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Integration of Science and Coastal Management: a Case Study of Hong Kong

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Integration of Science and Coastal Management: a Case Study of Hong Kong

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Abstract

Coastal management practices, regulatory decision-making, and land use planning activities along coastal areas have historically been made with insufficient scientific information concerning the dynamic environment. The idea of integration of science and coastal management has risen rapidly in both environmental science and public environmental policy since the mid-1990s, and encouraged innovative relationships between scientists and practitioners in a range of contexts.

In this paper, based on materials analysis, we explore the existing practices, evaluating past successes and failures in the management of coastal areas in Hong Kong. Though this case study we examine the challenges Hong Kong faces presently, illustrate the strong need for integrating science and coastal management. This is also the first step towards building a comprehensive indicator system of measuring how integration can contribute to better coastal management.

Keywords: Integration, Coastal management, Science, Hong Kong

1. Introduction

Coastal zones are vital in both ecological and socioeconomic terms. Almost half of the world's population lives within 150 km of a coastline (Cohen, Small, Mellinger, Gallup and Sachs, 1997) and the percentage is expected to increase in coming decades because of continued rapid population growth and migration to coastal areas (World Bank, 1996). Yet, these coastal regions encompass less than 20 percent of the inhabitable land space. High population growth combined with increasing poverty in some regions and increased consumption in others has led to large-scale deterioration of coastal environments and conflicts in many areas of the world.

Coastal Management initiatives spread all over the world to cope with declining coastal conditions and intensifying user conflicts to achieve sustainable development of coastal resources and coastal environment. Policies and actions should be guided by appropriate understanding of marine ecosystem processes and their interaction with various natural and human influences. Science has long been given extraordinary stature in environmental deliberations and it has undeniably become "the yardstick against which other forms of inquiry are judged and to which they are supposed to aspire" (Fuller, 2002). As new and more reliable information becomes available, our knowledge of these system is refined and, ideally, results in better decisions and actions. Therefore, environmental policy and management actions should be supported by adequate and reliable scientific information. Environmental monitoring and related scientific undertakings, on the other hand, should be aimed at providing necessary information, in a timely manner, to support coastal and environmental management.

Despite widespread recognition of the needs outlined in the previous paragraph, the relationship between coastal science and coastal management is far from linear mostly because of a lack of comprehension between coastal scientists and end-users (James, 2000; Lamberti and Zanutigh, 2005). And many management decisions continue to be made without scientific input (Sarewitz and Pielke, 2007). Clearly, a disconnect remains at the intersection between science and decision-making, i.e., between the information and knowledge produced by scientists and the information and knowledge applied by decision-makers. There are many reasons why scientific information and knowledge is not always used in environmental policy and management (Tribbia and Moser, 2008). Besides scientists and researchers are mainly focus on publishing their results in professional journals, they have little incentive to deliver information to non-scientists. Many do not engage in research with the underlying purpose to communicate findings to anyone outside their area of expertise (e.g., Kyvik, 2005; Willems, 2003). Scientists do also usually think that their information and knowledge is reliable and useful enough and not need to check in reality (e.g., Sarewitz and Pielke, 2007; Morse, 2005; Jacobs, Garfin, Lemart, 2005). On the other hand, time constraints, the non-familiar, technical jargon can form hurdles for decision-makers and non-experts to overcome (e.g., Dabelko, 2005). In order to deal with the science-practice disconnection, more and better information is needed and many researchers have suggested that certain intermediary organization – the so-called boundary organizations- should be established (e.g., Mitchell, Clark, Cash, Dichson, 2006; Cash et al., 2003, 2006; Guston, 2001; Gieryn, 1999; Daft, 1989). Such boundary organizations "involve the participation of actors from both sides of the boundary, as well as professional who serve a mediating role in the coproduction of knowledge that can be used by multiple audiences" (Guston, 2001, p.401). Boundary organizations have the overall dual purpose of protecting but also transcending the divide between science and practice. To do so they perform four critical functions, which help manage and maintain the relationship between information producers and users (Cash et al., 2003). They are convening, translation, collaboration and mediation functions.

The paper is composed of four parts. First, an introduction to science based coastal management. Second a description of the geography and human impacts of Hong Kong. The third section describes the coastal management mode of Hong Kong. Finally, the fourth part relates to a general overview where disscusion and conclusion highlight both the potential solutions for the coastal management and the role of science on coastal management.

2 Study area

2.1 Geography of Hong Kong

Hong Kong is located on the southeastern coast of China and has a total sea area of about 1,650 square kilometers, which forms about 60% of the total area of Hong Kong, and has its indented coastline about 800 kilometers long. The Pearl River Estuary lies to the west of Hong Kong, with eastern areas being exposed to the South China Sea (Figure 1).

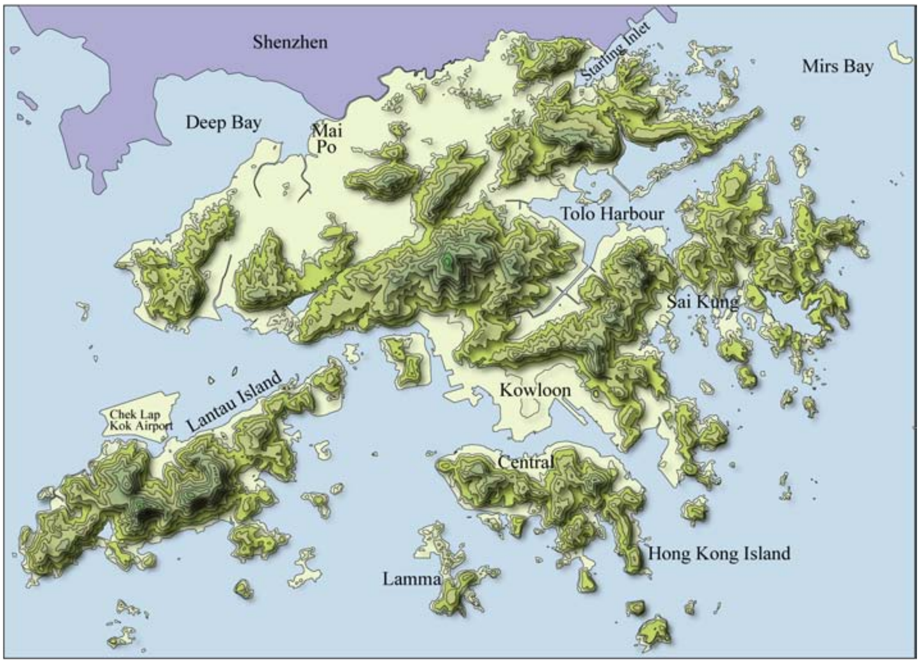

Figure 1 The marine environment of Hong Kong (Owen and Shaw, 2008)

Geographically, Hong Kong is situated just south of the Tropic of Cancer. The climate is predominantly subtropical. Temperatures can drop below 10 degrees Celsius in winter and often exceed 31 degrees Celsius in summer. About 90 percent of the rainfall occurs between April and September. The seasonal climate is influenced by two monsoons: the southwesterly monsoon results in warm wet summers, and the northeasterly monsoon brings cool dry winters.

The distribution and diversity of Hong Kong marine life are mainly attributed to the hydrography of Hong Kong, which is influenced by several ocean currents and by the Pearl River discharge. In summer, the Hainan current brings warm, highly saline surface water from the South China Sea (around Hainan Island) to Hong Kong, whereas in winter this is replaced by the Kuroshio Current, which brings highly saline temperate water from the Pacific Ocean. In addition, the winter northeast monsoon pushes the Taiwan Current past Hong Kong from Taiwan, bringing with it moderate temperature low salinity water from the East China Sea.

By contrast, the western Hong Kong waters are heavily affected by the freshwater discharge from the Pearl River, especially in the summer rainy season. This freshwater dilutes the salinity of western waters and introduces high sediment loads and turbid conditions. The river water is introduced as a surface plume that floats over more dense saline oceanic water, and progressively reduces its impact around the southern seas of Hong Kong.

About 40 percent of Hong Kong's total land area is committed to conservation and recreation, protected within 24 country parks and 17 special areas, providing an invaluable 'green belt' popular with hikers, nature lovers and tourists. There are also four marine parks and one marine reserve, occupying a total area of about 2,500 hectares. They comprise scenic coastal areas, seascapes and important biological habitats.

2.2 Human impacts

Development potential of the Coastal land can be classified into rural type developments and urban type developments. The former concentrate in the New Territories, whereas the latter are identified mainly along the coast of the Kowloon Peninsula, the northern coast of the Hong Kong Island, and the waterfront of the developed New Towns.

Rural development in Hong Kong includes fish culture and village development. Marine fish farming is an important commercial practical in Hong Kong. But its location in eutrophic coastal wasters often faces the threat of severe dissolved oxygen depletion associated with algal blooms and red tides. On the other hand, it also contributes to pollution and runs into direct conflict with public activities via coastal development projects such as reclamation, dredging, dumping of marine spoils, extraction of sand and the use of coastal resources for purpose like water recreation, fairways and typhoon shelters. Figure 2 shows the location of existing fish culture zones.

Hong Kong in the earlier days depended very much on fishing and farming. Thus, the traditional villages usually occupy a coastal location with the village houses clustered together the backdrop. Large piece of farm land located in front of the villages and extended to the edge of the beach/ coast.

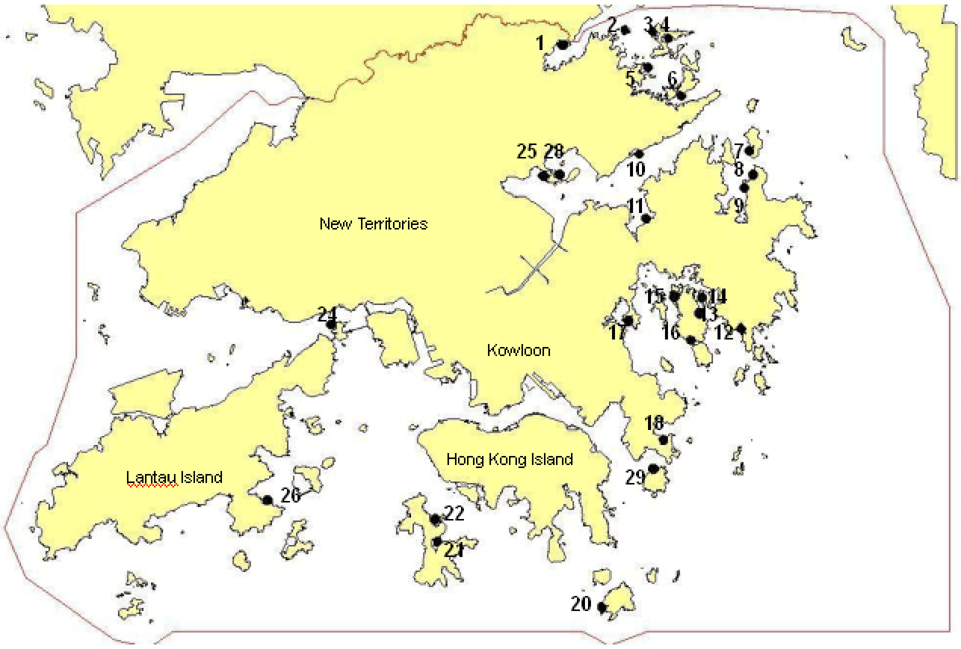

Figure 2 The fish culture zones (AFCD, 2009)

Reclamation is the major activities for urban development. The earliest reclamations of land from the sea in Hong Kong were of the extensive tidal flats that fringed the bays and estuaries in the New Territories. Their primary purpose was to increase the area of agriculture land. Reclamation at Sha Tau Kok, Nam Chung, Luk Keng, Shuen Wan, Yuen Long were accomplished by erecting bamboo stake fences, along which banks of mud were constructed. Landwards marine mud was desalinated by fresh waters controlled by ditches and sluices. Reclamations along the shores of Kowloon and Hong Kong Island have been incremental. However, increasingly large projects, such as the West Kowloon Reclamation and the shrinkage of Victoria Harbour, have increased public concern that a great natural asset is slowly being lost (Figure 3). Other reclamations including the Shatin, Tuen Mun and Chek Lap Kok reclamations are also significant and coastal reclamations have converted a total of 67 km^2 of the sea into land since 1887 (Owen and Shaw, 2008).

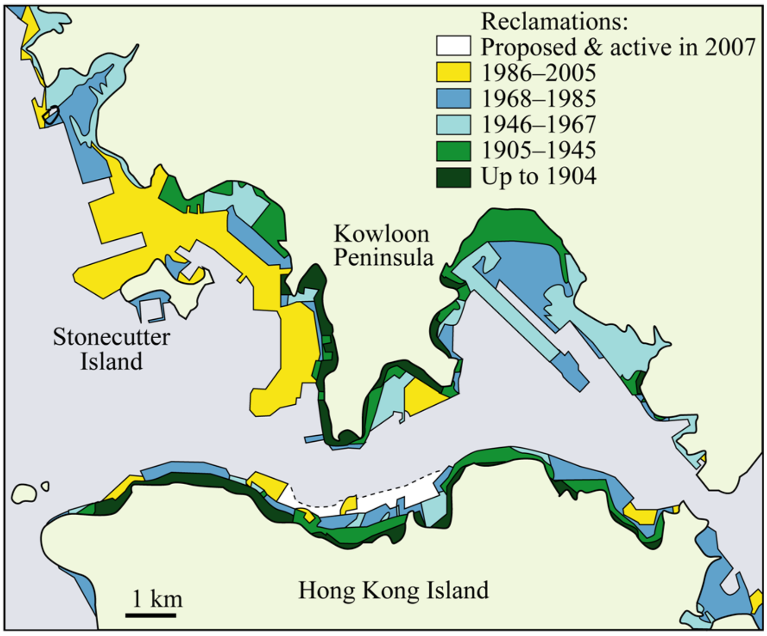

Figure 3 Kowloon reclamations (Owen and Shaw, 2008)

3 Profile of coastal management in Hong Kong

3.1 Existing control and management of the coast

The existence, adequacy and effectiveness of legislation are important in order to determine if the goals and objectives of coastal management are supported by a clear and enforceable legal basis. As Hong Kong is a special economic zone, it enjoys executive, legislative and independent judicial power, including that of final adjudication, in accordance with provisions of the Basic Law, which was enacted by the National People's Congress in accordance with the Constitution of the People's Republic of China.

In Hong Kong, coastal conservation and management is being carried out indirectly by different authorities under a number of Ordinances and Regulations. Table 1 is a summary of the related measures.

Table 1 Summary of Legislative Coastal Development Control and Conservation Measures

Type of measures	Related Ordinance	Responsible Agents	Remarks
Development Control	Town Planning Ordinance	Planning Department	Control land use of area covered by statutory plans
	Country Park Ordinance	Agriculture, Fisheries and Conservation Department	Control land use within country park and provides management
	Building Ordinance	Building Department	Regulates and controls the plans of built structure

Environmental Protection & Conservation	Marine Parks and Marine Reserves Regulation	Agriculture, Fisheries and Conservation Department	Control human activity within marine park and reserves and provides management
	Shipping and Port Control Ordinance	Marine department	Inspect vessels and oil installation and clean up any oil spills that occur in Hong Kong water
	Waste Disposal Ordinance	Environmental Protection Department	Management for the collection and disposal of Hong Kong's waste
	Water Pollution Control Ordinance	Environmental Protection Department	Controls discharge into Water Control Zone
Fisheries	Fisheries Protection Ordinance	Agriculture, Fisheries and Conservation Department	Regulate fishing practices and prevent activities detrimental to the fishing industry
	Marine Fish Culture Ordinance	Agriculture, Fisheries and Conservation Department	Regulate and protect marine fish culture

Control over development may also be achieved by means of some administrative instruments such as special control areas and lease conditions. The following table illustrates the major types of administrative control.

Table 2 Summary of Administrative Coastal Development Control Measures

Control Measures	**Responsible Departments**	**Remarks**
Lease Conditions and Moratorium on Development	Lands Department	Control land use and development intensity
Department Plans including Layout Plan and Outline Development Plan	Planning Department	Monitor and advise developments within the boundary of these plans
Designation of Sites of Special Scientific Interest (SSSI)	Agriculture, Fisheries and Conservation Department & Planning Department	Control development within SSSIs

Although the formation of these legislative and administrative control measures are intended to achieve better control and management of the coast, they are far from satisfactory and effective. And they have some inadequacies or loopholes.

3.1.1 Unclear responsibilities and sectoral based decision making

Decision on development proposals at the coastal areas are subject to control by a number of authorities and management agencies. Coastal protection, planning and management in Hong Kong suffer from centuries of uncoordinated decisions and actions at both the Territorial and District level. Sometimes several agencies are vested with the responsibility related to the same type of activity, but there is no clear framework for them to cooperate. For example, management of beaches is under the control of either Regional Council or Urban council, however monitoring of the water quality of the beaches falls under EPD's responsibility. Such poor cooperation among agencies leads to conflicting responsibilities, of which only sectoral based decision making could be accomplished.

3.1.2 Lack of system thinking and comprehension planning

System thinking provides scientists and managers with a mechanism to help understand the causes and effects in systems and to identify the core problems and refine management goals. It further enables scientists and managers to 'predict' the possible consequences of management actions to achieve these goals. System thinking also brings in factors outside the immediate topic, and can force recognition of different viewpoints (Bosch, Ross and Beeton, 2003).

Currently, there is an absence of any territorial strategic planning perspective for the coastal zone. In talking about strategic planning in Hong Kong, it seems relevant to refer to the Territorial Development Strategy (TDS) Review. The only relevant pages of TDS which mentioned about coastal management issues is the section on Marine Water Quality in the Environmental Baseline Condition published in July 1993. However, instead of providing a territorial guidance on coastal planning, the section only summarizes the existing control marine water quality by means of Water Control Zone. Neither advocating to the protection of marine area with merit conservation value, nor discussion on the adequacy of existing planning over the coast, is being touched upon by the TDS Review. At the district planning level, there is also a lack of planning regime which spans the whole of the coastal area. This may result in uses which are conflicting in nature but are being put adjacent to each other.

The existing fragmented planning and management activities are found to be inadequate and would induce lots of problems. It is because many coastal problems such as water pollution caused by land activities and has a cumulated effect, and that the piecemeal approach could not resolve the problem but passed it along the coast. A direct result is that almost every year Hong Kong beaches are affected by red tide, and the red tides usually spread from beaches to beaches.

3.1.3 Lack of adaptive approach

Natural systems are complex, and their management takes place against a dynamic background where change is continuous and unpredictable. The adaptive management approach has become a useful alternative to deal with such systems. Walter and Holling (1990) explain adaptive management as treating management strategies and policies as experiments that are conducted to learn more about the ecosystem's processes and structures. The results are then used to refine the strategies and policies over time. Adaptive managers therefore have the combined roles of defining desired realities, generating options and applying measurements that allow adjustments to be made to the management strategy.

The adaptive management process provides opportunities for 'learning-by-doing'. Such learning reveals how ecosystems respond, what the managers are doing, which strategies are successful and whose interests are served (Lee, 1999). Thus, Hong Kong should consider this ways as a cost-effective approach to deal with the complex coastal management issues.

3.2 Applying management-related science and technology

Several universities and research institutions are located in Hong Kong, which can assist in integrating science into coastal management (Table 3). Science plays an important role in coastal management. The mode of Hong Kong scientific support system can be shown as figure 4.

Table 3 Some research and institutions in the area with related research activities

Name of Institutions	**Area of Specialization**
The University of Hong Kong	Coastal ecology and physiology; Toxicology and bioremediation; management and conservation of marine resources
City University of Hong Kong	Coastal pollution and conservation; Environmental Diagnosis and Molecular Mechanisms; Ecosystem Studies; Impact and Risk Assessments; Mitigation, Control and Bioremediation Technologies
The Hong Kong University of Science & Technology	Marine Benthic Ecology; Marine Plankton Ecology; Marine Microbial Ecology; Marine Ecotoxicology & Pollution; Environmental Chemistry

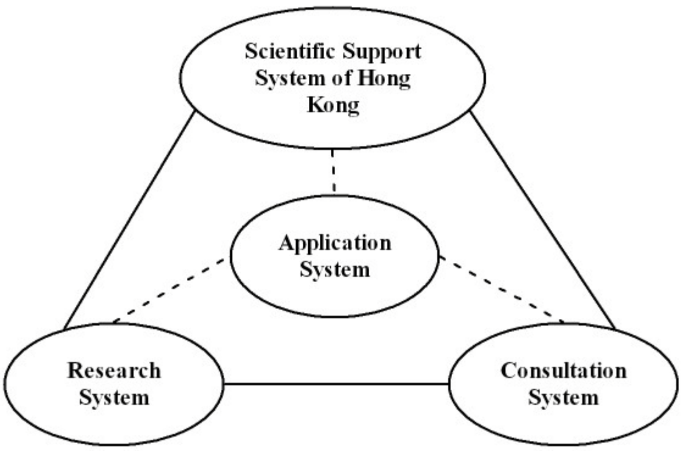

Figure 4 The Hong Kong scientific support system (adapted from Hong and Xue, 2006)

3.2.1 Consultation System

Consultation system not only can input the scientific information which makes actions in a more reasonable manner, but also make stakeholders involved the decision-making process. Since stakeholders (managers and other parties) also benefit or suffer differently from environmental actions and problems, there is equal as well as an efficiency way in having them all contributing their knowledge towards finding solutions. Failing to involve stakeholders make it possible that designing proposals that will not work for all, suffers lack of support for implementing a solution, and also excludes information that could be highly useful in reaching good decisions. Hong Kong has consultation platforms for different utilities and purposes. Such as, The Country and Marine Parks Board acts an advisory body to the Country and Marine Parks Authority. The Board consists of delegates from government agencies, academic institutions or universities and other stakeholder bodies. The Board operates functionally and holds meetings as required. There also have public consultations for every plan to collect the community views on the major issues, visions, aspirations and suggestions.

3.2.2 Research System

As mentioned above, there exist many universities and institutions in Hong Kong contributing to the scientific input for coastal management. Efforts are constantly being made in various applied sciences and environmental fields to strengthen the role of science in the sustainable management of the environment and resources of Hong Kong.

As the biomarkers are becoming increasingly popular for the environmental assessment of persistent organic pollutants (POPs) and other toxic contaminants. A US$1.1 million study was commissioned by the Environmental Protection Department of Hong Kong SAR, in 2001-2003 to develop a Biological Indicator System for Monitoring Marine Pollution monitoring in Hong Kong. The study recommended that the EPD to implement a bioindicator monitoring programme in conjunction with other water quality monitoring programmes to enhance the effectiveness of water quality management. A suite of 13 bioindicators were found to be useful. In 2004, EPD initiated a bioindicator monitoring programme. It includes nine bioindicators which are monitored once a year. Four indicators on biological community are monitored once every three years commencing in 2006 (PEMSEA, 2007).

Taking into account the environmental conditions and spatial gradients in pollution levels, the Hong Kong waters were divided into six zones. Field sampling was carried out in each of the six zones, i.e. Deep Bay (Zone 1), Western Waters (Zone 2), Tolo Harbour & Inner Mirs Bay (Zone 3), Port Shelter & Outer Mirs Bay (Zone 4), Southern Waters (Zone 5) and Victoria Harbour & Junk Bay (Zone 6).

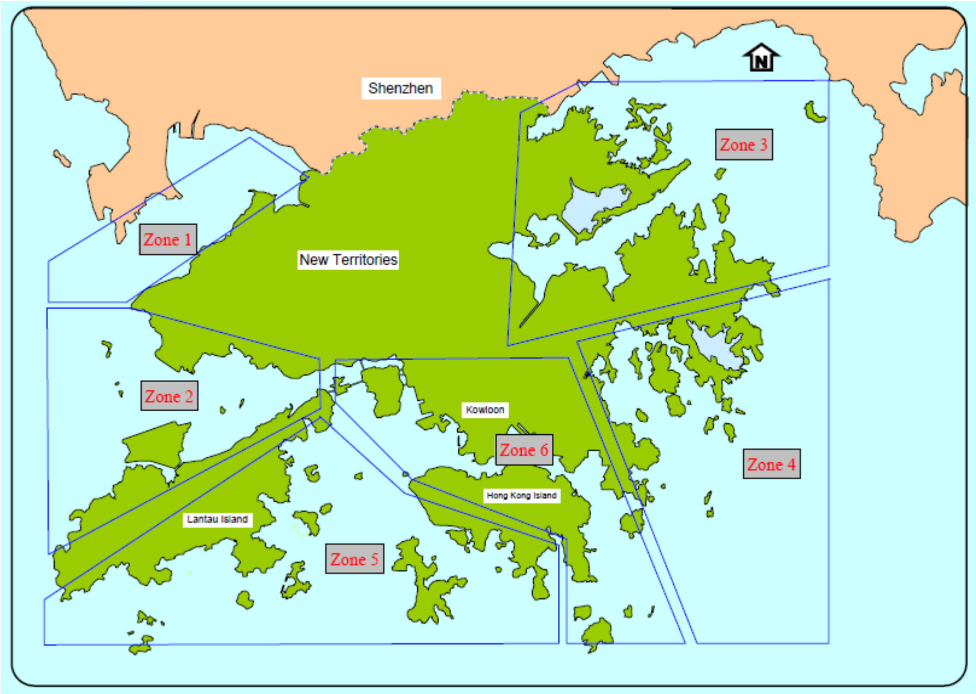

Figure 5 Six zones of bioindicator monitoring in Hong Kong waters (EPD, 2009)

Environmental risk assessment (ERA) is a tool to objectively determine the likelihood that contaminant release (or processes), either past, current or future, pose an unacceptable risk to human health or the environment. Risk-based approaches provide support to decision-makers in assessing potential impacts of various actions based on the weight of scientific evidence. Applications in Hong Kong include assessing risks associated with seafood safety, contaminated mud on dolphins, bridge construction over oyster farms, and harmful algal booms. It is applied not only to individual projects, but also to strategic policy and proposals, making it a valuable tool in the move towards a more sustainable path of development. Such as the most recent case of Hong Kong-Zhuhai-Macao Bridge was approved by some conditions when consider the construction impacts on marine park and Chinese white dolphins.

Another essential tool for environmental and resource management is the estimation of environmental or ecological carrying capacity (ECC). ECC is the ability of an ecosystem or environment to accommodate a certain activity without unacceptable impact. Estimation of ECC requires a clear definition of the problem, site conditions and water quality objectives and the use of hydrodynamic and water quality models. Carrying capacity (e.g., allowable organic and nutrient loading) was estimated and applied in formulating a sewage management strategy for the Hong Kong Harbour, which was severely contaminated by untreated sewage. The Harbour Area Treatment Scheme (HATS) is one of the most significant environmental infrastructure programs ever pursued in Hong Kong, costing US$27.7 million in the first two of its four stages. Carrying capacity was also estimated in a marine fish culture zone in Hong Kong to assess proper siting of fish farms and control stock density.

In the management of pollution from land-based sources, various treatment systems for wastewater and contaminated sediments are available. Conventional technologies can involve large capital investments, high operating costs, and skilled technical support, which mean that they are usually unaffordable for small coastal areas. Taking this into consideration, two alternative treatment technologies that are simple and flexible, easy to operate, cost-effective, natural and environment-friendly (no secondary pollution problems) and applicable to local conditions have been developed and applied in Hong Kong. The first one uses a constructed mangrove wetland for secondary treatment of municipal/domestic and nutrient-rich sewage, with the possibility for treatment of strong industrial sewage and remediation of toxic pollutants, such as polycyclic aromatic hydrocarbons (PAHs). Mangroves have high tolerance to nutrients and pollutants and wetlands can be constructed where wastewater is produced. The system has the advantage of low energy requirements, simple technology, easy maintenance and associated aesthetic and ecological values. The second method involves the use of algal biosorbents made from microalgal cells (produced from municipal sewage) immobilized as algal alginate beads for removal of metals and tributyltin (TBT) and removal and degradation of POPs, such as PAH, from industrial waste.

To tackle regional environmental issues, Hong Kong has been co-operating with the Mainland authorities in Guangdong Province through the Joint Working Group on Sustainable Development and Environmental Protection. The two governments have drawn up a Regional Air Quality Management Plan that aims to jointly reduce the four major air pollutant emissions by 20 percent to 55 percent by 2010, taking 1997 as the base year. A review of the management plan was completed in December 2007 and both sides are pressing ahead with the measures necessary in order to achieve the emission reduction targets. Since November 2005, a regional air quality monitoring network (with 16 monitoring stations covering the entire Pearl River Delta) has provided a daily public report known as the Regional Air Quality Index. In addition, the Environmental Protection Department (EPD), in collaboration with the Guangdong authorities and major industry associations in Hong Kong, launched a Cleaner Production Partnership Programme in April 2008. This five-year programme will provide technical support to Hong Kong-owned factories in the Pearl River Delta region to facilitate the adoption of cleaner production technologies and practices. Meanwhile, Hong Kong and neighboring Shenzhen are jointly implementing action programmes to reduce pollution of the adjoining water bodies, including Deep Bay and Mirs Bay. The EPD and the Shenzhen Environmental Protection Bureau also entered into agreements to strengthen co-operation on environmental protection and promote cleaner production, in December 2007 and November 2008 respectively.

3.2.3 Application System

Application system should be based on collaborative learning between scientists and managers. It means that the interaction between scientists and managers through the process will determine the effective of application system. Bosch et al. (2003) argue that science and management can be linked more effectively through the creation of collaborative learning environments, and better information management (Figure 6). So after scoping goals and objectives of management practices, we should access relevant data, information and knowledge, and then shared understanding of the information among stakeholders including scientists, managers, policy makers and finally, implementation and monitoring and evaluation of the actions.

By taking environmental management of marine fish culture in Hong Kong as an example, sound mariculture management based on scientific decision support tools is vital for the sustainable development of fish farming. To effectively management the mariculture activities, it is desirable to determine the carrying capacity of a prospective or existing site for a fish farm. The carrying capacity is strongly related to the hydrodynamic characteristics of the water body of interest (Lee, 2003). So water quality model and three-dimensional (3D) hydrodynamic modeling are needed to use. The general methodology can possibly be applied to the environmental management of mariculture in other sub-tropical coastal wasters. However, the most important thing is to improve the end-to-end process of knowledge co-production and application by enabling scientists and decision-makers to increase mutual understanding of capacities and needs while remaining within their respective professional boundaries.

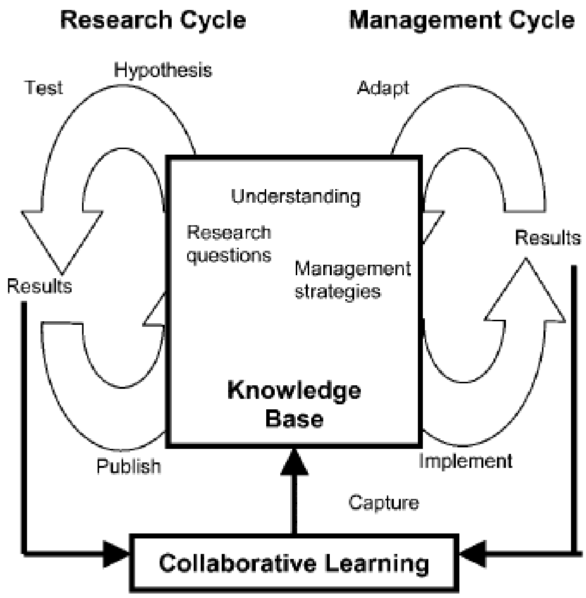

Figure 6 Linking research and management through collaborative learning and an integrated knowledge base (Bosch et al., 2003)

4 Disscusion and conclusion

Through analysis the coastal management model and the application of science in coastal management in Hong Kong, we can get the following findings:

(1) Existing marine ordinances and measures in Hong Kong are almost individual status and there is no integrated marine law.

(2) The government agencies in Hong Kong play important roles in the development of laws and regulations and the supervision of their enforcement. The department annual report is a good way to improve the performance. However, as eloquently stated at the 1992 United Nations Conference on Environmental and Development, achieving sustainable development of oceans and coasts will require new management approaches, that are “integrated in content and anticipatory in ambit” (UNCED, 1992). Hong Kong need to consider the activities of one sector on other sectors and on the

environment, to find new ways of resolving conflicts in multiple-actor and multiple-jurisdiction situations.

(3) The involvement of academic leaders, NGOs and other stakeholders in the coastal management process is a key to the success and smooth process of any coastal management initiatives. Hong Kong takes great efforts on the involvement of stakeholders in the process of coastal management. However, more attention should be paid on the public understanding of science.

(4) To address the complexity and unpredictability of coastal environmental and resource management, Hong Kong should consider the integrated and adaptive management approaches. Adaptive management generally requires that scientists participate in the management process on a more intimate and frequent basis than is comfortable and in roles that are nontraditional.

More researches particularly extensive interview and survey research, are needed to address these concerns. Undoubtedly, as more experience is gained using science in coastal management, new ideas for further improvements will emerge. As for building the indicators of measuring the integration of science and coastal management, we need to go deepen and do more researches to figure it out.

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References

AFCD (Agriculture, Fisheries and Conservation Department), The Government of Hong Kong Special Administrative Region, 2009. *Agriculture, Fisheries and Conservation Department Report 2003-2005*. Accessed on 27 December 2009 from http://www.afcd.gov.hk/misc/download/annualreport2005/text/eng/appendices/5.htm

Bosch, O. J. H, Ross, A. H and Beeton R. J. S, 2003. Integrating science and management through collaborative learning and better information management. *Systems Research and Behavioral Science 20,* 107-118.

Cash, D. W., Borck, J. C., Patt, A. G., 2006. Countering the loading dock approach to linking science and decision making: comparative analysis of El Nino/Southern Oscillation (ENSO) forecasting systems. *Science Technology Human Values 31*(4), 465–494.

Cash, D. W., Clark, W. C., Alcock, F., Dickson, N. M., Eckley, N., Guston, D. H., Jager, J., Mitchell, R. B., 2003. Knowledge systems for sustainable development. *Proceedings of the National Academy of Sciences 100*, 8086–8091.

Cohen, J. E., Small, C., Mellinger, A., Gallup, J. and Sachs, J., 1997. Letter: Estimates of Coastal Populations. *Science 278*: 1209-1213.

Dabelko, G., 2005. Speaking their language: how to communicate better with policymakers and opinion shapers – and why academics should bother in the first place. *International Environmental Agreements: Politics, Law and Economics 15*(4), 381–386.

Daft, R. L., 1989. *Organizational Theory and Design* (3rd ed.). St. Paul, MN: West Publishing Co.

EPD (Environmental Protection Department), the Government of Hong Kong Special Administrative Region, 2009. *Six zones of bioindicator monitoring in Hong Kong waters*. Accessed on 30 December 2009 from http://www.epd.gov.hk/epd/english/environmentinhk/water/marine_quality/files/zones_eng.pdf.

Fuller, S., 2002. Governing Science: A reply to critics. *Futures 34*, 457-464.

Gieryn, T. F., 1999. *Cultural Boundaries of Science: Credibility on the Line.* Chicago, IL: University of Chicago Press.

Guston, D. H., 2001. Boundary organizations in environmental policy and science: an introduction. *Science Technology Human Values 26*(4), 399–408.

Hong, H., Xue, X., 2006. *A review of integrated coastal management in Xiamen over the past decade.* Xiamen, P.R. China: Xiamen University Press.

Jacobs, K., Garfin, G., Lemart, M., 2005. More than just talk: connecting science and decisionmaking. *Environment 47*(9), 6–21.

James, R. J., 2000. From beaches to beach environments: linking the ecology, human-use and management of beaches in Australia. *Ocean and Coastal Management* 43, 495-514.

Kyvik, S., 2005. Popular science publishing and contributions to public discourse among university faculty. *Science Communication 26*(3), 288–311.

Lamberti, A., Zanuttigh, B., 2005. An integrated approach to beach management in Lido di Dante, Italy. *Estuarine, Coastal and Shelf Science 62*, 441-51.

Lee, K. N., 1999. Appraising adaptive management. *Conservation Ecology 3*(2):3.

Mitchell, R., Clark, W. C., Cash, D. W., Dickson, N. M. (Eds.), 2006. Global Environmental Assessments: Information and Influence. Cambridge, MA: The MIT Press.

Moser, S. C., 2005. Impact assessments and policy responses to sea-level rise in three

US states: an exploration of human-dimension uncertainties. *Global Environmental Change 15*(4), 353–369.

National Research Council (NRC), 1995. *Science, Policy and the Coast*. Washington, DC: National Academy Press.

Owen, B. and Shaw, R., 2008. *Hong Kong Landscapes Shaping the Barren Rock.* Hong Kong: Hong Kong University Press.

PEMSEA (Partnership in Environmental Management for the Seas of East Asia), 2007. Special EAS Congress 2006 Issue No.2. *Tropical Coasts* 14 (1).

Sarewitz, D., Pielke Jr., R. A., 2007. The neglected heart of science policy: reconciling supply and demand for science. *Environmental Science & Policy 10*, 5-16.

Tribbia, J., Moser, S.C., 2008. More than information: what coastal managers need to plan for climate change. *Environmental science & Policy* Ⅱ (2008), 315-328.

UNESCO, 2006. *A handbook for Measuring the Progress and Outcomes of Integrated Coastal and Ocean Management*. IOC Manuals and Guides, 46; ICAM Dossier, 2. Pairs: UNESCO.

Walters, C. J., Holling, C. S., 1990. Large scale management experiments and learning by doing. *Ecology 71*: 2060-2068.

Willems, J., 2003. Bringing down the barriers: public communication should be part of common scientific practice. *Nature 422*, 470.

World Bank, 1996. Guidelines for Integrated Coastal Zone Management. J. Post and C. Lundin (Eds.). Environmentally Sustainable Development Studies and Monographs Series No. 9..Washington, DC: The World Bank.