that as much of the feed is consumed as possible. Feeding may be also improved through the use of automatic feeder and by employing compensatory feeding. An experiment involving three automated feeding systems gave FCRs of 0.94, 0.93, and 1.05, providing good control of feeding and helping in the improvement of feeding efficiency (Myrseth, 2000).

In a feeding experiment on *Pangasius bocourti*, there was no significant difference in the final weight among the five groups tested indicating complete compensation in the fish experiencing restricted feeding. Improved feed conversion efficiency was experienced in the juveniles of *P. bocourti* when restricted feeding was conducted (Jiwyam, 2010). Atlantic halibut reared on a repeated 5/10 week starvation/re-fed regime for 3 years led to full growth compensation, higher feed conversion efficiency, lower male maturation, and improved flesh quality (Foss *et al*., 2009). In one of the compensatory feeding experiments conducted by SEAFDEC/AQD, biomass of milkfish reared in brackishwater ponds and fed every other day was comparable to stocks fed daily resulting to one-half of the usual FCR and 50% savings on feed inputs (de Jesus-Ayson, unpublished data). Based on these results, feeding regimes may be manipulated in such a way that feed inputs to the environment may be minimized without sacrificing production.

Aquaculture may be the ultimate solution to the problem of dwindling fishery production. Since most of the time, aquaculture does nothing good to the environment, and in order to compensate the diminishing fishery production and meet the demands of fishery products for the human population which continue to grow, aquaculture must be redesigned to minimize its impact on the environment and make it more environmentally and at the same time economically sustainable. Scientific studies on how aquaculture has destroyed habitats, polluted the waters, threatened non-target species, and a long list of other impacts; and how aquaculture should be done to make it sustainable and environment friendly are readily accessible. However, despite the easy access to such information, aquaculture continues to pollute the environment. Therefore, scientific findings should be properly and widely disseminated to fish farmers, hatchery operators, feed suppliers, policy makers, and government agencies to make them understand that protecting the environment is not the task of just one person but should be a joint effort of everyone producing from it, using it, and living in it. Science should be strongly supported by policies that are strictly implemented and enforced in order to achieve the goal of having a better and cleaner environment in the future.

6. ADAPTATION AND MITIGATION OF THE IMPACTS OF CLIMATE CHANGE

Capture fisheries and aquaculture are the most beneficial livelihood sources in coastal communities. However, the sustainability of these sources is being subjected to various threats and pressures especially during the past decades. In the advent of these serious fisheries and aquaculture concerns coupled with environmental changes, the people's dependence on fisheries in the Southeast Asian region for economic growth is in question. Considering that nowadays, extreme meteorological events have increasingly occurred with frequent and more severe manifestations. Therefore, it is valid to analyze how people involved in fisheries react and adapt to existing climate fluctuations (Daw *et al*., 2009). It is noteworthy that climate change affects fisheries and aquaculture directly by influencing the fish stock and the global supply of fish consumption, or indirectly by influencing fish prices or the cost of goods and services required by fishers and fish farmers (WFC, 2007).

In particular, strategies and interventions to mitigate the effects of climate change to the fisheries industry should be established. In aquaculture for example, the impacts of climate change to the various culture, and its effect to the cultured species and their vulnerability to the environmental changes as well as to the wild stocks targeted by capture fisheries, should be assessed. Environment friendly strategies to lessen the sectors' impacts to the environment should also be developed, which also pertains to the efforts to reduce the carbon footprint of fisheries. These efforts should be taken with serious consideration considering that many peoples in the Southeast Asian region are increasingly dependent on the fishery resources as evidenced in the per capita consumption that reached a new all time high (FAO, 2010a).

Since these resources come mostly from our vulnerable coastal areas, it is therefore important and urgent to integrate fisheries management in resource exploitation with the objective of ensuring sustainable utilization of the very important resources, protecting vulnerable areas and species, and eventually mitigating the effects and ensuring the stakeholders' adaptation to climate change.

6.1 Vulnerability of Coastal Habitats

It is most certain and widely recognized that the effects of climate change are (but not limited to) sea-level rise, seasonal monsoon/rainfall variations, increased and stronger incidence of storms and typhoons, increased land-based run-offs, and sea-surface temperature (SST) rise. These effects highly influence the productivity of the coastal habitats where most of the fishery resources are

confined. The Southeast Asian region has been considered as one of the most vulnerable areas to environmental variations caused by climate change because of its long coastlines and dependence in seasonal monsoon patterns, and where most coastal dwellers depends on fisheries for sustenance (IPCC, 2007 as cited Santos *et al*., 2011). In addition, poverty is still recognized as widespread in the Southeast Asian region especially along coastal communities (FAO, 2010a) where the people in these communities are most vulnerable to environmental changes brought about by climate change. At certain degree, habitats exhibit minimal natural recovery responses to climate change, but constant pressure from other anthropogenic activities and natural calamities hardly presses their integrity and recovery.

In coral reef ecosystem, SST rise is the main factor which has the most direct adverse effect as manifested in massive coral bleaching that started in 1998 and followed by subsequent similar events throughout the region up to the present, *e.g.* Andaman Sea and Aceh, Indonesia in 2010. The level of recovery in the coral bleaching events varies depending on the subsequent water physical conditions, availability of spats and food resources for corals to feed. Similarly, climate-related effects on mangroves will be highly manifested due to sea level rise as well as the frequency and intensity of strong surges. Sea level rise will have the most direct impact to these habitats and will dictate mangrove landward migration (Gilman *et al*., 2007). Likewise sea grass beds are affected by SST rise particularly impinging on the plant growth and other physiological functions. Distribution pattern of aquatic species would most likely shift due to temperature variations and sea-depth. Changes in terms of productivity in deeper areas will also be manifested (Short and Neckels, 1999).

6.2 Impacts of Climate Change on Capture Fisheries

Climate change is modifying the distribution and productivity of marine and freshwater aquatic species (**Appendix 5**) and is already affecting biological processes and altering food webs (FAO, 2009). Since fish are cold blooded animals, their adaptive capacity to the environment is highly affected by changes of water temperature. Changes in habitat temperature greatly affect their growth rate, metabolism, reproduction seasonality and efficacy, susceptibility to diseases and toxins and their spatial distribution (Lehody, 1997 as cited by Santos *et al*., 2011). Fish may tend to move to cooler tolerable waters thus changing their migratory patterns and known availability. This has been observed on migration of skipjack tuna, an economically important tuna species in the Coral Triangle area, which move to cooler Central Pacific region thus making a decline of stocks in this region (Alcala, 2010 as cited Santos *et al*., 2011).

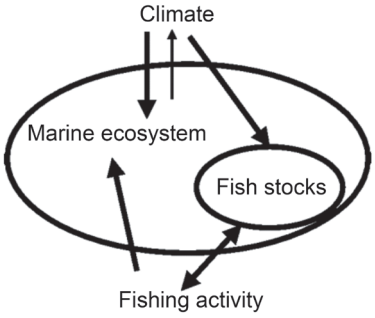

Fig. 41. Schematic representation of the impacts of climate change and fishing activity on the marine ecosystem and its fish component
(**Source:** *http://www.pnas.org/content/104/50/19709.full)*

Changes in the distribution through migration (either spawning and/or feeding) of stocks will ultimately affect the ability of fishing to detect target species at certain place and time. Other profound effect to stocks is the availability of food which could already affected by climate change. Warming of sea surface deepens the thermocline layer and disrupts the upwelling due to SST, and warming could likely influence primary productivity. In addition, ocean acidification affects the formation of calcium-carbonate phytoplankton shells and skeleton which are primary elements of the ocean's food chain.

The changes in global climatic patterns and season, will affect fish recruitment and population. The warming of river basins and estuarine waters could affect yields from fisheries either positively or negatively depending on the resulting dissolved oxygen concentrations and aquatic productivity. It is likely that species distribution will occur according to the adaptability of the species involved. Salinity changes in the coastal waters also encourage species re-distribution but the net effects on fisheries yields are unlikely to be significant as shown in **Fig. 41** indicating the representation of impacts of climate change and fishing activity on the marine ecosystem and its fish components.

6.3 Impacts of Climate Change on Aquaculture Development

As aquaculture requires water as culture media for its operation, any climate change however short term will have an impact to the overall operation. In particular, changes in water temperature could influence stocks growth rate and metabolism prolonging period of culture and increase production inputs. The variability of weather conditions, prolonged hot conditions, intense/stronger storm surges are just but a few that would most likely influence fish stocks vulnerability. A rising water temperature and adverse rainfall patterns will affect the physical, chemical

and biological quality of the water such as the dissolved oxygen, salinity, pH, nutrients and plankton dynamics. As such, greater impact will be experienced for those activities in the open environment like floating net cages in lakes and estuaries as well as in the open sea. Rising sea level poses great threat to the pond production system in the estuarine environment by flooding the land. Among the possible effect is water would have low carrying capacity which means lower productivity for aquaculture operation. Higher temperature will reduce oxygen solubility in water but raise the oxygen and food demand of fish following increased metabolism. Associated rise in gill ventilation rates can lead to increased uptake of aquatic pollutants, rendering the fish unfit for human consumption. Higher water temperatures can also favor the multiplication and survival of bacteria and parasites. In addition, the frequent change in water parameter is likely to create increased turbulence hence higher cost to install or maintain infrastructures to hold the fish.

6.4 Adaptation Strategies

SEAFDEC has been implementing programs for adaptation and mitigation of the effects of climate change in the Southeast Asian region, while the SEAFDEC Member Countries have also initiated individual efforts to lessen the impacts of climate change. In order to assess the individual country's efforts specifically focusing on the emerging regional policy issues related to climate change, SEAFDEC in close collaboration with the Member Countries through ASEAN Fisheries Consultation Forum (AFCF) has consolidated all activities to be implemented that are aimed at mitigating the impacts of climate change. The countries in the region have also widely recognized the concept of Climate Change Adaptation and that development of mitigation strategies should at all time be integrated in every fishery related programs and frameworks. Participatory approach in vulnerability assessment of climate change in coastal communities should be considered a simple device yet practical technology in the conduct of vulnerability assessment and simulations. Since environmental changes and seasonal variations are best observed at the people's level, local knowledge would come handy and helpful in formulating strategies for adaptation.

Furthermore, awareness programs on the short- and long-term effects of climate change to the environment should also be taken into consideration, and efforts should be solicited to mitigate such effects. Programs for livelihood diversification to lessen dependence on current income sources among fisherfolks should also be considered. Provision of other means of income among artisanal/subsistence fishers gives them opportunities and lessen their dependence on fishing, thus, lessen their vulnerability to environmental changes. Risk reduction among fishers working in harsh offshore conditions as well as the small-scale fishers in coastal waters is crucial. Likewise, governments should exert efforts to strengthen adaptive measures and provide safety at sea tools to fishers. Thus, wide range, reliable, accessible and up to date meteorological services should be in place in the Southeast Asian countries. Resource enhancement and rehabilitation activities should also be continued and appropriate strategies should be widely promoted in the Southeast Asian region.

In aquaculture, research and development initiatives should respond to the impact of climate change. In particular, assessment of culture media to the effect of climate change and development of adaptation strategies should be encouraged. Current researches should also gear towards culture stocks/strain development focusing on wider tolerance stocks to environmental changes. Alternative feed sources for aquaculture should be sought to lessen dependence to fishmeal. In particular, to lessen the impact of climate change on aquaculture activities, countries could implement appropriate action plans to safeguard the respective national aquaculture industry. Such action plans could include: a) regular monitoring of water quality parameters within aquaculture zones; b) study the impact of water parameter change to dynamic of growth and survival of traditional aquaculture organisms; c) conduct programs on domestication and selective breeding for aquaculture species; d) highlight and encourage land-based and indoor-closed system aquaculture operations; and e) implement surveillance and coordinating with meteorological department on weather changes for early warning adaptation and improve safety at sea standards for fishing operations.

6.5 Reducing Carbon Footprints from Fisheries

It has been a global consensus and concern that dependence on fossil fuels/non-renewable energy sources should be significantly reduced in the coming decades by tapping alternative and renewable energy sources. In addition, it has been widely and universally recognized that emerging climate change issues need immediate actions. At the global scene, technologies in fishing operations as well as reliance to fossil fuel had advanced in leaps and bounds, thus it may be deemed necessary to consider the impacts of climate change and the mitigation structures/strategies in the context of the fisheries sector. Through SEAFDEC, the fisheries and aquaculture sectors could strengthen their efforts to reduce carbon footprints to mitigate environmental impacts which lead to climate change. As reported, there are various ways of reducing fishing boats' carbon footprints: reduce fossil fuel consumption and/or offset footprint by compensating with other fishing activities (Bundit, 2011). Moreover, it is as well recognized

that reducing fossil fuel dependence in fishing operations would entail several measures that include the development and promotion of cost effective technologies, backed up by appropriate policy structures for the management of energy use in fisheries in the region. In addition, fuel and energy source alternatives should be identified, while R&D on environment-friendly and efficient capture technologies should be pursued (SEAFDEC, 2011b).

Specifically, several projects have already been initiated in the Southeast Asian region concerning measures to reduce fossil energy dependence in capture fisheries. The project of SEAFDEC on Responsible Fishing Technologies and Practices or "Fishing in Harmony in Nature" has been promoting the use of sails in fishing operations. Moreover, SEAFDEC/TD has been conducting studies to determine the ways and means of reducing the use of fossil fuel in fisheries which include improvement of designs of boats/vessels, and increasing engine efficiency which also entails gear modifications. In terms of alternative/less inflicting energy sources, the use of biofuels which have lesser impact than other fossil fuel has also been considered for promotion in the region's capture fisheries.

Concerns related to energy use in fisheries had become critical in the region, thus, policy intervention at the regional level would be necessary to address common interests in sustaining the fisheries industry in the midst of environmental challenges. In an attempt to address these concerns, the ASEAN developed the Plan of Action in Regional Energy Policy and Planning (APAREPP): 2010-2015, which aims to enhance national policy and planning activities of the ASEAN countries for integration into a cohesive and effective regional policy analysis and planning towards sustainable development. Moreover, SEAFDEC on its part would continue to promote alternative energy sources for both capture fisheries and aquaculture, support the use of energy savings and environment-friendly fishing technologies and sustain its projects on the reduction of the use of fossil fuel in fisheries (SEAFDEC, 2010d). Involvement of and awareness raising in the private sector should also be enhanced which will ultimately reduce the impacts while relevant programs should be promoted in collaboration with other institutions including the academe, NGOs, research institutions, especially in developing advocacies relative to minimizing the contribution of fisheries to climate change. To list a few, some specific strategies that could be adopted to address climate change could include: 1) reduce heavy dependence on oil by tapping alternative energy sources; 2) promote energy efficiency among industries and the private sector; 3) implement public awareness programs by government agencies and NGOs towards promoting energy efficiency, recycling and use of public transport; and 4) maintenance effective forest management and conservation.

7. HUMAN RESOURCES IN FISHERIES

7.1 Status of Human Resources in Fisheries

While moving towards global competitiveness, countries in the Southeast Asian region have confronted with issues and challenges that threatened sustainable development of fisheries. In view of such challenges, the availability of qualified human resources in relevant subjects and disciplines is envisaged to be one of the very crucial prerequisites for sustainable development and management of fisheries. In order to obtain information on the current status and gaps in human resources of countries in the region particularly in the government sector, a survey on the "Existing Human Resources and Expertise in Fisheries in the ASEAN Member Countries" was undertaken by SEAFDEC in early 2010. The questionnaire used during this survey primarily sought information on the availability of expertise in the areas of fisheries biology, capture fisheries, fisheries management, aquaculture, fisheries post-harvest, laws and legislations, cross-cutting issues, etc., in different gender and age groups. The inputs from countries, although doesn't cover the whole dimension of human resources profile, indicated the tendency in inadequate human resources in several subject areas (**Box 4**).

It could be said that during the past decade, human resource expertise in fisheries in most countries have been moving towards those that provide higher economic benefits, such as aquaculture, post-harvest and processing enterprises, etc.; as well as subjects that caught attention from policy makers/planners such as fisheries management and governance. In contrary, there are tendencies in shortage of human resources in some fundamental subjects, such as fisheries biology, laws and legislation, as well as the cross-cutting and emerging issues/challenges. It is therefore necessary for countries in the region to further review and form a clear picture of the current availability and gaps of relevant expertise and human resources, and come up with strategies to balance the availability of human resources in wide ranges of disciplines in responding to their respective future requirement.

In addition to the tendency in shortage of expertise in some fundamental fisheries-related subjects, many countries in the region also faced the problem that most of the young generations had shown no interest to engage in the activities, particularly capture operations. The situation is specifically more serious under the situation where fishery production and catch has continuously declined with the degradation of fishery resources, and the drastic increase in fuel price. In some localities, only those that have no better job opportunity choose to become fishers, resulting in a tendency in increasing average age of fishers. These