species because of difficulties in feeding and outbreak of disease (Vincent and Kodlewey, 2006; Koldewey and Martin-Smith, 2010).

More recently, however, AQD found that survival and growth of newborn seahorses are significantly improved in UV-treated water while mass mortality is effectively prevented by treating food organisms in formalin (Buen-Ursua *et al*., 2011). Such findings indicate that using disease-free copepods collected from the wild as feed through formalin treatment would advance the development of cost-effective aquaculture for the mass production of seahorses in Southeast Asia. The goal is not to promote new trade or increase existing trade in seahorses as this might encourage the exploitation of seahorses from the wild (Buen-Ursua, personal communication cited by Malaya Business Insight, 2011).

Other than the issues of vulnerability to diseases and finding the correct diet in captive breeding, genetic diversity and genetic purity of native species of restocked seahorses, disease transmission to wild populations as well as risk of community disruptions should be considered in carrying out seahorse releasing programs (Vincent and Koldewey, 2006; Buen-Ursua, personal communication cited by Malaya Business Insight, 2011). The genes of seahorses bred in one place might not be compatible with native seahorses, raising the risk that mixing them could compromise the genes of local seahorses. Stocks bred in hatcheries whose genetic composition is incompatible with the native population should not be released.

Thus, the characterization of the genetic makeup of seahorses bred in hatcheries and those found in the wild is very essential (Buen-Ursua, personal communication cited by Malaya Business Insight, 2011). As regards disease issues, thorough screening procedures are also necessary in any program that transfers captive seahorses into the wild (Vincent and Koldewey, 2006) as sudden influx of new individuals into a small area could result in changes in the social structure of the wild population which could result in increased competition for food, shelter, and mates (Vincent and Koldewey, 2006). Appropriate measures are therefore very important to avoid such risks, which could include development of tagging and/or marking techniques to monitor the release animals and to establish the impact of the stocking practices (Vincent and Koldewey, 2006).

Future Perspectives and Recommendations

Global interest in aquaculture of seahorses and other syngnathids has increased dramatically over the past decade (Vincent and Koldewey, 2006). As predicted from the global trade situation, the global resource level of wild seahorses would continue to decrease particularly in Southeast Asia. It is likely that the situation in the future would worsen and wild stocks of seahorses would encounter the risk of extinction unless immediate actions to stop overfishing and appropriately control the volume of trade are implemented by the countries of origin and trading countries. For example, catch of seahorses should be limited to 10 cm or less in body height which is the minimum size prescribed by the Animal Committee of CITES (Foster and Vincent, 2004) while the export/transport of live seahorses should be governed by specific guidelines (Vincent and Koldewey, 2006). Direct exploitation as well as habitat loss and degradation should be avoided by establishing and strengthening domestic legislations in order to protect seahorse populations in many countries from over-exploitation (Vincent and Koldewey, 2006).

Although culture of seahorses does not target the traditional Chinese medicine (TCM) markets and has not achieved commercial viability, production of cultured seahorses through development of sustainable aquaculture technology should be enhanced in order to protect the wild stocks of seahorses. In addition, since the ratio of wild-caught to cultured seahorses in the live aquarium trade is unknown (Vincent and Koldewey 2006), cultured seahorses could replace the wild seahorses to supply TCM and tonic products, live aquarium fishes, and curio items and souvenirs, thus, preventing further demands of wild seahorses. As emphasized by Vincent and Koldewey (2006), culture technologies for seahorses should be in line with the aim of minimizing negative environmental impacts and maximizing local socio-economic benefits, and through the compliance with the precepts of the Convention on Biological Diversity.

2. INLAND FISHERY RESOURCES

In 2009, the total fisheries production of the region was reported to be 28,917,096 MT of which 2,397,273 MT came from the inland fisheries sub-sector accounting for approximately 8% of the total fishery production (SEAFDEC, 2011). Despite the low figures as reported, the importance of inland fisheries could not be neglected due to its contribution to food security and poverty alleviation for peoples, particularly those from the low income group whose livelihood is very much dependent on the availability of natural resources. However, by the nature of inland fisheries being small-scale, multi-species, multi-gears, involving large number of fishers which are mostly part-time fishers, while the major parts of the fishery production are meant for household consumption, all these factors result in difficulties in the collection and accurate reporting of routine inland fishery data and statistics. Thus, the importance of inland fisheries is hence overlooked by planners and policy makers, giving this sub-sector low priority compared to the other development sectors that share the same water resources. The result could be manifold impacts to fishers and other fishery-related activities in the region while the accumulated impacts

over time could be much greater than one can imagine, particularly to those whose livelihoods are dependent on inland fishery activities.

Adding to the above-mentioned situation is the deterioration of natural inland fishery resources and habitats as well as the declining catch caused by irresponsible fishing operations, insufficient fishery management schemes, and the impacts from non-fishery activities. As a matter of fact, aquaculture practices have been introduced and promoted in several areas to increase fish production from inland waters. However, such introduction should be properly managed otherwise it could lead to negative impacts to the ecosystems and inland natural resources. In most cases, the beneficiaries from aquaculture operations may not only be those who lose their benefits from inland capture fisheries in terms of food security and livelihood. The promotion of aquaculture activities that aim to substitute inland capture production therefore undermines the culture value of fish eating traditions and other traditional knowledge which had been passed from generations to generations, and thus, the importance of inland fisheries should be recognized by the present and future planners and policy makers (Mohd Isa *et al*., 2011).

2.1 Status, Issues and Concerns

2.1.1 Inland Fisheries for Food Security and Poverty Alleviation

The inland fishery sector is known to significantly contribute to food supplies and healthy diets of millions of people all over the world. Production from inland fisheries is particularly important for poverty alleviation, food security and enhanced nutritional well-being of many people in rural communities, particularly in the developing countries as well as in the low-income food-deficit countries. In the Asian region, fish contributes to approximately 23% of the animal protein intakes and human diets (FAO, 2003). In certain parts of the region, for example in the Lower Mekong Basin, the importance of inland fishery products such as fish and other aquatic animals, *e.g.* snails, mollusks, shrimps, crabs, snakes, and other reptiles as well as water birds, is even more prominent.

The average basin-wide consumption of fish and other aquatic animals is estimated at 56 kg/capita/yr (Hortle and Bush, 2003), while in high-yielding fishing areas such as the rural communities of the floodplains around the Great Tonle Sap Lake in Cambodia, fish consumption could even be higher. Moreover, inland fisheries also provide direct employment to rural populations in terms of production and indirect employment through processing and trading of fishery products. More importantly, inland fisheries also provide significant opportunities for the integration of fishery operations into rural farming livelihoods, offer buffer against shortfalls in agricultural production, and make available alternative sources of food and income.

2.1.2 Data/Information Collection on Inland Fisheries

One important reason why the importance of inland fisheries is being undermined by non-fishery sectors, planners and policy makers is the lack of reliable data and information on inland fishery production. In view of its very nature, inland fisheries are usually not well-monitored, under-estimated and under-presented in many reports and statistics. Since major parts of the production are intended for household consumption, reliable statistics could not be systematically gathered using the conventional statistical collection methodologies. The discrepancy between officially reported catches where available and the estimates based on independent scientifically-based surveys focusing on collection of actual data, seems to suggest that the total reported production from inland waters is usually under-estimated by at least 2.5 to 3.6 times (Coates, 2002). This also suggests that the contribution of inland fishes to the total fish supplies is significantly higher than the volume that is estimated and reported.

Considering the complexity of inland fisheries and the difficulties in obtaining reliable statistics on inland fisheries, alternative methodologies such as indicator or sampling survey or fish consumption survey could be undertaken to come up with information that reflects the importance and role of inland fishery production in the countries' economies. Moreover, such approach could also provide the necessary conversion factors which when combined with routine fishery statistics or information from national census would generate more accurate information on inland fishery production of the region. In addition, local and indigenous knowledge on inland fisheries especially those associated with the abundance and distribution of species, fishing gears and methods, fish preservation and processing techniques could also be important source of information, and thus, should be gathered to support the sustainable management of the region's inland fisheries.

The need to improve the national statistical systems and capacity to collect data and information on inland fishery statistics is therefore well recognized. Therefore, under the current circumstance, it is necessary that data collected using the existing fishery statistical systems and outcomes from the currently available research studies should be synthesized and packaged, after which such information should be presented to policy makers and planners to raise their awareness and enable them to have better understanding on the importance of inland fisheries in the food security of the region.

2.1.3 Impacts of Water Barrier Construction on Inland Fisheries

One of the development projects that could generate significant impacts to inland ecosystems and fishery activities is the construction of water barriers such as dams, weirs, barrages, among others. In the Southeast Asian region, a number of dams and barriers had been constructed for the main purpose of providing continuous supply of water for irrigation, hydro-power electricity generation, domestic use, and flood control. The construction and operation of mainstream dams and other water barriers obstruct upstream and downstream migration of fishes, often resulting in the diminishing, disappearance or even extinction of many riverine fish species. The operation of dams also results in drastic changes of the hydrological patterns of streams, creating negative impacts to the natural population of migratory aquatic species as the release of water from dams does not usually consider the biological needs of aquatic organisms, but by the demand for hydroelectric power.

The operation of dams also reduces water flow during natural flood periods and increases flow during dry periods, resulting in changes of seasonal flood and continuity of the river and habitat systems. As the connection between rivers and floodplains or backwater habitats is essential in the life history of many riverine fishes that take advantage of seasonal floods and utilize the inundated areas for spawning and feeding, the loss or failure of such connection can impact on the species biodiversity which could even lead to extinction of certain species. In addition to changes of water flow patterns, the construction and operation of large hydro-power electricity dams could also impact on the physical characteristics of the water such as drop of upstream water temperature and dissolved oxygen, water stratification, sedimentation, accumulation of organic and inorganic substances including toxic substances. When upstream water is discharged, the impacts from such physical phenomena could also affect the living organisms in the long distance downstream waters.

Therefore, in order to mitigate the impacts from large dams, careful consideration should be given in the design and operation of dams. For example, extracting water from depths where water quality parameters such as water temperature and oxygen concentration of the discharged water are similar to those in the downstream of the dams. Moreover, the operation of dams and discharge of water should be synchronized with the biological rhythms and requirements of the aquatic species inhabiting the dams. This would require close coordination among the concerned agencies especially those involved in electricity generation, irrigation, and fisheries, while the construction of special and supplemental 'balancing reservoirs' or 'water regulating dams' could help in preventing extreme pulse discharges, maintaining the water flow at ecologically acceptable level. In addition, the development of several models of fish passes should be explored and initiated in order to facilitate the migration of aquatic species through various water barriers. Nevertheless, the effectiveness of fish passes which could be influenced by several factors including the dam's height, fish pass design, entrance location, water flow as well as other biological aspects of the aquatic species such as fish size, swimming abilities, migratory behavior, and population size, should be appropriately considered in designing and operating fish passes to ensure its effectiveness in mitigating the impacts from dams to the natural populations of aquatic organisms.

2.1.4 Inland Fisheries vs. *Aquaculture*

The deterioration of inland fishery habitats as a consequence of the aforementioned concerns results in the decline of the inland fishery resources, despite the seemingly increasing inland capture fishery production as claimed and reported by most of the countries in the Southeast Asian region. Nevertheless, as an attempt to increase fish supply from inland areas, aquaculture of freshwater aquatic species has been promoted and widely practiced in many countries.

The major cultured freshwater fish species that contribute to the total fishery production in the region include *Pangasius* spp., *Oreochromis* spp., *Labeo rohita*, and *Clarias* spp. Although aquaculture practices could contribute to the increase in inland fishery production, it could also generate impacts to inland fishery resources including the nutrient and chemical loads that cause eutrophication or mortality of aquatic animals in natural water bodies. Meanwhile, the collection of wild seeds for aquaculture purposes could impact the natural fishery resources and the introduction of non-indigenous species could lead to changes in species diversify and genetic diversity of certain areas. Moreover, the use of trash fish or fishmeal-based diets for aquaculture competes with the use of low-value fish for human consumption. Therefore, it has become imperative that these issues and concerns should be taken into consideration in the development and promotion of inland aquaculture.

2.2 Challenges and Future Direction

In several regional consultation processes, one of the priority areas raised that need special attention is maintaining the connectivity of the habitats in order to ensure the sustainability of inland fisheries. The construction of water alteration structures such as weirs, dams, roads, could create barriers to upstream and downstream migration of aquatic species, resulting in possible diminishing, disappearance or even extinction of species that migrate in upstream and downstream waters.

It is therefore important to conduct studies that aim to investigate and mitigate the impacts of water barrier construction and operation to the population of important aquatic species in the ecosystems. Conservation and improvement of habitats favorable for the aquatic species such as establishment of fish conservation areas or fishery *refugia*, artificial habitat improvement, deployment of materials and shelters to create nursery and feeding grounds for juvenile and broodstock, could also be undertaken to enhance the populations of various aquatic species. In addition to habitat conservation and rehabilitation, stock enhancement activities could be practiced to improve fish yield particularly for areas where the fishery resources had deteriorated and fallen below the ecosystems' carrying capacity. In an ideal case, stocking should consider the use of indigenous species or low trophic species, with seeds produced specifically for the purpose of stock enhancement.

In using seeds produced from aquaculture for stock enhancement, caution should be made as this approach could create negative impacts on the biodiversity of the ecosystem. Specifically in closed ecosystems such as lakes and reservoirs, the impacts from stocking of hatchery-bred seeds are localized and thus, may not be very substantial. However, the release of hatchery-bred seeds into natural open habitats could result in irreversible damage to the broad ecosystems, which could include loss of biodiversity where exotic species could dominate over the native species or loss of genetic diversity of the species. In general, releasing hatchery-bred seeds should be undertaken in a precautionary manner. Since the nature of inland fisheries and ecosystems are very diverse and could be different from place to place, different approaches should be considered in coming up with appropriate conservation and management measures for particular areas, taking into account the resources as well as the relevant social and economic dimensions. In addition, appropriate indicators should also be identified and used to evaluate the success of stock release and enhancement programs.

Furthermore, considering the wide-range of stakeholders in the fishery and non-fishery sectors involved in the utilization of inland fishery resources and the ecosystems, integrated water resources management approach as well as enhanced coordination and communication among the various agencies sharing the same water resources should be promoted. This could prevent if not minimize the impacts of one to the other sector, while the importance of inland fisheries should be made known and publicized particularly for policy makers and relevant management authorities in order to appropriately mainstream the requirements of inland fisheries into the overall development plan of the countries. Data collection on inland fisheries should be enhanced in order to appropriately value the inland aquatic resources. Routine and non-routine data and information as well as data collected through non-conventional methods such as fish consumption survey, and local knowledge should also be fully utilized for this purpose.

Responsible fishing technologies and practices should also be promoted, with due consideration given to the sustainable utilization of the resources especially the highly abundant but short life-cycle species, and top predator species. To effectively harvest these species without creating impacts to the other non-targeted species, selective fishing gears and practices should be developed and investigated as to their effectiveness and efficiency. In this regard, consideration must be given to relevant ecological and biological parameters, and traditional knowledge of local fishers in harvesting and utilization of the species. In order to reduce pressure to the inland fishery resources and enhance the livelihoods of fishers and the fishing communities, alternative fishery-related livelihoods could also be introduced such as production of value-added products from the catch, promotion of eco-tourism and recreational fishing, and aquaculture including rice-fish culture.

In addition, participatory approach should be considered and promoted for the effective management of inland fisheries. This could include the concepts of co-management, community-based fisheries management, and rights-based fisheries as appropriate as well as the Ecosystem Approach to Fisheries (EAF). Where appropriate, such schemes as granting of fishing rights, application of fishery licensing and registration, could also be promoted to replace open access with limited access to fisheries to ensure the effectiveness of the management measures.

Activities that aim to enhance the awareness of fishers and other resource users of the inland water ecosystems should also be undertaken, focusing on the need to conserve and manage the resources, adopt responsible practices. Moreover, efforts should be exerted to enhance the involvement and participation of fishers in community activities related to the resource conservation and management as well as in MCS activities, and ensure the long-term sustainable utilization of the inland fishery resources.

3. UTILIZATION OF FISHERY RESOURCES

Fishing activities, fish utilization and post-harvest technology in the Southeast Asian region are extremely varied. While fishing activities could range from commercial to small-scale and from marine to inland waters, and using modern and traditional capture techniques, fish utilization and post-harvest technology