Ecosystem-based Management of Coral Reef Fisheries

Issue 1: MPA benefits to fisheries

It is crucial to avoid 'overselling' MPAs on the basis that increased catches due to spillover and enhanced recruitment from spawning in the MPA will more than make up for lost fishing grounds, increased effort and higher costs of fishers displaced from the MPA. To date, this assumption has never been proven; and spillover is generally measured as movement of biomass out of an MPA. It is the net difference that makes the true measurement of spillover and has only ever been demonstrated for one species in one location.

Recommendation 1.0

Provide fishing communities with accurate and realistic predictions of MPA benefits; avoid 'overselling' MPAs

Case Study 1.1: Reverting to closures to alleviate overfishing in the Bramble Reef, GBR. (Robertson, J. 1998. Effectiveness of Temporary Reef Closures to Replenish Reef Fish Stocks in the Great Barrier Reef. Session 3: Fisheries and Protected Areas. In: International Tropical Marine Ecosystems Management Symposium (ITMEMS) 1998 Proceedings. 147- 154pp.)

Bramble Reef is a large inner shelf reef in the Central Great Barrier Reef which was closed to bottom fishing in January 1992 in response to the community concerns that the reef was being overfished. Bramble Reef closure was lead by a multi-representative consultative committee – which have helped maintained a sense of ownership and responsibility of closure among the community – which then continues to help in the strategizing in the reopening.

An inter-annual assessment of recruitment variables that results in the increase of fish stocks regionally (which can overshadow the effect of closure) was conducted and was found that in reality, the replenishment or the spillover will take more time to materialize. The true benefit of the Bramble Reef closure only became evident in the last year of closure. However, the continual assessment and monitoring results which was disseminated has educated the community considerably to achieve a consensus in the decision making of the reopening strategy.

Apart from decision making, the recruitment monitoring gave substantial forecasting on the actual potential yield of coral reef fish stocks resulting from the closure. In addition to replenishing the stocks from the closure, the forecast was identified to be also important to allow fishery management agencies to adjust the annual fish catch accordingly.

Case Study 1.2: Marine reserves as a quick fix to fishery replenishment? (Russ, G.R. and A.C. Alcala. 1996. Marine Reserves: Rates and Patterns of Recovery and Decline of Large Predatory Fish. Ecological Applications, 6 (3): 947- 961pp.)

Marine Protected Areas (MPA) or marine reserves serves as the protection of critical spawning stock biomass – to ensure recruitment supply to fished areas via larval dispersal is sustained. In recent years, the use of marine reserves in the management of fisheries in general is advocated as a cost- effective strategy to sustain fish stocks. However, there are very few data on rates at which gains are potentially useful to fisheries may be lost if unregulated fishing occurs in the reserves – be it during the closure or after the reopening.

In this case, two islands of the Philippines were closed: Apo Island (marine reserves established since late 1982) and Sumilon Island (established in December 1974). The study was conducted to assess the density and biomass of large predatory reef fish over the periods of up to 9-11 years at these two islands. The study does suggest a gain in density, particularly biomass – to be potentially useful in fisheries management to occur in reserves on scales of 5-10 years rather than just a few years. But the longer the reserves are closed to fishing; this would also mean that the fishermen would be displaced for a longer term which could result in another complication.

Too often, closures are planned around a short-termed time frame – from the time of closure to the reopening. There should be ample time to allow the recruitment to recover and t o ensure the usefulness of marine reserves as potential sources of recruitment to fished areas. Mean density of large predatory fish provides an excellent indicator of the effects of marine reserve protection, which increases in a linear pattern at approximately similar rates over periods of 10 years in two small Philippine reserves.

Case Study 1.3: No- take marine reserves to increase abundance and biomass. (Williamson, D.H., G.R. Russ and A.M. Ayling. 2004. No-take marine reserves increase abundance and biomass of reef fish on inshore fringing reefs of the Great Barrier Reef. Environmental Conservation 31 (2): 149-159pp.)

To effectively manage the perceived expectations of increased abundance and biomass of targeted fish species in a no-take marine reserve, it is usually the deterring case where there are no adequate studies which have data on this information before the reserve status is implemented. A study was taken place in two islands at the Great Barrier Reef, to collect data that will help in extrapolating whether the management of the zoning of the marine park has been effective. With the scarcity of data on the abundance and size structure of species targeted by fisheries in an area before a reserve status is applied.

The study done in the two marine reserves (Palm Island group and the Whitsunday Island group) was to estimate quantitatively the density and biomass of coral trout, for the 3-4 years before (1983- 1984) and the 12-13 years (1999-2000) after the establishment of the no-take reserves in 1987. In both island groups, the density and biomass of coral trout have significantly increased in the no-take reserves (1999-2000) when compared to those in the pre-protected areas (1983-1984) and fished zones (1999-2000). This suggests that the no-take reserves should be given adequate time (over a decade in this case) and protection to enable the target fish stocks to build up considerably within the marine reserves.

Although the estimates of coral trout abundance in protected zones cannot be concluded to have reached the maximum levels, evidence suggested that duration to full recovery of predatory reef fish biomass may often require several decades or more. Expectations for the no-take reserves to increase the abundance and mean size of targeted fish species should be informed by the awareness that it will eventually be limited by the point of saturation influenced by ecological factors. Key aspects like intra and inter-specific competition, prey availability and niche space – will always play the role that critically governs the population carrying capacity.

Case Study 1.4: Effective management for better MPA results. (White, A.T., R.L. Eisma-Osorio and S.J. Green. 2005. Integrated coastal management and marine protected areas: Complementarity in the Philippines. Ocean and Coastal Management 48: 948-971pp.)

MPA has been established since the 1974 in Philippines on Sumilon Island, Cebu. In stemming the increasing magnitude of destruction to coastal habitat and the decline of fisheries, the establishment of the MPA was expected to enhance fish yields to traditional fishers. The history of MPA in the Philippines has always been managed together with the evolution of its integrated coastal management (ICM). Thus, the increasing number of MPAs being established has demanded for a support base beyond the MPA to also become increasingly apparent.

A main character of a successful MPA project in Philippines is the strong involvement of stakeholder communities and the local government in the planning and enforcing process behind it. However, the MPA in Bohol has demonstrated that strong management does not always guarantee increased coral cover and fish abundance within and around the sanctuary. Fisheries management and the adoption of a more ecosystem- orientated approach to the management of large marine areas is essential to build on the success in the area, with adequate consideration to watershed management issues as well.

Case Study 1.5: Infringement matters in marine reserves. (Little, L.R., A.D.M. Smith, A.D. McDonald, A.E. Punt, B.D. Mapstone, F. Pantus and C.R. Davies. 2005. Effects of size and fragmentation of marine reserves and fisher infringement on the catch and biomass of coral trout, *Plectropomus leopardus*, on the Great Barrier Reef, Australia. Fisheries Management and Ecology, 12: 177-188pp.)

No-take marine reserves often displace fishers and for many cases, uninformed fishers would infringe into the closed reserve in the duration of the closure and reduce fish stocks. Hence, the expectation of the MPA to deliver an increase of fish recruitment would be thwarted with the unscheduled and uncontrolled infringement. Fishing is a crucial activity for many subsistence communities; hence the loss of fishing ground will affect their livelihood, dietary and socio-cultural needs. Due to this cut-off and displacement, most of the fishers are pushed to infringe the marine reserves in order to survive.

A stimulation model of the population dynamics and line fishing exploitation of common coral trout was designed to evaluate the effects of infringement of marine reserves on the Reef Line Fishery of the Great Barrier Reef. Fisher's behavior and the effect of their response are very important factors contributing to the effectiveness of management strategies, which includes the establishment of marine reserves. However, marine reserves size has insignificant effect on biomass and catch when infringement was allowed to occur across the entire closed area.

With the increasing importance of detailed models of fisher dynamics, it can only produce a more realistic evaluation of marine reserves if fishers' behavior and the potential response to the management decision to be incorporated into the stimulation model. Hence it is important to understand the fisher behavior and reactions to the proposed management decision when evaluating alternative management actions.

Case Study 1.6: Weighing the fishermen's needs in an MPA. (Lunn, K.E. and Dearden, P. 2006. Fisher's need in marine protected area zoning: a case study from Thailand. Coastal Management, 34: 183-198pp.)

The Ko Chang Marine National Park (MNP) consists of 47 islands and its residents live primarily on the park's natural resources. It is essentially the home to an extensive local fishing industry, where small-scale fishers were reported to be working on 95% of the park's marine waters. At the same time, the Ko Chang MNP is facing a rapid and increasing tourism development, which is garnering in a substantial income. With the growing interest on ecological and socioeconomic benefits of establishing MPA, Ko Chang became one of the many gazetted marine national parks in Thailand.

The multiple-use zoning has since been recognized as a way to achieve several objectives within a single marine protected areas and helping to ease current and potential conflict among user groups at the same time. However, the zoning plans has resulted in spatial separation of different resources uses that buffer fully 'no-take' and/or 'no- access' areas, prohibiting all fishing activities

within any area of the park. Following such ruling, the park management of Thailand has encountered typical repercussions which include poor compliance to local regulations and mounting conflicts among user groups.

There were only a little investment made by authorities to outline these regulations of closing, hence small- scale- fisheries has continued to operate unmonitored within the MNP area. Even though the tourism in the Ko Chang MNP is rapidly burgeoning, the small scale fishery serves as an important source of market and subsistence income to the local residents.

Although fishers generally have positive comments about the local tourism industry, the local boom in tourism and current activity patterns suggested little overlap between these industries. Surveys of foreign and domestic tourists suggested that the number and diversity of fish on the archipelago's reefs was already an area of minor concern for managers, however still having the potential to spark a conflict between reef fishers and tour operators. The fishers' continued dependence on fishing inside the boundaries of Ko Chang MNP underscores the need for increased monitoring, management and public awareness if the park is to be successfully implemented and reaches its objectives.

Issue 2: Data Needs for MPAs

If necessary, conduct research to determine critical spawning and nursery habitats, connectivity pathways, and resilience of habitats, ecosystems, and livelihoods. Not all fish species will respond in a similar fashion, thus the design of the closure should be particular to accommodate the target species to be replenished.

Recommendation 2.0

Obtain comprehensive biological and biophysical datasets before designing MPA networks or other fisheries management tools

Case Study 2.1: Designing MPAs with fishery data. (Manson, F.J. and D.J. Die. 2001. Incorporating commercial fishery information into the design of marine protected areas. Ocean and Coastal Management 44: 517-530pp.)

In compliance with the program from IUCN to promote the establishment of a global representative system of MPA, the Australian government has committed to expand and establish existing marine reserve system. The main objective of the fishing closure in the northern territory of Australia was to protect the nursery habitats (seagrass beds) and to minimize the catch of small prawns in these shallow areas.

Hence, an analysis of how fishery data and information from trawl fishery could contribute to the process of developing a system of candidate MPAs was conducted in the northern Australia. Referring to the Northern Prawn Foundation (NPF) logbook information, such as its bathymetry dataset and the commercial prawn trawl data; the daily catch of each boat in the fishery data was used to assist in the selection of the criteria for defining the size of the protected areas. When selecting the criteria to define the size of protected areas, the potential impact on the fishery should be understood. Hence the level of impact on the fishing grounds will depend on the extent of each ecosystem that is to be set aside.

However when fishery data are being used as a surrogate for ecosystem classification, the predicted minimum loss of catch during the closure depends much on the definition of the fishing grounds as well as the criteria taken into considerations. It is important to also consider that the spatial distribution of a fishery can change over time, so a decision must be made on whether to use historical or current data in defining a surrogate. But at the same time, the selection of candidate MPAs is also essentially based on the spatial variability of populations by examining their dispersal mechanism. After identification, these areas that act as a source of recruits should be strictly protected.

Thus, how the information is used have very different consequences on the proposals that are likely to be negotiated with fishery managers. There should not be exclusion of the stakeholders' participation, for instance the fishery management agencies; throughout the development of MPAs – even if it is an intermediate phase.

Case Study 2.2: Important components in designing MPAs. (Friedlander, A.M., E.K. Brown, P.L. Jokiel, W.R. Smith and K.S. Rodgers. 2003. Effects of habitat, wave exposure, and marine protected area status on coral reef fish assemblages in the Hawaiian archipelago. Coral Reefs 22: 291- 395pp.)

The relationships between fish assemblages, their associated habitats and the degree of protection from fishing were evaluated in the main Hawaiian Islands. It was understood that an effective MPA design depends on the diversity, quality and areal extent of habitat which will influence coral reef fish distribution, abundance and diversity.

Thus, a program was initiated by Hawaii Coral Reef Assessment and Monitoring Program (CRAMP) to better understand the ecology of Hawaiian coral reefs at spatial and temporal scale – consistent with its resource management. From the survey and sampling in Kauai, Oahu, Molokai, Maui and Hawaii (all with a certain extent of protection), it was found that environmental conditions such as the direction of wave exposure, amount of habitat complexity and level of protection from fishing was proven to be important determinants of reef fishes' assemblages and standing stock.

For instance, Kaneohe Bay at Oahu is a sheltered embayment and has the lowest species richness and diversity compared to all the other types of wave exposure. One of the main causal factors was because it has been subjected to anthropogenic stresses in the past. Higher fish abundance appeared to be influenced by higher rugosity, occurrence of embayment and high level of branching corals. However, the protection from fishing didn't make a difference in terms of number of fishes.

Thus marine reserves do not only rely on its protection level but also in the initial design of its network to increase fish stocks and biomass. This will ensure that the marine reserves networks are including all the species, life stages and ecological linkages. The study has provided managers with a much better idea of how to select and manage reef habitat for maximum benefit to fish populations.

Case Study 2.3: **Growth and habitat use in a shark nursery habitat**. (Duncan, K.M. and K.N. Holland. 2006. Habitat use, growth rates and dispersal patterns of juvenile scalloped hammerhead sharks *Sphyrna lewini* in a nursery habitat. Marine Ecology Progress Series, Vol. 312: 211-221pp.)

The scalloped hammerhead sharks (*Sphyrna lewini)* are large viviparous sharks that utilize nearshore nurseries such as the Kāne'ohe Bay as a birthing ground. To determine the role of nursery areas in the life- history strategy of the hammerhead sharks, the University of Hawaii's Institute of Marine Biology has conducted several studies using the tag and recapture technique. It was revealed that there is a high mortality rate of the juvenile sharks following the peak summer birthing period. An early weight loss of surviving juvenile sharks indicated a case of malnutrition and starvation, probably associated with poorly developed foraging ability, reduced food availability or both. However, it is also possible that the relative paucity of juvenile shark prey within the bay is a recent phenomena caused by anthropogenic alterations to the bay's ecology.

The data from this study also revealed that a significant number of surviving juvenile hammerhead sharks may remain in Kāne'ohe Bay for up to a year, where they will aggregate in deep turbid waters. Although nurseries such as the Kāne'ohe Bay functions to provide crucial protection to young sharks against large marine predators, fishing in the nursery can have negative effects on the biomass of hammerhead populations. The juvenile scalloped hammerheads' which have expanded its head and obligate ram ventilation increases its vulnerability to nearshore activities such as gill nettings. Hence, it is not suffice to just gazette a nursery ground such as the Kāne'ohe Bay but it is also crucial to understand how the growth rate and dispersal patterns of the targeted species will affect the efficacy of the nursery.

Case Study 2.4: Marine **reserves in complementing the homing behavior of grouper.** (Kaunda- Arara, B. and G.A. Rose. 2004. Homing and site fidelity in the greasy grouper Epinephelus tauvina (Serranidae) within a marine protected area in coastal Kenya. Marine Ecology Progress Series, Vol. 277: 245-251pp.)

Groupers are relatively large, long-lived reef fishes of commercial value that has a worldwide distribution in tropical oceans. The sedentary habits, low reproductive rates, with some species migrating to distinct reef sites to form spawning aggregations have facilitated the over-exploitation of this fish population worldwide. In Kenyan fisheries, commercial landings of groupers have declined steadily over the past 2 decades. Hence, the homing ability and the site-fidelity in the greasy grouper (*Epinephelus tauvina*) was conducted at Malindi Marine Park of Kenya to demonstrate whether marine protected areas have been strong conservation potential for these species.

Using acoustic telemetry device to track the movements of the greasy grouper, 67% transplanted groupers homed back to their capture site. The cue to return appears to be particularly related to spring tides and it is likely that these tidal currents could provide both timing and a directional clue to homing groupers. Homing behavior of the groupers may also be influenced by ontogenetic establishment of a home range as fish mature, when spatial learning becomes imprinted in mature groupers.

Hence, marine protected areas will have a strong potential in conserving this fish and complement the homing behavior of the groupers as it protect the home range and its brood stocks from being exploited by fisheries.

Case Study 2.5: Designing marine reserves according to the dispersal behavior of fishes. (Kaundra- Arara, B. and G.A. Rose. 2004. Out- migration of tagged fishes from marine reef National Parks to fisheries in coastal Kenya. Environmental Biology of Fishes, 70: 363- 372pp.)

Marine reserves are popularly perceived to have the potential to conserve fish species and communities through local increases in biomass and diversity. However the effectiveness of reserves in enhancing adjacent fisheries through spillover and in conserving reef fishes may be influenced by species or site differences in fish mobility and habitat structure.

This study that was conducted in the Kenyan waters of the western Indian Ocean quantifies the spillover of several species of commercial reef fishes from two national marine parks into the adjacent fishery. While the Kenyan marine parks receive total protection from extractive exploitation, the areas adjacent to the parks are designated as reserves. It was found that majority of the species tagged (88%) within the parks showed little spillover. There were only 3 commercially important species which had spillover from the parks (*Siganus sutor*, *Leptoscarus mahsena* and *Leptoscarus miniatus*) and the rate differs between parks and reef types.

The results complement the earlier finding that many coral reef fishes are highly sedentary, especially those that comes from patch reefs. The data further suggested that greater spillover is expected along habitats that provided continuity, such as a continuous fringing reef. Although continuous habitats may facilitate the movement of spillover, the rates of spillover are likely to be species and site specific and directional. With this factors coming into play, a marine reserve design must be based on species- specific behavior where the conservation of the species should include a contiguous habitat sufficiently large to span movement ranges.

Additionally, reserves that have seaward boundaries closer to the shore may facilitate greater offshore-onshore dispersal and lateral spillover may be minimal for some species. Hence, if the objective of the marine reserve is to enhance the fish stocks through spillover- the design of the marine reserve should revolve around the habitat, reef types and movement patterns of the targeted fish species.

Issue 3: MPAs vs alternative management practices

Other methods of restricting catch and/or effort are valuable which do not displace fishers, and may allow fewer conflicts between fishers and other reef resource users. Western approaches to fisheries management should be adequately addressed in the addition to MPAs.

Recommendation 3.0

Incorporate a range of fishery management tools and avoid reliance on MPAs only

Case Study 3.1: Perceptions of fishers determine compliance. (McClanahan, T.R., J. Maina and J. Davies. 2005. Perceptions of resource users and managers towards fisheries management options in Kenyan coral reefs. Fisheries Management and Ecology, 12 : 105-112pp.)

For an ethnically diverse nation like Kenya, its fisheries management is likely to be complicated with multi-species fisheries, numerous types of gear and different levels of governance. Such management will usually cause confusion and conflict, poor enforcement and unsustainable use of resources – as long as the multiple types of possible management are not fully understood and rationalized. For this purpose, the perceptions of managers and resource users associated with the management of Kenya's near-shore fisheries were explored with the focus on closed areas and gear restrictions.

Firstly the national government policy tries to increase fish catch and regulate fisheries through national laws and institutions has somehow undermined the effectiveness of traditional fishing regulated by customs. Due to this, it has led to few enforced restrictions and conflicts between national and traditional leaders. In an interview which involved a total of 232 fishermen, they were asked to scale the benefits of closed areas and gear-managed areas. There was a possibility that fishers from the interviews are not aware of these closed area effects but only seeing it as a benefit only to tourism which at the same time restricts their access to the resources.

However, there was a general agreement among groups on gears discouraged by both government and traditional fisheries leaders- only with minor discrepancies with the gears banned by the government. For example, spear guns which are banned, is popular with young fishers who lack money to purchase and maintain boats and these fishers are those likely to be slow to adapt to the current fishery laws. Despite good correspondence between managers and resource users on gear restrictions, there are poor compliance with the current gear used and good compliance with closed-area legislation and management. This may suggest that factors other than the degree of correspondence in shared perceptions are important for successful management.

Case Study 3.2: Relying on more than just MPA. (Baelde, P. 2005. Interactions between the implementation of marine protected areas and right- based fisheries management in Australia. Fisheries Management and Ecology, 12: 9- 18pp.)

The creation of MPA can cause several repercussions to a coastal community where its livelihood depends majorly in fisheries. In Australia, it has caused a myriad of confusion and controversy between government conservation and fishery agencies, the fishery industry and NGO. Although there is no doubt that there's a need for an MPA network to address the issue of fishery stock depletion and fleet overcapacity, the design of MPA should be adequately backed up by an effective resource allocation plans as according to ecosystem factors that affects local fish populations.

Fishery management agencies in Australia had carried out a major collaborative project to assess the performance of individual fisheries with respect to ecologically sustainable development objectives. However, cooperation between conservation and fisheries agencies is difficult to achieve despite its importance. Problems arise when both parties needs to negotiate their share of additional fishery enforcement costs generated by MPAs.

The precautionary principle is relevant in fisheries management but precise interpretations and operational framework are rarely formulated. This is a principle where the threats and risks which have been evaluated are treated as knowledge and information increase. However, this form of ecosystem approach in MPAs generates some disagreement among fishery scientist over the type and amount of research needed. Some believe that more research is warranted to better understand ecological dispersal, trophic interactions and the identification of critical habitat. But some of them remain skeptical, bearing little confidence that it will help in the short term setting of fisheries regulations.

Case Study 3.3: Effectiveness of combination fishery effort and selectivity. (Gobert, B., P. Berthou, E. Lopez, P. Lespagnol, M.D.O. Turcios, C. Macabiau and P. Portillo. 2005. Early stages of snapper-grouper exploitations in the Caribbean (Bay Islands, Honduras). Fisheries Research 73: 159-169pp.)

Sometimes known as "snapper-grouper complex", Lutjanidae and Serranidae are keystone coral reef species that are heavily exploited by artisanal or industrial fisheries in the Caribbean. This species are exploited by industrial or semi-industrial line fisheries, small-scale fishery with non-selective gears and small-scale fisheries using selective gears. The early or intermediate stages of snapper- grouper exploitation had not been described and analyzed with detailed catch and effort data. In addition to that, there has not been any significant public policy of fishery development or management for the local fishery which has been operating without any regulations.

Two main exploitation patterns are observed in the Bays Islands fishery in the coast of Honduras; where a powerful artisanal fleet fishes on a variety of banks to supply an export market with high-valued fishes was used in Utila. In Roatan and Guanaja, largely non-mechanized fleets close to shore on island shelves are used. This fishery pattern utilized handlines and spearguns to catch snappers and groupers for local consumption, but fishing pressure is high because of small selection sizes.

The Bays Islands fishery demonstrated that even though snappers and groupers are the only target of the finfish fisheries – it still yields a higher value of relative production compared to other reef fisheries in the Caribbean. This could be related to moderate fishing pressure and appropriate combinations of fishing effort and selectivity. However, this may not be a long term situation as Bays Islands fishery has also progressively broadens its species range depending at the expense of the most vulnerable large-sized species, and moved towards less selective gears.

Case Study 3.4: A conceptual framework to simplify the complexity of reef system. (Mangi, S.C., C.M. Roberts and L.D. Rodwell. 2006. Reef fisheries management in Kenya: Preliminary approach using the driver- pressure-state-impacts-response (DPSIR) scheme of indicators. Ocean and Coastal Management, doi: 10.1016/j.ocecoaman.2006.003)

Coral reefs are known to have a complex system with interrelated processes between the physical, chemical and biological components. Although the scientific community is mostly working on detailed and narrow aspects of a coral reef system, managers only require a holistic approach not necessarily at a very high level of detail in their management. Hence, a multi-disciplinary approaches to coral reef research and resource management is needed. Management practices need to look to an ecosystem approach that recognizes the interdependence of species and the need to understand the interacting social and political structures in the reef environment.

The efforts to understand the interdependencies have improved in linking the changes in the environment to the social and economic drivers and political response through socio-economic indicators. The driver-pressure-state-impacts-response (DPSIR) model is a conceptual framework that embraces the process and indicator linkages of the environmental functions. It has simplified environmental problems and solutions into variables that stress the cause and effect relationships between human activities that exert pressures on the environment and the society's response to the condition.

In this DPSIR study conducted in Kenya; the drivers, pressures, state, impacts and response indicators for evaluating overfishing and use of destructive fishing methods are proposed, based on the practice of reef fisheries management in Kenya. The detailed reviews shows that reef fisheries in Kenya should consider increasing the network of marine parks to include a substantial portion of the reef system as a non-fishing area. The network parks would function as the reserve for recruitment of fish to reach a larger size before they are caught. Gear exchange should also be pursued through providing credit facilities for fishers to purchase authorized gear and compensation for owners of gears that have been declared illegal.

These are just but a few of the results of the framework where DPSIR has worked well at simplifying the complexity of reef fisheries management and serves to inform policy makers, scientists and general public on the relevance of indicators to monitor changes in the status of coral reef, assessing trends in socio-economic pressures and appraising the effectiveness of fisheries management efforts in addressing these issues. All this is important in facilitating the

measurement of key indicators of governance performance, especially those focusing on outcomes rather than on processes in evaluating the effectiveness of the fishery management programs.

Issue 4: MPA monitoring

The information on fishing activity and community perceptions following the reopening of a temporary closure of a coral reef (for fish stock replenishment) is important for changes in resource allocation. Replenishment closures can be very effective but it's important to assess inter-annual recruitment variability that results in increased fish stocks regionally and can overshadow any effect of closure.

Recommendation 4.0

Conduct annual underwater monitoring of fish stocks to detect inter-annual change in fish stocks

Case Study 4.1: The accuracy in assumption. (Russ, G.R., B. Stockwell, A.C. Alcala. 2005. Inferring versus measuring rates of recovery in no-take marine reserves. Marine Ecology Progress Series, Vol. 292: 1-12pp.)

To answer the question of whether the rates of biomass recovery of fished species can be inferred reliably from once-only spatial comparisons of no- take marine reserves of different ages and fished areas- a study was conducted at 15 no-take reserves and 14 adjacent control (fished) sites in the central Philippines. The estimates of density and size structure of all species of Serranidae (Epinephelinae), Lutjanidae and Letthrinidae were made by underwater visual census (UVC) once in these monitored areas between June 2002 and April 2003. In the census, the habitat complexity was also monitored aside from just the estimates of fish biomass.

A comparison of site-specific predicted and observed rugosity estimates at the different monitoring sites is needed to be done as a correction factor to prevent underestimation of rugosity between the reserves. The study has proven that useful inferences can be made about rates of recovery in no-take marine reserves of different ages from once-only spatial comparisons of reserves and fished sites.

The increase in habitat complexity with duration of reserve protection does not indicate in the particular study's spatial comparison data; that the longer a site is protected, the better the habitat becomes. This is because its temporal monitoring found that habitat complexity did not co-vary with fish biomass- which was inferred to increase significantly in the reserves but stay relatively stable in the fished sites.

From this study, it was proven that one can make useful and reliable inferences about rates of recovery in no-take marine reserves from once-only spatial comparisons of reserve and fished sites. It also suggest that longer-lived target species is, the more circumspect one should be in making conclusions about rates of recovery from once-only spatial comparisons of reserves and fished sites. Hence, temporal monitoring studies are very important in predicting the rates of development in fish stocks in the marine reserves.

Case Study 4.2: Dispersal of target fishes and its conservation zones. (Holland, K.N., C.G. Lowe, B.M. Wetherbee. 1996. Movements and dispersal patterns of blue trevally (Caranx melampygus) in a fisheries conservation zone. Fisheries Research 25: 279-292pp.)

The coastal jacks or trevally family (Carangidae) are frequently heavily exploited as a component of subsistence, commercial fisheries and also a primary target species for sport fishing. Concerns are being raised about the need to address the protection for this species; however the complexity of tropical and sub-tropical fish assemblages presents challenges in the conservation and management of these resources. Hence, a major factor that is influencing the effectiveness of conservation zones is the rate of movement of fishes out of the protected area into unprotected areas.

In this study conducted on the patch reef surrounding the Coconut Island in Kaneohe Bay, Hawaii – the short and long-term movement patterns of blue trevally were monitored using a combination of sonic tracking and tag-and-release techniques. The tracked fishes displayed well-defined home ranges and predictable diel movements between separate daytime and nighttime sections of the home range. The limited range of the recaptured blue trevallies and the strong site fidelity displayed by the tracked fishes suggests that the dispersal of fish is much less than might have been predicted for a highly mobile, piscivorous fish – spending most of the time of their lives within the confines of the Coconut Island conservation zone.

This result has indicated a positive implication for the effectiveness of this harvest refugia for the blue trevally as the rate of transfer if fish across the refuge boundary plays an important role to the models that estimates the refuge effectiveness. The effectiveness continues to increase if the species becomes sexually mature under the protection of the refugia and proves that even small fisheries conservation zones could be an effective management option for increasing the spawning biomass of this species.

Issue 5: Local communites involvement

Recommendation 5.0

Engagement and the education of the local fishing communities to enhance the compliance and effectiveness of the fishery management

Case Study 5.1: Local fishery community participation – a people power revolution. (Alcala, A.C. and G.C. Russ. 2006. No-take Marine Reserves and Reef Fisheries Management in the Philippines: A New People Power Revolution. Ambio Vol. 35 (5): 245-254pp.)

Philippines have started its marine conservation and reef fisheries management program at Sumilon and Apo Islands since the 1970. These reserves have produced good evidence that no-take reserves managed by the local communities play a key role in biodiversity conservation and fisheries management. No-take reserves in the Philippines saw an expansion in the past 2 decades due to the major shift in national policy to devolve management responsibility to the local governments and communities.

An issue that was critically considered in all phases of the Philippines' MPAs and no-take reserves implementation was the influence of social and political context. In the establishment of the Selinog no-take reserve, one of the first steps in the process was placement into the community of trained community facilitators to begin the process of social preparation, community organization, marine- conservation and education programs. Through the training, local fishing communities are empowered with the given opportunity to have some say on how the marine resources that they depended on should be managed.

The experiences and knowledge of the Apo Islanders has played a pivotal role in convincing other local fishing communities of the efficacy of no-take reserves of the Selinog Island. The process of establishing this reserve took just over 1 year compared with 2 to 4 years to convince the local fishing communities on Sumilon and Apo Islands to accept the reserve concept.

A major lesson learned here is that one must initially devolve decision-making power down from centralized government control to local control. This is essentially to permit adequate participation and empowerment of coastal communities, yet at the same time it still poses as an implementation challenge to address problems on a national scale. The devolution of management responsibility back to the people who depended upon those resources the most has eventually benefitted the coastal fishing communities in Philippines.