify cost – effective opportunities for reducing GHG emission from fisheries sector; (ix) establish Weather Watch Groups for fisheries sector; and (x) identify efforts to increase climate literacy among stake holders in fisheries sector.

Climate change response is very complex to deal with. What is required is a non-carbon path. The threat of climate change and the rising oil prices should push governments to reduce their dependence on oil and must seek new alternatives. The consuming class has to change necessarily its life style to consume less. Real change that can effectively prevent major collision with the environment can come about only when the societal order is changed.