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Marine spatial planning for fisheries management and biodiversity conservation: More to be done

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Original Article

Abstract

Depletion of fishery resources and degradation of marine biodiversity are attributed to two main reasons, *i.e.*, overfishing and threats from intensified land-based human activities. Marine spatial planning (MSP) can be an important tool to mitigate the above-referred threats thereby conserving the fishery resources and biodiversity. Marine spatial planning is a typical ecosystem approach that can properly demarcate marine resources spatially and temporally to a variety of human activities, and meet multiple economic, social and ecological objectives. Marine Protected Areas (MPAs) are basic components in MSP for biodiversity conservation and fishery sustainability. Two case studies show how MSP can harmonize multiple uses of marine areas concerned and avoid conflicts; however for protection of some migratory species small or isolated natural reserves are not enough. In order to form a complete ecological system for marine biodiversity conservation and fisheries management, MSP needs to be combined with other planning instruments such as spatial planning of coastal zones and pollution control planning of river basins. Furthermore, spatial and temporal landscape ecology should be addressed in MSP to accommodate the "fisheries *refugia*" requirements. To this end regional and international cooperation are indispensable, and more researches should be conducted to better understand background status of ecosystem and fishery resources, and relevant management capability in the region concerned.

Keywords: *marine spatial planning; marine protected area; fisheries management; spatial planning of coastal zone; biodiversity conservation.*

Introduction

Depletion of marine fishery resources has drawn much attention from relevant sectors in the world. Research projects conducted in the east Asian seas show that marine fishery resources have degraded in this area in the last few decades (COBSEA, 2009). For example, fish catches from four traditional fishing grounds of China, *i.e.*, Bohai Sea, Zhoushan, South China Sea Coast and Beibu Gulf have significantly decreased since the 1990s; in the Pearl River Estuary, one of the most productive areas of South China Sea Coast fishing ground, current fish catch is only one tenth of that in the 1990s. In Thailand, fish catches from the Gulf of Thailand are well above the estimated maximum sustainable yields (MSYs). Catch rates (catch per unit effort, or CPUE, kg/hr) in the 2000s from Thai waters were only 7% of the corresponding levels in the early 1960s (UNEP/GEF, 2007).

Overfishing and intensified land-based activities are two main contributory factors that have led to the depletion of marine fishery resources. Overfishing has been ascribed to three factors. Firstly and most importantly, access to the resources is uncontrolled. The second important factor is the use of new or improved fishing technologies. Besides greatly increasing fish catch, these new technologies result in the capture of large quantities of juvenile or trash fish that are not targets, thus reducing the fishery resources. The third factor is the increased capacity for fishing, using vessels with higher tonnage or horsepower. For instance, the total fishing capacity of vessels in East China Sea in the 1990s was 7.6% more than in the 1960s; in China, the size of the fishing fleet was greatly increased, the number of steel vessels with more than 600 horsepower engines shown a 77% increase since 1997 through 2005 (UNDP/GEF, 2005).

Impacts of land-based activities are also three-fold. The first one is coastal development, particularly land reclamation that in many cases has directly caused fish habitat loss. Related to this is the industrialization and urbanization of coastal areas, which has led to the generation of large amounts of pollutants and waste which are mostly discharged into the sea. The third source is the intense anthropogenic inland activities which exert pressure on the sea through rivers that carry increasing pollutant loads, often greater than direct discharges. The pollutants mix with seawater and move everywhere in the sea, causing deterioration of the marine environment. One of the key problems nowadays is eutrophication of coastal waters caused by increased nutrient discharge from land-based sources. Even Brunei, with a coastline less than 200 kilometers, had to warn people twice within 6 months not to take poisoned fish due to the sustained red tide in 2013.

In this paper, by case study and discussion, the author tries to demonstrate that marine spatial planning (MSP), combined with other planning and management instruments, can be an important tool to mitigate the above-referred threats thereby conserving the fishery resources and biodiversity, and what are to be done for better application of MSP.

MSP: An ecosystem approach and its important roles

Marine spatial planning is a management tool that can be employed to spatially and temporally demarcate marine resource areas to different activities and provide a basis for sustainable use of marine resources (UNESCO, 2009; UNEP, 2011). Effective management is needed to address overfishing and causes of land-based anthropogenic activities resulting in damage to the marine ecosystem. However, effective management should start from planning.

As an ecosystem approach, the key component of marine special planning requires identification of the major objectives of marine resource utilization/conservation and conflicts among these objectives. These include identification of biologically and ecologically important areas, as this is the basic information required for demarcation of marine space so as to incorporate biodiversity objectives into planning and decision-making; identification of conflicts between human activities and nature, and the potential ways to reduce these conflicts so as to establish the context for planning networks of marine protected areas (MPAs); and identification of cumulative effects of human activities on marine ecosystem so as to seek solutions both spatially and temporally through this planning. In this way, marine spatial planning can help to balance ecological, economic and social objectives when utilizing marine areas.

Identification of marine areas with special ecological significance is essential for biodiversity conservation and fishery resource management. These areas with special ecological importance are usually ecologically valuable and/or vulnerable areas, such as, areas of high biodiversity, areas of high endemism, areas of high productivity, spawning areas, nursery areas, migration corridors and stop-over points, and important fishing grounds.

The areas identified with special ecological significance can be then translated into MPAs for fisheries management and biodiversity conservation in marine spatial planning. These MPAs may be designated for various functional areas such as fishery closure areas including seasonal closures, no trawl areas, critical habitat designations, offshore aquaculture areas, marine reserves/no-take areas.

The role of MSP is shown in Fig. 1. By allocating certain areas as natural MPAs for fishery resources and biodiversity conservation based on the ecosystem method, marine spatial planning can create a protective barrier between human activities and critical areas that contribute to fishery sustainability and biodiversity conservation. This barrier must be protective against all fishing efforts – it is a solid red line to all fishing efforts; however access to some other environment-friendly human activities, such as scientific research and education, inspection of MPAs, and limited tourism and regulated use by local communities may be permitted. In the latter cases, MSP creates a fence with limited entrances like a dotted-line in the figure, and meanwhile, negative impact on the MPAs such as pollution due to above-mentioned activities must be strictly controlled by regulations.

The ecosystem principles demand that selected marine protected areas for fishery resources management and biodiversity conservation should be interrelated to each other as much as possible. In other words, each MPA should not be isolated but related to each other to some extent biologically, as shown in Fig. 1. Protected areas for spawning grounds, juvenile fish nurseries and valued and endangered species protection directly benefit fishery resources conservation. These should be supported by other protected areas for critical habitats, such as mangrove forests, sea grass beds, coral reefs, and islands with special value of biodiversity. The elements for fishery resources and biodiversity conservation in the whole marine spatial planning should contribute to an interrelated and complete ecosystem.

Integrated management: other necessary planning instruments

Successful biodiversity conservation and fisheries management still need support of other planning instruments. As seen in Fig.1, marine spatial planning can create a barrier between MPAs and human activities in the sea, but MSP alone is not able

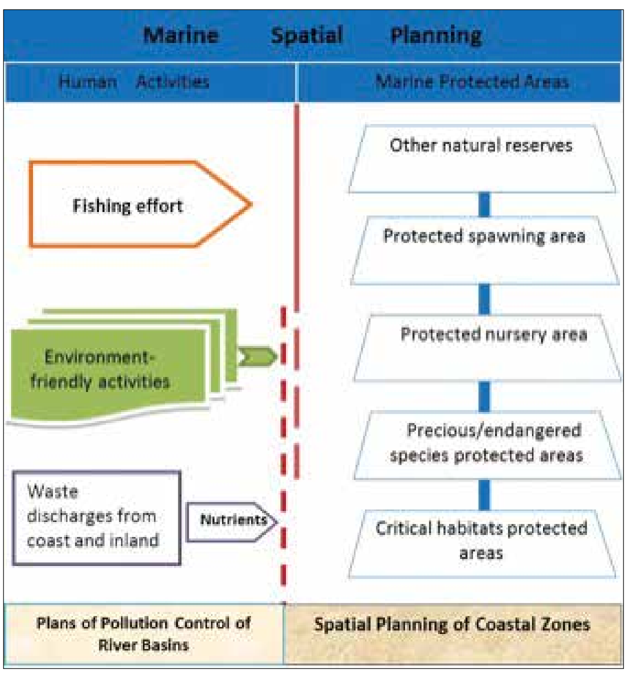

Fig. 1. Marine protected areas ensured by combined planning instruments.

to form a complete barrier. The barrier formed by MSP still has openings because it cannot stop human activities on land that may affect marine environment, such as pollution. Therefore spatial planning of coastal zones (SPCZ) and plans of river pollution control are needed to form another part of the barrier from the other end to create an integrated fence system. First of all, human activities in the coastal zone must be harmonized by SPCZ (UNEP/Sida/COBSEA, 2011). As with other ecosystem - based planning and management tools, firstly, spatial planning of coastal zones will demarcate the coastline into protected coastlines and development coastlines. To match the results given by MSP, SPCZ should include the coastlines with critical habitats, such as mangrove forests, coastal wetlands and sea grass beds on the shore or in the near shore waters, in protected coastlines, and ensure they are not occupied by ports, land reclamations etc. Secondly, spatial planning of coastal zones should help maintain water quality standards set for marine protected areas in both near shore and offshore environments. This can be achieved by integrating land use for industries and urban development in line with ecosystem requirements and by reducing the pollutant load into the sea (Guo, 2013). In addition, as seen in Fig. 1, pollution from inland activities through rivers must be controlled by implementing plans for pollution control in river basins; otherwise, water quality requirements for many marine protected areas cannot be met. Up to this end, MPAs can be ensured by the barrier jointly created by MSP, SPCZ and plans for pollution control in river basins. Similarly, the barrier created by the latter can be a fence with some entrances that may provide access for environment-friendly activities and allow necessary nutrient flow into the sea. From the above points of view, marine spatial planning is the end part of an integrated planning and management "from mountains to the sea". In China, this "unitized plan with waters and land" is legislatively supported by Marine Spatial Function Zoning, Environment Function Zoning of Coastal Waters, spatial planning of coastal zones, Pollution Control Planning of Coastal Waters, Water Quality Planning of River Basins, etc. These planning instruments operated by government administrations in charge of marine and environment management at different levels provide an integrated management framework for marine biodiversity conservation and sustainable fisheries.

Cases: Experience and lessons

Case 1: Daya Bay natural reserve of fishery resources

Daya Bay, established as a natural reserve in 1983, is located in the north of South China Sea near Hong Kong. It is an important natural reserve of fish resources with spawning grounds, sub-tropical coral reefs, sea turtles and very high biodiversity. However, for various reasons, its coastal zone was selected as the site for a large oil refinery in 1994. Consequently, downstream chemical industries and urbanization increased drastically in the area. Increasing demand for land has led to large-scale land reclamation along the coast and caused significant loss of habitats. Faced with the confliction between development and ecological resource protection, the government tried hard to reduce interference caused by development on the natural reserve by firmly maintaining the legislative status of the natural reserve. A variety of measures were taken to balance objectives of ecosystem conservation and development. For instance, the government requires that all development projects which have a bearing on the natural reserve be subjected to marine environmental impact assessment. It is forbidden for waterways to pass through core areas of the natural reserve, and wastewater from land-based sources must be discharged outside the natural reserve through long sea outfalls. In the meantime, engineering measures, like introducing fish fingerlings, have been taken to offset biological loss due to land reclamation and waterway construction. In recent years, four large artificial reefs have been constructed covering 35 km^2; 28,000 corals were replanted with a survival rate of 95.2%. Fish catch in the 1980s was between $11.1\text{-}18.1\times10^3$ tonnes in this bay with an area of 600 km^2, this declined later due to development in the coastal area in the 1990s, but have being recovering since 2004 due to continuous remedial efforts (Song *et al.*, 2012). This example is a good case of applying ecosystem principles of MSP discussed above. Balance between ecosystem conservation and other utilizations of marine resources is achieved not only by demarcating spatial resource in the marine area but also integrated management including habitat reconstruction. Marine Spatial Function Zoning and Environment Function Zoning of Coastal Waters have provided strong support to the integrated management.

Case 2: Guangxi Hepu national dugong natural reserve

Prior to the 1970s dugongs were fished, and they almost disappeared from the Guangxi coastal waters. In order to protect this endangered species, Guangxi Hepu Dugong Natural Reserve was established in 1986. This natural reserve is one of the demonstration sites for sea grass beds established in 2003 under the UNEP/GEF project "Reversing Environmental Degradation Trend in the South China Sea and Gulf of Thailand". Great efforts have been made to maintain this natural reserve which includes regulation, organizations, manpower and facilities. However, no dugong has been sighted since 1997.

The absence of a continuous and extensive sea grass habitat, which is a shortcoming of Hepu natural reserve, could be a factor contributing to the absence of dugongs, in spite of creating the natural reserve. Lessons should be learned from this case. Firstly, the requirements of landscape ecology must be taken into account in the establishment of marine protected areas and natural reserves. "*Ecological corridors*" have to be designated in some areas. Secondly, marine protected areas are usually small, while quantitative requirements for space may change with seasons and climate due to migration of some species like dugongs. This means that the general ecosystem principles of marine spatial planning must be applied to creation of MPA framework.

Discussion

For successful fisheries management and biodiversity conservation in a sea, the ecosystem and fishery resources in the sea must be fully understood so as to facilitate marine spatial planning for this sea. Taking the east Asian seas as an example, though some studies have been conducted to investigate ecological and fishery status in the east Asian seas, relevant data are scattered in the literature. It is impossible to draw a complete picture showing the current distribution of fishery resources and their relationship with the ecosystem, based on existing data. Obviously, in order to conserve biodiversity and fishery resources in the sea, background information on ecosystem and fisheries is the first need in marine spatial planning, particularly as an ecosystem approach. Therefore, more research should be initiated to collect the required background data. Based on these data, contour maps may be drawn, showing the current distribution of real fish stock, relative fish stock, *i.e.*, the ratio of existing fish stock to original natural fish stock, or the ratio of fish catch to maximum sustainable yields, etc. These contour maps would show where and to what extent over-fishing happened and is happening. Furthermore, based on the data gathered, it could be possible to identify the areas with special ecological significance for marine biodiversity conservation and sustainable fishery in this sea. This would form the basic framework of regional marine spatial planning.

It is also clear that the larger the area to which marine spatial planning is applied to, the more accurate would be the results as this would entail connections between larger marine ecosystems. Thus marine spatial planning for biodiversity conservation and fisheries management appears to be a trans-boundary issue needing regional and international cooperation. That is also why more research should be initiated to investigate the background status of fishery resources and ecosystems in the whole concerned sea as recommended previously.

Regional or international cooperation on marine spatial planning for biodiversity conservation and fishery management requires similar level of governance capability among partners. This aspect requires investigations on fishery legislations, and an examination of the capability for monitoring, control and surveillance in countries in the concerned region. This investigation will identify gaps in fishery legislation and management capability amongst the countries. Objectives can then be set for different countries for fisheries management capacity building since, for instance, weak surveillance may not be able to guarantee compliance of MSP.

Conclusion

Demarcating marine protected areas through marine spatial planning can play a key role in fishery resources and biodiversity conservation. From the planning point of view, more can be done jointly with marine spatial planning, such as the complementary Spatial Planning of Coastal Zones and river basin environmental planning to ensure requirements of marine protected areas. In addition, requirements of spatial and temporal landscape ecology should be better addressed through the ecosystem approach for marine spatial planning so as to accommodate the "fisheries *refugia*" requirements (Paterson *et al*., 2012). This will, in many cases, call for regional and international cooperation. To this point it is recommended that more research be conducted to investigate background information on ecosystem and fishery status, as well as management capability in the region that MSP is to be applied.

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