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# REBUILDING HONG KONG'S MARINE FISHERIES:
## AN EVALUATION OF MANAGEMENT OPTIONS

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**Fisheries Centre, University of British Columbia, Canada**

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Ussif Rashid Sumaila, William W. L. Cheung and Louise Teh

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*A Research Report from the Fisheries Economics Research Unit, Fisheries Centre, UBC*



FISHERIES CENTRE RESEARCH REPORTS ARE ABSTRACTED IN THE FAO AQUATIC SCIENCES AND FISHERIES ABSTRACTS (ASFA)

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## DIRECTOR'S FOREWORD

Fisheries scientists are not the only ones who know that world fisheries are in crisis. Most fishers experience it daily, via diminished catches, catches consisting of lower value species, and reduced incomes and profit. Many fishers therefore, especially among the young, would consider alternative land-based jobs. Unfortunately, most interventions in the fisheries sector, by governments and non-governmental organizations alike, are geared toward maintaining the *status quo* and do not address the issue of reducing fishing effort by encouraging fishers to consider land-based alternatives. These observations also apply to Hong Kong, a Special Administrative Region (SAR) of the People's Republic of China.

This two-part study of the Hong Kong fisheries sector is one of the few which squarely address the issue of effort reduction through retraining of fishers. In the first part, it identifies the number of fishers willing to switch to land-based jobs and the expectations of potential employers, including some in the marine sector. In the second part, it identifies "the potential economic gain (loss) to fishers and to society (Hong Kong as a whole) due to the implementation of different management scenarios".

The different management scenarios that are investigated here were formulated using the *Ecopath with Ecosim* software, which is now routinely used for such purposes in various parts of the world. It allowed quantifying the cost and benefits of different strategies for reducing the number of active fishers based in the Hong Kong SAR. The benefits predominate, but they can be obtained only if the Hong Kong government implements a long-term strategy. If it does so, it is likely that the ecosystem will recover from its presently depleted state and that the remaining fishers will have higher incomes. These results are not surprising, but they always need to be restated. This is, here, nicely done for the marine fisheries of Hong Kong.

**Daniel Pauly**
*Director, Fisheries Centre, UBC*
April 2007

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# EXECUTIVE SUMMARY

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Hong Kong's fisheries are primarily concentrated in the waters of Hong Kong, the Pearl River Estuary and the adjacent continental shelf in the South and East China Seas. In 2005, there were an estimated 4,150 fishing vessels and 9,200 fishers in the Hong Kong fishing industry (www.afcd.gov.hk). Fishing fleets landed approximately 29,000 tonnes of fish from Hong Kong waters, contributing HK$ 552 million in landed value (AFCD Port Survey 2001/02, unpublished data).

Fisheries in Hong Kong have undergone dramatic changes over the past five decades. Just after the Second World War, most Hong Kong fishers fished in Hong Kong and along the coast of south China with sail-driven junks. Catches of predatory fishes such as groupers, snappers and yellow croakers were abundant. Since the 1950s, with financial and technical assistance from the Hong Kong government, fisheries in the country have rapidly become mechanized. As a result, fishing effort increased dramatically and fishing power of bottom trawlers, in particular, increased a lot. Without proper fisheries management and limits on fishing effort, signs of over-exploitation of fisheries resources in Hong Kong waters became evident in the 1970s. Fisheries production was maintained by exploring new fishing grounds, further increases in fishing effort, and exploiting smaller and fast-growing species that could withstand higher fishing pressure. A scientific assessment in the 1990s, commissioned by the Hong Kong government and conducted partly by the Fisheries Centre, University of British Columbia, showed that the majority (12 out of the 17 species studied) of local commercial fish stocks was largely over-exploited. Most of the large food fish that once made up the major catches in Hong Kong waters were almost extirpated commercially. The Hong Kong marine ecosystem became dominated by juvenile fishes, and by species with high turn-over rates, such as small fishes and invertebrates.

In view of the over-exploitation of local fisheries resources, the scientific assessment in the 1990s recommended a number of fisheries management and restoration measures. These included: (i) establishing a fisheries licensing system; (ii) limiting new entrants into the fishery; (iii) establishing protected areas for nursery and spawning grounds (i.e., Fisheries Protection Areas); (iv) enhancing and restoring habitat; and (v) engaging in fish restocking trials. In particular, setting up a licensing system and designating marine protected areas were deemed as high priorities by the UBC research team. So far, recommendations to enhance habitats have been implemented through the deployment of artificial reefs, and small-scale fish restocking trials have been conducted. However, benefits of these measures for restoring local fisheries resources have yet to be empirically demonstrated.

In 2004, to implement the remaining recommendations from the scientific assessment, the Hong Kong government (Agriculture, Fisheries and Conservation Department) proposed the establishmentof a fishing license scheme, designation of Fisheries Protecton Areas (FPA) in Port Shelter and Tolo Harbour and Channel (including Long Harbour) (Figure 1), and a seasonal fishing moratorium (from June through July). With the aims of facilitating effective management and restoration of local fisheries resources, WWF Hong Kong proposed amendments to the government initiatives. These amendments included additional conditions to the fishing license scheme to ensure proper reporting of catches by fishers, and designation of no-take FPAs instead of the government proposal that offered only partial protection.

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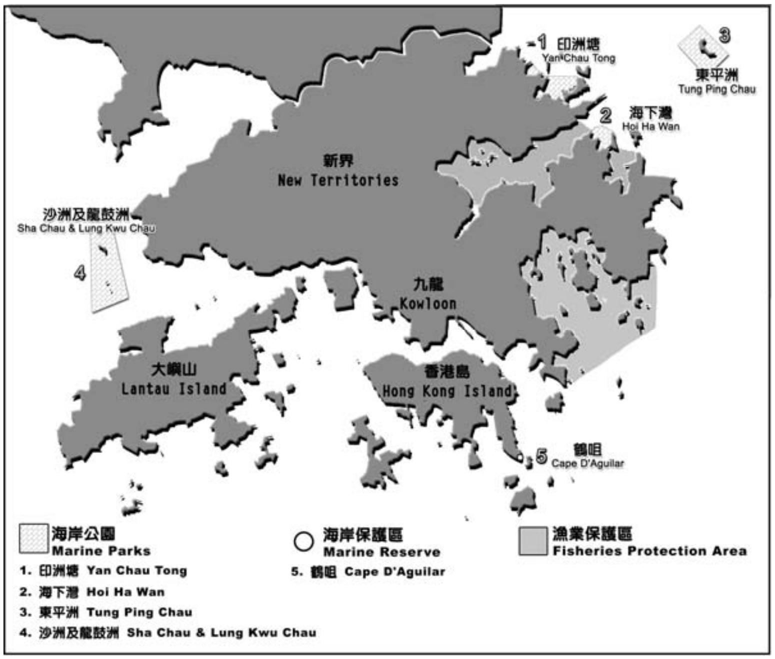


**Figure 1**. Map showing the existing marine parks and reserve, and the proposed Fisheries Protection Areas (FPAs) in Hong Kong.

The potential for these intiatives to lead to short-term negative socio-economic consequences for fishers is considered one of the key barriers preventing management action. Therefore, to properly and effectively implement these proposals, an understanding of the following are necessary: 1) the effects of these initiatives on fishing communities and Hong Kong society; and 2) fishers' willingness and ability to adapt to and accept these changes. This study is especially pertinent because it identifies, for the first time, the key socio-economic impacts, benefits and costs to fishers and wider communities from implementing the various management options.

In particular, the objectives of this study are to: (1) examine the economic and social consequences of implementing three possible fisheries management scenarios in Hong Kong; (2) evaluate the feasibility of creating alternative livelihoods under those scenarios; and (3) evaluate the economic consequences of successful implementation of the alternative livelihoods. Thus, findings from this study will provide critical information to the government of Hong Kong, non-governmental organizations, the private sector, and other stakeholders for examining the social and economic implications of different management plans for rebuilding Hong Kong's marine fisheries, and illuminating the way forward.

This study identified the management scenarios to be analyzed. This is crucial because these scenarios form the basis for the analysis of alternative livelihood strategies and the analysis of fisheries impacts presented in this report. The management scenarios we identified are:

***Scenario 1***

*Status quo*: Continuation of the fisheries and marine park management regimes in place in 2005:

• 4 marine parks (Hoi Ha Wan Marine Park, Yan Chau Tong Marine Park, Sha Chau and Lung Kwu Chau Marine Park, and Tung Ping Chau Marine Park) where trawling is prohibited and fishing with other methods is allowed with licenses;
• 1 marine reserve (Cape D'Aguilar Marine Reserve) where no fishing is allowed;
Chek Lap Kok Marine Exclusion Zone where no fishing is allowed ;
• Artificial reefs deployed in the Hoi Ha Wan Marine Park, Yan Chau Tong Marine Park, Sha Chau and Lung Kwu Chau Marine Park, Chek Lap Kok Marine Exclusion Zone, Outer Port Shelter and Long Harbour;
• Fishing effort is not regulated in areas other than the above.

***Scenario 2***

*Government initiatives*: Introduction of the three amendments to the Fisheries Protection Ordinance proposed by the HK SAR government, with timelines and framework as indicated by the HK SAR government in March 2006. This is in addition to the marine park management regime in place in 2005 (Scenario 1):

Scenario 2a:
Trawls are banned from fishing within Fisheries Protection Areas (FPAs) (Port Shelter, Tolo Harbour and Channel, and Long Harbour); all other fishing gears are allowed to fish in the FPAs, except where artificial reefs have been deployed; Recreational fishing is not regulated;
Licensing system is in place and is used to control commercial fishing effort.

Scenario 2b:
In addition to scenario 2a, a seasonal moratorium that is in line with the moratorium in the South China Sea that is imposed by the mainland Chinese authority is implemented, i.e., trawls and purse seines are banned from fishing in Hong Kong waters during June and July.

### *Scenario 3*

*WWF initiatives:* Introduction of all or part of WWF's "Save Our Seas" campaign objectives in 2007 (SOS: "Save Our Seas" Position Paper, 1 Dec 2005)

Scenario 3a:
No-take marine zones to cover all existing marine parks, and the proposed FPAs in Port Shelter, Tolo Harbour and Channel, and Long Harbour.

Scenario 3b:
Ban on bottom trawling in all Hong Kong waters, except in the southern waters (south of Lantau and Lamma Islands) where shrimp trawling is allowed.

Scenario 3c:
Creation of no-take zones covering the entirety of all HK's marine parks.

Scenario 3d:
Combination of Scenarios 3b and 3c.

Scenario 3d2:
Creation of no-takes FPAs in Port Shelter, Tolo Harbour and Channel, and Long Harbour

Scenario 3e:
Combination of Scenarios 3b and 3d2.

Scenario 3f:
Combination of Scenarios 3a and 3b.

This report attempts to collate opinions from fishers, recreational fishing, diving and marine-related tourism operators, and government officials on these management scenarios. Moreover, using ecosystem models, the potential impacts of each scenario listed above on the different fishing groups and sectors in Hong Kong waters are studied. This report is organized into two main parts: 1) alternative livelihood strategies for fishers and fishing communities, and 2) models for assessing fisheries impacts.

## Part 1: Alternative livelihoods for fishers and the fishing community

Effective fisheries management requires an understanding of the socio-economic consequences of management actions. Most experts agree that many fisheries around the world are in crisis, usually because fishing is depleting stocks faster than they can be replaced. Many would agree that actions are needed to stop the depletion. Unfortunately, managing fisheries and rebuilding stocks entails initial costs. In most cases, fishing will have to be reduced significantly in the short term. Subsequently, an important question is: what happens to the fishers while we wait for the fish stocks to rebuild? Our study addresses this question by conducting a survey of Hong Kong's fishers, as it is widely considered that asking fishers is the best way to begin to find feasible solutions to fisheries problems. We interviewed fishers and recreational fishing and diving shop operators, asking questions related to alternative livelihoods, vessel buy-backs, fisheries compensation, no-take marine parks and a trawl ban.

Our survey found that 54% of interviewed fishers were willing to switch jobs from fishing, with the remaining 46% stating that they would not consider it. This result implies that there is a good potential for well-designed alternative livelihood schemes to succeed. Also, dive and recreational shop operators were generally receptive to hiring fishers as new employees. The most frequent reason given for not hiring fishers was that they did not have the required skills. Therefore, any well-designed alternative livelihoods scheme will have to address how to develop the necessary skills among fishers. Our study suggests that the current alternative livelihood options within the marine sector (passenger/leisure boat operator, recreational raft fishing, and deep sea tuna fishing) would not be able to provide a sufficient number of jobs for the fishers who may potentially be affected by the management initiatives. Therefore, an alternative livelihood scheme would also have to look outside the marine sector.

The survey results indicated that a total of 75% of the interviewed fishers were willing to participate in a buy-back scheme if they were reasonably compensated for their vessels. These numbers show that a significant number of the fishers are willing to switch from fishing with the right buy-back package put in place.

There was overall strong support among dive and recreational operators for a total ban on fishing in marine parks, with 86% of all respondents either agreeing or strongly agreeing with this proposal. All marine tourism operators agreed with a total ban on fishing in marine parks. Around half of the alternative livelihood operators thought their businesses would benefit from no-take marine parks. In contrast, among fishers, only the small-scale fishers using P4/7 boats thought that marine parks did provide some benefits. P4/7 is a license class for small glass fibre-reinforced boats with outboard engines intended to be used for transportation to and from local mariculture rafts. However, many Hong Kong fishers employ boats with P4/7 license to fish in inshore waters. Thus they are categorized as the P4/7 sector.

When respondents were asked which scenario of the future they preferred, none chose to stay in the present situation (*status quo*). Different groups of fishers had different opinions about the range of proposed management policies, including the designation of partially or fully no-take areas, seasonal and annual trawl bans. The most prominent difference relates to the creation of no-trawl FPAs. While this had support from the P4/7 sector, it was, not surprisingly, opposed by the trawl sector. However, there were divergent opinions within the trawl sector. The big trawlers from one of the main fishing organizations opposed the policy outright, whereas smaller vessels (Tolo trawlers) were more receptive to the idea if they were to receive appropriate compensation.

Fuel cost has become the biggest concern for fishers as the high fuel price has largely lowered the profitability of all fishing sectors. Currently, government fuel subsidies cost taxpayers an estimated HK$ 48 million annually, while management of the fisheries, including enforcement, costs HK$ 24 million. In contrast, estimated benefits from the fisheries are roughly HK$ 150 million. This suggests that the economic performance of Hong Kong's fisheries is poor. The fisheries are sustained largely through the provision of government aid. Big trawlers are the worst affected by rising fuel costs due to their high fuel consumption. This is exacerbated by the fact that much of their capital is tied up in the vessel. It seems unlikely that the problem of high and increasing fuel costs is going to be solved soon. Also, the elimination of government subsidies that maintain or increase fishing capacity is part of ongoing World Trade Organisation (WTO) negotiations. If WTO agreement on subsidies elimination is reached, it may not be possible for Hong Kong to continue providing subsidies to its fishing sector (including the fuel subsidy). It may therefore be strategic for fishers to leave the fishing industry. This is probably why up to 75% of fishers are willing to participate in a buy-back scheme. It is important for both the government of Hong Kong and fishers to seize the opportunity to restructure marine fisheries to ensure restoration and sustainability of the resources while helping fishers adjust to the change.

Government can work to increase job and livelihood diversification for fishers. At the moment, fishers' ability to diversify their livelihood is constrained by factors beyond their control. These include a) strict regulations for converting fishing vessels to meet requirements for transporting passengers, as well as strict guidelines for commercial operation of recreational raft fishing (especially for the P4/7 sector); b) shrinking demand for low wage labour suitable for the current fishers in Hong Kong; c) limited market and growth potential for recreational fishing and diving industries; and d) difficulties for fishers wanting to sell their boats as there is little demand for fishing vessels. In addition, fishers acknowledge that their poor education is an obstacle to finding employment in other sectors.

Surveyed fishers consistently indicated that coastal development and pollution had affected fish stocks (both mariculture and capture). This important observation, supported by other studies, suggests the need for integrated coastal zone management in tandem with fisheries management to help deal with the problems of Hong Kong waters in a holistic manner. Successful reform of the mariculture industry, which is currently in decline, also offers potential benefits such as a) alternative livelihoods for fishers; b) reduction of negative impacts of mariculture on capture fisheries; and c) serve as a good source of income and seafood for Hong Kong.

We observed divergent opinions about protected areas in our survey. Dive respondents were more optimistic about the creation of no-take marine parks. Recreational fishing respondents saw no-take marine parks from two perspectives: on the positive side they thought it would attract more recreational fishers by increasing the abundance of fish. On the other hand, it might decrease their business as recreational fishing would be banned in marine parks. A majority of the fishers interviewed thought that protected areas did not provide any sort of benefits. Contrary to findings in other countries, most of the fishers did not think that protected areas had increased fish abundance or fish catch. Generally, the fishers were knowledgeable about the various management initiatives (e.g., Fisheries Protection Areas, Marine Parks and Reserve, etc.) proposed by the government. However, many of them did not believe the claims by the government, environmental groups or academia on the usefulness of the protected areas.

The negative opinions of fishers on the efficacy of marine parks may be a result of the lack of noticeable increase in catches and fish abundances from previously designated marine parks in Hong Kong. We think that their perceptions of failure are real and are likely due to sustained licensed and illegal fishing within the marine protected areas, so that fish abundance did not rebuild as anticipated. Nevertheless, the negative perception towards protected areas identified here may partly result from a limitation of the livelihoods survey and interview/questionnaire design.

A critical pre-requisite for successful restructuring of the fishing industry is effective control of fishing effort. To this end, the government should implement the fishing license scheme as soon as possible to lay the groundwork for other initiatives aimed at helping local fishing communities by restoring fishery resources. This re-emphasizes and reiterates the recommendations from earlier fisheries resources consultancy studies. Without a fishing license scheme, the number of vessels fishing in Hong Kong waters cannot be controlled, and vessels bought out may seep back in or be replaced by others.

In conclusion, this survey suggests that a sizable proportion of fishers in Hong Kong is willing to pursue alternative livelihoods under a well-designed fisheries adjustment program. Most fishers are pessimistic about the future development of Hong Kong fisheries because of the declining catches and increasing costs. Many are willing to switch to non-fishing jobs if opportunities are available. It therefore appears that the time is ripe for the Government of Hong Kong to work with fishers and NGOs to help secure the flow of fisheries benefits from Hong Kong waters to both current and future generations of citizens, and to assist those who wish to switch to alternative livelihoods to do so.

## Part 2: Economic impacts to the fishing industry and society

The goal of this part of the report is to assess the potential economic gain or loss to fishers and to Hong Kong society as a whole due to the implementation of different fishery management scenarios. The economic loss/gain to fishers is assumed to be the difference between the discounted net present value of profits (that is, the sum of profit over time in today's dollars) made under the *status quo* (present situation) management and that estimated under the different proposed management scenarios.

We undertake 3 types of assessments in this report: 1) cost-benefit analysis; 2) ecosystem modeling; 3) feasibility analysis using results from the livelihood study and ecosystem modeling.

The economic loss/gain to society is estimated using a cost-benefit analysis of the fisheries to society under different management scenarios. The benefits component includes profits from commercial fishing and from marine-related livelihoods such as recreational fishing, scuba diving and tourism. The cost component includes: *ex gratia* and vessel buy-back; monitoring, control and surveillance; retraining fishers; and subsidies on fuel and modification of fishing vessels to operate alternative livelihoods.

A distinction between benefits to fishers and to society is important because the gap between the outcomes preferred by private actors (i.e., fishers in the case of fisheries) and society in the use of environmental and natural resources is at the core of the challenges facing managers of these resources. This gap is due to what economists call 'externalities', which are costs or benefits arising from an economic activity that affects people (other than those who decide the scale of the activity). In this study, two things differentiate the way we calculate net present values to the fishers (represented by Hong Kong's various fishing sectors) and society. First, society is assumed to have a longer time horizon than private actors. Second, private actors, because they are businesses, are assumed to apply the market discount rate to calculate their present value of benefits, while society is assumed to use a lower discount rate because of its broader concerns, such as ensuring fisheries benefits to future generations (e.g., fish protein supply).

Data on benefits and costs of the management scenarios to the fishing sectors and to society are based on government published and unpublished data, results from the fishers' livelihood survey, and ecosystem modeling. Catches from Hong Kong waters were estimated from the government Port Survey in 2001/02. Analysis using global catch data shows that the government estimated catches in 2001/02 from Hong Kong waters appear to be up to 300% higher than the expected catches from areas that are geographically similar to Hong Kong. Thus, the catches are likely to be over-estimated by the government. Modeling of the Hong Kong marine ecosystem is based on previously-constructed ecosystem models (using the Ecopath with Ecosim modeling approach), updated with 2001/02 catch data. Notwithstanding the uncertainty in the input data, the results from the ecosystem simulation modeling (using Ecopath with Ecosim) are generally robust to such uncertainty.

In terms of net economic benefits, both fishers (as a group) and society would likely increase their long-term benefits (25 years for fishers and an infinite time-horizon for society) by moving away from the current *status quo* management. In particular, benefits to society are projected to increase many-fold. From an economic perspective therefore, the *status quo* scenario is not an optimum option. However, some fishing sectors and communities may lose from changing the *status quo*. Also, the performance of the private sector in the short and medium terms (5 and 10 years) is lower than in a 25-year time horizon. These may explain the opposition to change from some fishing sectors and communities. Given the potential large benefits to society of alternatives to the *status quo*, it may be beneficial to compensate losers in order to initiate action. This also highlights the need for the development of well-designed alternative livelihood schemes.

Overall, we estimate that management scenarios with a territory-wide trawl ban and no-take marine parks would deliver the highest net benefit to society (about HK$ 2.8 billion more than the *status quo*). The increase in net benefits, despite a decrease in landed values, agrees with economic theory: in a depleted, open-access system such as Hong Kong, competition among fishers leads to levels of fishing capacity or effort much greater than needed to achieve maximum economic rent, thereby wasting potential economic benefits from the resources. As fish stocks decline, the situation becomes exacerbated, with even more fishing effort required to maintain the same level of catch.

In terms of biomass, our modeling suggests that (i) no-trawl fisheries protection areas (FPAs) and partially-protected marine parks would be less effective in restoring the biomass of most fish groups, especially the large-bodied fishes, than scenarios with no-take FPAs and marine parks; (ii) a combination of no-take FPAs and marine parks would be effective in restoring the biomass of reef-associated fishes; (iii) for invertebrates, medium and large non-reef fishes and large pelagic fishes, a territory-wide trawl ban would be most effective in restoring their biomass; (iv) effects on the biomass of invertebrates and non-reef fishes could be seen in the short to medium term (5 years and 10 years); (iv) reef fishes (particularly medium and large-bodied fishes) respond relatively slowly to different fishing effort levels in each scenarios. In fact, our analysis shows that major changes in their biomass would be expected only after 25 years.

The slow recovery of major exploited stocks highlights the importance of protecting local spawning and nursery grounds. The proposed locations of the FPAs have been identified as spawning and nursery grounds for commercial species. In fact, this is a major reason for proposing the creation of FPAs in these areas. Thus, protecting these areas from all fishing activity should facilitate the recovery of depleted stocks. However, these spawning and nursery grounds could not be factored into the spatial simulation model employed in this study. Therefore, the recovery rate predicted from the simulation model may be conservative.

With respect to catch, our study reveals that (i) catch of invertebrates, mostly caught by trawlers and commanding high market prices, would generally decrease after the designation of FPAs, converting existing marine parks into complete no-take zones, or implementing trawl bans. Thus, these scenarios suggest a considerably reduced landed value for the trawling fleets; (ii) catches of reef-associated fishes show strong positive responses under most scenarios, particularly those with a combination of no-take FPAs and marine parks (Scenario 3a). Reef fishes are mainly caught by the P4/7 and miscellaneous sectors and these sectors would benefit most from the implementation of FPAs and marine parks; (iii) a territory-wide trawl ban, although effective in restoring biomass, may lead to a relatively larger reduction in catch and landed values of the fisheries (~25% reduction in catch and landed value from the *status quo*). On the other hand, since the profitability of most trawl sectors is much lower than that for small-scale fisheries, a territory-wide trawl ban could increase the net present value (NPV) of profits of the fisheries (by around HK$ 450 million more than the *status quo* in the 25-year timeframe), thus resulting in high net benefits compared to scenarios with no trawl ban; and (iv) overall, although no-take FPAs and marine parks may result in a slightly larger reduction in catch in the short term (less than 5% in a 5-year timeframe), our modeling suggests a slightly higher catch in the medium and long term (~5% in 25-year timeframe), compared to the no-trawl FPA scenario.

The modeling results are influenced by uncertainty in the data (especially catch data), by the model structure, and by a number of ecological assumptions. To understand how these uncertainties might have affected our results, we conducted a sensitivity analysis and compared our results with those of earlier modeling studies. The comparisons suggested that our model outputs are reasonably stable, except for the catch levels used. The model does not explicitly incorporate the recreational fishing sector. However, data on recreational fishing catch are sparse while the catch data in the simulation model are probably overestimates. Therefore, we believe that the exclusion of recreational fishing in the model should not affect the conclusions of this study. On the other hand, the potential impacts from recreational fishing, especially if a management scheme is not in place, should not be ignored. Further research is needed to provide more accurate and consistent catch estimates. The comparisons among the different scenarios are robust, but fine scale predictions from the model (in space and time) should be viewed with caution.

This study clearly demonstrates that moving away from the current *status quo* management, i.e., largely open access and unregulated fisheries, will provide long term benefits to both Hong Kong's fishers and society. The resulting short-term reduction in fishing effort that restoration will entail will have to be addressed with the implementation of appropriately-designed alternative livelihood programmes and buy-back schemes. With regards to alternative employment, current marine or fishing related options are not appropriate to accommodate the number of potentially displaced fishers. Thus, government and fishers will have to look for additional job opportunities outside the marine/fishing sectors.

Finally, we want to emphasize that the projected net benefits, both to fishers and to society, are based on the strong assumption that Hong Kong's fishery resources will be managed efficiently after the implementation of the new management scenarios. That is, there will be no growth in capacity and over-fishing of the stocks thereafter. This means that an effective licensing, monitoring, control and surveillance system, together with an incentive scheme for fishers to ensure sustainable and efficient fishing by the remaining Hong Kong fleet, will have to be put in place. It is also likely that the current method for recording catches will need to be revised so that accurate fisheries data is available to inform future fisheries management decisions.

# PART 1

## ALTERNATIVE LIVELIHOODS FOR THE FISHING COMMUNITY

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## Abstract

Most experts agree that many fisheries around the world are in crisis. Indeed, many would agree that something needs to be done to fix this problem. Unfortunately, however, doing something entails initial costs. In most cases fishing will have to be reduced significantly in the short term. And, many will ask, what do we do with our fishers while we wait for the fish populations to rebuild? This study addresses this question in the case of Hong Kong by conducting a survey of Hong Kong's fishers, as we believe that asking fishers is a useful approach to begin to find solutions to fisheries problems. The survey indicated that 54% of interviewed fishers were willing to switch jobs or go live on shore, with the remaining 46% saying that they would not consider it. This result implies that there is a good potential for well-designed alternative livelihood schemes to succeed. Also, dive and recreational shop operators were generally receptive to hiring fishers as new employees. The most frequent reason given for not hiring was that fishers did not have the required skills. Therefore, any well-designed alternative livelihoods scheme will have to address how to improve the skills among fishers. Given the concern expressed by fishers that the current alternative livelihood options in the marine sector (passenger/leisure boat operator, recreational raft fishing, deep sea tuna fishing) are not able to provide a sufficient number of jobs, an alternative livelihoods scheme will also have to look outside the marine sector.

## Introduction

Most experts agree that many fisheries around the world are in crisis. There is also wide agreement that something needs to be done to fix the problems (e.g., Pauly *et al*., 2002). Unfortunately, however, "doing something" entails initial costs. In most cases fishing will have to be reduced significantly in the short term, leading many to ask, what do we do with our fishers while we wait for the fish to rebuild? Our study addresses this question in the case of Hong Kong by conducting a survey of Hong Kong's fishers (and other stakeholders) to proposed changes, extensions and mitigations to Marine Parks and other spatial management measures (Wong, 1998). It is widely considered that asking fishers and users is the best way to begin to find solutions to fisheries problems (e.g., McCay *et al*., 2003).

Hong Kong's fisheries are primarily concentrated in the waters of the adjacent continental shelf in the South and East China Seas. In 2005, there were an estimated 4,150 fishing vessels and 9,200 fishers in the Hong Kong fishing industry (www.afcd.gov.hk). Fishing fleets landed approximately 29,000 tonnes of fish from Hong Kong waters, i.e., the waters administrated by the Hong Kong SAR, contributing HK$ 552 million in landed value (AFCD Port Survey 2001/02, unpublished data). The main fishing gears used include trawls (pair, stern, shrimp, pelagic/hang), gillnet, purse seine, long line, hand line, and traps. Approximately 32% of fisheries production from HK waters comes from the trawling sector (AFCD Port Survey 2001/02, unpublished data). The small-scale fishing sector (referred to as P4/7 sector) accounts for around 43% of fisheries production, and consists of fishers using a wide variety of fishing gears, for example, long lines, nets, traps and hand lines. The P4/7 sector employs small glass fibre-reinforced boats

[2] Cited as: Sumaila, U.R., Cheung, W.W.L., Teh, L.. 2007. Alternative livelihoods for the fishing community. *In* Sumaila, U.R., Cheung, W.W.L., Teh, L., Rebuilding Hong Kong's Marine Fisheries: An Evaluation of Management Options. Fisheries Centre Research Report 15(3), pp. 10-56. Fisheries Centre, the University of British Columbia, Vancouver.

with outboard engines. P4/7 fishers target higher value species such as crabs, rockfish, snapper, and rabbitfish Larger vessels (medium size purse seines and shrimp trawls, and large trawlers) target small pelagic species and invertebrates.

Fishing effort in HK has largely been unregulated and unmanaged to date (except in existing marine protected areas, which make up less than 2% of HK waters, and where use of some destructive fishing methods are prohitibited), resulting in intensive exploitation and severe depletion of fishery resources (Cheung and Sadovy 2004). Over the past decade, catches in local HK waters have declined by over 50% (Pitcher *et al*. 1998; Cheung and Sadovy 2004). Commercially important nearshore demersal species have declined, while those species remaining are of reduced size (Pitcher et al. 2000). For example, once important and abundant species, such as groupers and yellow croakers, are either rarely seen in markets, or have disappeared from commercial catches altogether (Cheung and Sadovy 2004). The effects of overexploitation are exacerbated by extensive coastal development and land reclamations which have degraded water quality and led to the loss of spawning and nursery grounds for fish.

## Study Site

The study covers all communities which are likely to be impacted by the proposed fishing regulations and potential designation of the Fisheries Protection Areas (FPAs) and no-take zones in Hong Kong. These include villages adjacent to, or close to, the proposed Fisheries Protection Areas (FPA: Port Shelter, Tolo Harbour and Channel, and Long Harbour), all current existing Marine Parks (MP: Hoi Ha Wan, Sha Chau and Lu Kwu Chau, Tung Ping Chau, Yan Chau Tong), and all fishers who will be affected by the proposed initiatives.

## Data collection

Fifty eight semi-structured interviews were conducted (in Cantonese) by William Cheung and Louise Teh from July 9-20, 2006 (Appendix 1). Interviewees included fishers, fishing cooperative leaders, fisheries managers, coastal villagers and operators of activities associated with marine resources that might be considered alternatives to fishing(e.g., scuba diving, recreational fishing, tourism, called ‘alternative livelihood operators’ hereafter). We contacted the interviewees through local fishers associations and cooperatives, the relevant government departments (e.g., the Agriculture, Fisheries, and Conservation Department, AFCD), and by visiting coastal villages. We also employed a “snowball” sampling approach, asking interviewees to introduce other potential respondents.

Interviews were semi-structured so that interviewees had a wide scope in answering questions, thus allowing any topics of interest to be elaborated upon. Interview questions were however, prepared ahead of time to serve as a guideline in covering important topics. Fishers were told that the purpose of the study was to find out about their livelihood and perceptions about proposed fisheries policies. Alternative livelihood operators were informed that the interview covered questions about providing alternative fisher livelihoods as well as fisheries management policies.

## Interview topics

One of the interview objectives was to investigate the readiness and capacity of the Hong Kong fishing community to cope with increased restrictions on commercial fishing, and their ability and willingness to adopt alternative livelihoods.

Fisher interviews covered the following topics: (i) demographics (age, education, family size); (ii) fishing activity (gear, vessel, target species, catch, fishing effort, number of years fishing); (iii) economics (fishing costs and incomes, other sources of non-fishing incomes, household expenditures); (iv) perception and attitude towards other types of potential employment; (v) fishers’ criteria for feasible alternative livelihoods; and (vi) whether fishers would be willing to move away from fishing to other activities.

Interview questions posed to two fisheries officers from the Hong Kong Agriculture, Fisheries, and Conservation Department (AFCD) covered: (i) plans for alternative livelihoods; (ii) financial costs of alternative activities, and availability of funds and personnel; and (iii) planned method/means of implementing alternative livelihoods.

Interviews involving operators of alternative livelihood activities included questions on: (i) potential growth of the industry; (ii) number of workers the industry needs and can support, skills required, training provided to unskilled workers; and (iii) workers' income.

## Methodology for the alternative livelihood analysis

Interview and secondary data were used to examine the social and economic feasibility and long-term sustainability of alternative livelihoods for potentially affected fishers. Secondary sources included published literature, data from the Hong Kong Census and Statistics Department, and unpublished reports from the AFCD and Civic Exchange Hong Kong.

For each of the fisheries management scenarios (described in a later section), we assessed the economic implications on fishers' livelihoods 5, 10 and 25 years following implementation with regards to the following issues:

1. *Which communities and fisheries areas will most likely be impacted by the various fisheries management scenarios?* This question was addressed mainly from the results of our impact on fisheries study (Part 2, this report*),* complemented by the interviews of fishers and fisheries managers.

2. *How dependent are the various fishing groups in the impacted areas on capture fisheries?* We addressed this question by reviewing the literature and publications on the social and economic conditions of Hong Kong citizens, in particular, fishers. We also looked for answers from the interviews with fishing communities, fisheries managers and other relevant stakeholders.

3. *Apart from fishing, what other livelihood activities do fishers in affected sectors engage in?* We answered this question mainly using insights from the fishing communities through survey interviews but also from secondary sources of data.

4. *What skills do potentially affected fishers possess? How can these be enhanced?* This question was addressed mostly from insights from the fishing communities, and also from secondary sources of information.

5. *What types of jobs are fishers willing to take, and are they willing to move away from fishing?* The best source of answers to this question was the interviews of fishing communities.

6. *What is the degree of training required to help fishers switch professions, and what is the estimated cost of such training?* Again, we sought answers to this question from the fishing communities, but we also used insights from fisheries managers, relevant NGOs, and experience from similar efforts from around the world.

7. *What is the potential demand for the provision of marine related tourism and recreation services, e.g., recreational fishing, scuba diving and snorkeling, sight-seeing, "traditional fishing community" tourist experiences, catering?* We used information on current tourism and recreational activities relevant to Hong Kong's marine ecosystem. Some useful information and insights were also derived from the survey.

8. *What are the additional costs that may be incurred by vessels transporting recreational fishers from within no-take FPA areas, notably Sai Kung village, to outside the no-take zones, e.g., fuel costs, and potential impact on their business?* The basis for our answer to this question included government publications and our interviews of fishers, managers and other stakeholders.

9. *What are the difficulties facing marine aquaculture, a profession which has previously offered alternative livelihoods to local fishers in Hong Kong, in the foreseeable future (e.g., poor water quality)?* We addressed this question by drawing on the existing literature on Hong Kong's aquaculture, the general

literature on issues related to marine aquaculture, and by interviewing fishers and fish farmers in Hong Kong.

*10. What are the attitudes and ability to change within the fishing communities of Hong Kong?* To investigate fishers' attitude and openness to alternative livelihoods, a section of the interview asked fishers to rate their acceptance of potential activities based on their perceived skills (or lack thereof), interest, and anticipated income.

# Interview results

## *Fishers' profile*

A total of 35 fishers and 3 fishing association representatives, covering both commercial and small-scale fishers from all major Hong Kong home ports, were interviewed (Table 1). The fishing association representatives indicated that they spoke for, and reflected, their members' views and opinions. There are approximately 9,500 both part time and full-time fishers in Hong Kong (AFCD, 2006). We acknowledge that the sample size was small; however we feel that the consistent responses and opinions we received from fishers indicate that our coverage of ports and gear types was adequate. Also, as the fishing association representatives spoke for their members, our results actually represented a larger portion of the fisher population than the number interviewed. Each of the 3 fishing associations we interviewed had membership numbers ranging from 400 (Tai Po) to 1000 (Hong Kong Fisheries Alliance). The majority of interviewed fishers were above the age of 40, had fished since they were young, and had little formal education.

**Table 1.** Summary of fisher profiles.

| Gear or Ports | No. of fishers |
|---|---|
| **Gear** | |
| Small-scale P4/7 (gill/trammel nets, traps, long line) | 18 |
| Purse seine | 3 |
| Trawlers (hang, stern, shrimp, pair) | 14 |
| **Home port** | |
| Aberdeen | 3 |
| Castlepeak Bay | 5 |
| Cheung Chau | 6 |
| Kat O | 3 |
| Lamma Island | 1 |
| Sai Kung | 7 |
| Tai Po | 8 |
| Tap Mun/ Kau Lau Wan | 5 |

## *Fishing activity*

### *Small-scale fishers using P4/7 boats*

Small-scale fishing using P4/7 (glass fibre-reinforced sampans 5 to 6 m in length of around 40 outboard horsepower) is seasonal, with fishers targeting differing species and switching gears according to the season. In summer, many fishers target crabs and low value, small pelagic fish (fry & juveniles) with trammel nets. Higher value species such as rockfish, snapper, and rabbitfish are caught during the winter using traps and gillnets. Conger pike eels and threadfin breams are also targeted using longlines during the winter. According to AFCD Port survey data, there were 2,745 actively fishing P4/7 boats operating in Hong Kong waters in 2001/2002. It should be noted that technically, vessels with P4/7 registration were originally intended to be used for transportation between land and floating mariculture cages, and not for commercial fishing.

Fishers using P4/7 boats tend to fish close (within 15 km) to their home ports. Those around the Sai Kung area might travel as far as the Ninepins and Tai Long Wan during good weather, while some fishers from the Tai Po area might go out to Tap Mun and Bak Sa Wan. On average, P4/7 fishers fish 21 days in a month (n=9, COV =2.8%), with some saying that they fish everyday, when possible. Fishers either rent a stall at the market to sell their catch, or deliver their catch to fish collectors. Cheap fish are kept as bait or as fish feed for cultured fish. Catches are very variable, ranging from a few to 300 catties, or 181 kg per trip (COV = 1.8%), although fishers point out that low catches are more prevalent than catches in the higher range. Peak catches occur during winter.

Most (11 out of 18) of the small-scale fishers using P4/7 boats interviewed also owned a mariculture operation, which offered supplemental income. Many had been in the mariculture business since the 1980s, and decreasing fisheries catches were frequently stated as a reason for getting into mariculture at that time. Mariculture-fishers catch their own fish to supply their operations, but also have to buy fish feed to supplement their catch. A severe occurrence of red tide caused major fish mortality in 1997/98, and mariculture has been on a steady decline since then. This is particularly the case in Tap Mun and Kau Lau Wan, where the red tide caused such severe losses that virtually all operations there have ceased. In recent years, fry mortality rates have been around 80-90%, whereas around 90% of fish fry used to survive before the red tide. Fishers attribute the high mortality rates to disease, pollution, and poor water quality stemming from coastal development and land reclamation.

### *Trawlers and purse seiners*

We interviewed 17 larger vessel operators, targeting small pelagic species and invertebrates with purse seines and trawls (i.e., hang, pair, stern, and shrimp trawl). The purse seine and shrimp trawl vessels are generally medium-sized wooden boats approximately 15 to 18 metres in length, with 108 to 300 horsepower inboard engines. These tend to operate in coastal waters within Hong Kong, whereas larger hang, stern, and pair trawlers based in Hong Kong usually fish in the South China Sea, except during the 2-month Chinese fishing moratorium. During the moratorium, they either do not fish, or fish occasionally within Hong Kong waters. On average, commercial trawlers fish 24 (n=8) days per month. As with the P4/7 sector, catches are also very variable, with interviewees mentioning catches per trip ranging from 10 to 1,000 catties (6 to 605 kg). Likewise, the catches of purse seines range from 100 to 100,000 catties (60 to 6,049 kg). The trawl vessels we interviewed were all owner-operated, with the help of 4 to 5 workers, mostly hired from China. According to AFCD Port Survey data, there were 596 trawlers and 92 purse seine vessels operating in Hong Kong waters in 2001/2002.

All fishers stated that their current catches were lower than their past catches. In general, fishers most frequently mentioned that catches had declined since 20-30 years ago (38% of responses, n=13), followed by 10-20 and less than 10 years (both 31%). The median perceived magnitude was a four-fold decrease; a 50-fold decrease was the largest mentioned. This result confirms earlier studies showing Hong Kong fish stocks in serious decline (e.g., Pitcher *et al.*, 1998), and demonstrates the need for management action. Around 40% (n=28) of fishers blamed decreased catches on coastal development projects and land reclamation, 36% on the use of destructive fishing methods (dynamite and 'electric nets') by Chinese fishing vessels, 14% on the increased number of fishers, and 11% blamed trawlers for destroying marine habitat. According to the interviewed fishers, 'electric nets' are trawl nets that are supplied with high voltage electric current. These could greatly increase the catchability (amount of fish on the fishing ground that are actually retained by the gear), but the electricity also kills large amounts of non-target organisms around the trawl nets. It has been reported that 5 kg of non-target organisms around the electric trawl net would be killed for every 1 kg of catch.[3]

## *Economics of the fisheries*

Daily fishing revenue (before expenses) is highly variable, reflecting the variability in catches. Small-scale fishers using gillnets or trammel nets reported daily revenues ranging from HK$100 to 1,000 per day (or

[3] Southern City News (translated).
(http://unn.people.com.cn/BIG5/channel2/3/14/200012/21/21528.html).

approximately HK$2,000 to 20,000 per month, based on an average of 20 fishing days a month). The monthly revenue of mid-size and large vessels ranges from HK$13,000 to 110,000 per month. In addition to fishing income, some small-scale fishers also have supplemental income from mariculture, part time work transporting passengers by boat, or from running recreational fishing operations from their mariculture rafts. For instance, mariculture and raft recreational fishing business can generate an additional HK$20,000 to 30,000 per month, while fishers can earn an extra HK$300 to 800 a day during the weekends (i.e., approximately HK$2,400 to 6,400 a month) transporting passengers or taking recreational fishers out for fishing trips.

Fishers are facing tough economic conditions: profit margins have decreased as fish prices have been falling while other operating costs, especially fuel, have been increasing. The resulting pressure on fishers due to lower profitability is expressed in the high numbers who are willing to accept a buy-out as, reported below. This provides Hong Kong a great opportunity to take action to protect or rebuild its fishery resources by reducing the amount of fishing. Fishers attributed the decrease in fish prices in recent years to the increasing volume of fisheries product imports from mainland China. The decreasing size of catches and fish prices has led some fishers to sell their own catch themselves, rather than pass through wholesales. In the past, most fishers sold their catch to a fish collector, who would then bring it to the wholesale fish market. In order to save on the commission charged by the fish collector (around 10%) and the retailer, many fishers now rent a stall at the local market to sell their own catch.

## *Fuel costs*

Fuel costs make up the major portion of fishers' operating costs, ranging from 30 to 60% of total costs (AFCD, unpublished data 2004). Small-scale fishers (P4/7 sector) use gasoline for their outboard motors, while trawl and purse seine vessels use diesel. The current high fuel prices have forced some of the mid-size and larger vessels to reduce their fishing activity, while some have stopped fishing altogether. Others have switched to more fuel-efficient sectors, such as the P4/7 sector. Subsidized (duty free) fuel is available to all fishing sectors. Industrial grade gasoline available to commercial fishers ranges from HK$1,000 to 1,200 per barrel (200 litres), while unsubsidized gasoline costs around $2,000 per barrel. The price of diesel is also subsidized by government, and ranges from HK$880 to 920 per barrel. These government subsides are provided for various socio-economic reasons, in particular to protect jobs. Using 2004 fuel cost data (AFCD unpublished data) and the number of fishing vessels reported in the 2001/02 Port Survey, we estimated that fuel subsidies to Hong Kong's fishing fleet was HK$237 million annually. Small-scale fishers spend around HK$100 to 500 per trip on fuel, while the cost of fuel is between HK$1,000 up to 20,000 per trip for mid and larger sized vessels. The latter fished both in Hong Kong waters and the South China Sea.

## *Capital and gear costs*

A glass fibre-reinforced P4 type boat used by small-scale fishers costs between HK$30,000 and 50,000. This includes the cost of the outboard motor, which has to be replaced every 3 to 4 years. Wooden mid-size purse seiners cost around HK$800,000, while trawlers cost HK$4 to 5 million. Gears, particularly nets, require substantial investment as well. For example, hang trawlers spend HK$10,000 to 30,000 for nets per year. The cost of small gill or trammel nets used by P4/7 operators ranges from $30 to 60 per net. Operating costs per trip range from HK$1,000 to 6,000 per trip for purse seine vessels, and HK$3,000 to 9,000 for trawlers. Repair and maintenance costs are substantial for the bigger vessels, requiring HK$30,000 to 100,000 per year. Trawl vessels have to be docked 3 to 4 times a year for maintenance, costing around HK$3,000 to 4,000 each time. Motor repairs alone can cost approximately $100,000 per year. Mainland Chinese crew are paid a salary of HK$2,000 to 3,000 a month, with the vessel owner providing food and shelter. Trawl vessels employ 4-5 workers, depending on the number of family members available to work onboard. In some cases, workers get a share of the revenue from the catch.

Based on interview data, we calculated the average revenue, costs, and profitability for P4/7 operators, purse seiners, shrimp trawlers, and hang trawlers (Table 2). Although we have a limited sample size (only one for traditional gillnet fisher), our analysis nonetheless is consistent with the trends from the AFCD fishing cost and earning studies results (AFCD unpublished). In particular, both analyses show that small-scale fishers have a profitability of over 40% of landed value, and that gillnet vessels have been operating at a loss in recent years. The gillnet vessel we interviewed used a traditional-style Chinese junk for fishing.

These vessels have a higher fuel consumption and maintenance cost compared to P4/7 boats, thus contributing to the lower efficiency of this sector. Our study shows shrimp trawls as very profitable, whereas the AFCD data gave them only moderate profitability. The difference is likely because of the smaller sample size of our survey.

**Table 2.** Estimated fishing profitability (percent of landed value) based on interview data (2006) and AFCD survey data (unpublished).

| Gear | Interviews | AFCD 2004 |
|---|---|---|
| P4/7 | 44 | 47 |
| Gillnet | -58 | -8 |
| Purse seine | 50 | 24 |
| Shrimp trawl | 23 | 8 |
| Pair trawl | Not available[1] | 10 |
| Stern trawl | Not available[1] | 3 |
| Hang trawl | 7 | 6 |

1. Available data did not allow us to estimate profitability. However, fishers generally reported low profitability because of high operating costs (especially for fuel) and low catch.

The combination of decreased catches, low fish prices and increasing fuel prices likely encouraged fishers to say that they have been unable to make a profit from fishing recently. In fact, 50% (n=24) of interviewed fishers said that they either cannot, or are barely able to make a living from fishing. The majority (58%) of these are trawl fishers, reflecting their low profitability as reported in Table 2 above. Many fishers stated that they were just making enough to cover expenses, and were living a day-to-day existence. Evidently, many fishers remain in the fishery in the hope that fuel prices will drop in the future. According to them fishing would be profitable if fuel prices were between HK$400 to 500 a barrel for diesel, almost half of the current fuel price. At the same time, some fishers would also be willing to leave the fishery (see below).

## *Fishers' perceptions*

### *Alternative livelihood*

54% (n=24) of interviewed fishers said they were willing to switch jobs, with the remaining saying that they would not consider it. Of those who were willing to switch jobs, concern about not being able to secure a job due to poor qualifications was high. We investigated whether there was a connection between fishers being able to make a living and their willingness to switch jobs. Among the fishers who could make a living (n=15), 8 (53%) were willing to switch jobs. Of those fishers (n=5) not able to make a living from fishing, 3 (60%) were willing to switch jobs. Thus, it appears that the proportion of fishers willing to switch job/livelihood was similar across both groups, regardless of the fishers' economic situation ($\chi^2$=0.48, df=5, NS). The majority of fishers were between the ages of 40 to 60. A breakdown of each age group was as follows: the youngest fishers, aged 20-30, made up 4%; age 30-40, 13%; age 40-50, 29%; age 50-60, 42%; age 60-70, 8%; and age 70-80, 4%. For the 40 to 50 year old group, the majority (57%, n=7) were not willing to switch jobs. In contrast, 60% of fishers aged 50 to 60 (n=10) were willing to switch jobs. A detailed breakdown of fishers' age group and their willingness to switch jobs is presented in Figure 1. There is no definite pattern in the relationship between age and willingness to leave fishing, possibly due to the limited sample size ($\chi^2$=0.48, df=5, NS).

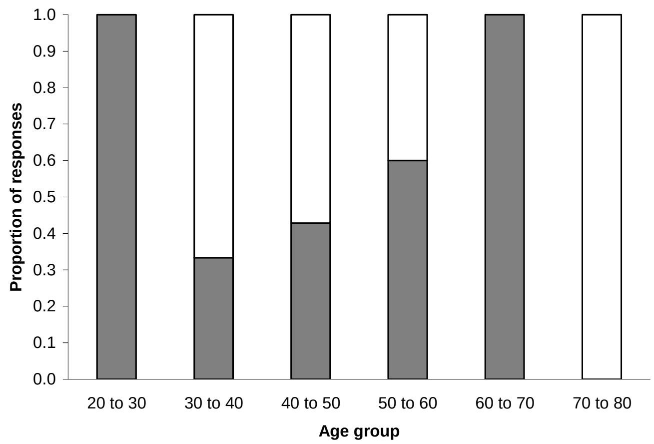


**Figure 1.** Willingness to switch to a land-based job by fisher age group. Grey bars indicate 'Yes', and white bars indicate 'No'.

According to fishers, it is not feasible at present for the current alternative marine livelihood options (passenger/leisure boat operator, recreational raft fishing, deep sea tuna fishing) to provide the number of jobs necessary to absorb all the fishers, if they should leave the fishery *en masse*. The fishers think that the number of boat operator jobs, whether for recreation or everyday transport, is limited. They also point out that since recreational fishing is a leisure activity, demand for that activity, and hence boat operators, will fluctuate according to the state of the economy. Many fishers say that those who wanted to participate in these alternative jobs would have done so already. Overall, fishers are pessimistic about their ability to find suitable alternative jobs. Many fishers pointed out that it would have been easier to switch livelihoods before 1997, as that was a period during which demand for construction workers was high. Lastly, legal and administrative barriers such as the issuance of boat licenses and regulations regarding boat modifications are further obstacles for current fishers considering these alternative options.

## *Buy-back and compensation*

Fishers were open to the idea of a government vessel buy-back scheme. 35% (n=20) were willing to participate in such a scheme, while another 40% were willing to participate if they were reasonably compensated for their vessel. This means that up to 75% of Hong Kong's fishers can be helped to move out of fishing. This is a positive result for both the Government and WWF's SOS Campaign, because it implies that with a well-designed adjustment package in place, significant restructuring can take place to reduce overfishing of Hong Kong's fishery resources. Ten percent of fishers would not consider a buy-back scheme at all. It should be noted that those who would not consider a buy-back appeared to be doing relatively well financially, as these fishers said that they were able to make a living from fishing, whereas others said they could not. Another 15% thought that it was not possible for the government to implement such a scheme. Fishers were asked about the level of alternative income they would require before they would be willing to permanently (i.e., until retirement) switch to a shore-based job. Responses varied between HK$7,000 to 11,000 per month. Although fishers' incomes are very variable, the above response is fairly consistent with the current range of earnings reported by individual fishers. In addition, the desired range of HK$7,000 to 11,000 is reasonable, given that the average monthly salary for "General Workers" in Hong Kong in 2005 was HK$ 7,350 (HK Census and Statistics Department).

## *Protected areas*

The proposal for a no-trawl Fisheries Protected Area (FPA) in Port Shelter and Tolo Harbour and Channel received a lot of support from the P4/7 fishers; 72% (n=11) of respondents (all small-scale gear from Sai Kung and Tai Po) were in agreement with the proposed no-trawl FPA. Only one group, the Hong Kong Fisheries Alliance categorically refused to accept it, because its members are mainly comprised of trawl fishers who would be adversely affected by the new policy. In contrast, another trawl association from Tai Po was more open to the proposal, and said that they were willing to accept the trawl ban if they received compensation for doing so. In contrast, a completely no-take FPA was less popular, with 6 out of 9 (67%)

of respondents not supporting the proposal. None of the respondents agreed with the establishment of a no-take Marine Park (Table 3). In general, fishers did not think that protected areas provided any sort of benefits; 63% (n=19) thought that marine reserves/protected areas had no effect or were no use, i.e., they did not think that protected areas had increased fish abundance or fish catch. It is interesting to note that those who thought that marine parks did provide benefits were all P4/7 fishers.

**Table 3** Willingness of respondents to accept proposed management policies. N indicates the total number of respondents to the question.

| Response | FPA (no-trawl) | FPA (no-take) | Marine Park (no-take) |
|---|---|---|---|
| Yes | 8 | 1 | 0 |
| No | 1 | 6 | 8 |
| Yes if compensated | 2 | 2 | 0 |
| N= | 11 | 9 | 8 |

## Alternative livelihood operator profile

We surveyed a total of 54 alternative livelihood operators, and conducted 20 face-to-face interviews, 8 of which were with dive shop operators and 12 with recreational fishing store operators. In addition, approximately 100 questionnaires were mailed or faxed to dive and fishing tackle shops in all parts of Hong Kong. There are 137 recreational fishing and 107 diving shops in Hong Kong, respectively. Another set of questionnaires was distributed during a WWF-sponsored diver workshop. Thirty-four questionnaires were completed and returned. In total, we had responses from 27 dive industry operators (including 2 diving/boat rental companies, 2 dive/ecotourism operators, 6 individual dive instructors, and 1 diving association member), 21 recreational fishing stores, 1 leisure boat operator, 1 aquatic consultant, and 4 ecotourist operators.

In terms of monthly gross revenue, the majority of dive (54%, n=20) and recreational fishing (75%, n=16) operators earned less than HK$60,000 per month (Table 4). A larger proportion of dive operators were in the high revenue range, of more than HK$120,000 per month (25%), compared to recreational fishing shops. In terms of customers, the biggest proportion of dive operators (48%, n=23) had fewer than 50 customers per month. In contrast, the majority of recreational fishing shops (58%, n=19) were in the medium range of 50 to 200 customers per month, with none in the lowest category of less than 50 customers per month (Table 4). In general, customer expenditure was quite low for all industries, with 72% (n=45) of overall monthly customer expenditure being less than HK$1,000.

**Table 4.** Breakdown of customer and average revenue scale by industry (%).

| | Diving | Recreational fishing | Ecotourism | Overall |
|---|---|---|---|---|
| **Customers per month** | | | | |
| < 50 | 48 | 0 | 50 | 28 |
| 50 to 200 | 17 | 58 | 50 | 37 |
| > 200 | 35 | 42 | - | 35 |
| **Average monthly revenue (HK$)** | | | | |
| <30,000 | 40 | 30 | - | 32 |
| 30,000 to 60,000 | 15 | 44 | 100 | 35 |
| 60,000 to 120,000 | 20 | 13 | - | 15 |
| >120,000 | 25 | 13 | - | 18 |

## Alternative livelihood operators and marine parks

Dive shops are more likely to make use of current Marine Parks (MP) (Table 5). Although small-scale commercial fishing (P4/7 and purse seine sectors) is permitted in MPs by license holders, there is no recreational fishing allowed within MPs, except in Tung Ping Chau Marine Park. Divers are the major recreational users of Tung Ping Chau and Yan Chau Tong MPs (Table 5). The majority of dive shops organize diving trips to the Sai Kung area, with less frequent trips to the MPs. In particular, divers rarely go to Sha Chau and Lung Kwu Chau, due to poor visibility there year-round. Dive operators cite the lack of fish in MPs and a longer distance from the major ports where divers board their boats as the primary reasons why they do not frequent those areas. 45% (n=47) of all respondents organize trips to Tung Ping Chau, and it is the most-visited MP for recreational fishers because recreational fishing is allowed there. Sha Chau and Lung Kwu Chau are the least visited MPs (Table 5).

**Table 5** Percentage of respondents who organize trips to each marine park

| Marine Park | Sample size (n) | % of total respondents | % of dive respondents |
|---|---|---|---|
| Tung Ping Chau | 21 | 35 | 62 |
| Yan Chau Tong | 17 | 28 | 71 |
| Sha Chau & Long Ku Chau | 10 | 17 | 40[1] |
| Hoi Ha Wan | 12 | 20 | 25 |

1. Divers responded to the survey often reported to have organized dive trips to ALL marine parks. However, it appears that they referred to marine parks in the eastern waters only as some respondents reported that the conditions in the Sha Chau and Lung Ku Chau MP were not suitable for diving (e.g. low visibility, busy marine traffic, etc.).

The majority of respondents (80%, n=49) thought that the current MPs were not effective in protecting the marine ecosystem and marine life. When split by industry type, 82% (n=26) and 71% (n=17) of dive and recreational fishing shops were of this opinion, respectively. The ecotourist operators all thought that there was inadequate protection offered by the MPs. Respondents commonly cited ongoing fishing activity by local small-scale fishers, illegal fishing by mainland Chinese fishers, and the small size of protected areas as reasons for ineffective protection. However, in spite of inadequate protection, 82% (n=51) of respondents felt that the presence of MPs was beneficial to their industry/business. 96% (n=26) and 71% (n=17) of dive and recreational fishing operators, respectively, were positive about the perceived benefits of MPs. Three out of the 4 ecotourist operators thought that MPs had offered benefits.

There was overall strong support from alternative livelihood operators for a total ban of fishing in MPs, with 86% (n=50) of all respondents either agreeing or strongly agreeing with this proposal. Dive operators showed a slightly higher agreement rate (88%, n=27), whereas the proportion of recreational fishing operators who agreed was lower at 80% (n=19). Indeed, recreational fishing operators expressed more opposition to the proposal, with 10% completely disagreeing and another 10% partly disagreeing. In contrast, only 8% of dive respondents expressed total disagreement. All ecotourist operators agreed with a total ban of fishing in MPs. These responses were very different from those given by the interviewed fishers, as none of them supported setting up no-take marine parks (Table 3).

The main reasons given in support of a complete no-take MP was that it would increase fish abundance and improve the marine environment. In contrast, those opposed to the idea thought that fish abundance would not increase. Respondents also indicated that a ban would restrict the rights of people, and that the fishing policy should distinguish between recreational and commercial fishing, since the latter (especially trawling) is more damaging to the ecosystem. Recreational fishing is currently not allowed in MPs except in Tung Ping Chau MP, where a special area for recreational fishing is designated. However, some recreational fishing operators still thought that a no-take MP would have negative effects on their business due to forgone economic benefits from recreational fishing that they felt should be allowed in MPs

Forty five percent (n=49) of respondents felt that a no-take MP would affect their business, with the rest feeling that MPs would not affect (45%), or might have some effect (10%) on their business (Table 6). A higher proportion of recreational fishing than dive operators felt that their business would be affected (56% versus 41%). 47% (n=40) of all respondents felt that their business would benefit, while 16% thought that no-take MPs would harm their businesses, and 37% thought that no-take MPs would have no impact on their businesses (Table 6). The reasons most commonly attributed to the perceived increase in business were : 1) an improved marine environment, which would attract more customers (divers or recreational fishers); and 2) an increase in fish abundance, which would attract more recreational fishers. The reason respondents expected business to decrease was due to the economic benefits presumed lost from the restrictions on recreational fishing in MPs. Not surprisingly, these responses came from the recreational fishing sector.

**Table 6.** Responses (in percentages) to questions on the effect of no-take marine parks (MP) on business.

| Question | Responses | | |
|---|---|---|---|
| | Yes | No | Somewhat |
| Affect business? (n=49) | 45 | 45 | 10 |
| | Benefit | Harm | No impact |
| Effect on business? (n=40) | 47 | 16 | 37 |

Respondents were asked how they thought a no-take MP would affect the number of their customers 1, 3, 5, and 10 years after its establishment. After 1 year, the largest proportion (31%, n=36) of respondents thought that there would be no change to their business, while 28% thought that their customers would increase. Dive operators were more optimistic about customers increasing in the short term, as 37% of them (n=19) expected customers to increase, while only 15% of recreational fishing operators (n=13) expected likewise (Table 7).

**Table 7** Percentage of responses to anticipated change in customers 1, 3, 5, and 10 years after FPA establishment. Results are grouped by all (All), dive (Dv), recreational fishing (RF), and ecotourist (Ec) respondents. Results are grouped by all (All), dive (Dv), recreational fishing (RF), and ecotourist (Ec) respondents.

| | 1year (n=36) | | | | 3 years (n=38) | | | | 5 years (n=34) | | | | 10 years (n=32) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All | Dv | RF | Ec | All | Dv | RF | Ec | All | Dv | RF | Ec | All | Dv | RF | Ec |
| **Increase** | 28 | 37 | 15 | 25 | 61 | 64 | 46 | 75 | 62 | 74 | 27 | 100 | 63 | 72 | 30 | 100 |
| **Decrease** | 14 | 5 | 31 | 0 | 11 | 9 | 15 | 0 | 12 | 5 | 27 | 0 | 13 | 6 | 30 | 0 |
| **No change** | 30 | 32 | 31 | 25 | 5 | 0 | 15 | 25 | 6 | 0 | 19 | 0 | 3 | 0 | 10 | 0 |
| **Don't know** | 28 | 26 | 23 | 50 | 24 | 27 | 24 | 0 | 20 | 21 | 27 | 0 | 21 | 22 | 30 | 0 |

In all cases, the majority of dive operators expected customers to increase and not decrease (Table 7). In contrast, a larger proportion of recreational fishing operators thought customers would decrease instead of increase after 1 year. An equal proportion of these respondents thought customers would increase as well as decrease after 5 and 10 years (Table 7).

Respondents were then asked to estimate the magnitude of change in the number of their customers 1, 3, 5, and 10 years after MPs become no-take. According to all respondents, the highest change was expected after 5 and 10 years of no-take MP, with a median increase in customers of 15% (Figure 2). After 1 year, the expected median customer increase was 5%, rising to 8% after 5 years. Dive and recreational fishing operators expected different trends of increase. Dive operators expected a progressive increase in customers as the years of no-take MP became longer. The median expected increase after 1 year was 5%, followed by 8%, and then 15% after 5 and 10 years. On the other hand, recreational fishers expected a consistent median increase of 8% throughout all years. Ecotourist operators expected a gradual increase in customers, starting at a median of 5% after 1 year, and rising to 6%, 7.5, and 15% after 3, 5, and 10 years, respectively.

## *Alternative livelihood operators on trawling and fisheries protection areas*

Almost all respondents (96%, n=48) thought that trawling affected the quality of diving or recreational fishing. The primary reasons given were that trawlers caught too much fish, thus reducing fish abundance, and that trawlers destroyed coral reef habitats. However, the reasons for the generally negative perceptions on trawling is not known. The majority (76%, n=53) of respondents had some knowledge about the proposed trawl bans in the Fisheries Protection Areas (FPAs) in Port Shelter, Tolo Harbour and Channel. Dive operators were in general more aware of this proposal, with 85% (n=26) of them confirming that they have some knowledge about the proposed FPAs, compared to 61% for recreational fishing shops. All the ecotourist respondents knew about the proposed FPAs also. Given the general negative perception of trawlers, it was not surprising that there was almost unanimous (96%, n=46) agreement that the establishment of non-trawl FPAs was a good idea. However, there were mixed opinions when respondents were asked whether all fishing activities (including recreational fishing) should be banned in the FPAs. 65% (n=51) of respondents thought that FPAs should be no-take areas. There was a distinct difference in opinion between the dive and recreational fishing industry on this topic; 81% (n=25) of the dive respondents thought that the FPAs should be no-take, whereas only 33% (n=18) of recreational fishing respondents thought likewise.

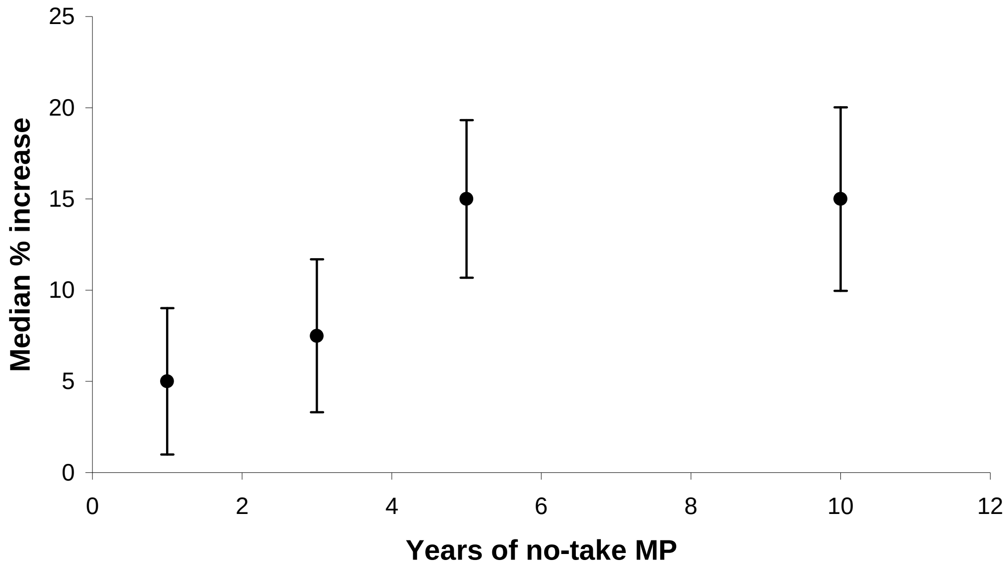


**Figure 2.** Anticipated increase in customers after establishing no-take Marine Parks for 1, 3, 5, and 10 years (all respondents, n=36, 38, 34, 32, respectively). Bars indicate the 1-standard deviation spread.

The FPA areas are currently visited by both divers and recreational fishers. All except one dive shop respondent (n=24) reported bringing divers to Port Shelter and Tolo Harbour, whereas less than half (41%, n=17) of recreational fishing shops reported that their customers go fishing at these areas. 60% (n=50) of all respondents thought that the establishment of FPAs would affect their companies, while around 22% thought it might be a possibility, and 18% thought that FPAs would not affect them. The majority (76%, n=42) of all respondents thought that FPAs would increase their business. 12% of respondents, all recreational fishing operators, thought that their business would decrease due to the restriction of recreational fishing in the FPAs. Another 12% thought that their business would be unchanged. Dive operators were more positive about the beneficial effects of FPAs, as 87% (n=23) of dive respondents thought that FPAs would increase their businesses. 59% (n=17) of recreational fishing shops thought likewise, while all the respondents (n=5) who thought that FPAs would decrease their businesses were recreational fishing shops.

There was a lot of support for banning all fishing activity in the FPAs. 72% either agreed or strongly agreed with the no take FPA, while 28% (n=47) of respondents either completely or partially disagreed with the idea. All 4 ecotourist operators supported a no-take FPA. Dive shops were a lot more supportive of no-take FPAs, with 88% (n=25) of dive shops agreeing, whereas only 33% (n=18) of recreational fishing shops expressed support. In the event of no-take FPAs being established, the majority (62%, n=42) of respondents did not expect to hire any extra employees, while 36% expected to hire an extra staff. Dive operators were more open to hiring new employees, with twice as many respondents (48%) expecting to hire new employees compared to recreational fishing operators (23%).

Overall, respondents were positive about the proposed trawl bans in FPAs. The majority thought that their customers would increase after establishment of the FPAs. When asked about the potential increase or decrease in customers 1, 3, 5, and 10 years after establishment of the FPAs, 44%, 78%, 75%, and 79% of all respondents, respectively, thought that customers would increase (Table 8). The highest increase was anticipated to occur 5 years after establishment of the FPA, with a median increase of 15%. Dive operators were the most optimistic about FPAs, with none of them expecting a decrease in customers (Table 8). They expected customers to grow progressively, with median increases of about 5, 8, 11, and 15% after 1, 3, 5, and 10 years, respectively after FPA establishment (Figure 3).

**Table 8** Percentage of responses to anticipated change in customers 1, 3, 5, and 10 years after FPA establishment. Results are grouped by all (All), dive (Dv), recreational fishing (RF), and ecotourist (Ec) respondents.

| | 1 year (n=32) | | | | 3 years (n=36) | | | | 5 years (n=28) | | | | 10 years (n=24) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All | Dv | RF | Ec | All | Dv | RF | Ec | All | Dv | RF | Ec | All | Dv | RF | Ec |
| **Increase** | 44 | 60 | 25 | 25 | 78 | 94 | 57 | 75 | 75 | 94 | 25 | 100 | 79 | 93 | 20 | 100 |
| **Decrease** | 6 | 0 | 20 | 0 | 6 | 0 | 14 | 0 | 11 | 0 | 38 | 0 | 13 | 0 | 60 | 0 |
| **No change** | 31 | 27 | 25 | 25 | 8 | 0 | 14 | 25 | 4 | 0 | 12 | 0 | 4 | 0 | 20 | 0 |
| **Don't know** | 19 | 13 | 50 | 50 | 8 | 6 | 14 | 0 | 10 | 6 | 25 | 0 | 4 | 7 | 0 | 0 |

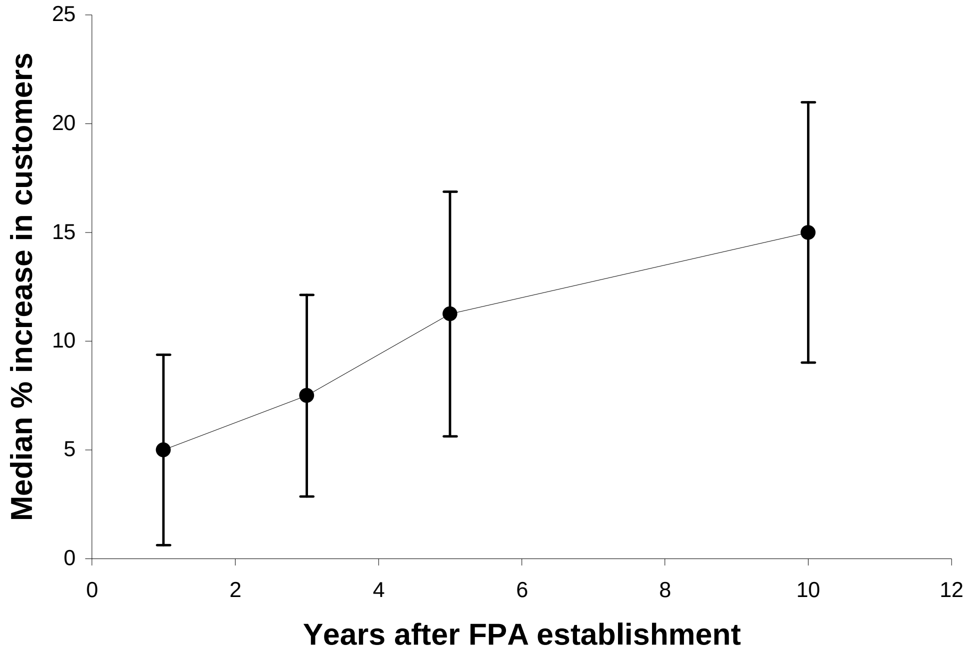


**Figure 3.** Anticipated median increase in dive customers 1, 3, 5, and 10 years after FPA establishment. Bars indicate the 1-standard deviation spread. The points are linked to highlight the trends.

Although most interviewed operators expected increase in customer numbers following FPA establishment, there were some who were pessimistic about the FPAs. Of the respondents who expected a decrease in customers, the anticipated median decrease in customers from FPA establishment was 8% in the first 3 years, dropping to 5% thereafter. Only recreational fishing respondents expected a decrease in customers due to the establishment of FPAs (Table 8). They expected customers to decrease by a median of 10% after 1 and 3 years of FPA establishment. This was then reduced to a median decrease of 8 and 5% after 5 and 10 years, respectively. In terms of average net change, recreational fishing respondents expected customers to decrease slightly by around 2% after 1 year. Customers were then expected to increase by 8% after 3 years, after which there was no expected change at the 5 year time period. After 10 years, customers were expected to increase by 6%. Overall, respondents from all industries expected customers to increase by 4% after one year of FPA establishment. This was then expected to increase to 8% after 3 years, with further increases to 10% and 9% after 5 and 10 years, respectively (Figure 4).

With regards to no-take FPAs, 68% (n=47) of respondents supported the proposal, with 43% totally agreeing, and 26% agreeing with no-take FPAs, respectively. Seventeen percent of respondents completely disagreed, while 11% partially disagreed with no-take FPAs (the majority of these respondents were from the recreational fishing industry, who thought that no-take FPAs would reduce their customers). Lastly, 4% of respondents had no opinion about no-take FPAs.

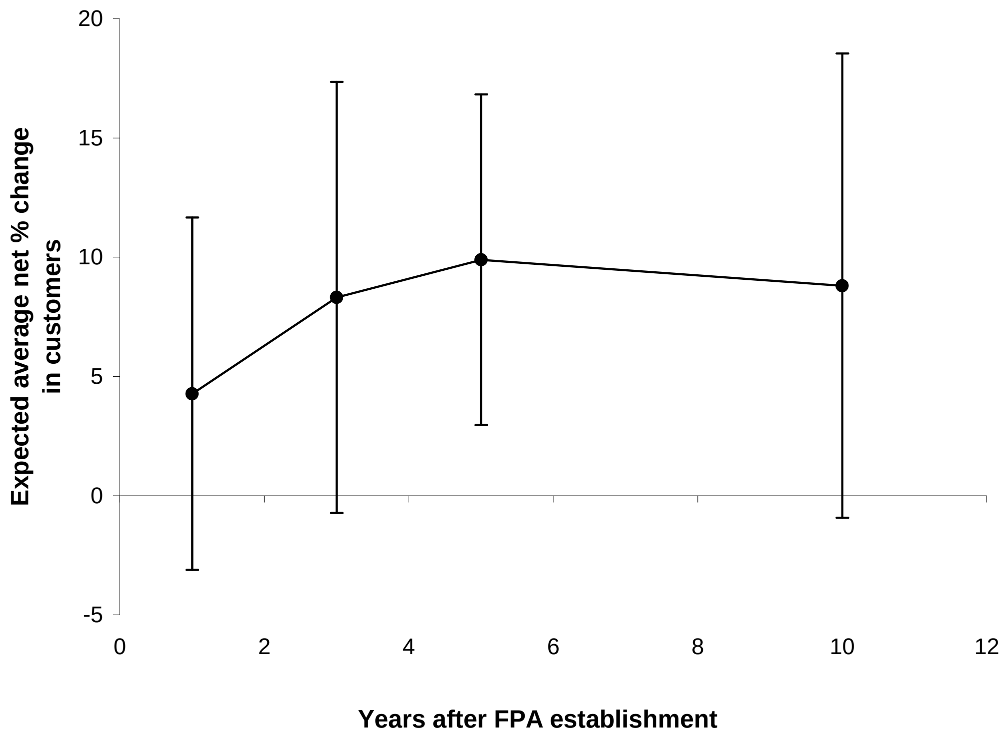


**Figure 4.** Anticipated average net change in customers for dive, recreational fishing, and ecotourism industries 1, 3, 5 and 10 years after FPA establishment. Bars indicate the 1-standard deviation spread.

## *Alternative livelihood operators on management options*

Survey respondents were asked about their preference for four management options, chosen to resemble the fisheries management scenarios reported upon in the section on fisheries impact analysis of this study. A detailed breakdown of all possible scenarios, such as those in the fisheries impact study, was not provided in the survey as it might have confused respondents. The four management options in the survey were: 1) maintain the *status quo*; 2) establish no-trawl FPAs and maintain MPs at *status quo*; 3) establish no-take FPAs and maintain MPs at *status quo*; and 4) establish no-take FPAs and no-take MPs. Most respondents (42%, n=52) preferred option 2. None of the respondents chose the *status quo*. Option 4 (no-take MPs and no-take FPAs) was the next most popular, which was chosen by 38% of respondents. It appears that one reason for the popularity of option 2 was due to concern for fishers' livelihoods. Some interviewees mentioned that although option 4 was the best choice for them economically, their concern for the livelihood of fishers made them choose option 2 instead. Both scenarios involving no-take FPAs (options 3 and 4) received support from the majority of the respondents (57%). Dive and recreational fishing operators showed different preferences. Half the dive operators preferred option 4, followed by option 2 (27%) and option 3 (24%). On the other hand, option 2 was the most popular choice by recreational fishing operators (68%), followed by option 4 (21%) and 3 (11%) (Table 9).

Under option 4, all MPs and FPAs as no-take areas, 43% of responses indicated that business profits would go up, while 22%, mainly recreational fishing operators, said profits would decrease. Twenty two percent and 6% of respondents referred to the possibility of new companies entering the industry or leaving the industry, respectively.

**Table 9.** Preference for each management option (%)

| Options | Overall (n=52) | Dive (n=29) | Rec. fishing (n=19) | Ecotourism (n=4) |
|---|---|---|---|---|
| 1: *Status quo* | 0 | 0 | 0 | 0 |
| 2: No trawl FPA, status quo MP | 43 | 28 | 68 | 25 |
| 3: No-take FPA, status quo MP | 17 | 24 | 11 | 0 |
| 4: No-take FPA & MP | 40 | 48 | 21 | 75 |

Another series of options involved anticipated change in customers given a change in the abundance of fish. The options were: 1) a reduction in fish abundance by half; 2) fish abundance doubles; 3) a five-fold increase in fish abundance; and 4) a ten-fold increase in fish abundance.

Under option 1, the majority (70%, n=30) of respondents anticipated a decrease in customer numbers, while 10% expected no change and 20% did not know what would occur if fish abundance was reduced by half. The majority of recreational fishing operators (79%, n=14) and dive operators (60%, n=15) expected a decrease. Of those respondents anticipating a decrease in customers, 54% expected a decrease by more than 20%. Recreational fishing shops were more likely to expect this level of decrease (73%), compared to 50% of dive respondents. The median rate of expected customer decrease was 20% for all respondents (Figure 5), 20% for dive operators, 20% for recreational fishing operators, and around 8% for ecotourist operators.

Under the second option where fish abundance doubles, the majority of respondents (84%, n=38) anticipated an increase in customers. The most frequently chosen magnitude of increase was 5 to 10% (35% of total respondents, n=31), with a median increase of 15% (Figure 5). The most common response for recreational fishing operators was an increase of 5 to 10%, with 55% of recreational fishing respondents choosing this range. The two most common responses for divers was a 5 to 10% and 10 to 20% increase (27% and 32% of responses, respectively). Among dive respondents, the median increase was 11%, while for recreational fishing, it was 20%.

The third option involved a five-fold increase in fish abundance; 76% (n=17) expected an increase in customers, with half (50%, n=12) anticipating an increase of more than 20%, with a median increase of about 18% from all respondents (Figure 5). The median increase was 18%, 15%, and 20% for dive, recreational fishing, and ecotourism respondents, respectively.

Lastly, the fourth option involved a ten-fold increase in fish abundance. 82% (n=22) anticipated an increase in customer numbers, with an increase of more than 20% (and maximum of up to 70%) being the most frequent response (79%, n=15). 78% (n=9) and 75% (n=7) of dive and recreational fishing respondents, respectively, chose this same level of change. The median increase was 20% overall (Figure 5), as well as for both dive and recreational fishing respondents. In general, the strongest impact on customer numbers was caused from a decrease and doubling in fish abundance. In comparison, there was no substantial impact from a five or ten fold increase in fish abundance (Figure 5).

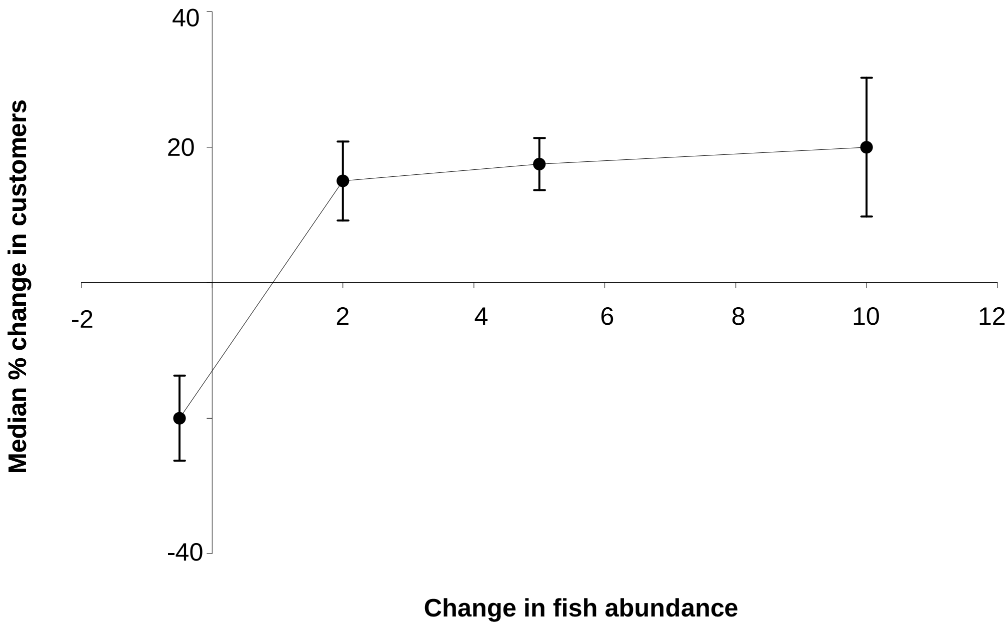


**Figure 5.** Anticipated change in overall customers in dive, recreational fishing, and ecotourism industries given fish abundance reduces by half, doubles, increases by 5 fold, and increases by 10 fold. Bars indicate the 1-standard deviation spread. The points are linked to highlight the trends.

## *Alternative livelihood operators on employment of fishers*

Dive and recreational shop operators were generally receptive about hiring fishers as new employees, with 55% (n=53) of respondents saying that they would consider hiring a fisher. Seventy percent of all dive, 52% of recreational fishing, and 50% of ecotourism respondents were willing to consider employing fishers, respectively. The most frequent reason given for not hiring was that fishers did not have the required skills, for example, sales skills. Fishers' age, attitude, suitability for business, and lack of interest in the job were other reasons cited for not hiring fishers. Of those willing to hire a fisher, 73% said that they would provide training. The most frequently mentioned training periods were one week (38% of responses, n=21), followed by 1 week to 1 month (29% of respondents). Those respondents who did not think training was necessary said that was because the new fisher employee would already be familiar with the task he was hired to do. Fishers were mostly likely to be hired as boat operators (51% of responses), followed by recreational fishing guides (24% of responses). Other positions included cleaning crew, sailor, dive master, and salesperson. Table 10 provides the breakdown of respondents' salary ranges for the positions of boat operator and fishing guide.

**Table 10** Breakdown (%) of respondents' monthly salary range (HK$) for marine alternative fisher jobs

| Job | Salary range (HK$) | | | |
|---|---|---|---|---|
| | <5000 | 5000-10000 | 10000-15000 | >12000 |
| Boat operator (n=24) | 17 | 58 | 21 | 4 |
| Fishing guide (n=18) | 22 | 56 | 22 | 0 |

## *Alternative livelihood operators on growth of dive and recreational fishing industry*

Dive shop operators stated that the most important factor for divers is good visibility, followed by the diversity and abundance of fish. As such, the Hong Kong dive industry is hampered by the poor clarity of

Hong Kong waters[4], and there is no special attraction in terms of marine life. The number of divers in Hong Kong has steadily increased over time. However, one small dive shop operator said it is now more difficult to do business compared to 10 to 20 years ago. In the past divers would invest in dive gear, but now only full time divers buy their own equipment, whereas most of the other divers just rent. In addition, there are now bigger dive stores which can buy gear at lower costs, thus putting smaller dive shops at a disadvantage. Overall, although the number of Hong Kong divers has been increasing, these divers do not generate much business for local dive shops with regards to expenditure on local diving trips. Instead, local divers tend only to learn to dive in Hong Kong, and then spend money diving in other parts of South East Asia. However, some dive companies do benefit, as part of their businesses involve arranging overseas diving packages.

Although there are a reported half a million recreational fishers in total in Hong Kong (AFCD unpublished data, 2004), shop operators indicate that the number of active recreational fishers is considerably smaller. The number of core recreational fishers remains fairly stable, with some new fishers entering and some leaving the activity. The Hong Kong recreational fishing industry is competitive, and there is constant opening and closing of fishing tackle shops because the number of recreational fishers is not increasing by much. Operators therefore did not think that the industry will expand much in the future, as the customer base in Hong Kong is too limited. Moreover, recreational fishing is a leisure activity which is affected by the state of the economy. Fishing tackle shop owners also indicated that many Hong Kong recreational fishers have taken advantage of cheap fishing tour packages to China, and gone there to fish instead. Overall, fishing tackle shops are not very profitable, and some shop owners may operate primarily because fishing is their interest, and not due to profit motivation.

## *Fisheries managers' view of government fisheries management plan*

An interview was conducted with two AFCD fisheries officers to obtain their views on how the government planned to deal with fishers affected by the proposed fisheries management plan (FMP). The goal of the FMP, which involves the creation of FPAs and a fishing license scheme, is to effectively control fishing activity in Hong Kong. The government views the fishing license scheme as a pre-requisite for other proposed management initiatives. Unfortunately, existing legislation is inadequate to enforce it. Currently, the AFCD is awaiting an adjustment of the Fishery Protection Ordinance (Cap 171), which will give it the legislative authority to carry out such policies. According to the AFCD, the most important aspect of the FMP is to implement the licensing policy, as this will enable the government to effectively control fishing effort. This is required before the government can provide any financial assistance to affected fishers. This is to ensure that fishing capacity does not build-up again after the programme.

The AFCD plans to help displaced fishers through developing alternative livelihood projects such as ecotourism, recreational fishing, and aquaculture development. Aquaculture programmes are aimed at improving the current state of the industry, such as an "Accredited Fish Farm Scheme" to improve the quality of aquaculture products, low-interest loans, and technical development and support to assist in culture techniques. The AFCD is also providing low interest loans for eligible fishers to convert their vessels for offshore fishing, another livelihood option that the AFCD is currently pursuing. Lastly, the government is also investigating the feasibility of buy-back and/or *ex-gratia* payments to deal with the affected vessels. Here, *ex-gratia* payment refers to monetary payment by the government as an act of grace to fishers whose livelihoods are negatively affected.

In terms of the likely success of alternative livelihood options, the AFCD officials we interviewed did not expect many of the existing fishers to go into offshore fishing. In fact, they said that those fishers who have the ability to fish offshore would have already done so. They did not foresee a surge in demand for the recreational fishing industry, either. A transition of small-scale fishers' to recreational fishing would also be hampered by the high cost (several hundred thousand HK$) required to convert fishing vessels to passenger boats due to strict safety requirements imposed by the Marine Department. Without the implementation of the licensing scheme to control the fishing effort, the government will not consider subsidizing the cost of converting fishing boats. The government is also unwilling to provide further fishing fuel subsidies to mitigate the cost of rising fuel prices.

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[4] Underwater visibility is often <5m but tends to be better in winter, and occasional visibility of up to 20m is possible (A. Cornish, WWF Hong Kong *pers. comm.*)

# Results of Alternative Livelihood Analysis

This section addresses the specific issues outlined in the technical proposal. These issues are as follows:

a. Which communities and fisheries areas will most likely be impacted by the various fisheries management scenarios?

b. How dependent are the various fishing groups in the impacted areas on capture fisheries?

c. Apart from fishing, what other livelihood activities do fishers in affected sectors engage in?

d. What skills do fishers to be affected possess? How can these be enhanced?

e. What types of jobs are fishers willing to take?

f. What is the degree of training required to help fishers switch profession, and what is the estimated cost of such training?

g. What is the potential demand for persons to provide services related to tourism and recreation e.g. recreational fishing, scuba diving and snorkeling, sight-seeing, niche “traditional fishing community” tourist experiences, catering?

h. What are the additional costs that may be incurred by vessels transporting recreational fishers from within no-take FPA areas, notably Sai Kung village, to outside the no-take zones e.g. fuel costs, and potential impact on their business?

i. What are the difficulties facing marine aquaculture, a profession which has previously offered alternative livelihoods to local fishers, in Hong Kong in the foreseeable future (e.g. poor water quality)?

j. Attitudes and ability to change within the fishing communities of Hong Kong

## *Impact of management scenarios on fisheries sectors and communities*

*Management scenarios analyzed*

Our first task was to identify the management scenarios to be analyzed. This is crucial because these scenarios form the basis of our analysis of alternative livelihood strategies and the analysis of fisheries impacts. The management scenarios we identified are:

### *Scenario 1*

*Status quo*: Continuation of the fisheries and marine park management regimes in place in 2005:

- 4 marine parks (Hoi Ha Wan Marine Park, Yan Chau Tong Marine Park, Sha Chau and Lung Kwu Chau Marine Park, and Tung Ping Chau Marine Park) where trawling is prohibited and fishing with other methods is allowed with licenses;
- 1 marine reserve (Cape D’aguilar Marine Reserve) where no fishing is allowed;
- Chek Lap Kok Marine Exclusive Zone where no fishing is allowed
- Artificial reefs deployed in the Hoi Ha Wan Marine Park, Yan Chau Tong Marine Park, Sha Chau and Lung Kwu Chau Marine Park, Chek Lap Kok Marine Exclusion Zone, Outer Port Shelter and Long Harbour;
- Fishing effort is not regulated in areas other than the above.

### *Scenario 2*

*Government initiatives*: Introduction of the three proposed amendments to the Fisheries Protection Ordinance proposed by the HK SAR government, with timelines and framework as indicated by the HK SAR government in March 2006. In additional to the marine park management regime as in place in 2005 (Scenario 1):

Scenario 2a:

- Trawlers are banned from fishing within Fisheries Protection Areas (FPAs) (Port Shelter, Tolo Harbour and Channel, and Long Harbour); all other fishing gears are allowed to fish in the FPAs, except where artificial reefs have been deployed; Recreational fishing is not regulated;
- Licensing system is in place and is used to control commercial fishing effort.

Scenario 2b:

- In addition to scenario 2a, a seasonal moratorium that is in line with the moratorium in the South China Sea that is imposed by the mainland Chinese authority is implemented, i.e. trawls and purse seines are banned from fishing in Hong Kong waters during June and July.

### *Scenario 3*

*WWF initiatives:* Introduction of all or part of WWF's "Save Our Seas" campaign objectives in 2007 (SOS: "Save Our Seas" Position Paper, 1 Dec 2005)

Scenario 3a:

- No-take marine zones to cover all existing marine parks, and the proposed FPAs in Port Shelter, Tolo Harbour and Channel, and Long Harbour.

Scenario 3b:

- Ban on bottom trawling in all Hong Kong waters, except in the southern waters (south of Lantau and Lamma Islands) where shrimp trawling is allowed.

Scenario 3c:

- Creation of no-take zones covering the entirety of all HK's marine parks.

Scenario 3d:

- Combination of Scenarios 3b and 3c.

Scenario 3d2:

- Creation of no-takes FPAs in Port Shelter, Tolo Harbour and Channel, and Long Harbour

Scenario 3e:

- Combination of Scenarios 3b and 3d2.

Scenario 3f:

- Combination of Scenarios 3a and 3b.

Using existing and updated models, we studied the potential impact of each scenario listed above on the different fishing groups and sectors in Hong Kong waters.

Fishing sectors refer to the following gear types: stern, pair, shrimp, hang, purse seine, P4/7 (see above for details) and miscellaneous (including long line and gillnet). Fishing communities are segregated by home ports, and include i) the main commercial trawler ports such as Aberdeen, Cheong Chau, and Castle Peak Bay, and ii) small-scale fishing communities such as Kat O, Tap Mun, Kau Lau Wan, and Tai Po and its outlying islands.

## *Net present value of benefits by fishing sector*

We use net present values (NPVs) of the flows of economic benefits to capture the benefits to the sectors in this paper. A full presentation of impacts on the biomass, catch and NPV is given in the Part II of this report. The equation below is a mathematical representation of the NPV:

$$NPV_s = \sum_{t=0}^{T} \frac{nLV_{s,t}}{(1+\delta)^t} \qquad 1)$$

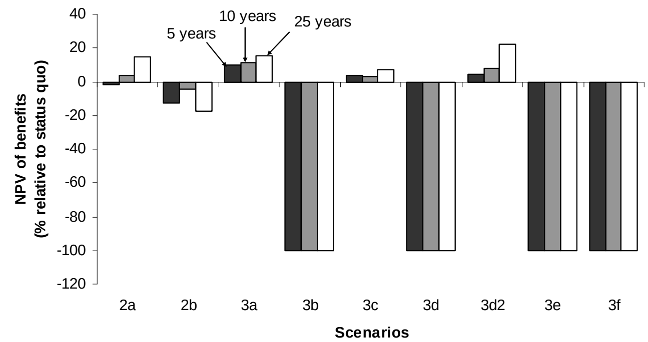
Where $NPV_s$ denotes the net present value to sector *s*, $nLV_{s,t}$ is the landed value less the cost of fishing by sector *s* in period *t*, the parameter $\delta$ denotes the discount rate, and $t=0,...T$ is the fishing period or year. In other words, the NPV is calculated by first determining the revenue from the catch in a given year by a sector, and deducting the cost of landing the catch to produce the net benefit. The yearly net benefit is then discounted in each year, and summed over the time horizon of the project. The NPV is therefore a summary measure of the benefits to each sector.

The management initiatives proposed by the government include two no-trawl FPAs (Tolo and Long Harbour and Port Shelter) with core areas of no-take zones (Scenario 2a). This scenario has positive impacts for all fishing sectors except shrimp trawls. The net benefits relative to the *status quo* for stern trawlers, pair trawls and hang trawls increase slightly in the 5 and 10 years time frames (Figure 6 a,c,d). The shrimp trawl sector is the only one which faces a negative impact from scenario 2a, with a decrease in net benefits by around 12% in 25 years. Net benefits for purse seiners increase in the long term compared to the 5 year timeframe. In 25 years, net benefits for purse seiners increase by around 15% from the *status quo*.

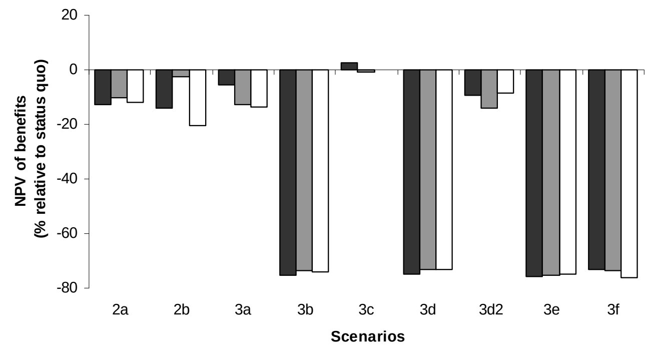
When a two-month moratorium on trawling and purse seining (in-line with the PRC regulations) is imposed, all trawl sectors lose relative to the *status quo*. Pair trawls experience the greatest loss of around 30% in net benefits, while stern trawls, shrimp trawls and hang trawls have losses of around 20% relative to the *status quo* in the 25 year time horizon. Net benefits for purse seines also decrease in the 5, 10 and 25 year time periods (Figure 6e). P4/7 and miscellaneous vessels benefit most from the seasonal moratorium, with net benefit increases of around 20 and 30% relative to the *status quo* in the short term (5 years) and long term (25 years) analysis, respectively (Figure 6f, g).

Generally, the purse seine sector sees increases in long term (25 years) net benefits from all the initiatives proposed by WWF (Scenarios 3a-3f, Figure 6e). The scenarios involving a Hong Kong wide trawl ban (3b and 3d) result in the highest increase in short term net benefits for both the P4/7 and miscellaneous sectors (Figure 6f and 6g). Increases range from around 35% for P4/7 to 40% for the miscellaneous sectors. The P4/7 and miscellaneous sectors experience an increase in long term net benefits under all scenarios except that the miscellaneous sector may experience a minor loss in the short and long terms under the no-take FPAs and no-take marine parks scenario (3a).

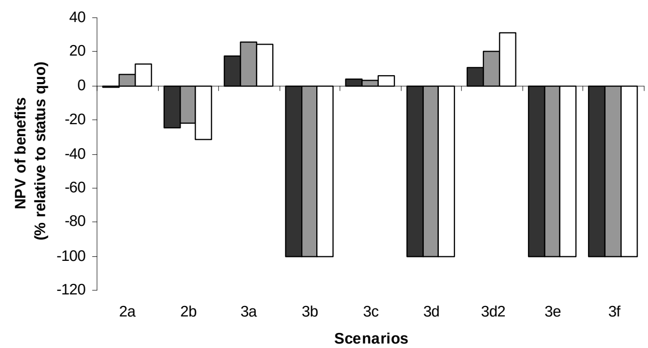
6a. Stern trawl



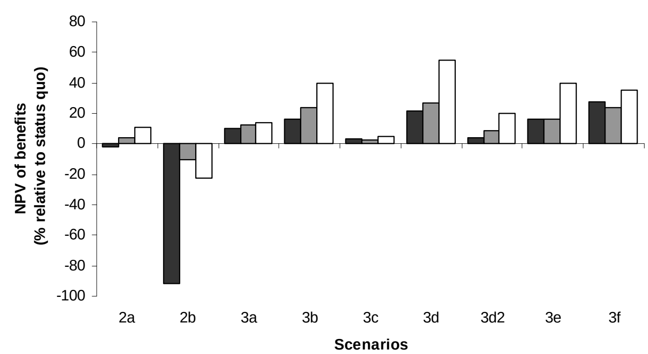

6b. Shrimp trawl



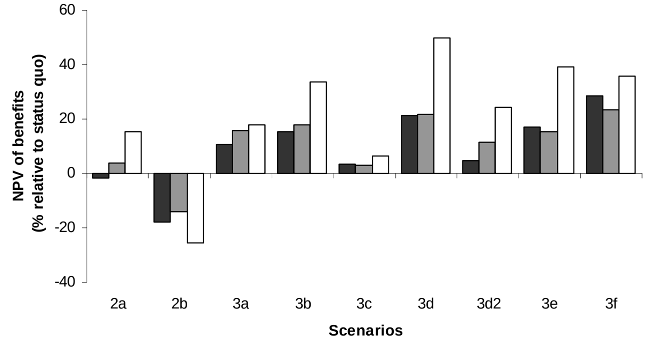

6c. Pair trawl



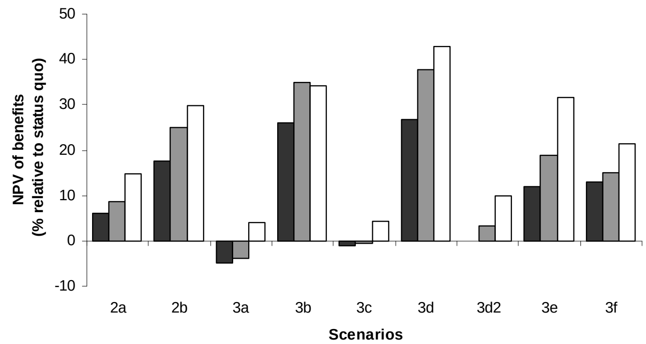

6d. Hang trawl



6e. Purse seine




6f. P4/7




6g. Miscellaneous

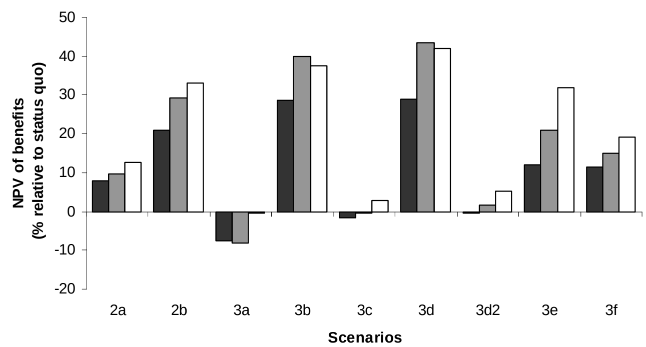



**Figure 6**. Percentage change in net present value of profits (private discount rate of 7%) relative to the *status quo* by 7 fishing sectors after 5, 10 and 25 years: a) stern trawl; b) shrimp trawl; c) pair trawl; d) hang trawl; e) purse seine; f) P4/7 and g) miscellaneous. Results are taken from Part II of this report.

With the exception of shrimp trawls, the trawl sector experiences small increases in net benefits for the scenarios involving no-take FPAs or MPs (3a, 3c and 3d2). The largest decrease in landed value for the trawl sector, with the exception of hang trawls, comes from scenarios involving a territorial-wide trawl ban (3b, 3d, 3e, and 3f). A territorial-wide trawl ban will definitely result in a big loss to the trawlers if we consider their fishing activities in Hong Kong waters only. However, some of the trawlers can fish outside Hong Kong waters, and thus may not be as seriously impacted by the trawl ban as predicted here.

## *Net present value of benefits by fishing area*

We predict that the fishing areas that are generally most seriously impacted by the various management scenarios (Port Shelter, Tolo Harbour, and Long Harbour areas) will suffer only minor losses in net benefits relative to the *status quo*. Indeed, under scenario 2a, the total net benefits from Port Shelter will be reduced by less than 5% in the 5 and 25 year time horizon models (Figure 7a), with a smaller loss in the long term (25 years) as fish abundance increases after protection. Imposing a seasonal moratorium in addition to the no-trawl FPAs (scenario 2b) results in a smaller loss in net benefits to the Port Shelter area than scenario 2a in 5 and 10 year time frames, but a slightly larger loss (about 3% relative to the *status quo*) in the 25 year time frame. The effects are similar in scenarios 3, in which no-take FPAs are incorporated. Scenario 3c does not involve FPAs (only no-take marine parks) and results in gains in net benefits in 10 and 25 year time frames, showing spill-over effects from the no-take marine parks. As all scenarios with trawl bans (3b, 3d, 3e, and 3f) result in large reductions in net benefits from the *status quo* in all areas (for Port Shelter, scenario 2a is virtually very similar to scenario 3b), they are not shown in Figure 7.

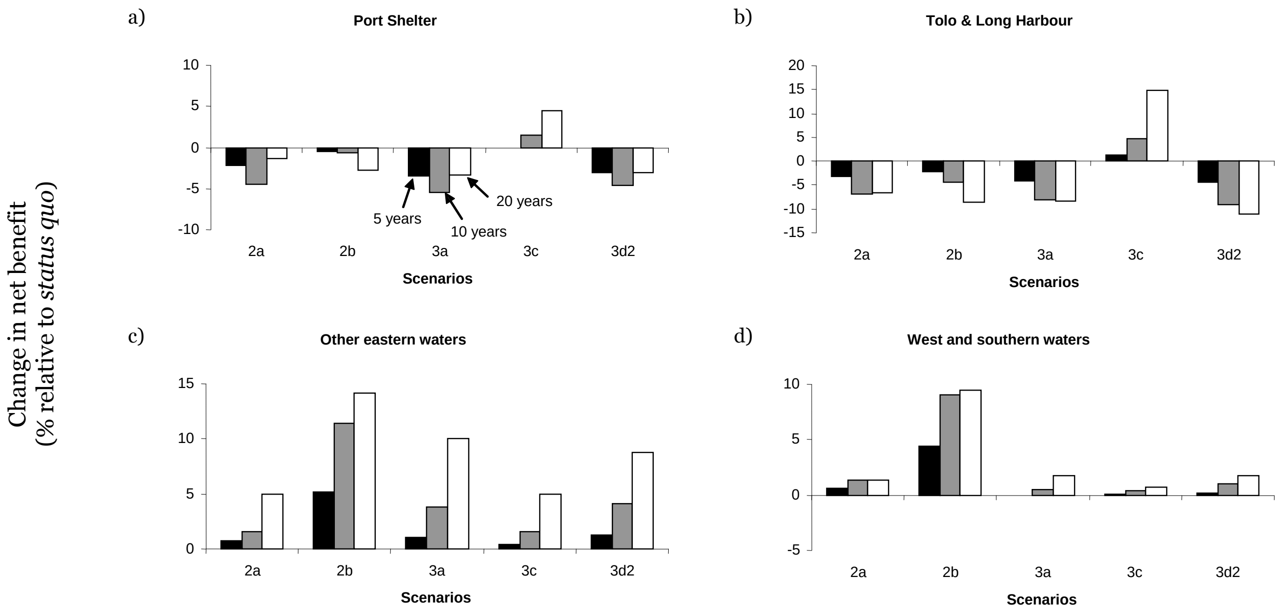



**Figure 7 a-d**. Change in forecast landed value relative to the status quo in a) Port Shelter; b) Tolo and Long Habour; c) Eastern waters other than a, b and d) western and southern waters (See impact to fisheries section for key to scenarios).

The pattern of changes is similar in Tolo Habor and Channel and Long Harbour. The larger increase in net benefits in scenario 3c (no-take marine parks) relative to those in Port Shelter is likely because of the higher benefits of spillover of commercial species from the no-take marine parks in the Tolo area, as most marine parks (Hoi Ha Wan, Yan Chau Tong and Tung Ping Chau) are in close proximity to Tolo Harbour and Long Harbour. The lack of a decrease in the loss of long-term NPV in scenario 3a is because the loss in economic benefits from prohibiting trawling in Tolo Habour is higher than those in Port Shelter.

Outside Port Shelter and Tolo and Long Harbour, net benefits in the eastern waters increase in all non-trawl ban scenarios. Scenario 2a increases the net benefits slightly from the *status quo* by no more than around 5% in 5, 10, and 25 years. The increase is bigger in scenario 3a in the eastern waters, with 1%, 4%, and 10% increases in 5, 10, and 25 years. A seasonal trawl and purse seine ban (2b) seems to have the strongest benefits. Implementing either no-take FPAs or no-take marine parks provides positive net benefits to areas further away from these protected areas.

The patterns of net benefits changes are generally similar in the southern and western waters, although the magnitude of the benefits is relatively smaller to those in the eastern waters. The gains from the scenarios in the western and southern waters suggest that benefits from the protected areas should also be experienced by communities further away. However, increase in net economic benefits in the western waters from designating the Sha Chau and Lung Kwu Chau MP as no-take (scenario 3) is relatively smaller than in Port Shelter and Tolo. This is mainly because of the larger area of the western waters relative to the small area of the MP.

## *Impact on communities*

The establishment of FPAs (scenarios 2a, 2b, 3a, 3d2, 3e) may have slight effects on eastern Hong Kong fishing communities that fish mainly in Port Shelter, Tolo Harbour, and Long Harbour. These include communities such as Tai Po and Sai Kung. If FPAs are made no-take, part of the leisure boat community in Sai Kung may be negatively impacted because they earn considerable income from squid/cuttlefish jigging tours, for which the major fishing ground is Port Shelter. Other recreational fishing-related businesses, such as fish tackle shops, may also be negatively affected by no-take FPAs.

The trawl ban scenarios (3b, 3d) would affect other communities with a large number of trawl fishers, such as Aberdeen, Cheung Chau, and Castle Peak Bay. However, many of the larger scale stern and hang trawlers from Aberdeen, Cheung Chau, and Castle Peak Bay tend to fish in Hong Kong waters only during the June and July fishing moratorium in the South China Sea (see previous section: Fishing Activities). Thus, they will not be as heavily impacted as the smaller scale shrimp and stern trawlers, which operate mostly in the coastal waters of Hong Kong. No-take MPs (scenarios 3c, 3e, 3f) will impact the small-scale fishing communities that currently fish within the Yan Chau Tong, Tung Ping Chau, and Hoi Ha Wan Marine Parks. These include the communities of Kat O, Tap Mun, Kau Lau Wan, and those around Tolo Harbour and Channel. Hang trawlers operating in Sha Chau and Lung Kwu Chau MP will also be affected, but as explained in the previous paragraph, the impacts will be much smaller than the small-scale fishing communities in eastern waters.

On the other hand, positive net benefits are predicted for fishing in other eastern waters and the southern and western waters outside protected areas. Thus, communities in the Port Shelter, Tolo Harbour and Long Harbour areas can offset some of their potential losses by shifting their fishing grounds. Moreover, some scenarios may also provide net benefits to communities fishing further from the protected areas.

## *Dependence of fishing groups on capture fisheries*

Only small-scale fishing is allowed in MPs, therefore P4/7s (sampans) are the fishing group most dependent on MPs in terms of catch and landed value. Hang trawlers are also allowed to operate in the southern part of Sha Chau and Lung Kwu Chau MP. In 2001/02, this sector accounted for 38% and 77% of total catches and landed value from MPs, respectively (AFCD Port Survey). Although these are large percentages, both the total catch from MPs and the actual catch and landed value that small-scale fishers take from MPs is very small relative to other fishing grounds. In fact, catches and landed values derived from MPs account for only 3 and 2% of small-scale fishers' total catches and landed value, respectively. Also, the home ports of most fishers fishing in marine parks are some distance from the parks. Furthermore, many small-scale fishers have other employment in addition to fishing. For example, they may transport passengers or recreational fishers during the weekends, engage in mariculture, or operate a raft recreational fishing facility. 85% (n=13) of small-scale fishers interviewed also had either a mariculture raft or a boat transport business. According to fishers, the proportion of income derived from fishing and non-fishing activities ranged from 2:1 to 1:2. Thus, overall, the establishment of no-take MPs is not likely to have a serious economic impact, even on the most vulnerable group of fishers.

The proposed FPAs in Tolo Harbour, Port Shelter, and Long Harbour are important fishing grounds for pair trawlers, who are estimated to derive 29% of their total Hong Kong catch, and 31% of total landed value from the FPAs (AFCD 2001/02 Port Survey, unpublished data). Tolo Harbour and Port Shelter are also the main fishing grounds for approximately 20 to 30 full-time small-scale shrimp and stern trawlers (less than 20 metres in length) from Tai Po, and to a lesser extent, Sai Kung town. These fishers depend heavily on fishing income, and state that they fish in the proposed FPAs 70 to 80% of the time, and up to 95% during winter. Thus, they will be the most heavily affected by the scenarios involving FPAs. These small trawlers are at a disadvantage because the vessels are not large enough to operate in unsheltered areas outside the harbour. On average, they make a profit of HK$400 a day, and our survey indicates that they do not have the education or skills for other jobs; thus, fishing is critical for their livelihood. However, they are open to the idea of accepting the FPA if they were to be given reasonable compensation for doing so. In addition to this fishing group, around 1,700 small-scale P4/7 vessels also operate in the FPAs. Compared to the MPs, the FPAs are relatively more important fishing grounds for small-scale vessels; 22%

and 18% of their total Hong Kong waters catch and landed values come from the proposed FPAs. Therefore under the no-take FPA scenario, small-scale fishers will be heavily impacted.

According to Hong Kong Census and Statistics data, the most common monthly income salary range for skilled agricultural and fisheries workers is HK$2000 to 3,999, followed by HK$4,000 to 5,999, and HK$10,000 to 14,999. From our interview data, the median fishing income for small-scale fishers was HK$7,500 per month. The monthly income for mid-size shrimp trawl and purse seines was HK$35,000 per vessel, while it was HK$14,300 for a medium sized gillnet vessel. Assuming that around 2 family members operate each of these vessels, and all crew are paid equally, fishing income per fisher is approximately HK$17,500 for shrimp trawl and purse seine fishers, and around HK$7,150 for gillnet fishers. The monthly income levels from interviews, with the exception of shrimp trawls and purse seines, fall within the range of official census data. The Hong Kong poverty line income ranges from HK$6,300 to HK$8,400 per month (China Daily, 13 August 2004), depending on the number of members in a household. Most of these small-scale fishers are therefore either just slightly above, or living below the poverty line. This implies that those who are not currently engaged in other part time work will likely feel more severe financial hardship with the loss of part of their fishing grounds.

## *Other livelihood activities by fishers in affected sectors*

Fishers in affected sectors are also engaged in mariculture, boat transport, and running recreational raft fishing businesses. The main mariculture areas are in Tai Po and, to some extent, its outlying islands, Sai Kung, and Kat O. Fishers that are engaged in boat transport are mainly from the P4/7 sector. Fishers in Sai Kung have the best opportunities to operate transport boats due to the high number of visitors there: they transport recreational fishers for boat fishing or to remote sites for shore fishing. In Hoi Ha Wan, we interviewed one fisher who was routinely hired by marine park visitors to go coral watching using a “water mirror” (i.e., sheet of glass). Fishers in the P4/7 sector also transport people to communities in outlying islands (e.g., Tap Mun, Kau Lau Wan), or are hired by researchers or engineering contractors for transport to survey sites. . Some of the fishers are hired to work as boatmen on leisure boats during weekends, particularly during the high season for leisure boat businesses in summer. Several raft fishing operations have started in the outlying Tai Po islands, Tolo and in Kau Sai Chau in Port Shelter. In Sok Kwu Wan on Lamma Island, a group of fishers have set up a ‘traditional fishing village’, funded largely by a local seafood restaurant, which offers recreational raft fishing combined with a tour demonstrating historical and cultural aspects of fishing in Hong Kong. This operation was just started so the respondent who informed us about this was not able to comment on its long-term profitability.

## *Fishers’ skills: current capabilities and methods for enhancement*

Most fishers possess limited skills besides fishing, boat operating, and mariculture operation. All the interviewed fishers acknowledged this; thus, only jobs requiring minimal education, such as construction or cleaning, or marine related jobs, such as boat operators or deckhands, would be immediately suitable for them. Fishers’ limited skill sets could be enhanced by basic training in certain skills such as English and Mandarin, to allow them to participate in the services (especially tourism) sector. The AFCD currently offers training in aquaculture and boating skills, both of which can potentially improve their opportunities for earning supplemental income. Many interviewed fishers holding licenses to operate fishing crafts also raised the concern that they do not have a license to operate leisure boats. In order to obtain this license from the Marine Department, they are required to pass a written examination which is difficult for them, as many are illiterate. Courses specifically designated for fishers (perhaps conducted and tested orally) may help them overcome the difficulties in getting the knowledge to get a leisure boat license, given that most fishers are very experienced in boat operation and navigation. Also, regular courses in modern mariculture practices might also enhance production from mariculture, which is considered to consist of old fashioned and low technology operations (Chan, 2005). However, the decline in mariculture has been due largely to factors beyond the control of mariculturists, for example, poor water quality and disease outbreak.

### ***Jobs that fishers are willing to take***

In general, fishers are willing to take on marine or fishing-related jobs, such as boat operators (for leisure boats or passenger transport), recreational raft fishing operators, or recreational fishing guides. However, fishers do not think that there are enough of these jobs to absorb all fishers who may potentially be displaced. In terms of non-fishing jobs, most fishers feel that the skill set they possess limits them to low wage, manual jobs such as construction. Many interviewed fishers stated that even if they were willing to take on non-fishing jobs, there are limited employment opportunities. In general, finding low wage jobs in Hong Kong is difficult due to the downturn in the manufacturing sector, reduced demand for construction workers, and an influx of unskilled immigrants from mainland China. The increasing number of low wage workers from mainland China also means that local workers face more competition in securing these jobs. The downward trend in the number of vacancies for manual workers (Figure 8) demonstrates that switching to alternative land-based jobs will be a difficult transition for fishers. Some fishers do not want to work as an employee as they have been used to the freedom of always working for themselves. The willingness of fishers to take on construction work may also be hindered by the new requirement for construction workers under the Construction Workers Registration Ordinance (Cap 583), which stipulates that all construction workers need to register at the Construction Workers Registration Authority, with the type of work allowed depending on the type of license they can obtain.

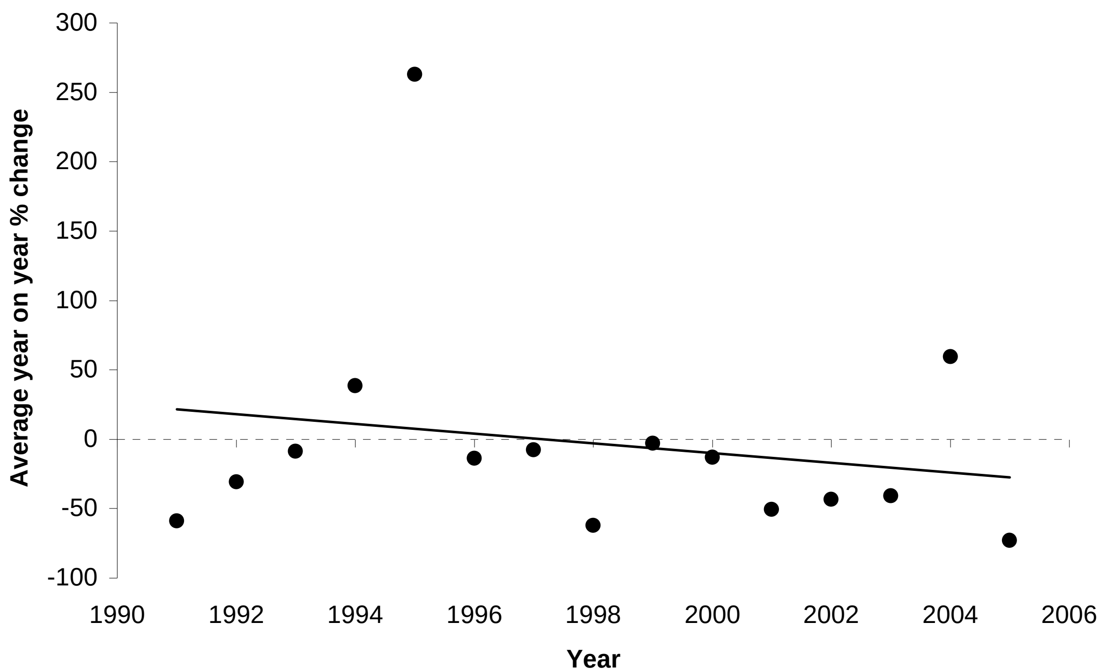



**Figure 8** Job vacancies for construction site workers. Source: Hong Kong Census and Statistics Department. The trend line shows that job vacancies have been decreasing in recent years.

### ***Degree and cost of training required to help fishers switch profession***

We estimated the cost of training based on responses from our survey of alternative livelihood operators. The survey respondents who were willing to hire fishers would hire them as boatmen, deckhands and recreational fishing guides. These jobs require skills and knowledge that fishers generally already possess, although any job requiring a license could pose a barrier (see above). Thus, the degree of training required for fishers to switch to these professions is small. The most common responses for duration of training were one week (38% of responses), and 1 week to 1 month (29% of responses). Given this, we chose an average training period of 2 weeks for our analysis. Based on a salary of HK$7500 a month (the most common average salary given by respondents), this amounted to a training cost of HK$3750 per trainee (not accounting for trainer's time).

Alternatively, fishers who are displaced from fishing may work in other non marine-related sectors, such as the construction sector. In such cases, the cost of re-training fishers can be calculated based on an assumed period of retraining and a minimum wage that can support the livelihood of the fishers during this re-training period. According to the Census and Statistics Department in Hong Kong, the average monthly salary for 'General Workers' in 2005 was HK$ 7,350. Assuming a maximum re-training period of 6 months, the cost of retaining one fisher is HK$ 44,100. The Hong Kong government already has an on-going fund that supports retraining of workers and thus we assume that extra costs are not needed to set up an additional retraining programme for this purpose. The total training costs calculated under each approach is consolidated in a later section (fisheries impact analysis section in this report).

The degree of training for fishers would vary, depending on the skills being taught. The AFCD currently provides fishers with training on offshore fishing and aquaculture. This is jointly funded by the government and the Hong Kong Fish Marketing Organization. In Taiwan, the government provided a retraining programme to fishers and farmers that lasted up to a maximum of 6 months. In the Philippines, a programme which provided direct assistance to small-scale fishers in overfished areas to find alternative employment cost US$ 75,000 annually in 1998 (APEC, 2000). Elsewhere, training has been provided to fishers on seaweed farming, handicraft making, seafood processing, and aquaculture (e.g., Sievanen *et al.*, 2005, Gell and Roberts, 2003). However, not all these activities might be appropriate in Hong Kong. Due to Hong Kong's role as a prominent port, a possible alternative might be to train fishers for work on container or cargo ships as deckhands and stevedores.

## *Potential demand for service workers in tourism and recreation related activities*

Following the SARS outbreak in 2003, tourism to Hong Kong has steadily re-built. In 2003, there were 15.5 million tourist arrivals to Hong Kong. This increased to around 22 million in 2004, followed by another increase to 23 million in 2006 (Hong Kong Tourism Board, 2006). Visitor numbers to Hong Kong are projected to grow, especially with the large influx of visitors from Mainland China. Incoming tourism receipts are forecast to increase by 6.5, 6.5, and 6% in value in 2007, 2008, and 2009, respectively (Euromonitor International, 2005). This will stimulate demand for associated services such as restaurants and hotels. In fact, the hotel industry was planning to increase existing hotel room numbers from 38,500 in 2004 to 51,000 in 2006 (Lam *et al.*, 2004). This indicates that employment in the services sector should increase as well. Hotel and restaurant associated jobs requiring limited education, such as cleaning, can provide potential employment for fishers. Figure 9 shows that both restaurant and hotel receipts are on an upward trend since 2003, after declining from the late 1990s to early 2000s.

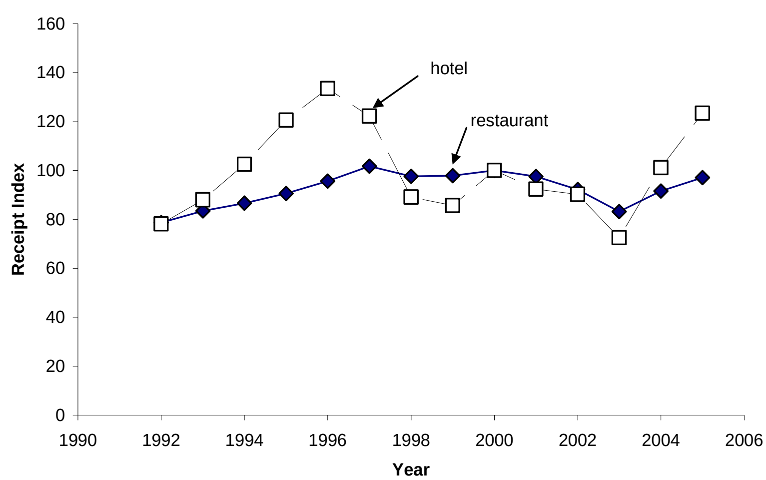



**Figure 9.** Index showing trend in restaurant and hotel receipts. Source: Hong Kong Census and Statistics Department.

In terms of what tourism growth implies for marine or coastal related recreation and tourism, the government of Hong Kong has several initiatives aimed at promoting or improving coastal districts and facilities. Under the Northern New Territories Green Tourism Development Programme, pilot projects to be completed in 2007 in Plover Cove and Tolo Channel include improving supporting facilities, developing island-hopping and sight-seeing tours, as well as conservation and educational initiatives. Other projects include the enhancement of the Stanley and Lei Yue Mun Waterfront. These improvements are likely to attract more visitors, both local and foreign, to waterfront locations, thus increasing the potential for involvement in marine related activities.

In a survey of recreational fishers, over 80% of respondents indicated that they would like more fishable seawalls and the establishment of fishing parks (AFCD, 2004 unpublished report). Therefore the improvement in waterfront facilities will likely attract this group of recreational fishers.

Hong Kong locals frequently visit beaches and country parks during the weekends (Euromonitor International, 2005). In fact, country and marine parks and areas of natural beauty were the most popular tourist attraction in 2004, accounting for more than 45% of visitors to tourist attractions (Euromonitor International, 2005). Visitors to country and marine parks and places of natural beauty grew by 28% during 2004. In light of creating alternative employment for fishers, this increase in demand is a positive development. Interestingly, two interviews conducted with restaurant owners at one of the Marine Parks indicated that their business had actually dropped because visitor numbers to the Marine Park had fallen since the area became protected. They stated that visitors were apparently deterred by the strict conservation/environmental regulations, such as not being allowed to collect or touch shell fish or other marine life. As well, the number of daily visitors was restricted to a certain level, resulting in fewer visitors than before.

Ecotourism has room to grow substantially in Hong Kong, potentially increasing tourism receipts by up to 7.2% (Hopkinson and Stern, 2002). The sustainability of ecotourism is an important factor determining whether this can be a reliable source of income for fishers. Currently, the form of 'ecotourism' in Hong Kong involves organized tours to remote islands or coastal villages and dolphin watching. Many of the tour guides lack appropriate training for leading such trips, leading to potentially negative impacts on the environment. At the same time, the shift in tourist demographics towards more shopping-oriented tourists from China might affect the long term development of the ecotourism sector in Hong Kong (Taipei Times, 2004).

The number of recreational fishers in Hong Kong is expected to increase by 30% in 10 years (AFCD, 2004 unpublished report). However, recreational fishing shop operators stated during our survey that the Hong Kong recreational fishing industry is pretty stable, and that the number of recreational fishers is not increasing much. Operators therefore do not think that the industry will expand much in the future, due to Hong Kong's limited customer base. In addition, recreational fishing is a leisure activity which is easily affected by the state of the economy.

Our questionnaire asked respondents about their expected change in customer numbers based on two different scenarios (the establishment of FPAs and no-take MPs) and during different time frames. The change in expected number of customers can be taken as a proxy for the potential demand for providing services in the diving, recreational fishing, and ecotourism industries. These results are presented in Table 11. Overall, the dive industry is most optimistic about growth in the number of customers both in the long and short term under both FPAs and MPs scenarios. In contrast, the recreational fishing industry expects to lose customers with the implementation of no-take MPs, and benefit slightly with the establishment of FPAs.

**Table 11.** Expected average net change (%) in customers of marine related industries in Hong Kong.

| | Industry | | | |
|---|---|---|---|---|
| **Options** | **Dive** | **Rec. fishing** | **Ecotourism** | **Overall[1]** |
| No-Take MP 1 year | 4 | -9 | 0 | 0.2 |
| No-Take MP 3 year | 8 | 1 | 0 | 4 |
| No-Take MP 5 year | 10 | -3 | 2 | 6 |
| No-Take MP 10 year | 13 | -3 | 14 | 9 |
| FPA 1 year | 7 | -2 | 5 | 4 |
| FPA 3 year | 9 | 8 | 6 | 8 |
| FPA 5 year | 10 | 0 | 7 | 10 |
| FPA 10 year | 13 | 1 | 1 | 9 |

[1] Overall average net change measures the combined changes from all three industries and is not equal to the sum of the three industry changes.

## Additional costs incurred by vessels transporting recreational fishers from within no-take FPA areas to outside the no-take zones, and potential impact on their business

Fuel is the major cost that would be incurred by vessels transporting recreational fishers. We estimated that recreational fishing vessels would have to travel an extra 3.5 to 14 km, and 1.3 to 13.5 km to reach fishing grounds outside Port Shelter and Tolo Harbour, respectively. The locations of recreational fishing grounds were based on a government recreational fishing survey (AFCD, 2004 unpublished report). Based on a fuel cost of around HK$12 to 17 per km, the extra fuel cost incurred by each recreational vessel was estimated to range from HK$42 to 248 for going beyond Port Shelter, and HK$16 to 230 for going beyond Tolo Harbour. If we assume that the boat operator can transfer the entire increase in fuel cost to customers, the percentage increase in cost to recreational fishers hiring different types of vessels is given in Table 12.

**Table 12.** Percentage increase in boat rental cost due to increased fuel consumption (with lower and upper limits).

| Type of vessel | Rental per trip (HK$) | Increase as % of current boat rental cost per trip | | | |
|---|---|---|---|---|---|
| | | Port Shelter | | Tolo Harbour | |
| | | Lower | Upper | Lower | Upper |
| P4/7 sampan (fish from vessel) | 663 | 6 | 36 | 2 | 35 |
| Wooden vessel (fish from vessel) | 891 | 5 | 27 | 2 | 26 |
| Pleasure craft (squid jigging) | 1,469 | 3 | 16 | 1 | 16 |
| Large P4/7 sampan (carry fisher to fishing spot) | 465 | 2 | 10 | 1 | 10 |
| Wooden vessel (carry fisher to fishing spot) | 2,367 | 5 | 26 | 2 | 25 |

According to the government recreational fisheries survey, over 55% of recreational fishers use vessels for fishing. Under the WWF Save Our Seas (SOS) proposal, no-take FPAs would allow recreational fishing only from artificial shorelines or existing raft fishing operations. There is therefore, the potential that a portion of the remaining 45% of recreational fishers who do not currently hire vessels will start to hire a vessel to fish at sea or go to raft fishing operations. Thus, at the least, recreational fishing vessels around the impacted areas can expect customer numbers to remain steady, with the likelihood that demand for recreational vessel hire will increase by a maximum of 45%.

## Difficulties facing marine aquaculture as an alternative livelihood to local fishers in Hong Kong in the foreseeable future.

Many of the fishers interviewed had been involved in mariculture since the 1980s. Mariculture production used to provide a good source of income. However, a severe occurrence of red tide caused major fish mortality in 1997/1998 (see above), and mariculture has been on a decline since then. This is particularly the case in Tap Mun and Kau Lau Wan, where the red tide caused such severe losses that virtually all the operations there have ceased. In recent years fry mortality rates have been around 80-90%, whereas around 90% of fish fry used to survive in the past (before the red tide). Fishers attributed the high mortality rates to disease, pollution, and poor water quality stemming from coastal development and land reclamation. Many fishers did not find mariculture to be profitable anymore. In fact, they have problems selling their fish due to poor prices. Despite these difficulties, many fishers continue to keep some fish in their rafts so as to keep their mariculture license, as government regulations require that fish be kept in the raft in order for the fishers to maintain their license. In addition, many mariculturists continue to keep some fish in hope that the industry will turn around in the future.

In recent studies of the current status of Hong Kong's aquaculture industry, Chan (2005) and Chau (2004) found that problems affecting mariculture were similar to those expressed by the fishers. Among the problems identified by Chan (2005) were: i) high mortality caused by poor inshore water quality and diseases; ii) unreliable and insufficient local supply of fish fry; iii) coastal development and pollution; iv) organic and nutrient enrichment of bottom sediment; v) red tides; vi) high wages for local workers and problems hiring foreign workers; vii) lower production costs in other countries, making Hong Kong cultures prices non-competitive; viii) using low quality 'mixed fish' as fish feed; ix) by-catch problems due to using small-meshed nets for catching fry; x) lack of technical expertise or support from government; xi) limited medication to treat fish diseases; and xii) lack of sustainable sources of fish meal for artificial pellet feed.

The aquaculture industry in Hong Kong uses low technology without any mechanization or innovation (Chan, 2005). This is therefore an area the government should focus on if aquaculture is to become a reliable source of alternative income for fishers (as it used to be during the 1980s). A list of recommendations for reforming Hong Kong's aquaculture industry can be found in Chan (2005). Briefly, the recommendations included 1) improving government communication with, and promotion of, the aquaculture industry; 2) establishing comprehensive fisheries management practices; 3) modernizing the aquaculture industry; 4) setting up an alternative fish food production system and centralizing the live seafood market.

### *Attitudes and ability to change within the fishing communities of Hong Kong*

In general, fishers feel that they are unqualified to pursue alternative jobs or livelihoods due to their age, education level, and skills. This underscores the need for well-tailored training courses to help those who want to move out of fishing to do so; 54% (n=24) of fishers said they were willing to switch jobs or go to live on shore, with the remaining 46% saying that they would not consider it. Of those who were willing to switch jobs, concern about not being able to secure a job due to their qualifications still remained. According to fishers, it is not feasible at present for the current alternative livelihood options (passenger/leisure boat operator, recreational raft fishing, deep sea tuna fishing) to provide the number of jobs necessary to absorb all the fishers (if they should leave the fishery *en masse*). On the positive side, none of the proposed management scenarios proposed calls for all fishers to stop fishing.

Interviewees were asked about their willingness to work in alternative jobs such as boat operators or recreational raft fishing. Currently 13% (n=24) of fisher respondents transport passengers on a part time basis. 43% would be willing to work as boat operators, although they stated that it is difficult to do so due to legal restrictions mentioned earlier in this report. The remaining 36% of respondents did not want to become involved in transporting passengers. Two out of 7 respondents were willing to get involved in recreational raft fishing. The remainder were not willing to participate due to reasons such as the suitability of their location for raft fishing, and the limited size of the market for this activity.

Fishers think that the number of boat operator jobs, whether for recreation or everyday transport, is limited. They are also realistic in pointing out that since recreational fishing is a leisure activity, demand for that activity, and hence boat operators, will fluctuate according to the state of the economy. In fact, many fishers say that those who wanted to participate in these alternative jobs would have done so already. Overall, fishers are pessimistic about their ability to find suitable alternative jobs. In addition to their own limitations mentioned above, the state of the job market is another obstacle as in Hong Kong, there is a lack of low wage/manual labour jobs that would be suitable for fishers. In fact, many fishers pointed out that it would have been easier to switch livelihoods before 1997, as demand for construction workers was high then. Lastly, legal and administrative barriers such as the issue of boat licenses and regulations regarding boat modifications are further obstacles for current fishers considering these alternative options. Among the fishers interviewed 35% (n=20) were willing to participate in a buy-back scheme, while another 40% were willing if the compensation amount was reasonable; 10% were not willing to participate, and another 15% did not think that it was possible for the government to implement such a scheme.

## Discussion and concluding remarks

This survey indicated that 54% of fishers interviewed were willing to switch jobs or go to live onshore, with the remaining 46% saying that they would not consider it. This result implies that there is a good potential for well-designed alternative livelihood schemes to succeed. Also, dive and recreational shop operators were generally receptive of hiring fishers as new employees. The most frequent reason given for not hiring was that fishers did not have the required skills. Therefore any well-designed alternative livelihoods scheme will have to address how to improve suitable skills among fishers. Given the concern expressed by fishers that current alternative livelihood options in the marine sector are restricted, any scheme will have to look outside the marine sector.

Training for fishers is an important activity for the AFCD and other government sectors. Currently the AFCD offers technical training courses for operating fishing vessel engines and equipment, and offers technical/information assistance for switching to other fisheries and related operations (offshore, fish processing, recreational fishing, and aquaculture). However, according to the interview results, fishers are not too keen on these activities. Also, given the possibility of a buy-back scheme, fishers will need skills other than those related to marine activities. Government programmes can therefore consider training which will give fishers more marketable skills outside the fishing sector, e.g., skills for carpentry or electrical trades, and offer skills to facilitate the acquisition of leisure boat operating licences. This implies that the AFCD will need to cooperate with other government departments, and the private sector.

Related to the willingness of over half of the fishers to switch jobs is the finding that a total of 75% of them were willing to participate in a buy-back scheme if they are reasonably compensated for their vessels. These numbers are very encouraging for the proposed management scenarios, as they show that a significant number of the fishers are willing to stop fishing under the right buy-back package.

There was overall, strong support among dive and recreational operators for a total ban of fishing in marine parks, with 86% of all respondents either agreeing or strongly agreeing with this proposal. All ecotourism operators agreed with a total ban of fishing in marine parks. Among fishers, only the small-scale fishers using P4/7 boats thought that marine parks did provide some benefits.

Apart from the trawl sector, there was significant support for a trawl ban. Almost all alternative livelihood operators who responded thought that trawling affected the quality of diving or recreational fishing because trawlers caught too much fish, and thus reduced fish abundance, and that trawlers destroyed coral reef habitats. This finding also lends support to the proposed management scenarios, some of which involve significant reductions in trawling activity to protect the habitat and reduce overfishing in Hong Kong waters.

When respondents were asked which scenario they preferred, none chose to remain at the *status quo* scenario. Different groups of fishers had different opinions about the range of proposed management policies. The most prominent difference deals with the creation of no-trawl FPAs. While this has support from the P4/7 sector, it was, not surprisingly, opposed by the trawl sector. However, there is a difference in opinion within the trawl sector as well. The big trawlers (Hong Kong Fisheries Alliance) oppose outright the policy, whereas the Tolo trawlers (smaller vessels) are more open to the ban, if they are to receive appropriate compensation.

Fuel cost is the biggest concern for fishers now – it has affected the financial performance (profitability) of all fishing sectors. Big trawlers are the worst affected due to their high fuel consumption. This is exacerbated by the fact that a lot of their capital is tied up in the boat. It does not seem to us that the problem of high and increasing fuel cost is going to go away soon. Hence, it is likely to continue to erode the bottom line of fishers, which means that it may be strategic for fishers to get out of fishing. This is probably why up to 75% of fishers are willing to participate in a buy-back scheme. It is important for both the government of Hong Kong and fishers to seize the opportunity to restructure the country's fisheries to ensure restoration and sustainability of the resources, while helping fishers to adjust to the change. However, an important pre-requisite for successful restructuring of the fishing industry is an effective control of fishing effort. As such, the government should implement the fishing license scheme (a re-emphasis of the recommendations from fisheries resources consultancy studies (Environmental Resouce Management, 1998)) as soon as possible to lay the ground for other work to help the local fishing communities and restore fisheries resources.

Government can work to increase job and livelihood diversification for fishers. At the moment, the ability of fishers to diversify their livelihood is constrained by factors beyond their control. These include: a) strict regulatory guidelines for converting fishing vessels to meet requirements for transporting passengers, and guidelines for the operation of recreational raft fishing (especially for the P4/7 sector); b) shrinking demand for low wage labour; c) limited market and growth potential for recreational fishing and diving industries; d) for those fishers wanting to sell their boats, there is no demand for fishing boats, and e) mariculture, the traditional alternative livelihood has become a non-profitable and risky investment. In addition, fishers acknowledge that their poor education is an obstacle to finding employment in other sectors. One observation from the survey is that fishers consistently indicated that coastal development and pollution had affected fish stocks (both mariculture and capture). This suggests the need for integrated coastal management in tandem with fisheries management to help deal with the problems of Hong Kong's marine resources in a comprehensive manner.

We observed divergent opinions about protected areas in our survey. Dive respondents were more optimistic about the creation of no-take MPs. Recreational fishing respondents saw no-take MPs in two perspectives: On the positive side they thought it would attract more recreational fishers by increasing the abundance of fish. On the other hand, it could also decrease their business, because no direct economic benefits can be derived from MPs if recreational fishing is also banned within them. A majority of the fishers interviewed did not think that protected areas provided any sort of benefits. Contrary to the findings in other countries (e.g. Russ *et al.,* 2004), most of the fishers did not think that protected areas had increased fish abundance or fish catch.

A relevant question here is why is the experience regarding the efficacy of marine protected areas in Hong Kong as captured by our survey so negative? This may partly be because of their bad experience from local protected areas schemes and partly because of the limitations of the livelihoods survey and interview/questionnaire design. Fishers did not report noticeable increases in benefits from the existing marine parks and reserves. This might lead them to discount the potential benefits from future protected area programmes. Also, the sample size of our survey is relatively small (even though those interviewed covered the major fishing sectors). The combined interviews and questionnaires covered about 15% of total recreational fishing shops, and 25% of dive shops in Hong Kong. Mail-in questionnaires were not as informative as interviews. Some of them contained missing subtleties or opinions that were expressed during interviews. Finally, the accuracy of the responses to questions on the percentage increase in customers appeared to be limited.

This survey shows that a sizable number of fishers in Hong Kong are willing to pursue alternative livelihoods under a well-designed fisheries adjustment program. In fact, the current costs of the fisheries (i.e., fuel subsidies, management costs) outweigh the benefits, and the profitability from fishing is low or negative for fishers. It appears to us therefore, that the time is ripe for the Government of Hong Kong to work with fishers and non-government organizations to devise a plan to help secure the flow of benefits from Hong Kong waters to both the current and future generations of citizens of Hong Kong.

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# Appendix 1. Questionnaire for fisher interviews

Date: |_|_|-|_|_|-|_|_|_|_|Code: |_|_|_|Location:___________

## 1. Personal Particulars

1.1 Age: |_|_|

1.2 No. of fishing year: |_|_|

Year started fishing career

1.3 Place of Birth: HK/___________

1.4 If not HK born, year of immigration: _____________

1.5 Was your last generation fishermen: **Yes|_|No |_|**

1.6 No. of people in household:

1.7 Single/Married, if married, no. of children ( )

1.7 Education: Primary/Secondary/Tertiary

1.8 Major Home port

| **Locations** | **Start of career** | **Mid career** | **Most recent year** |
|---|---|---|---|
| ShaiKeeWan | \|_\| | \|_\| | \|_\| |
| Aberdeen | \|_\| | \|_\| | \|_\| |
| Castle Peak Bay | \|_\| | \|_\| | \|_\| |
| Cheung Chau | \|_\| | \|_\| | \|_\| |
| Tai Po | \|_\| | \|_\| | \|_\| |
| Tai O | \|_\| | \|_\| | \|_\| |
| Sai Kung | \|_\| | \|_\| | \|_\| |
| Others | \|_\|_______________ | \|_\|_______________ | \|_\|_______________ |

## 2. Fishing method(s)

2.1

| **Gear** | **Start of career** | **Mid-career** | **Most recent year** |
|---|---|---|---|
| Gill net | \|_\| | \|_\| | \|_\| |
| Longline | \|_\| | \|_\| | \|_\| |
| Handline | \|_\| | \|_\| | \|_\| |
| Shrimp trawling | \|_\| | \|_\| | \|_\| |
| Pair trawling | \|_\| | \|_\| | \|_\| |
| Stern trawling | \|_\| | \|_\| | \|_\| |
| Hang trawling | \|_\| | \|_\| | \|_\| |
| Purse seining | \|_\| | \|_\| | \|_\| |
| Others | \|_\|_______________ | \|_\|_______________ | \|_\|_______________ |

2.2

| **Type of Junk used** | **Size(feet)** | **Power** | **Period** |
|---|---|---|---|
| ________________ | \|_\|_\|_\| ft/m | ___________ | Start of career |
| ________________ | \|_\|_\|_\| ft/m | ___________ | Mid career |
| ________________ | \|_\|_\|_\| ft/m | ___________ | Most recent yr |
| ________________ | \|_\|_\|_\| ft/m | ___________ | _____________ |

2.3

| **Major fishing area (use AFCD fishing zone map), also ask % of time spent fishing in that area in most recent year fishing trip** | **Period** |
|---|---|
| ______________________________________________ | Start of career |
| ______________________________________________ | Mid-career |
| ______________________________________________ | Most recent yr |
| ______________________________________________ | ________ |

Could you please estimate the % of time you spent fishing in Hong Kong waters?

Outside HK waters, where did you fish?

2.4 Reasons for your change in fishing grounds

a. Reduced catch on previous ground|_|

b. Improvement on technology|_|

c. Too much vessels on previous ground|_|

d. Restriction of fishing on previous ground |_|

e. Others _______________________________________________

## 3. Species composition

3.1 **The species caught (most recent year)**

| **Species name** | **Gear** | **Time of year caught** | **Location of catch** | **% of total catch** |
|---|---|---|---|---|
| __________ | ___________ | ___________ | ___________ | _________ |
| __________ | ___________ | ___________ | ___________ | _________ |
| __________ | ___________ | ___________ | ___________ | _________ |

3.2

a. Where do you sell your fish?

|_|Hong Kong
|_|China
|_|Macau
|_|Others ____________

b. Who do you sell the fish to?

| | Percentage of total catch |
|---|---|
| \|_\|FMO | ______________________ |
| \|_\|Directly to market retailer | ______________________ |
| \|_\|Directly by yourselves | ______________________ |
| \|_\|To fish collector | ______________________ |
| \|_\|Others | ______________________ |

## 4. Catches and Effort

4.1 Fishing seasons

a. When is the high fishing season (list months)?

b. When is the low fishing season (list months)?

4.2 Do you switch gear during the different seasons?

If yes what gear do you use during:

High season:

Low season:

| Season | Gear | Catch per trip (kg) | | Hours per trip | | No. of fishing days per week | |
|---|---|---|---|---|---|---|---|
| | | Max | Min | Max | Min | Max | Min |
| High | | | | | | | |
| Low | | | | | | | |

## 5. Fishing Costs

1. Do you own your boat?
2. How old is your boat?
3. How many years does a boat last?
4. What fuel does your boat use? Diesel/Gasoline/none
5. What is the fuel consumption per trip/month?

## 6. Fishing Income

1. Is fishing your only source of income?

2. If no what other source of income do you have?

a.What proportion of household income does fishing make up?

3. What is your daily/monthly income (net) from fishing?

| | **HK$/day** | | | **HK$/month** | | |
|---|---|---|---|---|---|---|
| | Max | Min | Avg | Max | Min | Avg |
| High season | | | | | | |
| Low season | | | | | | |

What proportion of it is from Hong Kong waters?

1. Do you have another job? Y/N (if Y go to 5)
2. What is your other job?
    a. Where is it located?

   b. Do you do it year round? Y/N (if Y go to 6, N go to 9)
3. What time of the year do you do your other job?
   a. For how many months?
4. How much income (daily/monthly) do you get from that job?
   Daily HK$___Monthly HK$___
5. Do other members of your household fish?
6. Do other members of your household work?

Wife / Husband / Son / Daughter /Aunt / Uncle / Father / Mother / Cousin /Other

   a. What type of work do they do?
   b. How much do they contribute to monthly household income (% or HK$)?

**7. Alternative Livelihood**

1. Do you see that you/your children will continue to rely on fishing as major source of income? If not, why?
2. Is the income you earn from your current fishing practice enough to live on?
   a. What do you do when you do not earn enough from fishing?
   Borrow from bank___Borrow from friends/family___
   Borrow from government /fishers cooperatives___
   Get another job____Use savings___
   Do nothing___
   Apply for government low-income social benefits___
3. If there were other jobs available that offer same income as fishing, would you switch jobs or continue to fish? Why?

4. If you choose to continue fishing, will you consider changing your current fishing practice? How?
   ___ Spend more time fishing further offshore (where?)
   ___ Spend more time fishing further inshore (where?)
   ___ Change fishing method (to what gear?)
   ___ Develop distant water fishing
5. Has your fishing income increased or decreased from before (5, 10, 15 years ago)?
6. Would you be interested to work in:
   i) Tourism (e.g., boat driver/fishing guide) Y/N Why?
   ii) Aquaculture Y/NWhy?
   iii) Fish processing factory Y/NWhy?
   iv) Other (specify)

How much income per month would you expect an alternative livelihood could provide you if you were to switch to it from fishing?

7. Do you think you have the skills required to work in:

i) TourismY/N

ii) AquacultureY/N

iii) Fish processing factoryY/N

iv) Other

8. Are you willing to learn the required skills?
9. Would you be willing to do another job full time or just part time (and continue fishing rest of the time?
10. Would you be willing to stop fishing altogether?
11. If the government were to establish a vessel buy-back scheme, will you consider giving up fishing? Why?

## 8. Fish trade

1. Who/Where do you sell your fish to?
2. How many years/months have you been selling to this buyer?
3. What types of fish do you sell to this fish trader?
4. How does the fish trader pay you?
   Cash__Credit__Exchange for fuel/bait__
5. How much fish do you keep for your own consumption?

6. Do you sell to this same place year round?
   a. If no where else do you sell to?
   b. Why do you switch to a different buyer?
7. Does the price of fish change during the year?
   a. When is it highest/lowest?
8. Can you tell me the price of main fish species sold:
9. In a normal catch, what proportion of the catch is of expensive fish, and what proportion is of cheaper fish?

## 9. Perception about fishing restrictions

1. Have your catches from HK waters declined from the past?
   a. By how much (% or factor) has your catches decreased?
2. What do you think has caused the decrease in catches?
   a. Increase in no. of fishers ____
      - Can you estimate the % increase in fishers in your fishing area since you began fishing?
      - Where did the new fishers come from?

   b. More efficient gears ____

c. Other ___

3. What do you think should be done to prevent further decreases in catches?
4. Do you think the fish/ fishing grounds (in HK) have to be protected? Why or why not?
5. Do you think establishing a marine reserve (no fishing allowed) within HK fishing grounds would help the fish populations to recover? If yes, do you think you can benefit from it?
6. Would you agree to a marine reserve in your current fishing ground (within HK)?
   - If no would you continue to fish there even if it was made into a reserve?

# Appendix 2. Questionnaire for Alternative Livelihood Operators

Name: ____________________________

Company name: ___________________

Contact Tel no.: ___________________

Email: ____________________________

If we need further questions regarding this survey, can we contact you again?

__Yes__No

1) Business type:

__Dive shop

__Recreational fishing shop/ guide

__Boat rental

__Ecotourism

__Others, please specify _______________

2) Location of the company: _______________________________

3) Number of years in operation: ___________

4) Customers (no. of persons) per month:

__< 50__50-100__100-150__150-200__>200

5) Do you have

__ Same number of customers each month, or

__ More customers during certain months? (Circle months)

JanFebMarAprMayJunJulAugSepOctNovDec

6) Average spending per customer per month:

__<HK$500__$500-$1000 __$1000-$2000 __$2000-$3000

__$3000-$4000__$4000-$5000 __>$5000

7) Average income from business per month:

__<HK$30,000 __$30,000-$60,000 __$60,000-$120,000 __>$120,000

8) Where do you take your customers (for diving or fishing)?

_______________________________________________________________________

9) Do you take your customers to the following areas:

___ Tung Ping Chau

___ Yan Chau Tong

___ Sha Chau and Lung Kwu Chau

___ Hoi Ha Wan

10) How many trips do you make to each of the marine parks per month? (Circle choice)

Tung Ping Chau 0 1-5 5-10 10-15 15-20 >20

Yan Chau Tong 0 1-5 5-10 10-15 15-20 >20

Sha Chau & LKC 0 1-5 5-10 10-15 15-20 >20

Hoi Ha Wan 0 1-5 5-10 10-15 15-20 >20

11) How many people are there in each trips?

___1-5__5-10___10-20___20-30___30-40___>40

12) How much does each of your customers pay, on average, to go diving/fishing/visiting at these areas?

Tung Ping Chau _________

Yan Chau Tong _________

Sha Chau & LKC _________

Hoi Ha Wan _________

13) Do you think that the fish/marine life is adequately protected in the marine parks?

___Yes___No

14) Does the presence of marine parks benefit or disadvantage your operation?

___Yes___No

15) Do you agree that the current marine parks should be made into no take zones (prohibit all kinds of fishing)?

___Do not agree ___Slightly disagree ___No opinion ___Agree ___Strongly agree

16) If you **AGREE** that marine parks should be made into no take zones, please specify your reasons for agreeing (can choose more than one):

___There will be more fish

___ It will improve the marine environment

___There will be benefits to other sectors besides fisheries

___It will be good for my business

___ Other, please specify ______________________________________________

17) If you **DISAGREE** that marine parks should be made into no take zones, please specify your reasons for not agreeing (can choose more than one):

__Fish stocks will not recover

__Fishermen will be out of work

__Not all fishing boats should be banned (state which should not be banned_________)

__It cannot be enforced

__It will ruin my business

__Other, please specify ____________________________________________

18) Do you think the conversion of all marine parks into no take zones will have an impact on your business?

__Yes__No_Maybe

If your answer is YES,

a) how will you business be affected?

__Increase business

__Decrease business

__No change

b) Why do you think it will have an impact?

____________________________________________________________

19) How many more / fewer customers do you anticipate after the marine parks are designated no take zones? (Circle choice)

1 year __increase __decrease __no change __don't know

3 year __increase __decrease __no change __don't know

5 year __increase __decrease __no change __don't know

10 year __increase __decrease __no change __don't know

If you think that customer number will increase, how much increases will there be?

1 year __< 5% __ 5-10% __10-20% __>20%

3 year __< 5% __ 5-10% __10-20% __>20%

5 year __< 5% __ 5-10% __10-20% __>20%

10 year __< 5% __ 5-10% __10-20% __>20%

If you think that customer number will decrease, how much decreases will there be?

1 year __< 5% __ 5-10% __10-20% __>20%

3 year __< 5% __ 5-10% __10-20% __>20%

5 year __< 5% __ 5-10% __10-20% __>20%

10 year __< 5% __ 5-10% __10-20% __>20%

20) If marine parts are made into no-take zone, will the cost of your business increase/decrease?

__No change

__decrease 1-30% __decrease 31-60% _decrease 61-90% __decrease>90%

__increase 1-30% __increase 31-60% __increase 61-90% __increase>90%

21) If the marine parks are made into no take zones, you will:

__Hire more staff (How many? _________)

__Lay off staff (How many? __________)

__No change

22) If you have to hire staff are you willing to hire ex-fishermen?

__Yes

a) Will you be willing to spend time or money to train ex-fishers to become tourism/service/dive workers? __Yes __No

b) How much time are you willing to spend to train the ex-fishers?

Time: ____1-2 days ____2-4 days ____4-6 days __one week

____> 1 week (enter no. of days: _____)

c) What jobs would you hire the fishermen to do?

__Boatman __Waiter __Cleaner __Gardener __Fishing guide

Other, please specify_______________________________________________

__No, why (can choose more than one answer)?

__Lack of work skills

__Unable to speak English

__Attitude

__Age

__Other, please specify

23) What is the average monthly salary of these jobs?

Boatman:_______

Waiter:_________

Cleaner:________

Gardener:_______

Fishing guide:____

Others:______

**Creation of Fisheries Protection Areas**

24) Do you know about the proposal for creating 3 new Fisheries Protection Areas in Port Shelter, Tolo Harbour, and Channel?

__Yes_No

25) Do you think this is a good or bad idea?

__Good__Bad

Why? ____________________________________________________

26) Should these Fisheries Protection Areas be no take zones (no fishing)?

__Yes__No

27) Do you currently take your customers diving/fishing in the Fisheries Protection Areas? How many tours per month on average do you organize to these areas?

No of tour per month

__Port Shelter (0 1-5 5-10 10-15 15-20 >20)

__Tolo Harbour (0 1-5 5-10 10-15 15-20 >20)

__Tolo Channel (0 1-5 5-10 10-15 15-20 >20)

__Long Harbour (0 1-5 5-10 10-15 15-20 >20)

28) How many people on average in each tour?

__1-5__5-10__11-20__21-30__31-40__>40

29) How much do your customers pay, on average, to go diving/fishing/visiting at these areas?

Port Shelter________

Tolo Harbour________

Tolo Channel________

Long Harbour_________

30) Do you think the creation of new FPAs will have an impact on your business?

__Yes__No__Maybe

If your answer is YES,

a) How will you business be affected?

__Increase business

__Decrease business

__No change

b) Why do you think it will have an impact?

_______________________________________________________

31) How many more / fewer customers do you anticipate after the designation of the Fisheries Protection Areas? (Circle choice)

1 year __increase __decrease __no change __don't know

3 year __increase __decrease __no change __don't know

5 year __increase __decrease __no change __don't know

10 year __increase __decrease __no change __don't know

If you think that customer number will increase, how much increases will there be?

1 year __< 5% __ 5-10% __10-20% __>20%

3 year __< 5% __ 5-10% __10-20% __>20%

5 year __< 5% __ 5-10% __10-20% __>20%

10 year __< 5% __ 5-10% __10-20% __>20%

If you think that customer number will decrease, how much decreases will there be?

1 year __< 5% __ 5-10% __10-20% __>20%

3 year __< 5% __ 5-10% __10-20% __>20%

5 year __< 5% __ 5-10% __10-20% __>20%

10 year __< 5% __ 5-10% __10-20% __>20%

32) If Fisheries Protection Areas are designated, will the cost of your business increase/decrease?

___No change

__decrease 1-30% __decrease 31-60% _decrease 61-90% __decrease>90%

__increase 1-30% __increase 31-60% __increase 61-90% __increase>90%

33) Do you think your responses above will change if the Fisheries Protection Areas are made into no take zones (no fishing)?

___Yes, how? ______________________________

___No

34) Do you agree that the FPAs should be made into no take zones?

___Do not agree ___Slightly disagree ___No opinion ___Agree ___Strongly agree

35) If Fisheries Protection Areas are designated, you will:

__Hire more staff （How many? _________）

__Lay off staff(How many? __________）

__No change

**Trawling**

36) Do you think trawling affects the quality of diving/ fishing experience?

__Yes, why?

__Trawlers catch all the fish

__Destroys the coral reef habitat

__ Reduces fish abundance

__No

37) Overall, which option do you think is best?

__*Status quo* (Marine parks with no new Fisheries Protection Areas)

__Creation of Fisheries Protection Areas (not no-take zones) and marine parks as now

__Creation of Fisheries Protection Areas (no fishing) and marine parks as now

__no take zones in all new Fisheries Protection Areas and marine parks

38) Overall do you think that making all the FPAs and MPs into NTZs will have an impact on the industry (dive, ecotourism, or recreational fishing)? Y/N?

__Yes

If YES, what do you think the impact will be (can choose more than one)?

__Businesses cannot make a profit

__Businesses will increase their profits

__New businesses enter the industry

__Current businesses leave the industry

__Other, please specify___________________________

__No

39) Overall, how will the creation of NTZs in the 3 FPAs and all MPs directly affect your business? ________________________________________________________________________

40) If fish abundance changes from the current amount, how many more/fewer customers do you anticipate?

**Fish abundanceEffects on customer no.**

**Half:** No changeIncrease/decrease (< 5% / 5-10% / 10-20% / >20%) Don't know

**Double:** No changeIncrease/decrease (< 5% / 5-10% / 10-20% / >20%) Don't know

**5 times:** No changeIncrease/decrease (< 5% / 5-10% / 10-20% / >20%) Don't know

**10 times:** No changeIncrease/decrease (< 5% / 5-10% / 10-20% / >20%) Don't know

# PART 2

## Economic impacts to the fishing industry and society

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## Abstract

The goal of this contribution is to assess the potential economic gain (loss) to fishers and to society (Hong Kong as a whole) due to the implementation of different management scenarios. The economic loss (gain) to fishers is assumed to be the difference between the discounted net present value of profit (that is, the sum of profit over time in today's dollars) that they would have made under *status quo* (current) management and the different management scenarios proposed. On the other hand, the loss (gain) to society is the difference in the discounted net present value of the benefits that would accrue to Hong Kong as a whole under the *status quo* and the different management scenarios investigated using the Ecopath with Ecosim software. We find that in terms of net economic benefits, both fishers as a group and the society are likely to increase their benefits by moving away from the current *status quo* management. From an economic perspective, therefore, the *status quo* scenario is not an option. However, some fishing sectors and communities will lose from change in management from the *status quo*. Also, the performance of the private sector in the short and medium terms (5 and 10 years) are lower that in the 25 year time horizons. The combined cost in the short term and to certain sectors explains why there is opposition to change from the *status quo*. Given the benefits to society, it is good economics to compensate losers in order to get movement. We therefore conclude that there is a need to develop well-designed alternative livelihood schemes to remove the obstacle to introducing ecologically and economically sensible management of the ecosystems of Hong Kong.

## Introduction

The main objective of this report is to evaluate the potential economic loss or gain to fishers and to Hong Kong society resulting from the implementation of various fishery management scenarios. The economic loss or gain to fishers is assumed to be the difference between the discounted net present value of profits (that is, the sum of profit over time in today's dollars) made under *status quo* (current) management and that estimated under alternative proposed management scenarios.

This distinction between benefits to fishers and society is important because the gap between the outcomes preferred by private actors and society in the use of environmental and natural resources is at the core of the challenges facing managers of these resources. This gap is due to factors that economists call 'externalities' (Baumol and Oates, 1988). In this study, two things differentiate the way we calculate net present values to fishers, as represented by fishery sectors, and the society. First, society is assumed to have a longer time horizon than private actors. We therefore evaluate benefits to fishers using 5, 10 and 25 year time horizons, while benefits to society are assumed to flow through time or in perpetuity. Second, the market discount rate is applied to calculate the present value of benefits to private actors. On the other hand, because of the concern for future generations, society is assumed to use a discount rate lower than the market rate (Sumaila, 2004, Sumaila and Walters, 2005, Berman and Sumaila, 2006). The lower

[5] Cited as: Sumaila, U.R., Cheung, W.W.L., Teh, L.. 2007. Economic impacts to the fishing Industry and society. *In* Sumaila, U.R., Cheung, W.W.L., Teh, L., Rebuilding Hong Kong's Marine Fisheries: An Evaluation of Management Options. Fisheries Centre Research Report 15(3), 57-112. Fisheries Centre, the University of British Columbia, Vancouver.

society rate captures, to some extent, broader values from the ecosystem, e.g., existence, cultural and bequest values.

## Simulation modeling

Impacts of the different management scenarios on the Hong Kong fisheries and marine ecosystem were evaluated using the Ecopath, Ecosim and Ecospace software (Polovina, 1984; Christensen and Pauly, 1992; Walters *et al.,* 1997; Walters *et al.,* 1999). (See Box 1 for an introduction to this modeling approach). A mass-balanced Ecopath model representing a possible ecosystem state of the Hong Kong waters in the early 2000s was constructed. The model is an update of an earlier version of a Hong Kong ecosystem model (Pitcher *et al*., 2002, 2005). The previous version is hereafter called the 90s HK model as the model parameters were based on surveys conducted in the late 1990s (Pitcher *et al,*. 2002). The 90s Hong Kong model was used to evaluate the impacts of a range of management scenarios including those that are covered in this study (Pitcher *et al*., 2000, 2002; Buchary *et al*., 2003).

In this updated version, catch data obtained from the 2001/02 Port Survey (AFCD unpublished data) were used. The AFCD believed that the estimated catches from this survey were more accurate than the earlier survey in 1996/97 as the 2001/02 survey was conducted by their department, while the earlier survey was conducted by a consultant. As such, they were more certain of the quality of the 2001/02 survey (Rock Kowk, AFCD, pers. comm.). Still, the validity of the 2001/02 catch estimates is evaluated and discussed in a later section.

Since the estimated catches from the 2001/02 survey increased by about 45% from the 96/97 estimates, the biomass and production to biomass (P/B) ratio of most of the exploited groups had to be adjusted upward to achieve mass-balance. The revised model parameters are given in Appendix 1. The basic model structure, i.e., the number and definition of functional groups, and fishing fleet structure of the groups are largely unchanged from its earlier version (see Pitcher *et al.* 2002 for detailed descriptions of the model). The species composition in each functional group is listed in Appendix 2.

To model the effects of the spatial scenarios in this study, spatial dynamic simulations using Ecospace based on the updated HK model were conducted. The basic set up of the spatial model followed the 90s HK model. Hong Kong waters was represented by 5 x 5 $km^2$ cells (Figure 1). Habitat types were defined as: reefs, non-reef and marine mammal habitats. Each functional group was assigned to be associated with one or more habitat types. The marine mammal habitat is defined based on the key occurrence area of the major groups of marine mammals (Chinese white dolphin and Finless porpoise). The inclusion of this 'habitat' is primarily to mimic the local distribution of these marine mammals. However, the habitat does not exclude the marine mammals group from entering other habitat types, or non-mammal groups entering into the marine mammal habitat. Five types of management areas were defined: marine parks, marine exclusive zone and marine reserves, fisheries protection areas (non-core) and fisheries protection areas (core), and a special shrimp trawl area (Figure 1). The special shrimp trawl areas are proposed by the WWF Hong Kong's SOS Campaign as an area where shrimp trawling is allowed when a territorial-wide bottom trawl ban is implemented, and include some of Hong Kong's most productive shrimp grounds. Total area of this shrimp trawl area was set at 75 $km^2$ (15 x 5 $km^2$ cells). The Cape D'Aguilar marine reserve and the Chek Lap Kwok Marine Exclusive Zone, both areas where fishing is prohibited, were too small to be represented separately in the model. Therefore, they were combined and represented as a single cell. As the prime focus on this report is on comparing the specified spatial management scenario, total fishing effort for each sector was assumed constant throughout the simulation time horizon, except the total trawl ban scenarios in which fishing effort from trawlers were essentially reduced to zero. The basic set up of the Ecospace model follows the 90s HK model (Pitcher *et al*., 2002).

In each simulation, the model was run under the *status quo* (*i.e*., no change in fishing effort, four partly protected marine parks and one no-take reserve and marine exclusive zone) until the ecosystem was close to an equilibrium state (i.e. until the biomass of the functional groups became stable). Thus, any changes in biomass from this equilibrium state will be a result of the different scenarios implemented. Initial simulation runs indicated that 25 years would be required for the functional groups to re-organize themselves under the spatial setting. The length of this re-organization period does not have any empirical meaning. Instead, it merely reflects the extent to which the initial Ecopath structure deviates from the spatial setting. After the 25-year initial run, the spatial management scenarios were implemented in the simulations and the time-series changes in biomass and catches relative to the equilibrium state were recorded. Simulations were conducted for 5, 10 and 25-year models. Since the main objective of this study is to compare the impacts of the management scenarios on the fisheries, total fishing effort in Hong Kong waters was assumed to be unchanged overtime from the *status quo* in all scenarios.

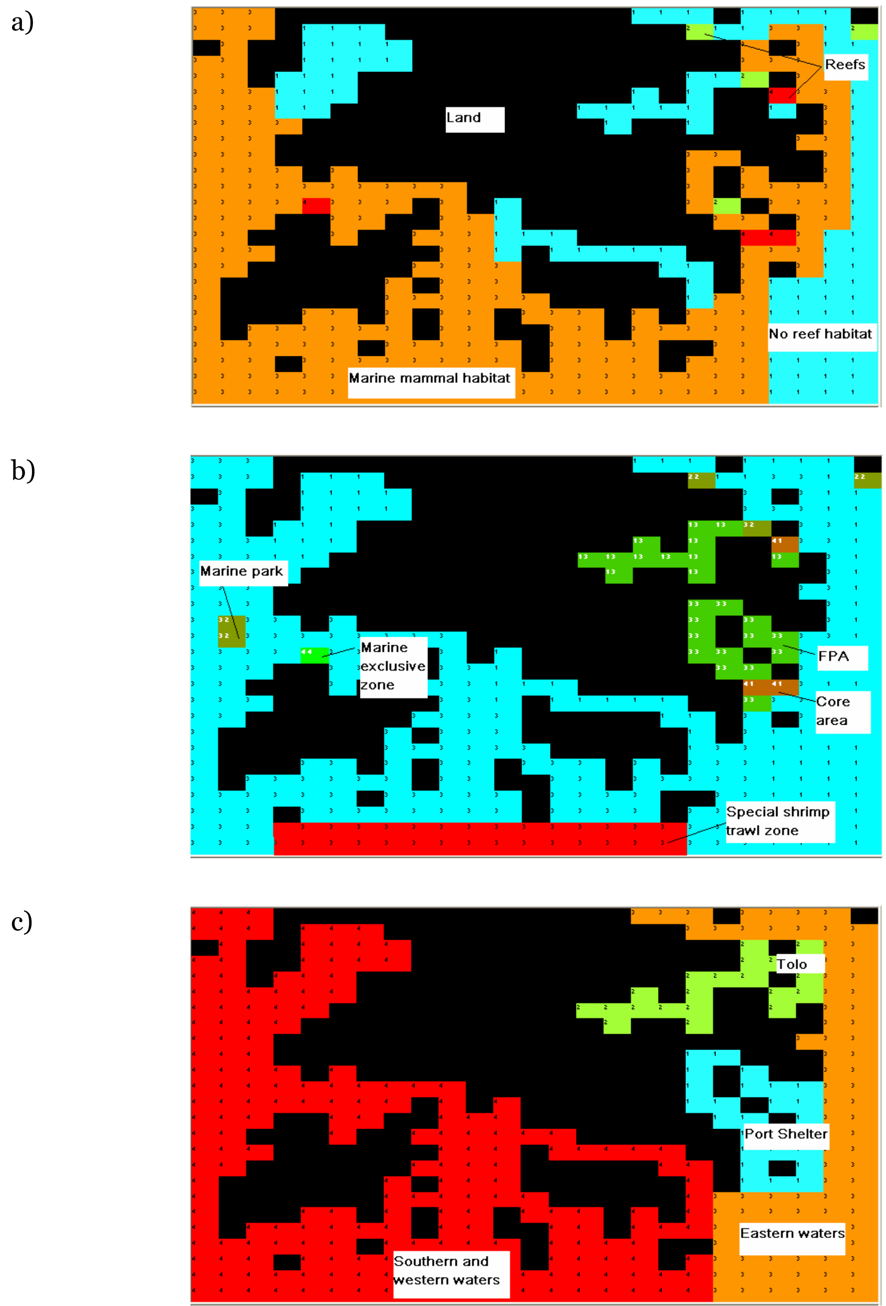



**Figure 1.** Ecospace simulation, the Hong Kong waters ecosystem is represented by (a) base map of habitats, (b) base map of management areas, and (c) base map of fishing regions.

**Box 1: *The Ecopath with Ecosim model***

Based on the mass-balance principle, Ecopath can be used to develop hypothesis of ecosystem structures that are possible thermodynamically (Christensen and Walters, 2004). In most Ecopath models, species, usually those with similar biology and ecology are aggregated into functional groups to reduce the number of modelled units. The model is governed by the mass-balance principle which is based on two basic equations. The first one ensures balance between production, consumption, predation, fishery, migrations and other mortalities among groups:

$$(P/B)_i \cdot B_i \cdot (1\text{-}EE_i) - B_j \cdot (Q/B)_j \cdot DC_{ji} - Y_i - E_i - BA_i = 0 \qquad \text{...1.1)}$$

The second equation ensures balance between consumption, production and respiration within a group:

$$Q_i = P_i + R_i + GE_i Q_i \qquad \text{....1.2)}$$

where $(P/B)_i$ is the production to biomass ratio; $B_i$ the total biomass; $EE_i$ the ecotrophic efficiency ($1\text{-}EE_i$ represents mortality other than predation and fishing); $Y_i$ the total catch; $E_i$ the net migration; $BA_i$ the biomass accumulation of functional group *i*; $(Q/B)_j$ is the consumption to biomass ratio for predator groups *j*; $DC_{ji}$ is the proportion of group *i* in the diet of predator groups *j* ; *R* is respiration while *GE* is the proportion of unassimilated food (Christensen and Walters, 2004).

The model maintains mass-balance by solving equations 1.1 and 1.2 for all groups simultaneously. Thus any of the four basic input parameters (*B*, *P/B*, *Q/B*, *EE*) in each group has to be estimated to ensure mass-balance. Since *EE* is difficult to measure empirically, it is usually estimated through the mass-balance process provided that data to estimate other parameters are available. In cases where data for *B, P/B or Q/B* are unavailable, *EE* is assumed to be 0.95.

Ecosim is a dynamic simulation model which simulates changes to the ecosystem that is described under Ecopath. It estimates changes of biomass among functional groups in the ecosystem as functions of abundance among other functional groups and time-varying harvest rates, taking into account predator-prey interactions and foraging behaviours (Pauly *et a*l., 2000; Walters *et al.*, 2000). Ecosim is governed by the following basic dynamic equations (Christensen *et a*l,. 2000):

$$\frac{dB_i}{dt} = g_i \sum_j C_{ji} - \sum_j Cij + I_i - (M_i + F_i + e_i) B_i \qquad \text{...1.3)}$$

and

$$C_{ij} = \frac{v_{ij} \cdot a_{ij} \cdot B_i \cdot B_j}{v_{ij} + v'_{ij} + a_{ij} \cdot B_j} \qquad \text{...1.4)}$$

where the left side gives the growth rate of group *i* in terms of its biomass, $g_i$ is growth efficiency, *M* and *F* are natural and fishing mortalities, *I* and *e* are immigration and emigration rates, $C_{ji}$ is the consumption of group *j* organisms by group *i* organism, *v* and *v'* parameters represent rates of behavioural exchange between invulnerable and vulnerable states and $a_{ij}$ represents rate of effective search by predator *j* for prey type *i*. The behaviours of functional groups in dynamic simulations are heavily affected by the 'vulnerability factor' – a scaling factor of *v* which determines the foraging behaviour of the functional groups in predator-prey interactions (Walters *et al.* 1997; Walters & Martell 2004).

Ecospace consists of spatial replicates of Ecosim simulations in grid cells on a pre-defined base map. Each spatial cell is linked through: (1) dispersal of organisms, (2) spatial movement of fishing effort in response to changes in profitability of fishing, and (3) creation of protected areas (Walters *et al.* 1999; Walters 2000).

The Ecopath with Ecosim, and the Ecospace software were used to address questions posed in the technical proposal.

## Management scenarios analyzed

Our first task was to identify the management scenarios that would form the basis of our fisheries impacts analysis. The scenarios we used are:

### *Scenario 1*

*Status quo*: Continuation of the fisheries and marine park management regimes in place in 2005:

- 4 marine parks (Hoi Ha Wan Marine Park, Yan Chau Tong Marine Park, Sha Chau and Lung Kwu Chau Marine Park, and Tueng Ping Chau Marine Park) where trawling is prohibited and fishing with other methods is allowed with licenses;
- 1 marine reserve (Cape D'aguilar Marine Reserve) where no fishing is allowed;
- Chek Lap Kwok Marine Exclusive Zone where no fishing is allowed
- Artificial reefs deployed in the Hoi Ha Wan Marine Park, Yan Chau Tong Marine Park, Sha Chau and Lung Kwu Chau Marine Park, Chek Lap Kok Marine Exclusion Zone, Outer Port Shelter and Long Harbour;
- Fishing effort is not regulated in areas other than the above.

### *Scenario 2*

*Government initiatives*: Introduction of the three amendments to the Fisheries Protection Ordinance proposed by the HK SAR government, with timelines and framework as indicated by the HK SAR government in March 2006. In additional to the marine park management regime as in place in 2005 (Scenario 1):

Scenario 2a:

- Trawls are banned from fishing within Fisheries Protection Areas (FPAs) (Port Shelter, Tolo Harbour and Channel, and Long Harbour); all other fishing gears are allowed to fish in the FPAs, except where artificial reefs have been deployed; recreational fishing is not regulated;
- Licensing system is in place and fishing effort is controlled.

Scenario 2b:

- In addition to scenario 2a, a seasonal moratorium that is in line with the moratorium in the South China Sea that is imposed by the mainland Chinese authority is implemented, i.e., trawls and purse seines are banned from fishing in Hong Kong waters during June and July.

### *Scenario 3*

*WWF initiatives:* Introduction of all or part of WWF's "Save Our Seas" campaign objectives in 2007 (*SOS* : "Save Our Seas" Position Paper, 1 Dec 2005).

Scenario 3a:

- No-take marine zones to cover all existing marine parks, and the proposed FPAs in Port Shelter, Tolo Harbour and Channel, and Long Harbour.

Scenario 3b:

- Ban on bottom trawling in all Hong Kong waters, except in the southern waters (south of Lantau and Lamma Islands) where shrimp trawling is allowed.

Scenario 3c:

- Creation of no-take zones covering the entirety of all HK's marine parks.

Scenario 3d:

- Combination of Scenarios 3b and 3c.

Scenario 3d2:

- Creation of no-takes FPAs in Port Shelter, Tolo Harbour and Channel, and Long Harbour

Scenario 3e:
- Combination of Scenarios 3b and 3d2.

Scenario 3f:
- Combination of Scenarios 3a and 3b.

Using existing and updated models, we studied the potential impact of each scenario listed above on the different fishing groups and sectors in Hong Kong waters.

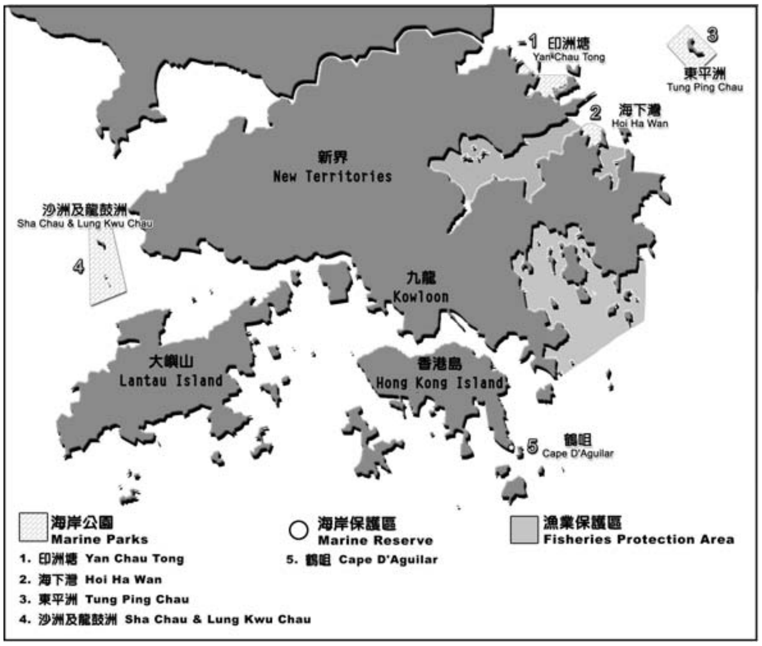



**Figure 2**. Map showing the existing marine parks and reserve, and the proposed Fisheries Protection Areas (FPAs) in Hong Kong.

The site selection for the FPAs was made by AFCD (Figure 2), based on information contained in a previous report (ERM 1998) showing these to be important spawning and nursery areas.

## General results

We explored the effects of the different scenarios on the fisheries and different ecosystem groups. Indicator groups across the ecosystem were selected to evaluate changes in their catches in different management scenarios. The indicator groups included both invertebrates and fishes such as jellyfish, cephalopods, reef and non-reef fishes.

### *Biomass of indicator species*

Jellyfish abundance often increases in highly depleted ecosystems when most predatory species are heavily depleted and energy flows shift from the demersal to pelagic system (Pitcher and Pauly, 1998). Thus increased jellyfish abundance can be an indicator of possible ecosystem degradation. Our model predicts that jellyfish abundance decreases in 10 and 25 years from the *status quo* with no-trawl FPAs (scenario 2a) and under the scenarios with no-take FPAs and MPs (scenario 3a, 3c and 3d2) (Figure 3a). The reduction is particularly large in scenarios 3a and 3d2, in which Port Shelter, Tolo and Long Habour are designated as no-take zones. The decrease in jellyfish abundance is mainly due to the increased predation mortality of jellyfish because of the recovery of predatory species after the implementation of the management measures. For instance, increased abundance of demersal fishes can reduce jellyfish abundance through increased feeding on the jellyfish polyps.

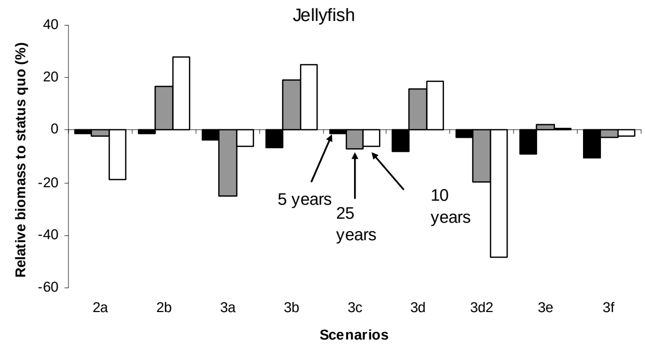
Jellyfish biomass increases slightly in the seasonal trawl ban and the territorial-wide trawl ban scenarios (2b and 3b) (Figure 3a). Jellyfish is mainly caught and discarded by the trawling sectors. Therefore, the trawl ban reduced fishing mortality on jellyfish and increased their abundance. On the other hand, when trawl ban is accompanied with no-take marine parks or FPAs (scenarios 3c, d, e and f), the reduced fishing mortality of jellyfish will be cancelled by the increased predation mortality resulting from the recovery of the large predatory species (see below). Thus, jellyfish abundance eventually declined within 10 or 25 years. It should be noted that because of the limited data availability, the current model could not fully account for the ecology of jellyfish in detail. Therefore, predictions on the responses of this group to the management scenarios, particularly the unexpected increases in jellyfish abundance under the trawl ban scenarios, are less certain.

Benthic crustaceans and shrimps, important and valuable groups targeted by the bottom trawling sectors, increased rapidly in abundance after implementation of management measures but abundance reduced in the longer term (25 years) simulations (Figure 3b). These groups generally have short life cycles and thus high turn-over rates, which allows them to withstand the high fishing mortality in Hong Kong waters (Pitcher *et al.* 1998). Therefore, when fishing effort was reduced because of the designation of partial or total no-take zones (marine parks and FPAs), their biomass increased rapidly (in 5 years) because of their high productivity. However, their biomass decreased in the medium and long terms (10 and 25 years) as the abundance of their major predators, the larger demersal fish groups (with longer life cycle and thus lower productivity), recovered.

The predicted changes in abundance of benthic invertebrates agree with observed changes in heavily trawled areas. Heavy trawling removes predators of benthic invertebrates and modifies benthic habitat. This greatly increases the productivity of the high-turnover species (such as benthic invertebrates) adapted to disturbed habitats, and partly explains the booming of benthic invertebrates fisheries (highly-valued) after the collapse of ground fish stocks in the NE Atlantic (Worm and Myers, 2003). Thus this represents a trade-off between the valuable invertebrate fisheries and the recovery of predatory species (Cheung and Sadovy, 2004). The biomass of cephalopods (squid and cuttlefish) increases in almost all scenarios (except 3c, with no-take marine parks) in 25 years (Figure 3c). Setting up no-take marine parks had little effect on this group, probably because of its high mobility and dispersal rate relative to the small-size of the marine parks. However, a territory-wide annual trawl ban reduces the fishing mortality considerably and thus exerts a positive impact on cephalopods, with 20 to 40% increase in biomass from the *status quo* in the various scenarios and time horizons. In shallow inshore waters where trawl nets often sweep a large fraction of the water column, pelagic species, in particular squid and cuttlefish, are well-represented in the catch. Indeed, squid and cuttlefish are reported as the main catch for pair and stern trawlers, respectively, by AFCD. In our model, catches of cephalopods from bottom trawlers represent about 20% of their total catch. Therefore, a territorial-wide trawl ban is predicted to have a positive impact on the abundance of cephalopods. Cephalopods have a high recreational value through the recreational squid/cuttlefish jigging fisheries. The increase in cephalopod biomass may generate considerable revenue to the tour companies and leisure and passenger boats operators, especially in the Port Shelter area.

Biomass of reef fishes increases significantly in most scenarios, with the biomass of small reef fishes responding much faster to protection (Figure 4). With no-trawl FPAs (scenario 2a), biomass of small reef fishes changes slightly after 5 years, but more than triples in 10 and 25 years. The decrease in biomass of small reef fishes from 10 to 25-years in the no-take FPAs scenarios (3a, 3d2 and 3e) mainly result from the increased predation mortality, as the biomass of the medium and large reef fishes (predators of small reef fishes) increase. Large increases in the biomass for medium and large reef fishes relative to the *status quo* occur only after 25 years, with the biggest increase being almost 4 to 8 times over the *status quo* biomass.

The no-take FPAs and no-take marine parks (3a) together greatly increase the biomass of reef fishes in 25 years, compared to the no-trawl FPAs scenario (2a). Under scenario 3a, the biomass of small, medium and large reef fishes increase around 4 times from the *status quo* in 25 years, No-take FPAs have stronger positive effects than no-take marine parks alone, basically because of the larger area of protection offered by the earlier scenario. Addition of a territorial-wide trawl ban (scenario 3f) offers double the benefits to small reef fishes and increases the benefits to large reef fishes by 50% in the long term compared to the scenario with no-take FPAs and no-take marine parks only (scenario 3a). The predicted recovery of medium and large reef fishes is generally slow. This is because at the start of the simulation (after the 25 years equilibrium run), the biomass of reef fishes in most reef habitats have been a)

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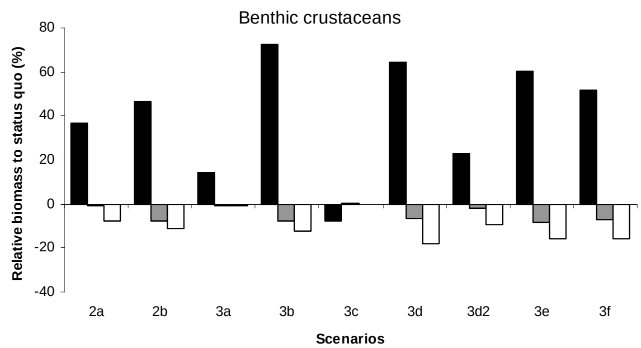


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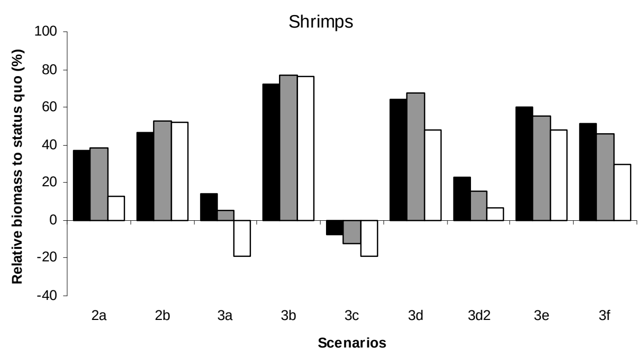



*d)*

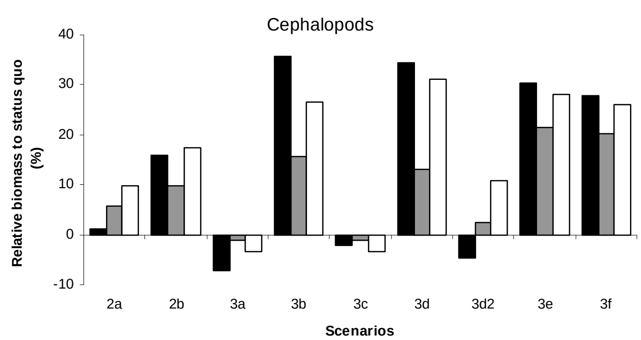



**Figure 3.** Changes in biomass relative to the *status quo* (scenario 1) for (a) jellyfish, (b) benthic crustaceans, (c) shrimps, and (d) cephalopods in 5 (black bars), 10 (gray bars) and 25 (white bars) years.

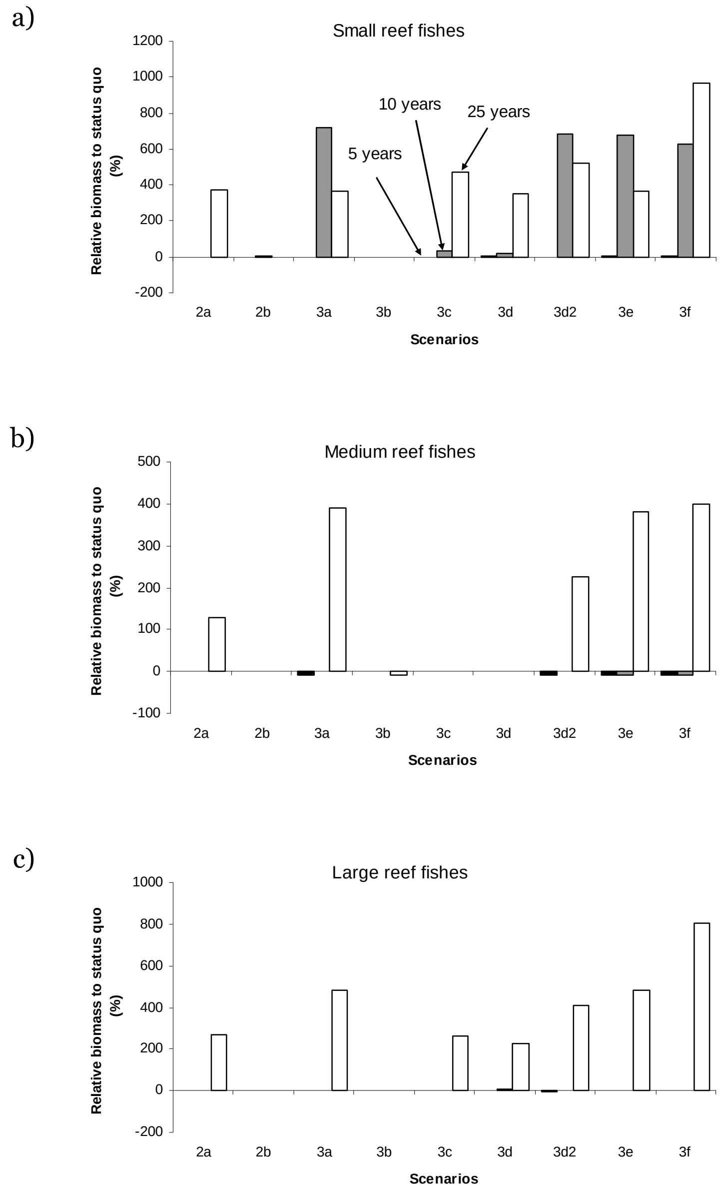



**Figure 4**. Changes in biomass of (a) small reef fishes, (b) medium reef fishes and (c) large reef fishes relative to the *status quo* in 5, 10 and 25 years.

greatly depleted, except in the no-take area (marine reserves + marine exclusive zone). Since the Hong Kong marine ecosystem is assumed for the purposes of modeling to be a closed system (no immigration or emigration into or out of the system), the rate of recovery of fishes in the depleted reefs depends heavily on the dispersal and re-colonization of juveniles and adult reef fishes from the no-take reefs within Hong Kong. However, in reality, recruitment from outside Hong Kong waters are likely (Cornish, 2000) and should help to restock the depleted reefs, thus allowing a faster rate of recovery. Therefore, the predicted rate of recovery by the model should be considered conservative. This also indicates that the actual recovery rate would depend strongly on the availability of local recruits and spawning stocks, and the degree of recruitment from outside Hong Kong waters. This is an area for future studies.

Reef fishes are important to the small scale fishing sectors (the P4/7, miscellaneous sectors) and the alternative livelihood operations such as diving, recreational fishing and ecotourism. Thus the large increases in biomass from setting up the FPAs, in particular, if it is no-take, are predicted to offer considerable increase in benefits to the small scale sector and to the society in the long term given that the proportion of the small scale sectors in local fisheries is large.

Biomass of large non-reef fishes increases in all scenarios while biomass of medium non-reef fishes increases only in the scenarios with a territorial-wide trawl ban (Figure 5). Changes in the biomass of the small non-reef fishes are opposite to the medium non-reef fishes. Biomass of small non-reef fishes decreases in all trawl ban scenarios and increases in the others. Overall, the trawl ban scenarios (3b, 3d, 3e, 3f) offer the most benefits to the non-reef fishes, with over 50% and 40% increase in biomass for the medium and large non-reef fishes, respectively.

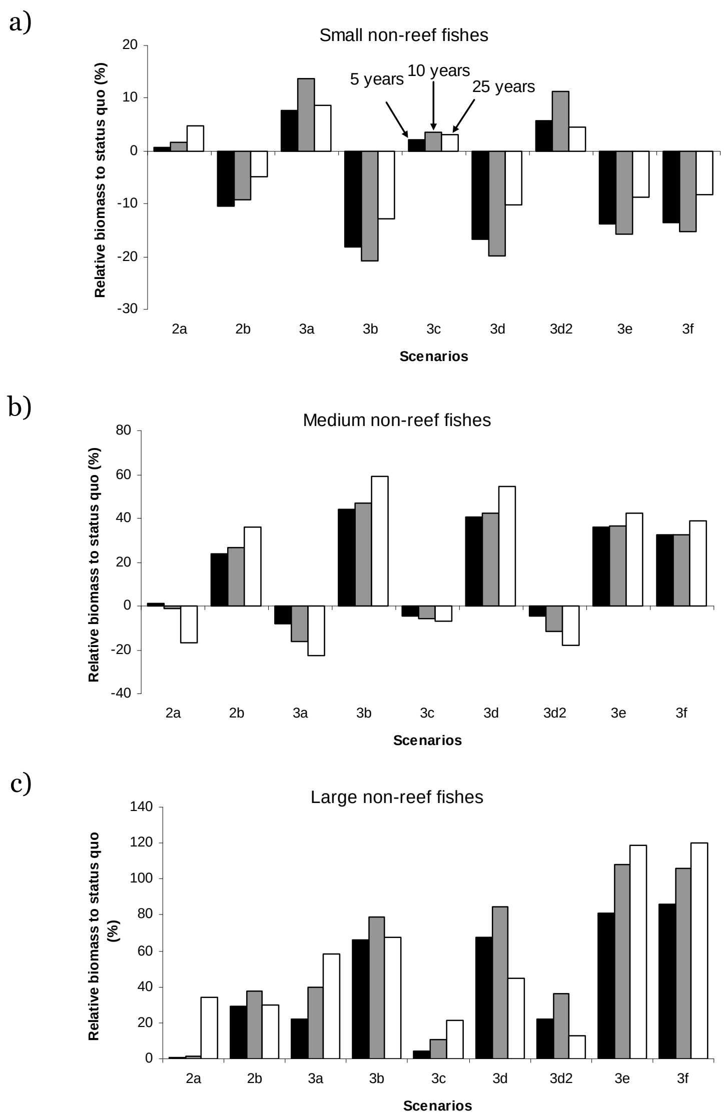



**Figure 5**. Changes in biomass of (a) small non-reef fishes, (b) medium non-reef fishes and (c) large non-reef fishes relative to the *status quo* in 5, 10 and 25 years.

Biomass of large pelagic fishes increases the most (over 30% from the *status quo*) in scenarios with territorial-wide trawl ban in 5, 10 and 25 years (Figure 6). This trend is opposite in small and medium pelagic fishes as biomass decreases under the trawl ban scenarios, mainly a result of increased predation from the large pelagic fishes. For large pelagic fishes, increases in biomass under scenarios without trawl ban are small, less than 20% changes from the *status quo*. With no-take FPAs (scenarios 3a and 3d2) biomass of small and medium pelagic fishes increase by 5% from the *status quo* in 5 years, followed by an increase of over 15% in 10 years. No-trawl FPAs do not have strong effects on the biomass of pelagic fishes.

All in all, biomass of reef fishes increases the most with no-take FPAs and marine parks, while invertebrates, non-reef fishes and pelagic fishes groups benefit most from a territorial-wide trawl ban. The rate of recovery of reef fishes depends strongly on the availability of local spawning biomass and the recruitment from outside Hong Kong waters. Biomass of benthic invertebrates (shrimps and other crustaceans) increased rapidly after protection from trawling, but their biomass gradually declined as the abundance of their predators increased. As benthic invertebrates are generally valuable commercially, the interactions between these groups and their predators may become a trade-off in restoring the Hong Kong marine ecosystem.

a)

b)

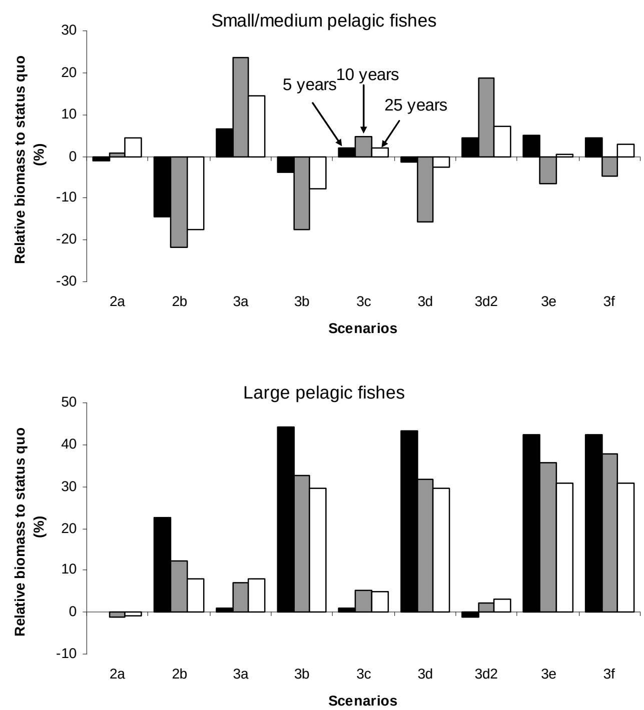



**Figure 6**. Changes in biomass of (a) small/medium pelagic fishes and (b) large pelagic fishes relative to the *status quo* in 5, 10 and 25 years.

## ***Catches by indicator groups***

We explored the effects of the scenarios on different ecosystem groups. We selected indicator (fish & invertebrates) groups across the ecosystem and evaluated their changes in catches under different management scenarios.

Catches of jellyfish, benthic crustaceans and shrimps generally decrease in all management scenarios, except the one with a seasonal trawl ban (scenarios 2b) (Figure 7 a, b and c). These groups are mainly caught by the trawl gears. Thus, it is expected that the decrease in catch is biggest in the territorial-wide trawl ban scenarios (3b, d, e and f).

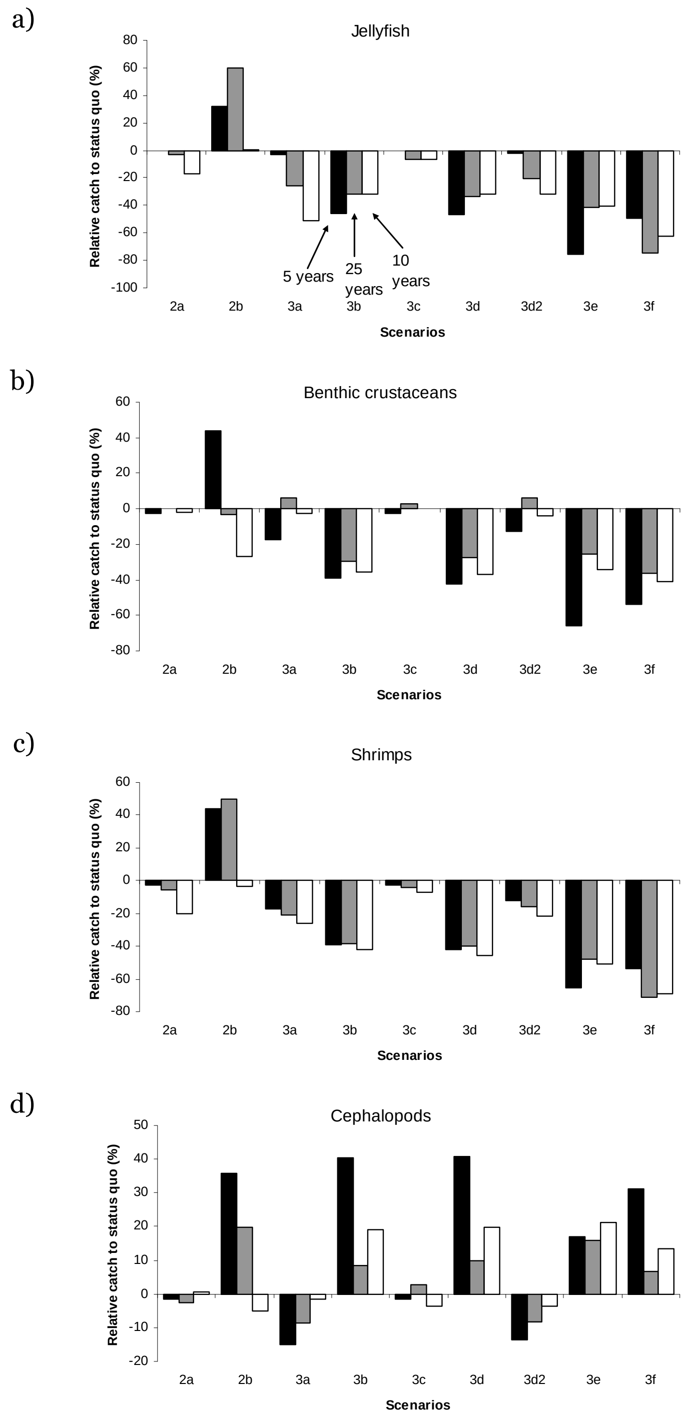



**Figure 7**. Predicted percentage changes in catch of invertebrate in each scenario relative to the *status quo* for (a) jellyfish, (b) benthic crustaceans, (c) shrimps and (d) cephalopods.

The scenario with no-trawl FPAs only (scenario 2a) result in a moderate reduction in jellyfish catch over the medium and long term (less than 20% in 10 and 25 years). On the other hand, implementing a seasonal trawl-moratorium increases the catches of benthic crustaceans and shrimps (scenario 2b). This indicates that the bottom trawl sectors may benefit from the seasonal trawl ban. With no-take FPAs and marine parks, reduction in jellyfish catches change from 20% in 10 years to 50% in 25 years. Reductions in catches of benthic invertebrates are relatively similar for the non-trawl ban scenarios with no-trawl or no-take FPAs (2a, 3a, 3d2). The scenarios with only no-take marine parks have a small effect on benthic invertebrate catches in the short to long term.

Changes in catches of cephalopods (squids, cuttlefishes, and octopus) are more variable across different time frames and scenarios (Figure 7c). Cephalopods are mainly caught by the purse seine and P4/7 sectors. In the short term (5 years), cephalopod catches increase from 20 to 40% from the *status quo* in all seasonal or total trawl ban scenarios (2b, 3b, 3d, 3e and 3f). The increased cephalopod catches is a result of the increase in biomass from reduced fishing mortality and the subsequent increase in catch by the purse seine sector as the trawling sectors are excluded from fishing. However, catches then decline from the 5-year levels in the medium and long term (10 and 25 years).

Changes in catches of reef associated fishes follow their biomass closely, and show strong positive responses under most scenarios (Figure 8). Reef fishes are mainly caught by the P4/7 and miscellaneous sectors. In scenario 2a, there is minimal change in catches of small, medium and large reef fishes in 5 years time. Catches of small reef fishes show the quickest response, with an increase in catches of almost 150% in the 10 year model. In the 25 year model, catches of small reef fishes increase greatly relative to the *status quo*. Medium and large reef fishes do not show a large response except in the 25 year time horizon model. The slow responses of catches of medium and large reef fishes are closely linked to their biomass dynamics, which depends heavily on re-colonization and recruitment from local and external (outside Hong Kong waters) sources.

The pattern of change in scenario 3a is similar to 2a, but the magnitude of change is much bigger. Catches of small and large reef fishes increase by over 300% and 250%, respectively in the 25-year model (Figure 8). Changes in medium reef fish catches in scenario 3a are similar to those in 2a. Implementing either no-take FPAs or no-take marine parks separately (scenario 3c and 3d2) does not result in as much as an increase in catch of small and large reef fishes as in scenario 3a (with no-take FPAs and no-take marine parks). A territorial-wide trawl ban (scenario 3b) slightly affects the catches of reef fishes as these groups are not the main catches of bottom trawl gears. The large positive effects observed in scenarios 3d, e, and f are due to the no-take FPAs and no-take marine parks that offer protection to reef habitats and the associated species. In particular, reef fish biomass increases largely in the long term after protection, both within and outside the FPAs and marine parks, which also increases the catches from the unprotected areas. In general, the reduction in catch in the short term (5 year timeframe) is relatively small, considering that the major fishing grounds for the P4/7 sector (main sector catching the reef fishes) are closed in the no-take FPAs scenarios (3b, 3d, 3d, 3f).

The trend is opposite for medium non-reef fishes in which catches increase in scenarios with seasonal or total trawl ban and decrease in non trawl ban scenarios (Figure 9b). With a territorial-wide trawl ban (scenarios 2b, 3b, 3d, 3e and 3f), catches increase up to 40% from the *status quo*. However, the catches decrease in scenarios with no-take FPAs. The decrease ranges from 20 to 40%, from 5 to 25 years. The no-trawl FPAs (2a) scenario results in a moderate decline in catch of 4 to 20% from 5 to 25 years while the effect is small with no-take marine parks only (3c). The largest reduction in catches in all time periods occurs under the no-trawl and no-take FPA scenarios (3a and 3d2).

Catches of large non-reef fishes show positive responses in all scenarios (Figure 9c). This group is mainly caught by small scale sectors. Scenarios with relatively large increases in catch are those with a territorial-wide trawl ban. The small scale sectors benefit from the increased biomass of large non-reef fishes, which offsets loss of catches from the trawl ban. This increases the overall catches in the trawl ban scenarios.

Pelagic fishes are mainly targeted by the purse seine, hang trawl and pair trawl sectors, and their catches are negatively impacted by most scenarios (Figure 10). The trawl-ban scenarios (2b, 3b, 3d, 3e and 3f) result in reduced catches of small/medium pelagic fishes over all time frames, while large pelagic fishes increased. Therefore, the lower small/medium pelagic fishes catch is likely driven by the reduction in small/medium pelagic fish abundance as the predatory large pelagic fishes increase in biomass.

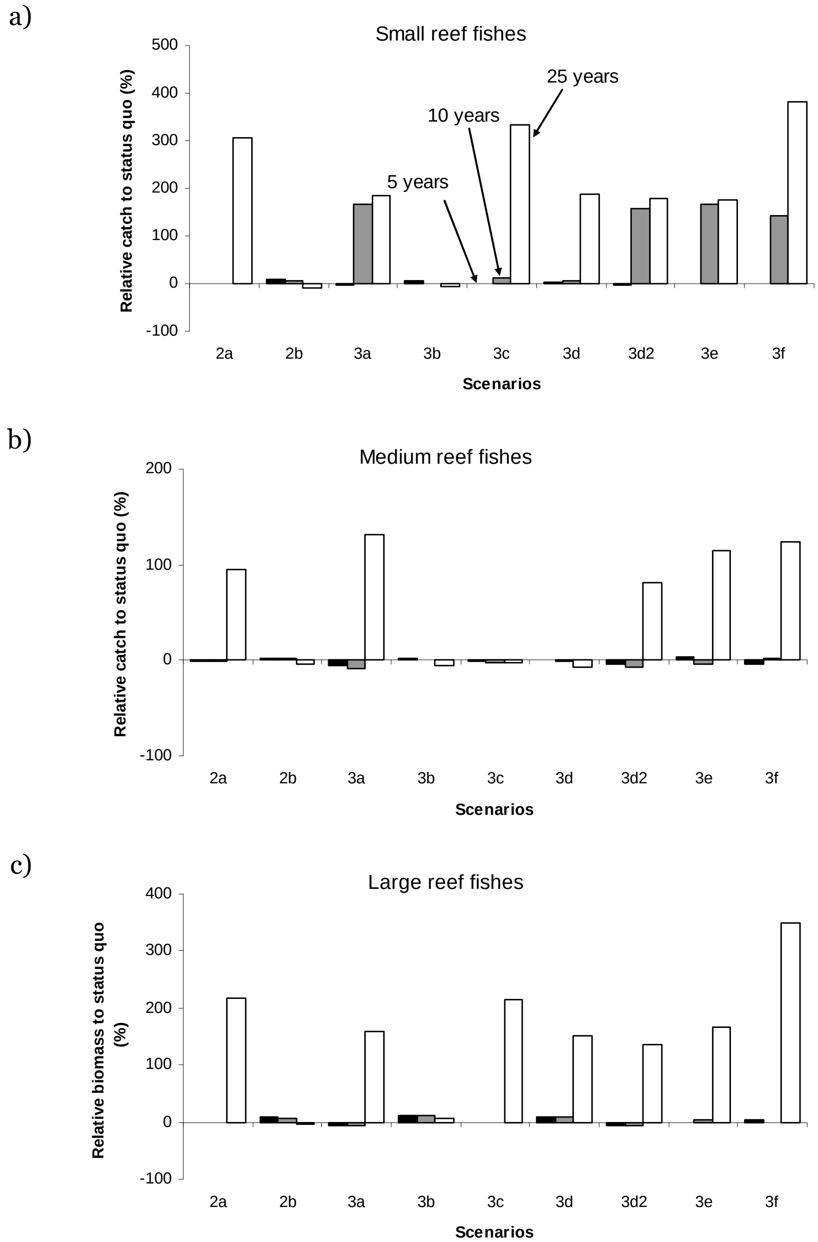



**Figure 8**. Predicted percentage changes in catch of reef fishes in each scenario relative to the *status quo*: (a) small reef fishes, (b) medium reef fishes and (c) large reef fishes.

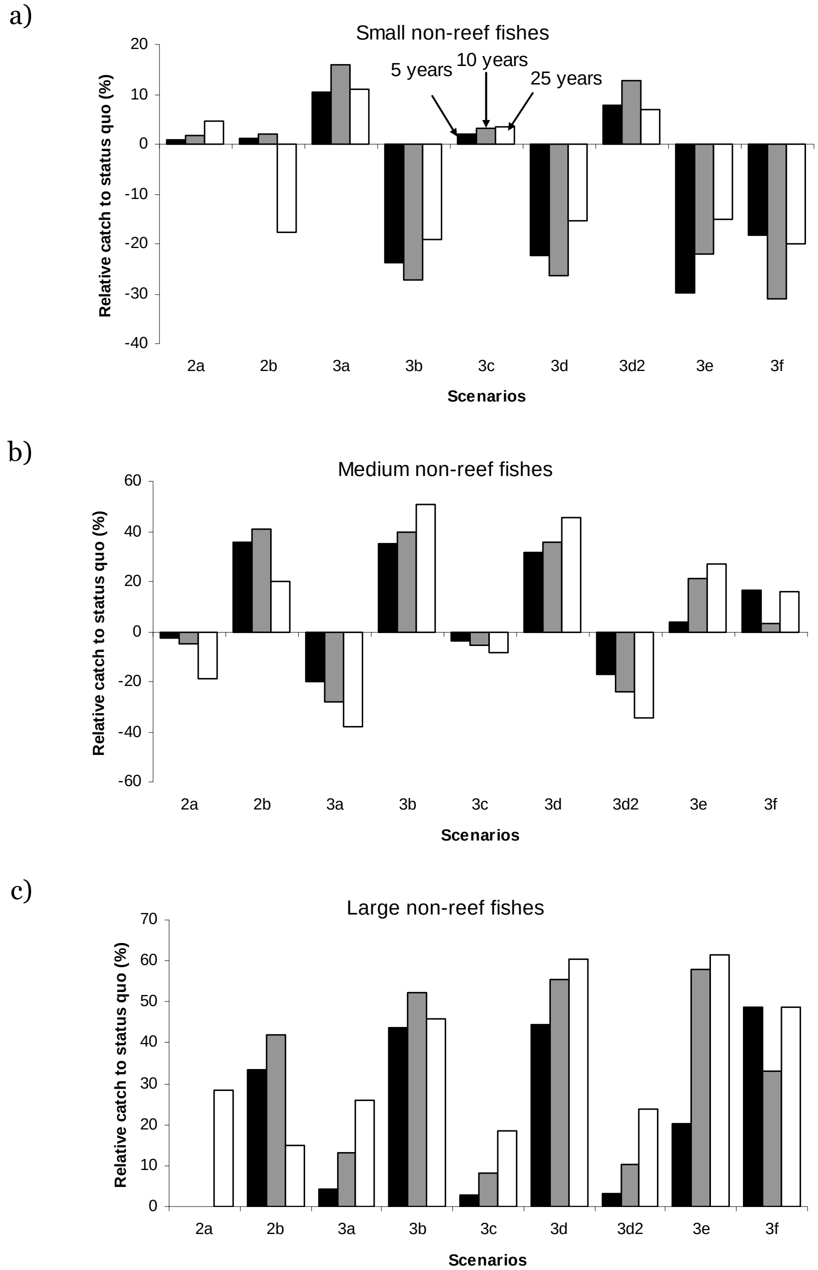



**Figure 9**. Predicted percentage changes in catch of non-reef fishes in each scenario relative to the *status quo*: (a) small non-reef fishes, (b) medium non-reef fishes, and (c) large non-reef fishes.

a)

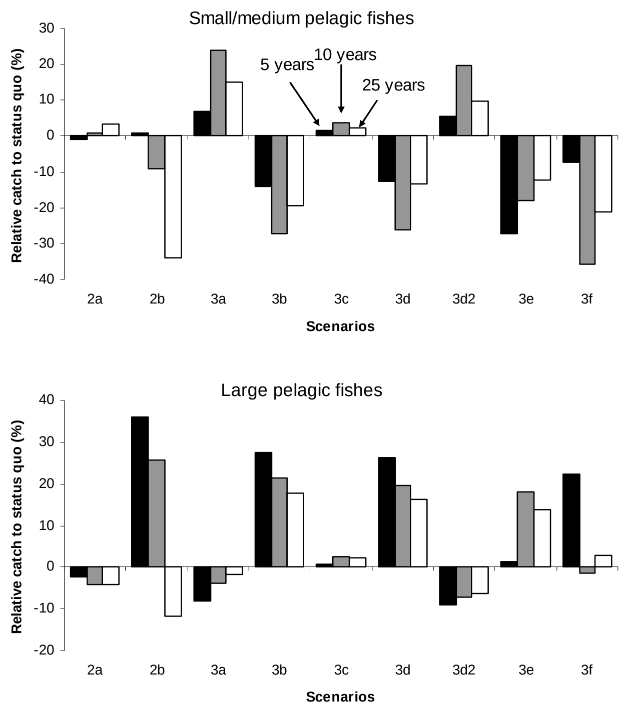



**Figure 10.** Percentage changes in catches relative to the *status quo* for different groups in 5, 10 and 25-years time horizons.

In summary, no-take FPAs and marine parks have strong positive effects on the catches of reef fishes, small/medium pelagic fishes and small and large non-reef fishes. However, for medium and large non-reef and pelagic fishes, the territorial-wide trawl ban scenarios exert the biggest positive effects on their catches. In general, territorial-wide trawl ban, combined with no-take marine parks and FPAs, is predicted to result in the largest biomass increase for most fish groups in the long term. However, catches of invertebrates, such as shrimps and other benthic crustaceans, would decline. No-take FPAs and no-take marine parks would be effective in restoring reef fish abundance. These predictions agree with those from previous studies using the 90s Hong Kong ecosystem model (Pitcher *et al.*, 2002).

The following sections used the model predictions to evaluate the overall benefits of the various management scenarios to the private sectors and the society in the short, medium and long terms. Such analyses were not conducted in previous studies in Hong Kong.

## *Total catches, landed values and net benefits from various scenarios*

Under all scenarios that do not involve large-scale restrictions on the trawl sectors (scenarios 2a, 3a, 3c and 3d2), total catches increase in the 10 and 25-year analysis from the *status quo* (Figure 11.) Among these four scenarios, the increases are largest in scenario 3a (2 no-take FPAs and 4 no-take marine parks), while increases are least in scenario 3c (4 no-take marine parks only). The increase is mainly due to the rebuilding of stocks after protected areas are set up in the medium to long terms. In the 5-year time horizon under all four scenarios, annual catch is generally lower than in the *status quo* management regime in all four scenarios, because stocks have not recovered in the short period of protection. At the same time, the loss of fishing grounds from the protected areas leads to reduction in catch.

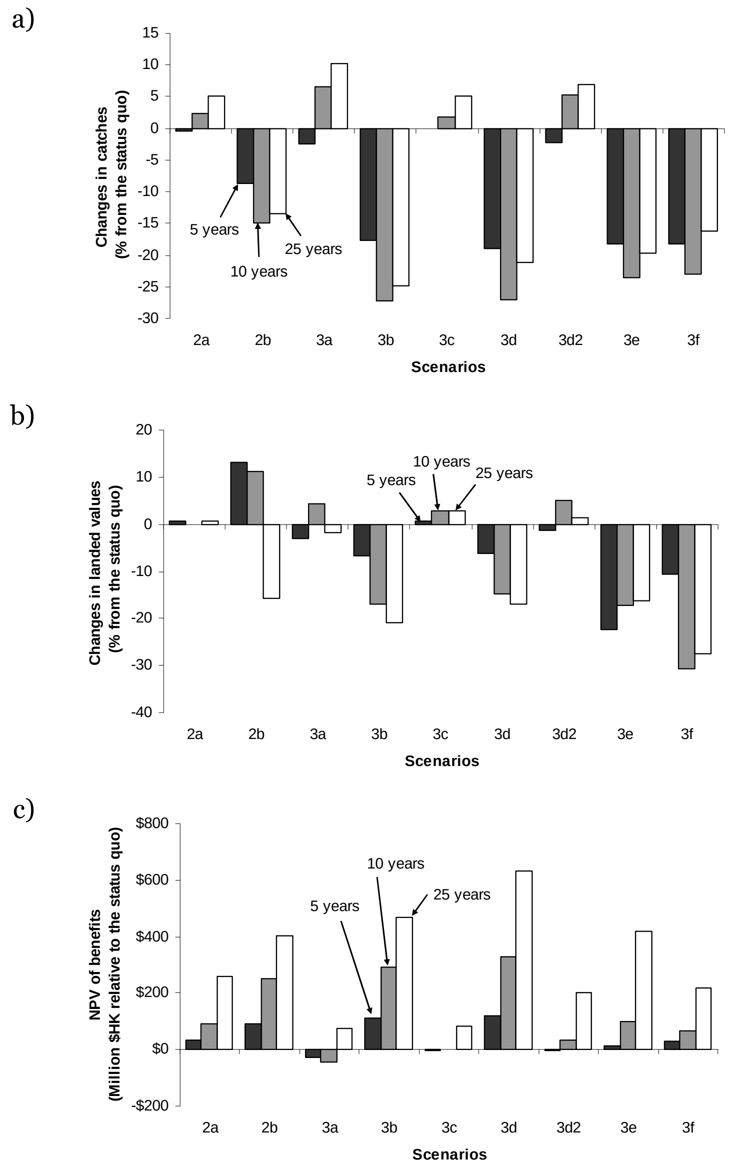



**Figure 11**. Percentage changes in (a) annual catch, (b) landed value and (c) net present value of the benefits from fishing in Hong Kong waters relative to the *status quo* under the various management scenarios, after 5, 10 and 25 years. Discount rate was assumed to be 7% to calculate the net present value.

All trawl moratorium scenarios result in a reduction in catch from the *status quo*. When a seasonal trawl moratorium is imposed (scenario 2b), annual production decreases by 10% to 15% from the *status quo* (Figure 11a). However, when a territory-wide total trawl ban is implemented (scenarios 3b, d, e and f), annual catch reduces by up to 25%. According to the 2001/02 Port Survey, the trawl sectors contribute over 43% of catch to the total catch from Hong Kong waters. Thus removing the trawl sectors from Hong Kong waters is expected to have a large impact on annual production. However, the creation of a designated shrimp trawl area where shrimp trawls are allowed to operate within the territorial wide trawl ban can help considerably to offset the reduction in annual catch.

The landed value results are generally consistent with the changes in annual catch in each scenario (Figure 11b). However, increases in landed value are smaller than the increase in catches for scenarios 2a, 3a, 3c and 3d2. Again, this is because of the trade-off between catching the valuable invertebrates by trawls and the large fishes by the small scale sectors. In these management scenarios, the increase in landed value from the increased catches of large fishes was discounted by the reduced landed value from the reduction in trawling grounds, thus lowering the overall landed values. Landed values from scenario 2b (seasonal moratorium, with no-trawl FPAs) increased in the 5- and 10- year timeframes but deceased in the 25-year timeframe. This shows that the benefits from the no-trawl FPAs and seasonal moratorium could not compensate for the losses in landed values in the long term.

The net present values (NPV) of the benefits (= landed values minus cost, with the flow of benefits through time discounted by a discount rate for private sector of 7%) from most scenarios increase although most of their landed values (= catches x per unit values) decrease (Figure 11c). The net benefits relative to the *status quo* are highest in the scenarios with no-take marine parks, territorial-wide trawl ban and a special shrimp trawl area (scenario 3d) (Figure 11c). NPV increases largely in the long term. NPV from the scenarios with no-take FPAs and marine parks (3a) may incur a loss in the short term (5-year time horizon model), but become positive over the long term (25-year time horizon model). However, the NPV of benefits from this scenario is relatively low compared to scenarios 2. The territorial-wide trawl ban scenario (with a special shrimp trawl area) (3b) can provide the second highest benefits, while adding a no-take FPA to the scenario (3e) may slightly lower the net benefits. Again, these predictions are in line with the results from previous studies in Hong Kong (Pitcher *et al.*, 2002).

The increase in net benefits (revenue minus cost) despite a decrease in landed values agrees with economic theory. In a depleted, open access system such as Hong Kong's marine ecosystem, fishing capacity (i.e., fishing effort) is well past the level that can achieve maximum economic rent (MER) – theoretical fishing capacity or effort that can maximize the net benefits (Gordon, 1954). Thus, the mostly unregulated fisheries in Hong Kong have led to economic waste and dissipation of the economic benefits which the fisheries are capable of producing. This is schematically shown in Figure 12 and is empirically demonstrated from the low profitability in many fishing sectors in Hong Kong, particularly the trawl sectors. The management scenarios reverse this situation and increase overall efficiency, and thus the net benefits from the fisheries. For instance, the trawl sectors have low profitability, although they have high annual catch and landed values. In the annual territorial-wide trawl ban scenarios (3b), these sectors are excluded from fishing in Hong Kong waters, except for the more profitable shrimp trawls which are allowed to fish in a special shrimp trawl area. Although annual catch and landed values decrease greatly, the overall profitability, and thus the net benefits, of the Hong Kong inshore fisheries increases.

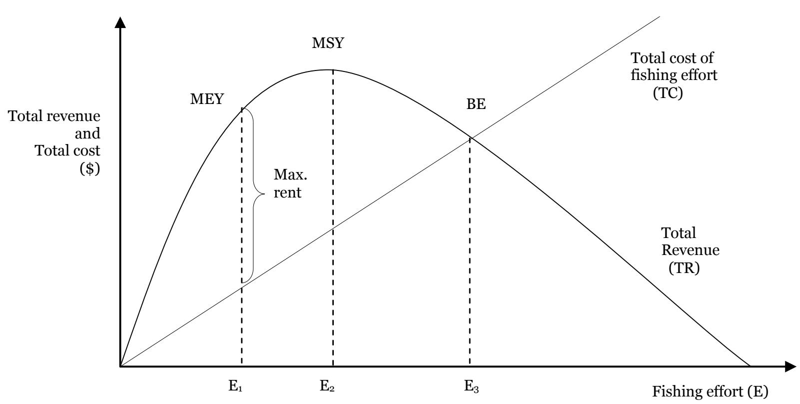



**Figure 12**. Schematic diagram comparing net benefits that can theoretically be obtained from well managed fisheries relative to the current depleted status of the Hong Kong fisheries. Over-exploitation from the mostly unregulated fisheries (fishing effort at $E_3$) in Hong Kong led to economic waste and dissipation of the economic benefits which the fisheries are capable of producing. Reducing fishing effort from $E_3$ to $E_1$ can restore the productivity of the fisheries resources and increase the net benefits from the fisheries. MSY – maximum sustainable yield, MER – maximum economic rent, BE – bionomic equilibrium.

## *Comparison of estimated catches from the 1996/97 and 2001/02 Port Surveys*

Estimated annual catch from Hong Kong waters in 2001/02 was 28,838 tonnes, which is over 60% more than the 17,685 tonnes estimated in 1996/97 (Table 1). From both surveys, 'mixed fish' contribute most to the catch. However, the proportion in weight of 'mixed fish' to the total catch reduced greatly from 45% in 1996/97 to 16% in 2001/02. The 'mixed fish' is an aggregate of catches from groups that do not have separate categories. The decrease in catches of this group in the latest Port Survey should not be caused by the difference in the level of catch aggregations between the two surveys as the 1996/97 Port Survey has more detailed categories of catch than the 2001/02 survey. The 20 groups with the highest catch (excluding 'mixed fish') are generally consistent between the two surveys, with scads, sardine, rabbitfish, croaker, crab and anchovy at the top of the list. However, the absolute catch of these groups increased largely in 2001/02. In particular, the high catch of reef fishes such as groupers (340 tonnes) in 2001/02 is inconsistent with observations from market surveys (Yvonne Sadovy, University of Hong Kong, pers. comm.). This shows the high uncertainty on the accuracy of the Port Survey estimates.

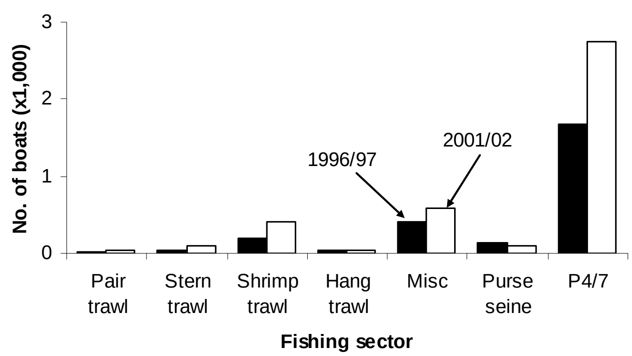
Although the volume of catch differs largely between the two surveys, the estimated mean trophic levels of the catch is similar. The mean trophic level of catch is calculated from the average trophic level of the species (groups), weighted by their annual catches. The mean trophic level of catch (or the marine trophic index, MTI) is considered a major indicator of marine biodiversity by the IUCN-World Conservation Union (Butchart *et al.,* 2004) and the Convention on Biological Diversity (Pauly and Watson, 2005). Based on the trophic level estimated from the 1990s Hong Kong Ecopath model and the model developed in this study, the estimated MTIs for both periods are 2.96. This indicates that the structure of the Hong Kong marine ecosystem is unlikely to have changed considerably between the 1990s and 2000s. However, the current MTI suggests a marked decline from the 1950s level (MTI=3.23) (Cheung, 2001) and the situation does not seem to have improved since the 1990s.

**Table 1.** Top 20 groups (including 'mixed fish') of catch by weight in the 1996/97 and 2001/02 Port Surveys.

| | **1996/97 Port Survey** | | **2001/02 Port Survey** | |
|---|---|---|---|---|
| **Rank in catch** | **Common name** | **Catch (t)** | **Common name** | **Catch (t)** |
| 1 | Mixed fish | 7,912 | Mixed fish | 4,492 |
| 2 | Scad | 1,211 | Rabbitfish | 2,305 |
| 3 | Sardine | 986 | Sardine | 2,220 |
| 4 | Croaker | 903 | Croaker | 1,953 |
| 5 | Anchovy | 834 | Scad | 1,899 |
| 6 | Crab | 656 | Squid | 1,811 |
| 7 | Rabbitfish | 598 | Shrimp | 1,751 |
| 8 | Silver shrimp (Acetes) | 382 | Anchovy | 1,713 |
| 9 | Pony fish | 346 | Crab | 1,639 |
| 10 | Rockfish | 324 | Seabreams | 1,618 |
| 11 | Shrimp | 315 | Threadfin bream | 682 |
| 12 | Squid | 299 | Mullet | 655 |
| 13 | Gizzard shad | 291 | Cardinalfish | 512 |
| 14 | Seabreams | 224 | Scorpionfish | 505 |
| 15 | Conger-pike eel | 222 | Conger-pike eel | 501 |
| 16 | Flathead | 184 | Mantis shrimp | 442 |
| 17 | Mullet | 181 | Pomfret | 417 |
| 18 | Mantis shrimp | 170 | Hairtail | 348 |
| 19 | Hairtail | 166 | Grouper | 340 |
| 20 | Melon coat | 119 | Ponyfish | 272 |
| 21 | Cuttlefish | 106 | Snapper | 261 |
| | **Total catch** | 17,685 | | 28,838 |

Three possible reasons that may explain the increase in catch: (1) the number of fishing boats reported to have fished in Hong Kong waters increased from 1996/97 to 2001/02 for most fishing sectors except purse seine boats (Figure 13a). The increase was especially large for the P4/7 sector. The increase in fishing boats (thus fishing effort) may have led to a short-term increase in total catch; (2) increase in abundance of exploited populations. Catch-per-unit-effort (CPUE), calculated from dividing the catch by the number of fishing boats by sector, can be used as a relative index of abundance of exploited populations. CPUE of pair trawls and purse seines reduced by over 60% and 20%, respectively, while those from the other sectors increased. It is not impossible that the abundance of demersal groups (e.g. benthic invertebrates, demersal fish etc.) increased, which led to an apparent increase in CPUE for the fishing sectors that targeted demersal groups (except hang trawl). On the other hand, the apparent changes in CPUE may not reflect changes in stock abundance. The changes may instead be caused by changes in fishing behaviour of the fishers, for instance, increased fishing time (in Hong Kong waters), improved fishing technology, etc; (3) measurement error. Using global the *Sea Around Us* data, our analysis (see section below for details) indicates that the estimated catch from the 2001/02 is extremely high compared to the recorded catch from areas with similar productivity and characteristics as Hong Kong. However, the estimated catch from 1996/97, which amounts to around 11 t km$^{-2}$, falls within the range of recorded catch. Therefore, it is likely that the 2001/02 Port Survey over-estimated the catch from Hong Kong waters. In particular, the estimates from the Port Survey depended almost entirely on reports from fishers. Incentives for mis-reporting may have been high if fishers were aware that their reported catch in the Port Survey would be used to calculate their *ex gratia* payments, or calculate their buy-back prices. Thus, it is crucial that regular surveys are conducted to collect more reliable catch data or to cross-validate and, if needed, correct the data collected from the Port Survey.

*a)*




*b)*

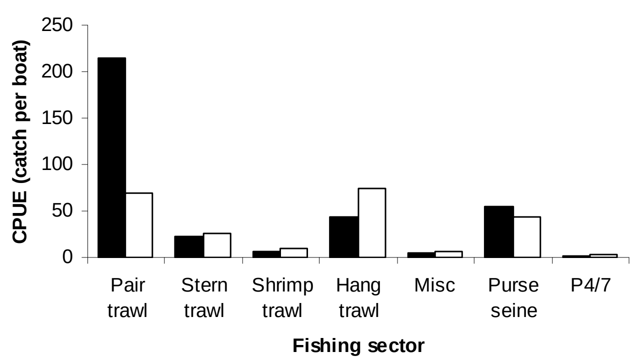



**Figure 13**. Comparison of estimates by fishing sectors from the 1996/97 and 2001/02 Port Surveys on (a) number of fishing boats and (b) catch-per-unit-effort (CPUE) in catch per boat.

Currently, we do not have enough data to make a definitive conclusion on the relative contribution of the above to the increased catch. Data from fisheries independent surveys would greatly help to resolve this problem. Fisheries independent stock assessment data are available from 1996/97 (Pitcher *et al.* 1998), and it would be highly desirable if a similar assessment can be repeated in the 2000s.

## *Validation of annual production figure from the 1996/97 and 2001/02 Port Survey*

The 1996/97 and 2001/02 Port Surveys employed similar methodology to estimate catches from Hong Kong waters. During the surveys, fishers from different fishing sectors were selected and asked about catch composition, catch volume, fishing grounds, etc. from their last fishing trips. The data were used to extrapolate the total catch from Hong Kong waters. Since the surveys relied almost entirely on reported catches from fishers, the high sampling errors and systematic bias may largely affect the accuracy of the estimates.

To test the validity of the estimated catches from the Port Surveys, estimates of annual production from Hong Kong waters from the 1996/97 and 2001/02 Port Surveys (AFCD unpublished data) was cross-referenced against a range of plausible production from similar regions in the world's oceans. To do this, estimates of annual catch rate (t $km^{-2}$ $year^{-1}$) segregated into 30 x 30 minute cells covering the world's oceans were obtained from the *Sea Around Us* Project database (Watson *et al.*, 2004 ; www.searoundus.org).

We determined the range of plausible annual productivity in areas similar to Hong Kong, whose waters occur within a latitudinal range of 20°N to 24°N along the coast and with average primary productivity of about 1.3 $gC \cdot m^{-2} \cdot day^{-1}$. Primary productivity refers to the rate of fixation of inorganic carbon by living organisms, leading to the formation of organic compounds. The primary productivity estimate used in this study is based on depth integrated chlorophyll pigment concentration as derived from SeaWiFS (http://seawifs.gsfc.nasa.gov/SEAWIFS.html) data, and photosynthetically active radiation calculated as in Bouvet *et al.* (2002). The data were then spatially interpolated into 30 x 30 minute cells using the method described by Lai (2004). We obtained annual catch rates (t $km^{-2}year^{-1}$) in year 2004 from the 30 x 30 minute cells representing waters that have similar characteristics as Hong Kong waters, i.e., same latitudinal range, along the coast and having primary productivity values that were within a 25% range of those in Hong Kong. Production estimates from 2004 were assumed to be close to the carrying capacity of the resources (Watson and Pauly, 2001). We then calculated the distribution of the fishery production capacity of these cells. Annual production estimates from the 2001/02 Port Survey were then compared with this probability distribution. This method of validating the estimated catch is roughly the same as the statistical methods developed to test for over-reporting of catches from China (Watson and Pauly, 2001).

Production from Hong Kong waters estimated from the 2001/02 Port Survey is significantly higher than the production capacity of waters that are geographically similar to Hong Kong waters (Figure 14). The 2001/02 Port Survey estimated that annual production in Hong Kong waters was over 16 t $km^{-2}$. However, the median catch rate from areas similar to Hong Kong waters is around 4 t $km^{-2}$. This indicates that the catches from the Port Survey may be over-estimated. Further, as fisheries resources in Hong Kong are largely over-exploited, the likelihood of the Hong Kong ecosystem supporting such high level of fisheries production is low. On the other hand, estimates from the Port Survey are the only available production figures from Hong Kong waters at such level of detail in recent years. Also, the government assesses local fisheries based on this dataset. Thus, our analyses in this study are based on the Port Survey estimates but the effects of their potential over-estimations are evaluated in a later section.

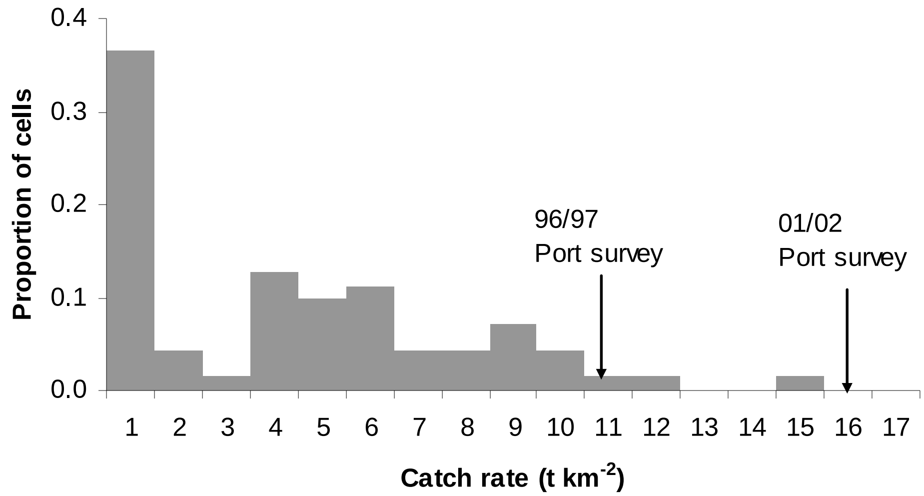



**Figure 14**. Distribution of annual catch rates (tkm$^{-2}$) in areas that are similar to Hong Kong (i.e. same latitudinal range, along the coast and having primary productivity values that were within a 25% range of those in Hong Kong). The catch rate data were provided by the *Sea Around Us* Project. The arrows indicate the estimated catches from Hong Kong waters from the 1996/97 and 2001/02 Port Surveys.

## Economic costs to the Hong Kong SAR Government

In this section, we used the results from both the livelihood survey (Part 1 of this Report) and the fisheries impact analysis modeling to estimate the overall economic costs of fisheries management (or *mis*-management) in Hong Kong waters. The components of the costs include *ex gratia* payment by the government, cost of vessel buy-back to reduce fishing capacity, cost of re-training and providing for displaced fishers to work in developing alternative livelihoods, and the cost of government fuel subsidies.

### *Ex gratia payments to fishers due to loss of fishing grounds*

The Hong Kong SAR Government has set a precedent for making *ex gratia* payments, for instance, when the Cape D'Aguilar Marine Reserve (a strict no-take zone) was established in the mid 1990s. Briefly, the total amount of *ex gratia* payment was calculated as follows: the value of the annual catch for that region of Hong Kong per hectare was calculated for the reserve area based on the most recent Port Survey data for the grid encompassing the reserve area. This value was then multiplied by 7 for permanent loss of fishing grounds to obtain the total *ex gratia* sum. This was then divided amongst the eligible fishers, with some weighting for the size of fishing vessel employed. The method of calculating *ex gratia* was partly developed by consensus with fishers (AFCD pers. comm.), and is similar to the method detailed in Walters *et al.* (in press).

The above approach is usually used to value small businesses (Desmond and Marcelo, 1987; Finley and Hays, 1988), and would therefore be appropriate to use in this study. However the more standard approach used to determine *ex gratia* payments is to calculate the loss in net present value of net benefits by the fishing sector due to the implementation of a given scenario. We applied both approaches in our analysis for comparison purposes and for producing a range of values. First, we determined the annual profits that would be lost by each sector as a result of the management scenarios relative to the *status quo*. This was then discounted using the ongoing business borrowing interest rate (base rate=7%) through the 25-year time horizon model to determine the total *ex gratia* payments. The AFCD approach gives higher *ex gratia* payments because it is based on gross revenues while the conventional economic approach (NPV) is based on profitability. It has been argued that the gross revenue approach is more appropriate for small businesses, and therefore may be more appropriate here because most of the fishing enterprises in Hong Kong can be classified as small businesses (Desmond and Marcelo, 1987; Finley and Hays, 1988).

Using the AFCD method, depending on the scenarios, estimates of *ex gratia* payments range from HK$ 4 million to 1.4 billion (Figure 15). Scenario 2a (no-trawl FPAs) would require *ex gratia* payment of around HK$ 39 million while Scenario 3a (no-take FPAs and marine parks) would require HK$ 463 million. All scenarios that include trawl-bans (3b, 3d, 3e and 3f) result in high estimated *ex gratia* payment (over HK$ 0.9 billion) because of the need to compensate for the loss of territorial wide fishing grounds in Hong Kong for stern and pair trawlers and part of the shrimp trawlers (assuming 90% loss of fishing ground).

The *ex gratia* payments determined using the standard method are lower than estimates from the AFCD method in most scenarios, and often many times so (Figure 15). Using the base discount rate of 7%, the estimated *ex gratia* payment ranges from HK$ 0 for scenario 3c (no-take marine parks) to HK$215 million for scenario 3f (trawl-ban with no-take FPAs and no-take marine parks). *Ex gratia* payment for scenario 2a is around HK$ 23 million, while that for scenario 3a is only slightly higher than scenario 2a, at around HK$ 28 million. This is much lower than the estimates using the AFCD method. No *ex gratia* payment is required for scenario 3c because every fishing sector would have an increase in discounted net benefits over the *status quo*. The lower estimate from the standard method is due to the use of net profits instead of the total revenue from each fishing sector. Also, profits of some fisheries sectors increased after the management scenarios were implemented, thus the reduction of catch from the loss in fishing grounds was offset by the increased catches from the rebuilt stocks. It should be noted that although the sum of net benefits for all fishing fleets in all the scenarios (25 year timeframe) are positive, some of the sectors would have a net loss in benefits which are included in the calculation of the *ex gratia* payment. Considering that the estimated total landed value of the fisheries from the 2001/02 Port Survey is about HK$ 552 million, the *ex gratia* payment estimated from the standard method would range from 4 to 38% of this value, depending on the scenarios.

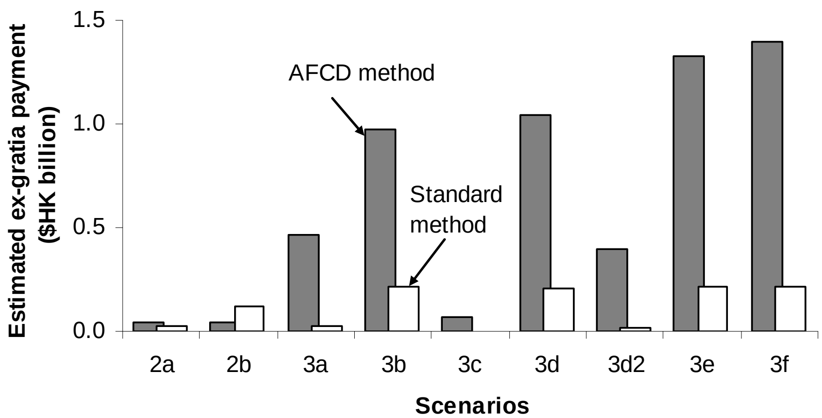



**Figure 15**. Estimated ex-gratia payment required under the different management scenarios using the methods employed by AFCD and the standard economic method. Base discount rate for the standard method is set at 7%.

## *Fishing vessel buy-back*

Similar to the calculation of *ex gratia* payments, the cost of buy-backs can be calculated using the AFCD method (multiplying the landed value by 7) and NPV method (using the NPV of benefits through 25 years). For the NPV method, we calculated the buy-back cost for each scenario. Assuming that fishers are perfectly rational in deciding whether to enter a buy-back scheme or not, they would only leave the fisheries if the buy-back price is higher than or, at least equal to, the net benefits that they could make. Also, fishers would not accept a price that is lower than their current benefits from fishing under the *status quo*. Therefore, buy-back price in each scenario is set by the NPV of net benefits from the scenario. However, if this net benefit is lower than those that the fishers could obtain from the *status quo* scenario, buy-back price is set using the *status quo* NPV of net benefits.

Using the results from the simulation modeling, we estimated the potential number of displaced fishing vessels. Firstly, we calculated the catch per fishing boat by each sector based on the estimates from the 2001/02 Port Survey. We then assumed that this was the minimum catch to support one unit of fishing effort (boat). Secondly, we predicted changes in catch for each fishing sector in each scenario using the results from the simulation modeling. We divided the predicted catch from each fishing sector from the model by the catch per boat to estimate the number of fishing units (vessels) that could be supported under each scenario. The differences between the numbers of fishing vessels that can be supported by each scenario and those by the *status quo* represent the potential number of displaced vessels. To estimate the cost of buying back all the displaced vessels in each scenario, the per vessel buy-back cost for each sector under each scenario was multiplied by the number of displaced vessels.

To estimate the cost of buying back all the displaced vessels in each scenario, the per vessel buy-back cost for each sector under each scenario was multiplied by the number of displaced vessels. Total cost of buy-back is estimated for each scenario (Figure 16).

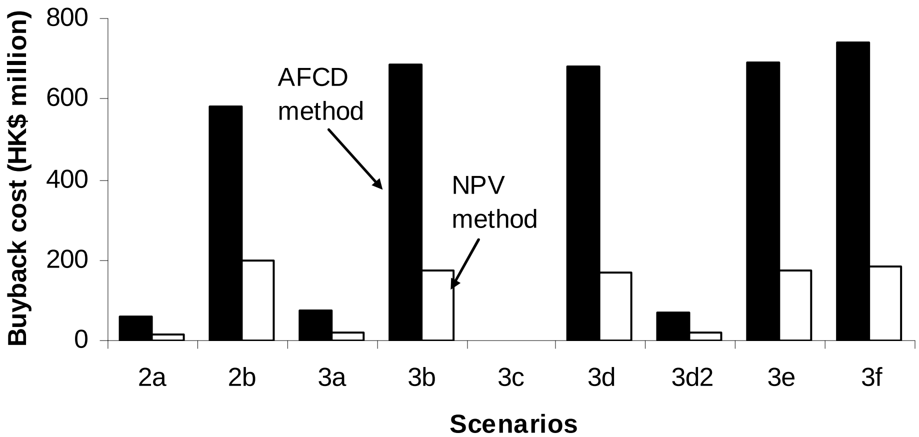



**Figure 16**. Cost of fishing vessel buy-back from Hong Kong waters calculated using the AFCD method and the NPV method for each scenario. For the NPV method, the base estimates use a discount rate of 7%.

Scenarios with no-take marine parks only (scenarios 3c and 3d2) require the least buy-back cost as the number of affected vessels is small. All stern and pair trawlers and part of the shrimp trawls are assumed to be bought-back under the scenarios with territorial-wide trawl ban (3b, 3d, 3e, 3f), thus resulting in the highest buy-back cost of around HK$ 700 and 170 million using the AFCD and NPV methods, respectively. In reality, the buy-back cost may be lower because some of the bigger fishing vessel, particularly the trawlers, may spend more time fishing outside Hong Kong waters instead of giving-up fishing.

Buy-back costs estimated using the AFCD method is generally much higher than the expected NPV of benefits for all scenarios. Scenarios that involve seasonal or territorial-wide trawl bans resulted in much bigger differences compared to the non-trawl ban scenarios. The entire government budget for 2006-07 is estimated to be HK$ 245.6 billion (http://www.budget.gov.hk). Thus the cost of buying back all fishing boats from operating in Hong Kong waters would be less than 0.3% of the annual government budget even when the maximum buy-back cost is considered.

## *Re-training of fishers for alternative livelihoods*

To estimate the cost of re-training fishers for marine-related alternative livelihoods such as working for the scuba diving and recreational fishing sectors, we asked operators of these businesses their opinion on hiring and training fishers to work for them (see Alternative Livelihoods for the Fishing Community report for details). We then estimated the number of jobs that could potentially be generated from the alternative livelihood operators. The cost of training a fisher to work in these alternative livelihood businesses was estimated as the product of the medians of the reported period of training and the daily salary for the employee of the alternative livelihood businesses. Based on the questionnaire responses, this amounted to HK$ 3,750 per trainee.

Alternatively, fishers who are displaced from fishing may work in other non marine-related sectors, such as the construction sector. In such cases, the cost of re-training fishers can be calculated based on an assumed period of retraining and minimum wage required to support the livelihood of the fishers during this re-training period. In Taiwan, the government provided a retraining programme to fishers and farmers for a maximum period of 6 months. According to the Census and Statistic Department in Hong Kong, the average monthly salary for 'General Workers' in 2005 was HK$ 7,350. Assuming a maximum re-training period of 6 months, the cost of retaining one fisher is HK$ 44,100. The Hong Kong government has an on-going fund that supports retraining of workers. Thus, we assume that no-extra cost is needed to set up additional retraining programmes for fishers.

We estimated the number of fishers that may potentially be displaced from fishing by estimating the number of displaced fishing vessels for each scenario using results from our simulations. As detailed in the previous section, using the results from the simulation modeling, we estimated the number of displaced fishing vessel for each scenario. Based on our interview survey, we found that fishing vessels in inshore waters are generally operated by two family members, with additional crew hired as needed from Mainland China. As our analysis focused on Hong Kong fishers only, the effects of the scenarios on the demand for mainland crew are not considered. Thus the total number of displaced fishers was calculated by assuming that an average of two fishers would be out of jobs when one fishing vessel is displaced. In addition, from the interview survey, we observed that it was uncommon for fishers to shift between fishing sectors because such changes would require major investment in fishing gear and a different set of fishing knowledge. An exception was the shift to the P4/7 sector, which seems to be more common since the last decade, especially with the rapid increase in fuel cost (Cheung and Sadovy, 2004). The P4/7 sector has a high profit margin and requires relatively small capital investment and operating cost. In a depleted ecosystem and with increasing operating costs, fishers from larger scale sectors have increasingly moved into the P4/7 sector. This is shown by the increasing number of vessels in the P4/7 sector despite a reduction in vessel numbers in most other sectors (Cheung and Sadovy, 2004). Alternatively, we assumed that the government does a good job at limiting fishing effort growth in each sector. In this case, no fisher is able to change from one fishing sector to another, and thus they would be prevented from fishing altogether.

The number of fishers that are displaced from fishing range from 1 to 798 if they are not allowed to shift between fishing sectors, while there will be no fishers displaced if fishers are allowed to shift to the P4/7 sector (Table 2). As expected, when the extent of the protection is smaller (e.g., 3c, no-take marine parks only), the number of displaced fishers will be smaller. Also, the P4/7 sector is predicted to benefit from all scenarios in the long term. If shifting between fishing sectors is allowed, virtually all the displaced fishers may theoretically be supported by changing to the P4/7 sector. However, because of the other factors such as the difficulties in adapting to new fishing techniques, fishers' un-willingness to change, etc., only part of the fishers may undertake such changes. Some fishers that have been fishing outside Hong Kong waters may shift to the P4/7 sector if their previous fishing operations become less profitable, thereby increasing the overall fishing effort in Hong Kong waters. Therefore, the government should effectively and carefully limit and regulate the number of fishing vessels.

We predicted the number of jobs available for fishers from recreational fishing, diving and marine-related tourism businesses based on the interview survey (Table 3). Respondents of the survey were asked to estimate the magnitude of change in customers 1, 3, 5, and 10 years after marine parks became no-take and after the designation of Fisheries Protection Areas. Also, respondents were asked to provide the anticipated change in customers given a change in the abundance of fish. The scenarios included: 1) a reduction of current fish abundance by half; 2) doubling; 3) 5-times; and 4) 10-times the current fish abundance. Details of the results are reported in Part I of this report. Given the predicted number of customers, we estimated the increase in revenue to each business given the average spending of each customer and the number of businesses in Hong Kong. Using information from our survey, we estimated that 17% of the total revenue would be spent on staff salaries. This was used to estimate the total expenditure on salaries. From the interview survey, we also estimated the expected salary for jobs potentially available for fishers. Using these data, the additional number of jobs created from the various scenarios was estimated. To prevent double counting of additional number of jobs estimated from protected area-based questions and abundance-based question, we used, for each scenario, the estimate from whichever method yielded higher values (Table 2).

**Table 2**. Estimated number of fishers displaced from the fisheries based on the 2001/02 Port Survey and results from the simulation modeling.

| Scenarios | Number of fishers displaced relative to the *status quo*[1] |
|---|---|
| 2a | 65 |
| 2b | 513 |
| 3a | 204 |
| 3b | 713 |
| 3c | 1 |
| 3d | 707 |
| 3d2 | 201 |
| 3e | 798 |
| 3f | 768 |

[1]Fishers are not allowed to shift to the P4/7 sector.

**Table 3**. Number of jobs created from recreational fishing, diving and marine-related tourism operations estimated from the alternative livelihood study. Method a : based on the questions on change in customer number relative to management scenarios; Method b : based on the questions on change in customer number relative to fish abundance.

| | Jobs created (method a) | | | Jobs created (method b) | | |
|---|---|---|---|---|---|---|
| Scenarios | Min | Median | Max | Min | Median | Max |
| 2a | 17 | 52 | 69 | 38 | 114 | 151 |
| 2b | 17 | 52 | 69 | 38 | 114 | 151 |
| 3a | 36 | 74 | 93 | 38 | 114 | 151 |
| 3b | 0 | 0 | 0 | 38 | 114 | 151 |
| 3c | 19 | 57 | 76 | 0 | 1 | 2 |
| 3d | 19 | 57 | 76 | 38 | 114 | 151 |
| 3d2 | 17 | 52 | 69 | 38 | 114 | 151 |
| 3e | 17 | 52 | 69 | 46 | 138 | 184 |
| 3f | 36 | 74 | 93 | 38 | 114 | 151 |

The displaced fishers are assumed to firstly take up the additional jobs from the alternative livelihood operations created from the various scenarios. If such additional jobs are not enough for all displaced fishers, we assume that the remaining fishers will join the retraining programme. Thus the total cost of providing alternative livelihood to fishers can be estimated from the retraining cost for marine-related jobs and the government re-training programme (Table 4).

**Table 4**. Estimated total cost of re-training fishers.

| Scenarios | Total cost (HK$ million)[1] |
|---|---|
| 2a | 0.24 |
| 2b | 18.04 |
| 3a | 4.40 |
| 3b | 26.86 |
| 3c | 0.00 |
| 3d | 26.59 |
| 3d2 | 4.28 |
| 3e | 29.60 |
| 3f | 29.30 |

[1] Based on simulation modeling results.

Total costs of re-training fishers estimated based on both the Port Survey and simulation modeling are highest in the scenarios with territorial-wide trawl ban (scenarios 3b, 3d, 3e, 3f) (Table 4). The high re-training costs with a trawl ban are expected as the inshore trawlers would stop fishing due to the closure of their major fishing grounds.

Based on the results from the simulation model, scenarios with no-take FPAs and marine parks (3a) require re-training costs of about HK$ 4.4 million. Estimations based on simulation modeling are considered more reasonable than those from the Port Survey data. This is because the method based on the Port Survey data assumes that all affected fishers would leave the fisheries, even if the fishers obtain a relatively small amount of catch from the affected areas. This may not be a realistic representation of the responses of the fishers to the various management scenarios. Thus, the estimates derived from the model are conservative and reasonable and will be used in the latter part of this report.

## *Subsidies for fishing vessel modification to facilitate alternative livelihoods*

It may be necessary to subsidize vessel modification to facilitate movement from fishing to tourism and recreational activities. Based on the interview survey, fishers and officials from the AFCD noted that the Marine Department has a strict set of requirements for boats that carry passengers commercially. This makes it very difficult, if not impossible, to modify existing fishing vessels to conduct alternative livelihood businesses such as passenger transport, recreational fishing or leisure boating legally. Given the current situation, we assume that the cost to transform fishing vessels for alternative livelihood business is equivalent to acquiring a vessel designed for such purposes.

The number of fishing vessels that would require modification for participating in the alternative livelihood operations is limited by the scale of the alternative livelihood business. Based on the government recreational fishing survey, 290 fishing-related vessels participate in recreational fishing operations, with the majority of them engaged on a part-time basis. This agrees with findings from our alternative livelihood survey. However, the maximum potential number of full-time jobs created from the potential alternative livelihood operations (recreational fishing, diving and marine-related tourism) is below 200 jobs. Due to costs and regulatory conditions associated with switching occupations, it is likely that the newly created jobs will be filled by those fishers already participating in alternative livelihood jobs part-time, i.e., by switching from part time to full time. Alternatively, these new jobs may be taken up by fishers who are currently not engaged in any alternative livelihood operations. These two scenarios form the lower and upper limits of our analysis.

We estimated the subsidies that would be needed for fishing vessel modification to facilitate alternative livelihood activities by assuming that funds are provided to fishers to buy a boat suitable for alternative livelihood activities. We interviewed fishers who had attempted to modify their existing fishing boats to fulfill the requirements from the Marine Department for carrying passengers for commercial purposes legally. Their experience was that the requirements were strict and it would be very costly to modify their fishing boats to comply with the regulations. Fisheries officers from the AFCD also agreed that existing regulations from the Marine Department made it difficult for fishers to legally convert their fishing boats to carry passengers for recreational fishing or diving. However, estimates on the cost for such vessel modifications were not available. Based on the interviews, it was estimated that a glass fibre-reinforced boat with outboard engine (those used by the P4/7 sector) would cost approximately HK$ 40,000, while HK$ 200,000 would be required to buy a second hand leisure boat. Using the median (HK$120,000) of these two estimates as a basis for calculating the total subsidies required, we obtained total cost ranging from HK$ 15,000 to 12 million required to subsidize up to 100 boats, depending on the scenarios and the number of displaced fishers who participate in the transition.

## *Costs of monitoring, control and surveillance*

Monitoring, control and surveillance (MCS) is crucial if the effort to restore and sustain Hong Kong's fisheries is to be successful. We asked AFCD to provide estimates of management and enforcement costs under the various scenarios (Table 5).

**Table 5**. Cost of MCS under the different management scenarios. Estimates were provided by AFCD.

| | Total cost[1] ($HK million/year) | | | | |
|---|---|---|---|---|---|
| **Scenarios** | **Fisheries Division** | **Marine Parks Division** | **Total** | **Difference from *status quo* (%)** | **Total NPV[2] (25 years)** |
| 1 | 6 | 18 | 24 | 0 | 492 |
| 2a | 14 | 18 | 32 | 33 | 656 |
| 2b | 14 | 18 | 32 | 33 | 656 |
| 3a | 18 | 21 | 39 | 62 | 800 |
| 3b | 18 | 18 | 36 | 50 | 738 |
| 3c | 6 | 21 | 27 | 13 | 554 |
| 3d | 18 | 21 | 39 | 62 | 800 |
| 3d2 | 18 | 18 | 36 | 50 | 738 |
| 3e | 26 | 18 | 44 | 83 | 902 |
| 3f | 26 | 21 | 47 | 96 | 964 |

[1] The cost includes personnel, capital investment (e.g., patrol vessels), maintenance and other expenses (e.g. fuel) ;

[2] The current value estimates are discounted at the government rate of 4%.

Setting up no-take FPAs and no-take marine parks would require an intermediate amount of resources for MCS compared to other scenarios. The cost of MCS is high under scenarios 3e and 3f with annual costs of HK$ 44 and 47 million, respectively, in which no-take FPAs and a territorial-wide trawl ban are included. The cost of setting up partially protected marine parks and FPAs cost least among the scenarios (scenario 2a and b). According to the AFCD, existing marine parks mainly use relatively cheap, outboard speed boats for patrol and enforcement work. Their capital costs as well as annual maintenance are far less than the proposed big vessels used for managing a no-take FPA. Furthermore, the number of staff to be deployed would be less. These result in a smaller cost of MCS for these scenarios (AFCD, unpublished data)

Fishers could potentially be employed to conduct MCS. This has been suggested and practiced with success in some fisheries, for instance, in protected areas management in the Philippines (Pomeroy, 1995). In this way, the cost of MCS could partly be transferred back to provide alternative livelihood to fishers, thus reducing the actual cost of MCS to the society. Future studies can look into the possibility of such an arrangement in Hong Kong.

### *Cost of fuel subsidy*

Subsidy to the fisheries should be included as a cost in analyzing the costs and benefits of the fisheries resources to society. Although the government denied that they provided subsidies to the fisheries (Albert Leung, AFCD, pers. comm.), fishers with valid fishing boats were entitled to buy fuel (gasoline and diesel) with lower fuel tax. Currently, the subsidy for diesel is estimated to be HK$2.89 per litre, or approximately 40% of the pump price. The subsidy for industrial grade gasoline is also around 40% of the market price. Based on fishing cost and earnings data collected by the AFCD for 2004, the cost of fuel subsidies amounted to around HK$237 million.

## Potential impacts of the different management scenarios

In this section, we evaluated the potential economic impacts of the management scenarios on the fishing and non-fishing communities.

### *Value of catch from Hong Kong waters*

Changes in the landed values and net benefits of the fisheries were predicted from simulation modeling (see general results section). The NPV estimates show that implementing most of the management scenarios will have some degree of benefits through time to the fishing industry in Hong Kong. However, at the fishing sector level, there will be trade-offs in costs and benefits. For instance, increase in large reef and non-reef fishes would favour the P4/7 and miscellaneous sectors, which target these species. However, benefits to shrimp trawls that target benthic invertebrates would be reduced due to decreased abundance of benthic invertebrates resulting from the reduced fishing grounds and decreased productivity of shrimps and other benthic invertebrates following increased abundance of their predators (fishes) (Cheung and Sadovy, 2004). Based on the government cost and earnings study (AFCD unpublished), the jobs provided per unit of revenue (estimated from the wages divided by the total revenue by sector) are 2-3 times higher for the small scale sectors compared to the trawlers. Therefore, given a management objective of maximizing jobs, it would be preferable to encourage the small scale sector rather than the trawl sectors.

## *Potential shifting of fishing effort by area within Hong Kong waters in response to new restrictions on fishing*

We predicted the shifting of fishing effort by comparing the landed value per unit of vessel for each fishing sector within FPAs with their average landed value per vessel in Hong Kong. This is based on the theory of the Ideal Free Distribution (IFD) model. IFD predicts that fishing effort will distribute to areas that maximize profits per unit of effort until the benefits become homogenous across different areas. Thus, if landed value per vessel in the FPAs is low compared to the average from HK waters, it means that the fishing sector will readily move to fish in areas outside the FPAs. On the contrary, a high value per vessel in FPAs means fishing fleets will try to stay as close to the FPAs as possible, so their effort would likely be concentrated along the boundary of the FPAs. Dependence on marine parks as fishing grounds is small so effects of effort redistribution from no-take marine parks should be minimal too.

**Table 6**. Ratio of landed value per boat per unit area relative to the average over all Hong Kong waters.

| Fishing sectors | Port Shelter | Tolo and Long Harbour |
|---|---|---|
| ST | 2.3 | 0.3 |
| SHT | 1.8 | 1.1 |
| PT | 2.7 | 4.8 |
| PS | 3.4 | 2.8 |
| P4/7 | 9.7 | 6.2 |
| Misc. | 1.1 | 0.5 |

The Port Shelter and Tolo and Long Harbours are important fishing grounds for the pair trawl, purse seine and P4/7 sectors, because fishers can get relatively higher value fishing in these areas compared to other parts of Hong Kong. Thus, it is expected that when these fishing gears are prohibited from fishing within the FPAs, they will concentrate their fishing effort along the FPA boundary.

Port Shelter is a valuable fishing ground for stern trawlers because landed value here is twice as high as compared to other parts of Hong Kong. On the other hand, value per vessel for stern trawlers in Tolo and Long Harbour is lower than other areas, so they will readily distribute their effort to other parts of Hong Kong waters when they are restricted from fishing in the Tolo/Long Harbour FPA. If the shrimp trawl and miscellaneous sectors are prohibited from fishing within the FPAs, they may probably shift their effort to other Hong Kong waters, with a slight concentration along the boundary of the Port Shelter FPA.

## *Potential redistribution of the Hong Kong fleet in the South China Sea.*

In general, the annual catch of the fisheries in Hong Kong waters represents only about 10% of the total catch from the Hong Kong fishing fleet. However, fisheries resources in the northern shelf of the South China Sea, the major fishing ground for the Hong Kong fishing fleets, have been decreasing over the last few decades. The catch-per-unit-effort of many commercially targeted demersal fishes have declined by more than 80% in 15 years from the 70s to the 80s (Pang and Pauly, 2001; Ho 2005). Based on recent surveys by the South China Sea Fisheries Institute, the decline continued from the 1980s to the 2000s (Qiu, Y., South China Sea Fisheries Institute, pers. comm.). Fishing regulations imposed by the Mainland China management authority have become increasingly stringent, partly because of the serious over-exploitation of the resources. Hence, there may be limitations to the shifting of current fishing effort from Hong Kong waters to the South China Sea.

Based on the interview survey, those fishing boats that currently fish largely within Hong Kong waters would have limited ability to expand their fishing grounds. This was particularly the case for the vessels based in the eastern waters of Hong Kong. These vessels included P4/7 boats, and some shrimp and stern trawls. Most of these boats had valid fishing licenses for fishing in Chinese waters. However, the P4/7 glass fibre-reinforced sampan is designed for inshore conditions and would not have been able to travel far to fish outside Hong Kong waters. Similarly, some of the small shrimp and stern trawls could fish at the boundary of Hong Kong waters, but could not withstand the rougher conditions further offshore. The medium sized fishing vessels, which generally have licenses to fish in Chinese waters, would be able to fish in the Pearl River estuary and the South China Sea. During the two months fishing moratorium, mid size trawlers mostly operate within Hong Kong waters, while the large size fishing vessels do not operate at all. The situation may be slightly different in the western waters, where the ports are close to the Pearl River estuary, which is more sheltered, thus allowing smaller boats to fish outside Hong Kong waters.

On the other hand, given increasing fuel costs, some of the fishers from the larger scale sectors may fish closer inshore to reduce fuel cost. Some may even convert to the P4/7 sector, which generally has lower capital and recurrent costs and higher profitability relative to other sectors. This may be part of the reason for the reported increase in the number of fishing boats operating within Hong Kong waters (see earlier section). Also, if fisheries productivity were to be restored in Hong Kong waters, there is a potential for the vessels that are currently fishing in Chinese waters to spend more time fishing in inshore waters.

## *Changing fuel costs*

Fuel cost forms a significant part of the cost of fishing. With rising fuel cost, everything being equal, profitability of fishing will decline. We made three assumptions about fuel costs (remain at current level, decrease, and increase by some percentages based on historic data) in our analysis of fisheries impacts to provide a range of possible outcomes.

We estimated the change in fuel prices for the next 25 years by doing the following. Firstly, we obtained real prices (standardized to 2005 constant prices) of gasoline and diesel at pumps in the USA from 1996-2005. Second, we calculated the average rate of change of the prices per gallon over this period, which turned out to be US$ 7.6 and 7.7 gallon$^{-1}$ year$^{-1}$ for gasoline and diesel, respectively. Finally, we used the calculated rate of price changes to extrapolate relative changes in fuel cost in the next 25 years.

Relative changes in fuel cost for the different fishing sectors in Hong Kong under the various scenarios were estimated. The outboard engine used by the P4/7 sector consumes gasoline while most vessels in the other sectors consume diesel. Assuming that other costs are kept constant over time, we estimated the percentage of fuel cost relative to the total revenue changes based on our predicted rate of change of fuel prices for each fishing sector. Based on the changes in fuel cost, we then calculated the magnitude of decrease in the net benefits in each scenario for the 5, 10, and 25-year time horizon (Figure 17). If fuel cost were to decrease at the same rate in the next 25 years, the magnitude of change would be similar, except that the direction of change in net benefits becomes positive.

Fuel cost has a large impact on the benefits from the fisheries under all scenarios (Figure 17). In the 5-year, 10-year and 25-year time horizon models, net benefits decrease by HK$ 0.1 - 0.3 billion, 0.4 – 0.8 billion and 1.3 – 1.8 billion, respectively. Since trawlers spend over 50% of their revenue on fuel, compared to the small scale sectors such as P4/7 and purse seines, which spend 20 – 30% of their revenues on fuel, trawlers are most severely impacted by fuel price changes. As such, scenarios with a trawl ban appear to receive less impact from the increase in fuel cost as trawlers are excluded from fishing in Hong Kong waters and thus are not included in the calculation in these scenarios.

Government fuel subsidies for the fishing sectors on fuel are important components in evaluating the overall cost and benefits of the management scenarios. This will be evaluated and discussed further below.

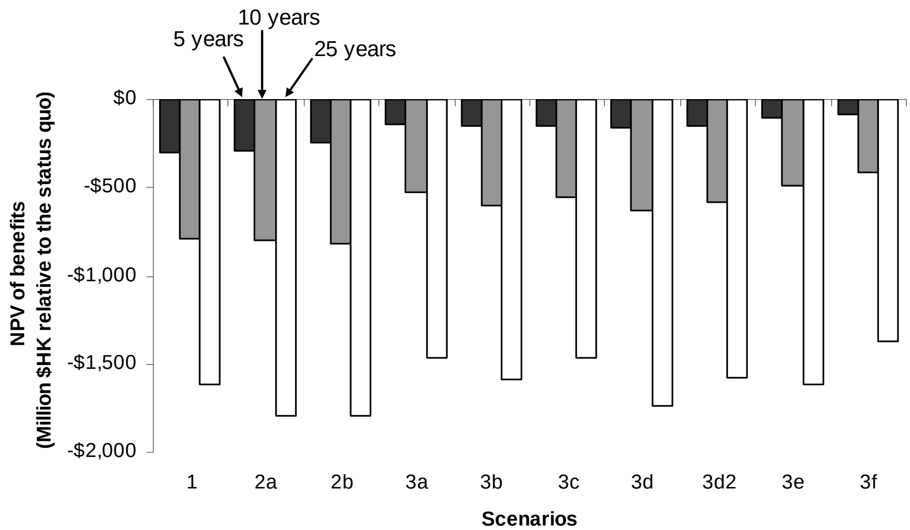



**Figure 17**. Decreases in NPV of benefits in the scenarios from the base runs (assuming no change in fuel cost over time) if fuel cost increases annually. Rate of increase/decrease in fuel cost is predicted based on the change in real pump price of gasoline and diesel in the USA in the past 10 years.

## *Revenue from non-extractive services related to tourism and recreation*

### *Revenue from overseas visitors*

Revenue from non-extractive services was estimated from tourism statistics and the alternative livelihood study. According to the tourist statistics from the Hong Kong Tourism Board (HKTB, 2005), the total number of visitors to Hong Kong that stayed over-night in 2005 was 14.8 million people. These visitors spent HK$ 69 billion, including accommodation, shopping, transportation, catering etc. The visitors stayed 3.7 nights on average in Hong Kong. Thus, an 'over-night' visitor spent an average of HK$ 1,260 per day. Also, a survey by the Hong Kong Tourism Board estimated that 24% of the visitors were interested in eco-tourism (HKTB, 2001). Because eco-tourism, especially when marine-related, may require more than half a day for a visitor to complete the trip, the visitor will then have to spend an extra day in Hong Kong before he/she can leave. Multiplying the number of visitors presumed interested in ecotourism with their average spending, we estimated potential spending from overseas visitors on ecotourism to be HK$ 4.67 billion per year.

The average break-down of tourist expenditure (for 1999-2004) shows that 32% and 12% of tourism spending goes towards accommodation and food, respectively (Euromonitor Industry Report, 2005). Based on our estimated spending of HK$ 4.67 billion by potential marine-related tourists, HK$ 1.0 and 0.53 billion goes to the accommodation and food sectors, respectively. These amounts account for about 8% of total tourist spending. Therefore, potential marine-related tourist spending on food and accommodation constitutes less than 10% of total tourism spending on these sectors.

This represents a rough estimate on the upper limit of the potential value of marine-related tourism in Hong Kong. It has been noted that visitors' interests in 'ecotourism' includes hiking, walking in parks, etc, and not necessarily marine-related activities (Hopkinson and Stern, 2002). Moreover, although the visitors expressed interest in ecotourism, this may not be a strong enough motivation for them to stay an extra day in Hong Kong (Mackercher and Andrew, 2005). Nevertheless, given limited data on the breakdown of visitors interested specifically in marine-related tourism, our estimates can help us understand the potential benefits to society from developing marine-related tourism in Hong Kong.

## *Revenue from the residents of Hong Kong*

Marine-related tourism for local visitors includes scuba diving and snorkeling, recreational fishing, dolphin watching, etc. The World Wide Fund for Nature (Hong Kong) estimated that 10,000 local tourists per year joined dolphin watching tours in Hong Kong. Price for a dolphin watching tour ranges from HK$ 100 to 350 per person. Based on the median of the range (HK$ 225 per person), we estimated that direct revenue to dolphin watching amounted to HK$ 2.25 million per year.

The alternative livelihood survey estimated the total revenue from recreational fishing, scuba diving and marine-related tourism operators in Hong Kong. The estimated total revenue from these operations ranges from HK$ 121 to 816 million per year. These estimates represent mainly direct spending on these activities and do not include indirect expenditure such as catering in the course of carrying out these activities. A survey on recreational fishing in Hong Kong conducted by AFCD estimated the total expenditure (direct and indirect) on recreational fishing amounted to be HK$ 1 billion per year. Thus, our estimates should be viewed as conservative estimates of the revenue from these activities.

## ***Seafood supply and consumption***

We predicted local demand for seafood based on government statistics. We obtained estimates of per capita seafood demand over the past 10 years from the government (AFCD unpublished data). We also estimated the projected population for Hong Kong in the next 5, 10 and 25-year time horizons (Census and Statistics Department 2004). Assuming that per capita seafood demand will be maintained at the average value of the past 10 years, we estimated the total seafood demand by the Hong Kong population in the future.

Using our predicted annual production from the simulation model, we calculated a self-sufficiency ratio for each scenario. In this study, the self-sufficiency ratio refers to the proportion of seafood demand that can be fulfilled by supply from fisheries in Hong Kong waters. This ratio was calculated for the 5, 10 and 25-years time horizons and compared between the different scenarios (Figure 18).

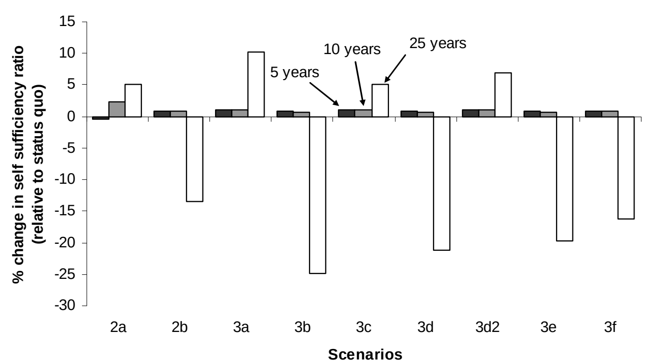



**Figure 18**. Changes in the self-sufficiency ratio relative to the *status quo* in the 5-year (dark bars), 10-year (gray bars) and 25-year (open bars) time horizons under different scenarios. The self-sufficiency ratio is the total fishery landings in Hong Kong waters relative to the predicted seafood consumption in Hong Kong.

All the non-trawl ban scenarios (2a, 3a, c, d2) show slight increases in the self-sufficiency ratio relative to the *status quo*. This means the production of seafood increases faster than the predicted future demand. The increases are largest in scenario 3a (no-take marine parks and no-take FPAs), with about 7% increase in self sufficiency ratio from the *status quo* in the 25-year model.

The trawl ban (seasonal or total) scenarios (2b, 3b, 3d, 3e, 3f) lead to drops in the self-sufficiency ratio (13 – 25%) in the long term. However, catch from Hong Kong waters represents only about 10% of the total domestic landings. The majority of seafood consumed in Hong Kong is either caught outside Hong Kong waters from the South China Sea, or imported from China or other countries. Thus, it is uncertain whether the drop in production from Hong Kong waters will have significant impacts on the local seafood demand. On the other hand, depletion of local fisheries resources may leave Hong Kong vulnerable to price fluctuations, particularly if seafood supplies from elsewhere decrease because of over-exploitation. Thus it would be desirable for Hong Kong to maintain the potential productivity of inshore fisheries resources.

## *Links between the fishing industry and industries dependent on it*

The objective of this exercise is to recognize that associated industries may be impacted under the 3 fisheries scenarios, and identify them so that future studies may be carried out. The impact analysis carried out so far is all about how the various scenarios are likely to impact the fishing (or what some call the harvesting) sector of the food chain. But clearly, this is not the full picture, since a number of post-fishing activities will also be affected. A simplified classification of the fish chain is made up of : (i) the catching or fishing sector ; (ii) the processing sector ; (iii) the wholesale sector ; (iv) the retail sector ; and (v) the consumer. As can be seen below, this classification can vary depending on the fishery, availability of data, etc. Thus, qualitative analysis was carried out to indicate where the greatest negative or positive impacts are likely to occur so that further more-detailed studies can potentially be undertaken.

Gudmundsson *et al.* (2006) reported on four case studies performed to determine how revenue is distributed through the fish value chain. We apply the findings in this report to our analysis of how different scenarios are likely to impact the non-fishing part of the food chain listed above. The starting point for our analyses are the revenues generated by each scenario relative to the *status quo* scenario as determined by our modeling exercise.
Gudmundsson *et al.* (2006) analyzed the revenue distribution of the fish chain of : (i) Icelandic cod ; (ii) Tanzanian Nile perch ; (iii) Danish herring ; and (iv) the Moroccan anchovy. They found out that 18%, 27%, 19%, and 36% of the revenue from a tonne of the Icelandic cod went to the fishing, processing, wholesale/secondary processing, and retailers, respectively. In the case of Tanzanian Nile perch, 16%, 5%, 18% and 61% of the revenues are estimated to go to fishers, fishmongers, processing, and wholesale/secondary processing/retail sectors, respectively. Equivalent numbers for Danish herring are 8%, 17%, 38% and 37%, respectively. Finally, the revenue from a tonne of Moroccan anchovy is split among the fishing, processing and wholesale/secondary processing/retail sectors, respectively, into 4%, 21% and 75%.

We apply these numbers to our study as follows. First, we divide the fish chain into the fishing and post-fishing sectors, where the latter consists of the processing sector, the fishmongers, the wholesale sector, and the retail sector. Second, we identify the proportion of the total revenue that is retained by each sector based on our survey and information from the four cases above. These are then applied to the distribution of income between fishing and non-fishing sectors in Hong Kong.

The potential fish chains for Hong Kong as identified from our survey are:

Chain 1: Fishers > Fish collector > Wholesale market > Retailer
Chain 2: Fishers > Fish collector/wholesale market > Processor > Retailer
Chain 3: Fishers > Fish collector/wholesale market > Retailer
Chain 4: Fishers > Retailer
Chain 5: Fishers being the retailer

The common chains of trade that can be found in the different fishing sectors in Hong Kong are identified in Table 7.

**Table 7.** Common occurrence of the fish chains of different fishing sectors in Hong Kong. Y – Yes, N – No.

| | Chain 1 | Chain 2 | Chain 3 | Chain 4 | Chain 5 |
|---|---|---|---|---|---|
| **Stern Trawl** | Y | Y | Y | Y | Y |
| **Shrimp Trawl** | N | N | Y | Y | Y |
| **Pair Trawl** | Y | Y | Y | N | N |
| **Purse Seine** | Y | Y | Y | N | N |
| **P4/7** | N | N | Y | Y | Y |
| **Miscellaneous** | Y | Y | Y | Y | Y |
| **Hang Trawl** | Y | Y | Y | N | N |

The fish collectors generally go around the fishing grounds and ports to collect catches from fishing vessels. Respondents from our survey estimated that the fish collectors generally take 10% commission from the value of the catches. The wholesale markets are run by the government's Fish Marketing Organization (FMO). There are currently seven FMO wholesale markets. The FMO is a non-profit organization, and its revenue is obtained from the commission on sale value of the landings. The commission for sales by auction or by negotiation is calculated at 7% of the sales value. The commission for sales by direct sale method is calculated at 7% of the sales value or at a rate of five dollars per 15 catties (i.e., about 9 kilograms), whichever is less. For simplicity, we used the 7% commission on sale value in our analysis. For fish processors and retailers, we used the average percent of revenue from the above four case studies in our analysis. This assumption is a bold one but in the absence of data on Hong Kong fisheries for a similar analysis to be carried out, the assumption is probably sufficient.

Based on the above data, we calculated the split of revenues between fishing and non-fishing sectors. For chain 1, 41% and 59% of revenue goes to the fishing and non-fishing sectors. For chain 2, 3 and 4, the splits are 28% and 72%, 44% and 56%, and 48% and 52% between fishing and non-fishing sectors respectively. For chain 5, since fishers are retailing their catch, the fishing sector can get 100% of the revenue.

Our estimates suggest that 36% to 62% of the revenue from landings goes to the non-fishing sectors (Table 8). The shrimp trawl, P4/7 and miscellaneous sectors get a high percentage of the total revenue (thus, low percentage to non-fishing sector). The findings agree with the government cost and earnings studies and our interview survey which indicated that these three fishing sectors were operating at high profit margins compared to other sectors. This is encouraging given the various approximations we made in the calculations because of scarce data.

**Table 8.** Revenue per unit of landings that goes to non-fishing sectors such as wholesaling, processing and retailing in fishing sectors.

| Sectors | Revenue to non-fishing (%) | Non-fishing: fishing revenue ratio |
|---|---|---|
| Stern Trawl | 47.91 | 0.92 |
| Shrimp Trawl | 36.08 | 0.56 |
| Pair Trawl | 62.44 | 1.66 |
| Purse Seine | 62.44 | 1.66 |
| P4/7 | 36.08 | 0.56 |
| Miscellaneous | 47.91 | 0.92 |
| Hang Trawl | 62.44 | 1.66 |

Incorporating the revenue from non-fishing sectors, the total annual revenues from landings amount to around HK$ 1.3 billion in 5, 10 and 25-year analyses under the *status quo*, with about HK$ 0.6 billion going to the non-fishing sectors (Figure 19). Focusing on landed revenues of the non-fishing sectors, the net present values from 5 and 10 years decrease from the *status quo* in scenarios involving territorial-wide trawl ban (3b, 3d, 3e, 3f) (Figure 20). The decreases are greatest in the trawl ban with no-take marine parks and FPAs scenarios, in which landings decrease greatly.

In addition to the post-harvesting sector considered here, the management scenarios are also likely to affect upstream sectors, e.g. the demand for fishing gear or fishing boats. However, according to fishers, most of their fishing gears, such as nets, are bought from China. Fishing boats are also built in China due to lower labour costs. Since it appears that those upstream sectors are not prevalent in Hong Kong, inclusion of these sections should not considerably change the overall picture of the links between fishing and non-fishing sectors depicted from our analysis.

This analysis identifies several key areas to further the understanding of the fish marketing chains and the potential impacts of fisheries management policies on the non-fishing sectors. Firstly, data on the volumn or proportion of catch that flows through the different chains are needed. Also, structure of the chains and the players involved should be properly identified. The financing of each node or players along the fish chain should be better understood.

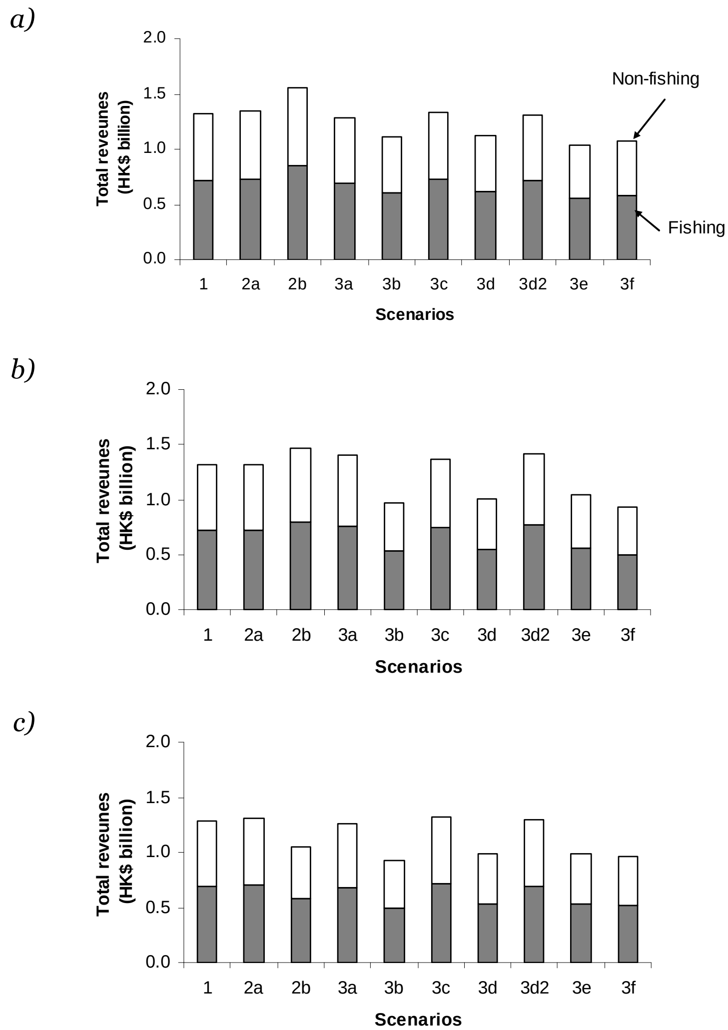



**Figure 19**. The estimated annual revenue from landings to the fishing and non-fishing sectors in (a) 5 years, (b) 10 years and (c) 25 years.

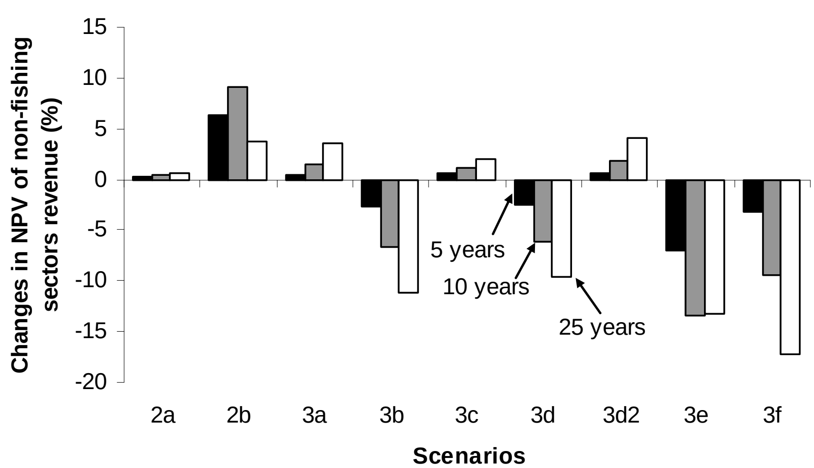



**Figure 20**. Estimated changes in discounted revenue to the non-fishing sectors in the different scenarios relative to the *status quo*. Discount rate is assumed to be 7% per annum.

## Overall costs and benefits of management scenarios to society

### *Counting costs*

We conducted an accounting of the societal costs and benefits under the various scenarios analyzed. The costs include : 1) the additional cost of management, control and surveillance (MCS); 2) buy-back of excess fishing capacity, which includes the cost of *ex gratia* payments; 3) subsidies to modify existing fishing vessels for alternative livelihood operations; 4) retraining fishers to work in alternative livelihoods or other businesses; and 5) fuel subsidy costs. Buy-back, vessel modification, and retraining costs are incurred in the first year of the analysis, while management and fuel subsidy costs are recurring annual costs. Currently, the subsidy for diesel is estimated to be HK$2.89 per litre, or approximately 40% of the pump price. The subsidy for industrial grade gasoline is also around 40% of the market price. Using 2004 fuel cost data (AFCD unpublished data), the cost of fuel subsidies amounted to around HK$237 million per year, or $60,340 per vessel. However, this estimate was based on the number of vessels reported by the AFCD 2001/2002 Port Survey, w4hich included vessels that fished both inside and outside Hong Kong waters. Thus the HK$237 million per year is likely an over-estimate of annual fuel subsidies to fishing in Hong Kong waters. To calculate fuel subsidies for vessels fishing within Hong Kong waters only, we estimated fishing effort based on results from the simulation model (see 'Fishing vessel buy-back', p.96 for details). Under the *status quo* scenario, this resulted in an annual subsidy cost of HK$ 48 million. Management costs were assumed to increase by an amount equal to inflation each year. Buy-back costs applied only to fishers who were willing to leave the fishery. From our fisher interview results, this group made up 75% of respondents (see Part 1, this report). Vessel modification costs were applicable only for fishers who were not willing to leave the fishery. This group constituted 25% of the respondents. Fuel subsidies accounted for 40% of fuel prices, and were assumed to change according to the level of fishing effort for each scenario.

### *Measuring benefits*

The benefits to society are defined as the sum of the difference in net revenues from commercial fishing and from the alternative livelihood operations (recreational fishing, diving and tourism) under the *status quo* and other management scenarios. The net present value of benefits relative to the *status quo* was calculated for each scenario. Since we were estimating the benefits to society, and not the private sector, a social discount rate of 4% was used (Hopkinson and Stern 2002). As mentioned earlier in this report, the societal benefits under each management scenario do not end at the 25 year time frame, but continue through time. Thus, the total benefit to society is equal to the NPV of flows of net benefits in perpetuity.

### *Net benefits*

The flows of costs and benefits described above were netted out and discounted to determine the net present value of benefits to Hong Kong. The results obtained and the net private benefits to fishers in the 25 year time horizon model are reported in Figure 21. We see from this figure that the net benefits relative to the *status quo*, both to fishers as a group and the society, are positive. But society clearly benefits more by moving away from the *status quo* management. The results are generally robust to alternative estimates of buy-back costs. It should be noted that the performance of the private sector in the short and medium terms (5 and 10 years) are lower than that in the 25 year time horizon. Also, although the sum of net benefits for all fishing fleets taken together in all the scenarios are positive in the 25 year time horizon, some of the sectors would have a net loss in benefits. The combined short term cost to certain sectors explains why there is opposition to change from the *status quo*. Given the benefits to society, it makes sense economically to compensate potential 'losers' in order to initiate change.

The government no-trawl FPA and seasonal moratorium scenario (2b) delivers the least benefit of HK$ 0.5 billion to society. Scenarios with no-take FPAs and no-take MP (3a) generate less benefits than scenario 2a (no-trawl FPAs). This is because scenario 3a results in a short term (5 years) loss from the *status quo* which greatly lowers its overall discounted benefits. The territorial-wide trawl ban with special shrimp trawl area and no-take marine parks scenario (3d) generates the highest societal net benefit (HK$ 2.8 billion). Fisheries benefits and fuel subsidy savings are the main drivers of the positive net benefits.

Thus, the territorial-wide trawl ban scenarios do best as they involve the displacement of more trawl vessels, hence, less fishing effort and fuel usage while the small scale sectors such as the P4/7 and the miscellaneous sectors are allowed to continue fishing, and thus realize the economic benefits from stock recoveries. On the other hand, scenario 2b involves an increase in fishing effort (number of vessels) after 21 years, thus leading to increases in fuel subsidy costs. Management costs are another driver of net benefits. Scenario 3c has the lowest management cost, contributing to its high net benefits even though its fisheries benefits are less than those in scenario 3d2. This implies that the government can potentially increase societal benefits by streamlining its monitoring and surveillance costs.

The revenues obtained from the alternative livelihood operations make important contributions to the net societal benefits. Therefore, active and sustainable development of these sectors should increase the societal benefits from the marine ecosystem. However, it should also be noted that the revenues depend on gains in extra customers for the businesses, and based on the interview survey, the customer gains are a function of the management policies and fish abundance (see Part 1, this report). Thus, the estimated benefits are sensitive to the predicted biomass changes from the simulation modeling. The benefits and costs to the private sectors, society and the marine ecosystem are summarized in Table 9.

In summary, all the scenarios have the potential to deliver higher net benefits to the society than that under the *status quo*. In addition, a restored ecosystem is likely to increase non-market values that are not explicitly captured by our analysis. Studies that aim to capture such non-market values can be conducted to include this component into the costs and benefits calculations reported herein (see Berman and Sumaila, 2006 and references therein). Capturing these non-market values in the cost-benefit analysis will further increase the societal benefits that can be obtained from a properly managed ecosystem.

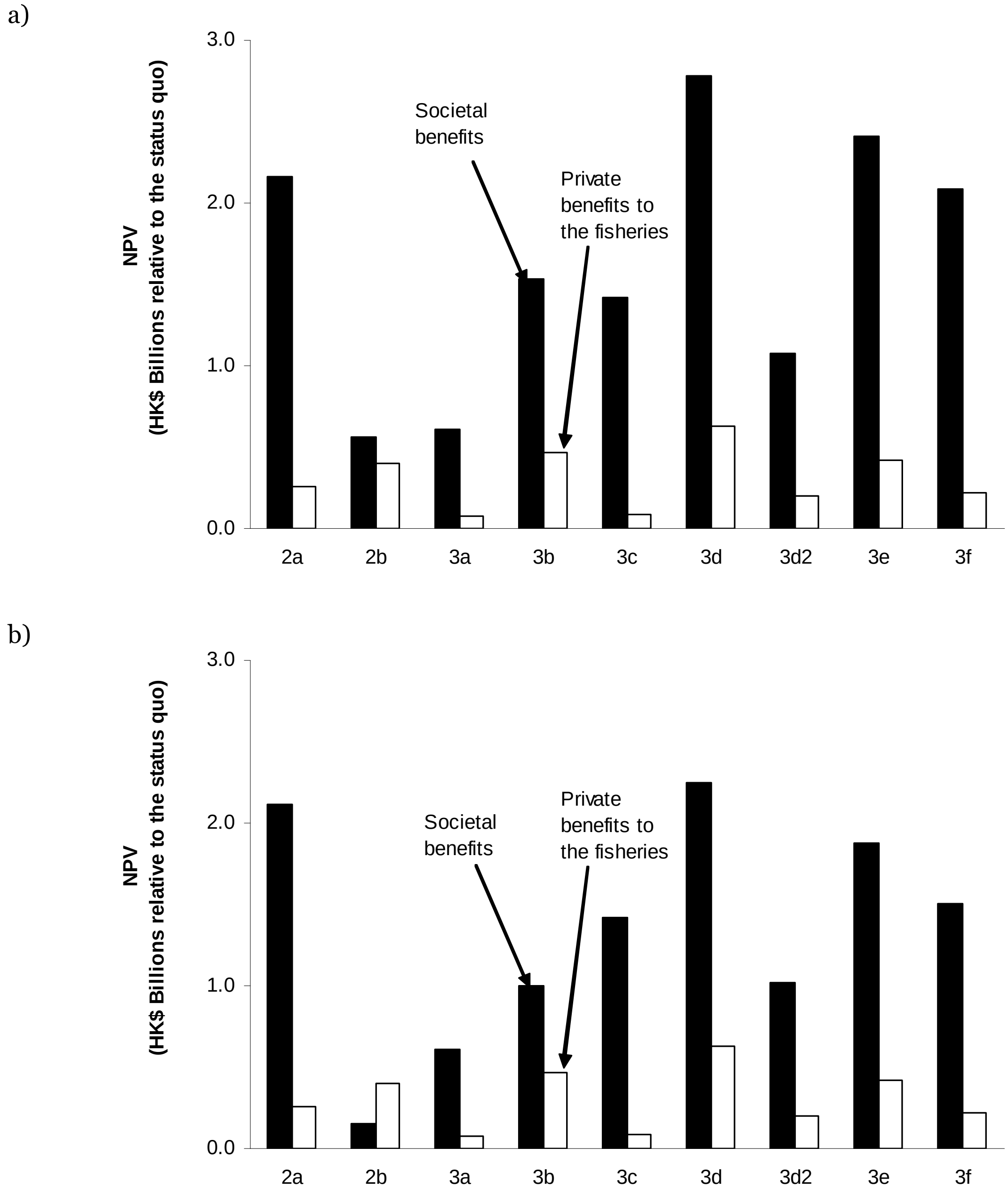



**Figure 21**. Net present value of benefits relative to the status quo from the Hong Kong marine ecosystem to the society (black bars) and the benefits to the fishing sectors of Hong Kong (open bars). Societal benefits included buy-back costs that were calculated from (a) the NPV method and (b) AFCD method.

**Table 9**. Summary of the benefits and costs of the management scenarios to the fishing sectors, society and the Hong Kong marine ecosystem relative to the *status quo*. The arrows ↑ and ↓ represent 'increase' and 'decrease' from the *status quo*, respectively. Dashes (–) represent no change.

| | | Fishing sectors | | | Society | Ecosystem[3] | | |
|---|---|---|---|---|---|---|---|---|
| | **Scenarios** | **Total catches** | **Landed Value** | **NPV of benefits** | **NPV of benefits** | **Large reef fishes** | **Large non-reef fishes** | **Large pelagic fishes** |
| 2a | No-Trawl FPAs | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↓ |
| 2b | No-Trawl FPAs and seasonal moratorium | ↓ | ↑ | ↑ | ↑ | - | ↑ | ↑ |
| 3a | No take FPAs and MPs | ↑ | ↓ | ↑ | ↑ | ↑ | ↑ | ↑ |
| 3b | Trawl ban in all HK water | ↓ | ↓ | ↑ | ↑ | - | ↑ | ↑ |
| 3c | No take MPs | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| 3d | Trawl ban and No-Take MPs | ↓ | ↓ | ↑ | ↑ | ↑ | ↑ | ↑ |
| 3d2 | No-take FPAs | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| 3e | Trawl ban and No-take FPAs | ↓ | ↓ | ↑ | ↑ | ↑ | ↑ | ↑ |
| 3f | No-take MPs, FPAs and trawl ban | ↓ | ↓ | ↑ | ↑ | ↑ | ↑ | ↑ |

1. The non-fishing sectors include the recreational diving, recreational fishing and tourism industry. ;
2. The cost of management scenarios to the society relative to the *status quo* include cost of ex gratia and vessel buy-back, cost of monitoring, control and surveillance, subsidies on fuel and modification of fishing vessels to operate alternative livelihood, and cost of retraining fishers;
3. The benefits to the ecosystem are indicated by the change in biomass of large-bodied fishes. An increase in biomasses of large fishes indicates recovery of the ecosystem.

## Sensitivity analysis

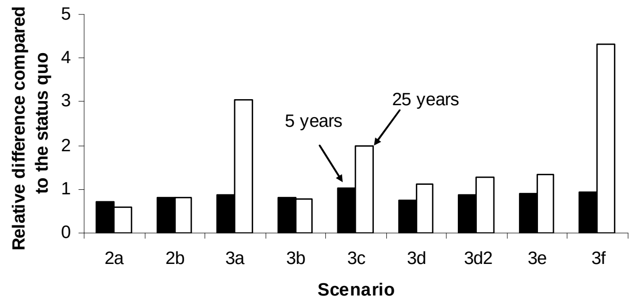
The effects of using the 2001/02 Port Survey catch data in the updated Hong Kong ecosystem model was assessed by comparing the outputs from the previous version (the 1990s model) (Figure 22). The 90s Hong Kong model was based on catch data collected from the 96/97 Port Survey (Pitcher *et al.*, 2002) in which the estimated catch was around 50% lower than the 2001/02 survey. Our previous analysis (section 2.2 of this report) suggested that the 2001/02 catch data might be over-estimated. This section explores the effects of this uncertainty on our analyses. The differences between the outputs from the two models are indicated by the proportional difference in changes in biomass and catches relative to those in the *status quo* scenario from each model. Thus, when the relative difference (y-axis of Figures 22 & 23) is higher than 1, the 2001/02 model estimated a bigger change (relative to the *status quo*) than the 90s model, and *vice versa* when the relative difference is less than 1.

The updated Hong Kong model (based on the 2001/02 catch data) generally predicted similar changes in biomass and catches of invertebrates and fishes except in a few scenarios where the 2001/02 model predicted biomass and catch several times higher than the predictions from the 1990s model (Figure 22 & 23). For instance, in scenarios 3a and 3f, the 2001/02 model predicted over two and four times the biomass and catch of shrimps, respectively. Moreover, the 2001/02 model generally predicted more rapid increase in biomass and catches for reef fishes in scenario 2a, and catches of large pelagic fishes in the territory-wide trawl ban scenarios (3b, d, e, and f). The higher biomass recoveries and catch increases predicted by the 2001/02 model are likely due to the higher catches specified in the 2001/02 model. Any management scenario that limits fishing effort releases the stocks from high exploitation pressure. This would result in a more rapid response to recovery compared to a model with almost half the specified catches.

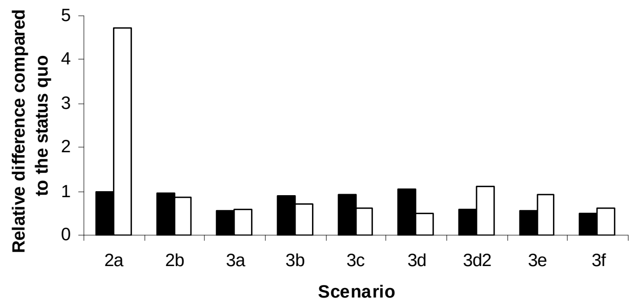
The sensitivity analysis provides support to our simulation modeling. The analysis showed that the relative pictures obtained from the modeling studies are robust to the large uncertainty in the catch data. This may be a result of the mass-balance assumption in the Ecopath with Ecosim modeling approach. Mass-balance imposes a thermodynamic constraint to the possible ecosystem states and limits the system dynamics even when some of the input parameters are uncertain. On the other hand, absolute values from the model should be viewed with caution as they are sensitive to the magnitude of the input parameters. The ultimate challenge of the model is to compare model predictions with monitoring data. This could evaluate the accuracy of the model forecasts and, at the same time, improve the model and its predictions.

It should be stressed that accurate catch data are important in effective fisheries assessment and management, as such data could provide useful indicators about the ecosystem state (Fulton *et al.*, 2005; Link, 2005). Currently, the catch data were collected by a Port Survey in which fishers were interviewed for information regarding their previous fishing trips. Annual catches by taxonomic groups, fishing gears and areas were then extrapolated from the survey data. Since this method relies almost entirely on fishers' voluntary information, uncertainties could result from the fishers' memories on fishing experience and intentional or unintentional mis-reporting in addition to the sampling errors. Incentives for mis-reporting may be particularly high if fishers are aware that their reported catch in the Port Survey will be used to calculate their *ex gratia* payment or calculate their buy-back price. Thus, it is crucial that regular surveys are conducted to collect more reliable catch data or to cross-validate and, if needed, correct the data collected from the Port Survey.

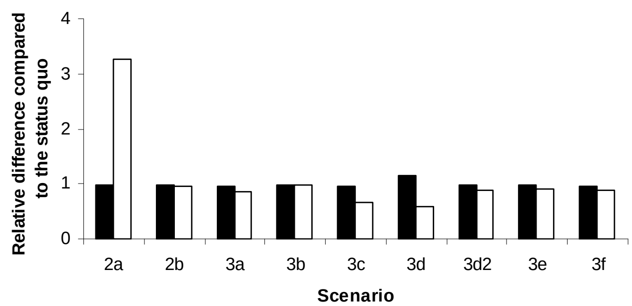
a) Shrimps




b) Small reef fishes




c) Large reef fishes




d) Large pelagic fishes

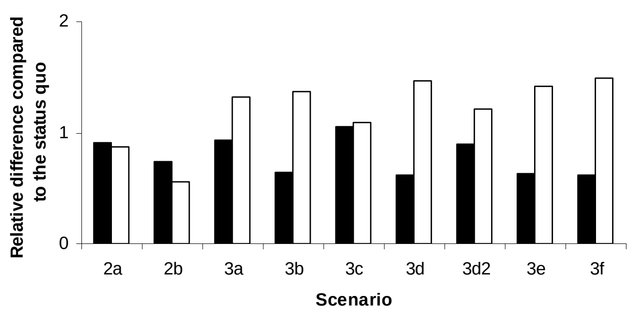



**Figure 22**. Difference in outputs from the updated HK model relative to the previous version (the 1990s model): (a) biomass of shrimps, (b) biomass of small reef fishes, (c) biomass of large reef fishes, and (d) biomass of large pelagic fishes in 5 (black bars) and 25 (open bars) years.

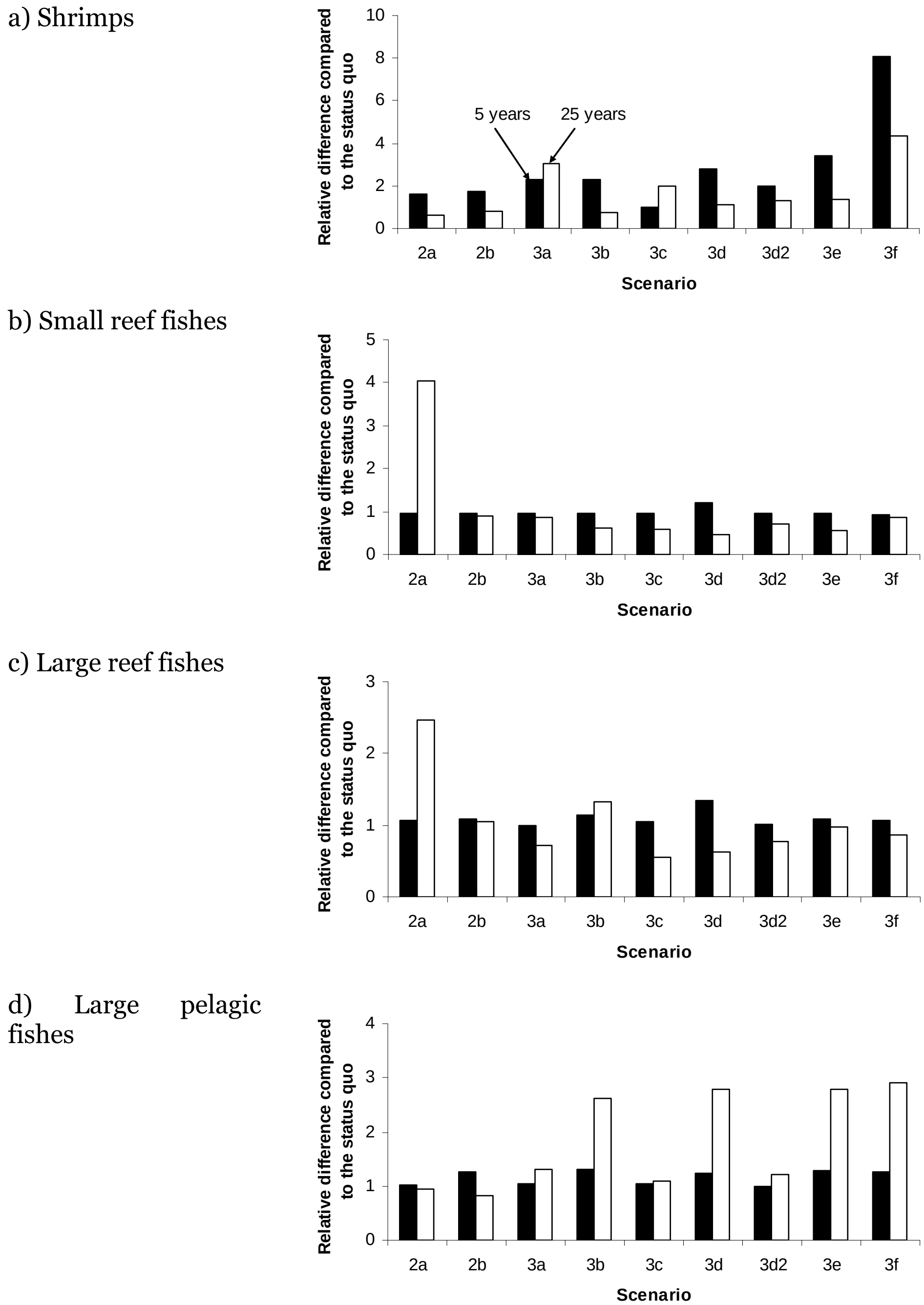



**Figure 23**. Difference in the outputs from the updated HK model relative to the previous version (the 1990s model): (a) catch of shrimps, (b) catch of small reef fishes, (c) catch of large reef fishes, and (d) catch of large pelagic fishes in 5 (black bars) and 25 (open bars) years.

## Model assumptions and uncertainties

### *1. Modeling reef habitats*

The representation of reef habitat in the spatial model is limited by the spatial resolution of the grid system. The Hong Kong marine ecosystem is represented by 5 x 5 $km^2$ cells and this resolution is too coarse to accurately represent the relatively small and patchy distribution of reef habitats in Hong Kong. Thus reef habitats from different areas are collectively represented by 5 spatial cells. This affects the predicted spatial distribution of organisms, and fishing effort.

## 2. Compliance with management

The model assumes perfect and instantaneous compliance with all fishery regulations. However, in reality, non-compliance is likely especially during the time just after the implementation of the new regulations. In particular, illegal fishing in the existing marine parks and reserve was reported from our survey and it is likely that such illegal fishing activities may occur if the various management scenarios were to be implemented. Alternative scenarios of changes in fishing effort were evaluated in previous studies (Pitcher *et al.*, 2002, 2005). The studies found that continued increase in fishing effort would cause further deterioration of the ecosystem and fisheries from the *status quo*. Therefore, effective control of fishing effort is essential.

## 3. Recreational fishing

The model does not explicitly incorporate the recreational fishing sector. A recent survey conducted by AFCD (AFCD unpublished data) estimated that about 0.58 million Hong Kong people went recreational fishing at least once a year. Thus, we acknowledge that the impact of recreational fishing on local fisheries resources may be significant. However, data on recreational fishing catch are sparse. Moreover, we showed that the catch data in the simulation model are probably overestimates. Therefore, we believe that the exclusion of recreational fishing in the model should not affect the conclusions of this study. On the other hand, data on catch from recreational fishers should be collected in the future. Such data can then be incorporated into the simulation model.

## 4. Parameter uncertainty

The simulation models (Ecopath, Ecosim and Ecospace) that we employed in this study required considerable amounts of biological data, many of which could not be estimated from reliable local data. In such cases, these parameters were obtained from empirical equations or from areas that are similar to the Hong Kong ecosystem (see Pitcher *et al.*, 2002). As such, the absolute values of the estimated results should be viewed with caution. This is particularly the case for the short-term simulations (5-year) because the uncertainty of the simulation trajectory at short time scales is particularly high. The results become more reliable when comparing results from simulations that have reached, or are nearly reaching equilibrium. Nonetheless, we believe that the results should be valid for broad scale comparisons of impacts between management scenarios.

## 5. Structural uncertainty of the model

Various structural assumptions and approximations are made in the model given the amount of data available. Firstly, the Hong Kong marine ecosystem is assumed to be closed (no migrations or dispersal with systems outside Hong Kong waters). This is probably not completely valid given the small area of Hong Kong waters and its connectivity with the Pearl River Estuary in the west and the South China Sea in the east. Effects of this assumption have been covered in the previous sections. For instance, dispersal, migration and recruitment from outside Hong Kong waters may increase the recovery rate of the stock when management scenarios are implemented. Secondly, detailed ontogenic changes in spatial resource usage (e.g., spawning and nursery grounds) are not modeled. Thirdly, oceanographic and other physical changes (e.g.,nutrient inputs) are not represented in the model. Furthermore, effects of non-fishing impacts such as reclamation and pollution on the ecosystem are not included in the model. This is likely to affect the prediction on the absolute changes of the ecosystem. In addition, the economic component of the model is static, i.e., profitability of fishing fleets and prices do not change dynamically with time, except to account for inflation, as the ecosystem changes. However, the major focus of this study is to compare the fisheries impacts across management scenarios. Therefore, our analysis should be more robust to these assumptions and approximations.

## Discussion and concluding remarks

We find that in terms of net economic benefits, both fishers as a group and the society are likely to increase their benefits by moving away from the current *status quo* management. The available evidence clearly shows that the Hong Kong marine ecosystem is seriously over-exploited. Maintaining the *status quo* means a loss of potential productivity and benefits to the fisheries and the society from the ecosystem. Moreover, there may be other problems such as deterioration of functions and aesthetics values (Pitcher *et al*., 2005). Therefore, any management policies that reduce fishing effort can help restore the productivity, and thus profitability, of the fisheries. On the other hand, the management policies have external costs to the fishing sectors and the society.

Overall, the fishing industry in Hong Kong would benefit from any scenarios presented in this study in the long-term. However, some fishing sectors and communities will lose from change in management from the *status quo*. In particular, although the management scenarios can increase the net benefits from fishing, the overall catches and landed values will decrease in the short and medium term. This agrees with economic theory which predicts over-capacity in a depleted, open access system such as in Hong Kong. Therefore, under the management scenarios, some fishers may have to be displaced from fishing. This may become a social problem if the fishers cannot find alternative livelihoods.

Specifically, the benefits and costs vary for different fishing sectors and under different management scenarios. Our study reveals that:

- Catch of invertebrates generally decreases after the designation of FPAs, marine parks or trawl bans. Invertebrates are mostly caught by trawlers, and command high market prices. Thus, these scenarios reduce the landed value of the trawling fleets considerably;
- Catches of reef associated fishes show strong positive responses under most scenarios, particularly those with a combination of no-take FPAs and marine parks (Scenario 3a). Reef fishes are mainly caught by the P4/7 and miscellaneous sectors and these sectors benefit most with the implementation of FPAs and marine parks;
- A territorial-wide trawl ban is effective in restoring biomass. However, it may lead to a large reduction in catch and landed values of the fisheries. On the other hand, since profitability of most trawl sectors are much lower than those for small-scale sectors, a territorial-wide trawl ban could increase the overall profitability of the fisheries, thus resulting in the highest net benefits compared with the other non-trawl ban scenarios. In addition, the special shrimp trawl area in southern Hong Kong waters can allow one of the most profitable fishing sectors to continue fishing under a territorial-wide trawl ban. This appears to be a good compromise to help offset the loss in benefits from banning trawling; and
- Overall, no-take FPAs and marine parks may result in a slightly larger reduction in catch in the short term but a slightly higher catch in the medium and long term, compared to the no-trawl FPA scenario.

All scenarios that do not involve territorial-wide trawl ban may result in positive impacts to the non-fishing sectors along the fish chain in Hong Kong in the short, medium and long terms. However, territory-wide trawl bans would have a relatively large impact on the non-fishing sectors.

The society is predicted to benefit from all the management scenarios. The direct benefits, if implemented, would include the increased profits generated from better-managed fisheries. Also, the management scenarios restore the abundance of organisms (especially fishes), to some extent, in Hong Kong waters. Since we identified a positive relationship between fish abundance and revenue in the diving, recreational and tourism industries (see Part 1 of this Report for details), the management scenarios provided extra benefits to non-fishing sectors in Hong Kong society. In addition, the government is providing fuel subsidies (in terms of reduced fuel tax). As the size of the fishing fleets reduces with the management scenarios, the amount of government spending on fuel subsidies can also reduced.

Implementation of the management scenarios may also be costly to the society. Firstly, the government may need to bear the *ex gratia* payment and buy-back cost to designate no-take zones or to reduce the capacity of the fishing fleets. Secondly, the government, private sectors or non-governmental organizations may also need to provide training or funding to help fishers find alternative livelihoods.

Moreover, to effectively implement the management policies, the government must increase their spending on monitoring, control and surveillance.

The good news is that the total benefits from the implementation of the management scenarios largely exceed their cost. Specifically, scenarios with territory-wide trawl bans with no-take marine parks deliver the biggest net benefits to society, although trawl bans incur the biggest cost. Besides the increased net benefits from the fisheries, the cost of fuel subsidy was substantially reduced with territory-wide trawl bans. These offset the increased costs of *ex gratia* payment, vessel buy-back, retraining of displaced fishers, and monitoring, control and surveillance. No-take FPAs and marine parks result in slightly less gain in net benefits to society compared to the no-trawl FPAs scenario. This is because the no-take FPAs and marine parks may result in a short term loss from the *status quo* that greatly lowers its overall discounted benefits. Costs for no-take FPAs and marine parks scenarios are intermediate, while the no-trawl FPA scenario is less costly to the government.

Regarding how the different scenarios will affect domestic seafood supply in Hong Kong, our study revealed that implementing FPAs (no-take or no-trawl) can increase the contribution of catches from local waters. However, the trawl ban scenario would reduce supply from local waters. In any case, catch from Hong Kong waters only contributes a small percentage (~10%) of total catches to the Hong Kong fishing fleets. Therefore, the overall impact of management scenarios on Hong Kong seafood supply is likely to be small. However, maintenance of the potential productivity of local fisheries resources may help to buffer the country against the impacts of regional and/or global fluctuations in seafood supplies and prices in the future.

In terms of biomass, we find that the combination of no-take FPAs, no-take marine parks and territorial-wide trawl ban are most effective in restoring the biomass of large fishes (including reef-associated, non reef-associated and pelagics). The no-trawl FPAs and partially protected marine parks are less effective in restoring the biomass of most fish groups. Although the recovery of non-reef or pelagic fishes could be seen in the short to medium terms (5 years and 10 years), reef fishes (particularly the medium and large-bodied fishes) respond relatively slowly under the scenarios. Our analysis shows that major changes in the biomass of reef fishes (after the implementation of the management scenarios) may only be evidenced in the 25-year time horizon. The slow recovery of large reef fishes may be because of the current depletion of most adult reef fishes. Thus, recovery may largely depend on recruitment from reefs outside Hong Kong waters. This also highlights the importance of protecting local spawning and nursery grounds. The proposed locations of the FPAs have been identified as spawning and nursery grounds for commercial species. In fact, this is a major reason for proposing the creation of FPAs in these areas. Thus, protecting these areas should facilitate the recovery of depleted stocks.

It is worth noting that to derive the results reported in this report, we relied on simulation modeling and made a number of assumptions. Further, the analysis had to contend with uncertainty in the data (especially catch data). To understand how this uncertainty may affect our results, we conducted sensitivity analysis, which shows that model outputs are reasonably stable, except for the catch levels used. Thus, further research is needed to provide more accurate and consistent catch estimates. Finally, our results are robust comparisons of the different scenarios, but fine-scale predictions from the model (in space and time) should be viewed with caution.

In conclusion, our study clearly shows that a territory-wide trawl ban appears to provide the most benefits in terms of net economic benefits to the fishing sectors and the society. Moreover, the combination of the trawl-ban with no-take FPAs and no-take marine parks performs best in restoring the depleted marine ecosystem of Hong Kong. However, the increased cost from implementing the FPAs and marine parks lower the overall net benefits. The choice of the optimal scenarios would thus depend largely on the management goals. Also, we want to emphasize that the projected net benefits both to fishers and to society are based on the strong assumption that the fishery resources of Hong Kong will be managed effectively after the implementation of the new management scenarios, particularly with regards to the avoidance of future overcapacity and over-fishing. Moreover, previous studies of Hong Kong fisheries suggested that continued increase in fishing effort would cause further deterioration of the ecosystem and fisheries from the *status quo*. This means that an effective licensing, monitoring, control and surveillance system, together with an incentive scheme for fishers to ensure sustainable and efficient fishing by the remaining Hong Kong fleet, will have to be put in place.

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# Appendix 1a.

Functional groups and their basic parameters used in the Hong Kong ecosystem models. Values in parentheses are estimated by the model. B – Biomass, P/B – Production to biomass ratio, Q/B – Consumption to biomass ratio, EE – Ecotrophic efficiency, NRA – non reef-associated, RA – reef associated, Ju – Juvenile, Ad – Adult.

| Group no. | Functional group | B ($t\ km^{-2}$) | P/B ($year^{-1}$) | Q/B ($year^{-1}$) | EE |
|---|---|---|---|---|---|
| 1 | Benthic Producers | 153.00 | 11.89 | - | (0.01) |
| 2 | Phytoplanktons | 13.00 | 231.00 | - | (0.77) |
| 3 | Corals | 0.47 | 1.09 | 9.00 | (0.99) |
| 4 | Zooplanktons | (14.70) | 32.00 | 192.00 | (0.19) |
| 5 | Sea Turtles | 0.00 | 0.10 | 2.50 | 0.95 |
| 6 | Jellyfish | 1.53 | 5.01 | 25.05 | (0.26) |
| 7 | Living bottom structure (LBS) | 0.00 | 0.25 | 0.50 | (0.80) |
| 8 | Small zoobenthos | 70.37 | 6.57 | 27.40 | (0.43) |
| 9 | Macrozoobenthos | (1.99) | 3.00 | 12.50 | 0.95 |
| 10 | Benthic Crustacean NRA | 0.36 | 5.65 | 26.90 | 0.95 |
| 11 | Benthic Crustacean RA | 0.80 | 2.80 | 8.35 | (0.72) |
| 12 | Prawns NRA | 0.22 | 5.05 | 16.35 | (0.68) |
| 13 | Prawns RA | 0.83 | 7.60 | 41.54 | (0.43) |
| 14 | Cephalopods NRA | 0.60 | 3.10 | 11.97 | (0.85) |
| 15 | Cephalopods RA | 0.19 | 3.10 | 11.97 | (0.13) |
| 16 | LBS-associated fish Juv | (0.20) | 4.00 | 10.89 | 0.95 |
| 17 | LBS-associated fish Ad | (0.02) | 1.50 | 6.64 | 0.95 |
| 18 | Small Demersal RA | 0.96 | 4.00 | 10.47 | 0.95 |
| 19 | Small Demersal NRA | 2.50 | 4.00 | 10.89 | (0.99) |
| 20 | Medium Demersal RA | 0.31 | 2.00 | 8.63 | (0.67) |
| 21 | Medium Demersal NRA | 0.35 | 2.40 | 8.63 | (0.97) |
| 22 | Large Demersal RA Juv | 0.31 | 4.18 | 15.00 | (0.80) |
| 23 | Large Demersal RA. Ad | (0.06) | 0.92 | 5.11 | 0.95 |
| 24 | Large Demersal NRA. Juv | 0.30 | 4.00 | 10.89 | (0.85) |
| 25 | Large Demersal NRA. Ad | (0.09) | 0.92 | 4.53 | 0.95 |
| 26 | Small Pelagics | 2.09 | 4.00 | 11.00 | 0.98 |
| 27 | Medium Pelagics | 0.21 | 2.50 | 7.59 | 0.95 |
| 28 | Large Pelagics Juv | 0.21 | 4.00 | 10.81 | (0.72) |
| 29 | Large Pelagics Ad | 0.05 | 1.20 | 5.90 | (0.26) |
| 30 | Rays and Skates | 0.13 | 0.50 | 6.35 | (0.0048) |
| 31 | Small Sharks | 0.13 | 0.40 | 6.83 | (0.0025) |
| 32 | Large Sharks Juv. | 0.0010 | 0.40 | 6.83 | (0.32) |
| 33 | Large Sharks Ad. | 0.0010 | 0.20 | 4.13 | (0.11) |
| 34 | Fish-eating Seabirds | 0.0008 | 0.06 | 61.28 | (0.00) |
| 35 | Invertebrate-eating Seabirds | 0.0023 | 0.06 | 72.76 | (0.00) |
| 36 | Marine Mammals | 0.01 | 0.05 | 14.77 | (0.55) |
| 37 | Detritus | 200.00 | - | - | (0.49) |

## Appendix 1b.

Estimated fishery catch (t km$^{-2}$) by functional groups and gear types in the updated HK model. ST – stern trawl, Sht – shrimp trawl, PT – pair trawl, PS – purse seine, Misc – miscellaneous, HT – hang trawl.

| | Landings (t km$^{-2}$ year$^{-1}$) | | | |
|---|---|---|---|---|
| **Functional group** | **ST** | **Sht** | **PT** | **PS** |
| Benthic Producers | | | | |
| Phytoplanktons | | | | |
| Corals | | | 0.01000 | |
| Zooplanktons | | 0.01938 | | 0.00160 |
| Sea Turtles | | 0.000012 | | |
| Jellyfish | | | | |
| Living bottom structure (LBS) | | | | |
| Small zoobenthos | | | | |
| Macrozoobenthos | | 0.03330 | | 0.00040 |
| Benthic Crustacean NRA | 0.01400 | 0.41480 | 0.00810 | 0.00460 |
| Benthic Crustacean RA | 0.00740 | 0.15990 | 0.00810 | 0.00350 |
| Prawns NRA | 0.00280 | 0.45340 | | |
| Prawns RA | 0.00280 | 0.45340 | | |
| Cephalopods NRA | 0.15730 | 0.02680 | 0.02230 | 0.32920 |
| Cephalopods RA | | 0.00020 | | |
| LBS-associated fish Juv | 0.08840 | 0.04210 | 0.02080 | 0.04620 |
| LBS-associated fish Ad | 0.00070 | 0.00020 | | 0.00120 |
| Small Demersal RA | 0.12590 | 0.13320 | 0.03450 | 0.30480 |
| Small Demersal NRA | 0.48110 | 0.51150 | 0.07050 | 0.25090 |
| Medium Demersal RA | 0.00760 | 0.00190 | 0.00020 | 0.01290 |
| Medium Demersal NRA | 0.10870 | 0.03900 | 0.00390 | 0.02790 |
| Large Demersal RA Juv | 0.09820 | 0.04090 | 0.01980 | 0.04600 |
| Large Demersal RA. Ad | 0.00520 | 0.00220 | 0.00100 | 0.00240 |
| Large Demersal NRA. Juv | 0.14880 | 0.00730 | 0.00120 | 0.07570 |
| Large Demersal NRA. Ad | 0.01650 | 0.00080 | 0.00010 | 0.00840 |
| Small Pelagics | 0.27710 | 0.05670 | 1.03670 | 1.03300 |
| Medium Pelagics | 0.02150 | 0.00080 | 0.00040 | 0.17300 |
| Large Pelagics Juv | 0.09320 | 0.04160 | 0.02060 | 0.04250 |
| Large Pelagics Ad | 0.00130 | 0.00010 | | 0.00080 |
| Rays and Skates | | | | |

## Appendix 1b con't .

Estimated fishery catch (t km-2) by functional groups and gear types in the updated HK model. ST – stern trawl, Sht – shrimp trawl, PT – pair trawl, PS – purse seine, Misc – miscellaneous, HT – hang trawl.

| | Landings (t km$^{-2}$ year$^{-1}$) | | | |
|---|---|---|---|---|
| **Functional group** | **P/7** | **Misc** | **HT** | **Total** |
| Benthic Producers | | | | 0.0000 |
| Phytoplanktons | | | | 0.0000 |
| Corals | | | | 0.0100 |
| Zooplanktons | | 0.11076 | | 0.13174 |
| Sea Turtles | | | | 0.00001 |
| Jellyfish | | | | 0.0000 |
| Living bottom structure (LBS) | | | | 0.0000 |
| Small zoobenthos | | | | 0.0000 |
| Macrozoobenthos | 0.0669 | 0.0024 | | 0.1030 |
| Benthic Crustacean NRA | 0.1957 | 0.1110 | 0.0027 | 0.7509 |
| Benthic Crustacean RA | 0.1958 | 0.1160 | 0.0027 | 0.4934 |
| Prawns NRA | 0.0305 | 0.0164 | 0.0172 | 0.5203 |
| Prawns RA | 0.0305 | 0.0164 | 0.0172 | 0.5203 |
| Cephalopods NRA | 0.3775 | 0.0510 | 0.1699 | 1.1340 |
| Cephalopods RA | 0.0008 | | | 0.0010 |
| LBS-associated fish Juv | 0.2444 | 0.0773 | 0.0827 | 0.6019 |
| LBS-associated fish Ad | 0.0171 | 0.0047 | 0.0004 | 0.0243 |
| Small Demersal RA | 1.1811 | 0.4034 | 0.1288 | 2.3117 |
| Small Demersal NRA | 0.6822 | 0.6340 | 0.4328 | 3.0630 |
| Medium Demersal RA | 0.2697 | 0.0781 | 0.0044 | 0.3748 |
| Medium Demersal NRA | 0.1716 | 0.1317 | 0.1945 | 0.6773 |
| Large Demersal RA Juv | 0.4774 | 0.1565 | 0.0868 | 0.9256 |
| Large Demersal RA. Ad | 0.0251 | 0.0082 | 0.0046 | 0.0487 |
| Large Demersal NRA. Juv | 0.1923 | 0.18740 | 0.0156 | 0.6283 |
| Large Demersal NRA. Ad | 0.0214 | 0.0208 | 0.0017 | 0.0697 |
| Small Pelagics | 0.7042 | 0.1320 | 0.7282 | 3.9679 |
| Medium Pelagics | 0.1310 | 0.0360 | 0.0607 | 0.4234 |
| Large Pelagics Juv | 0.1006 | 0.0469 | 0.1646 | 0.5100 |
| Large Pelagics Ad | 0.0011 | 0.0013 | 0.0095 | 0.0141 |
| Rays and Skates | 0.0001 | 0.0001 | | 0.0002 |

## Appendix 2.

Species composition of each functional group (based on *Buchary et al.*, 2003).

| No. | Functional groups | Group description |
|---|---|---|
| 1 | Benthic producers | Marine algae (epilithic algae, endolithic algae, reef turf algae, benthic fleshy algae, macroalgae, and benthic algae) and spermatophytes (sea grass) |
| 2 | Phytoplankton | Diatoms and dinoflagellates |
| 3 | Coral | All hermatypic corals in Hong Kong |
| 4 | Zooplanktons | Copepods, ostracods, bivalve larvae, cirripedia larvae, cladocerans, echinoderm larvae, larvacea, other mollusk larvae, and larvacea; mysids, sergestids, euphausiids, amphipodes, luciferidae, and other decapod larvae; chaetognaths, annelids and ichthyoplankton |
| 5 | Sea turtles | Mostly *Chelonia mydas* |
| 6 | Jellyfish | Includes Cnidarians (hydrozoa and scyphozoa) |
| 7 | Living bottom structure (LBS) | Sponges (*Poterion* spp.), gorgonians (sea fans and sea whips), soft corals, sea pens, sea squirts and sea anemones |
| 8 | Small zoobenthos | Includes all burrowing benthos of the size less than 1.0 mm. These include polychaetes, mollusks, echinoderms, crustaceans, sipunculans, and benthic stage larvae of other larger organisms |
| 9 | Macrozoobenthos | Includes all mollusks and echinoderms larger than 1.0 mm, such as conch, oysters, scallops, clams, cockles, mussels, sea urchins, sea cucumbers, and sea stars |
| 10 | Benthic Crustaceans, non-reef associated | Portunidae (*Charybdis* spp., *Portunus* spp., and *Scylla serrata*), Solenoceridae, Squillidae, Decapoda, and Tachypleidae |
| 11 | Benthic Crustaceans, reef associated | Palinuridae (*Panulirus versicolor*) and Portunidae (*Portunus pelagicus*) |
| 12 | Penaeid prawns, non-reef associated | Penaeidae (*Parapenaeopsis* spp., *Penaeus* spp. and *Trachypenaeus* spp.) |
| 13 | Penaeid prawns, reef associated | Penaeidae (*Metapenaeopsis* spp. and *Metapenaeus* spp.) |
| 14 | Cephalopods, non-reef associated | *Loligo* spp., *Sepioteuthis* spp., *Octopus indicus*, *O. indicus*, *O. aegini*, *O. dofleini*, *O. dollfusi* and *O. membranaceus* |
| 15 | Cephalopods, reef associated | *Octopus cyaneus*, *O. vulgaris*, *Sepia* spp, *Sepiella* spp. and *Euprymna mosei* |
| 16 | LBS-associated fish Juvenile | Juvenile stage of fishes predominantly associated with LBS including Carangidae, Lethrinidae, Lutjanidae, Polynemidae and Sphyraenidae |
| 17 | LBS-associated fish Adult | Adult stage of fishes listed in group 16 |
| 18 | Small demersal reef associated fish | Demersal reef fishes with less than 30 cm total length including Apogonidae, Cirrhitidae, Gerreidae, Haemulidiae, Holocentridae, Kyphosidae, Labridae, Lutjanidae, Monachantidae, Nemipteridae, Pempheridae, Pomacanthidae, Pomacentridae, Scorpaenidae, Sebastidae, Serranidae, Zanclidae, Antennariidae, Priacanthidae, Syngnathidae and Synanceiidae |
| 19 | Small demersal non-reef associated fish | Demersal fishes associated in non-reef area (*e.g.*, muddy and sandy area) with less than 30 cm total length, including Ambassidae, Blennidae, Callionymidae, Carangidae, Chaetodontidae, Cynoglossidae, Gerreidae, Gobiidae, Haemulidae, Leiognathidae, Microdesmidae, Monachantidae, |

| No. | Functional groups | Group description |
|---|---|---|
| | | Monodactylidae, Mugilidae, Mullidae, Nemipteridae, Platycephalidae, Plotosidae, Polynemidae, Sciaenidae, Scorpaenidae, Sillaginidae, Sparidae, Stromateidae, Synodontidae, Terapontidae, Tetraodontidae, Aploactinidae, Ariidae, Bothidae, Eleotridae, Paralichthyidae, Rhyacichthyidae, Soleidae, Synanceiidae, Triacanthidae and Triglidae |
| 20 | Medium demersal reef associated fish | Demersal reef fishes with 30-60 cm total length, including Acanthuridae, Apogonidae, Blennidae, Carangidae, Chaetodontidae, Haemulidae, Labridae, Lethrinidae, Lutjanidae, Muraenidae, Pomacanthidae, Scorpaenidae, Serranidae and Sparidae |
| 21 | Medium demersal non-reef associated fish | Demersal non-reef fishes with 30-60 cm total length, including Carangidae, Cynoglossidae, Dasyatidae, Labridae, Malacanthidae, Mugilidae, Platycephalidae, Scaridae, Scatophagidae, Sciaenidae, Synodontidae, Tetraodontidae and Syngnathidae |
| 22 | Large demersal reef associated fish Juvenile | Juvenile stage of the demersal reef fishes with more than 60 cm total length, including Carangidae, Chaetodontidae, Fistularidae, Labridae, Lethrinidae, Lutjanidae, Percichthyidae, Serranidae, Sparidae, and Ophichthidae |
| 23 | Large demersal reef associated fish Adult | Adult stage of the fishes listed in group 22 |
| 24 | Large demersal non-reef associated fish Juvenile | Juvenile stage of demersal non-reef fishes with more than 60 cm total length, including Carangidae, Centropomidae, Fistularidae, Kyphosidae, Mugilidae, Muraenesocidae, Paralichtydae, Platycephalidae, Rachycentridae, Sciaenidae, Serranidae, Congridae, and Ophichthidae |
| 25 | Large demersal non-reef associated fish Adult | Adult stage of fishes listed in group 24 |
| 26 | Small pelagic fish | Pelagic fishes with less than 30 cm total length, including Atherinidae, Bregmacerotidae, Carangidae, Centrolophidae, Clupeidae, Engraulidae, Mugilidae, Synodontidae, Terapontidae and Hemiramphidae |
| 27 | Medium pelagic fish | Pelagic fishes with 30 - 60 cm total length, including Carangidae, Carangidae, Cheilodactylidae, Clupeidae, Lacteridae, Scombridae and Sphyraenidae |
| 28 | Large pelagic fish Juvenile | Juvenile stage of pelagic fishes with more than 60 cm total length, including Carangidae, Lobotidae, Scombridae and Trichiuridae |
| 29 | Large pelagic fish Adult | Adult stage of fishes listed in group 28 |
| 30 | Rays and skates | Dasyatidae, Gymnuridae, Myliobatidae and Rajidae |
| 31 | Small sharks | Sharks below 100 cm total length including Carcharhinidae, Hemiscylliidae and Orectolobidae |
| 32 | Large sharks Juvenile | Juvenile stage of sharks over 100 cm total length including Carcharhinidae |
| 33 | Large sharks Adult | Adult stage of large sharks group |
| 34 | Fish-eating seabirds | Sea and shore birds with fish dominates in their diet, including Ardeidae, Gaviidae, Laridae, Pelecanidae and Treskiornithidae |
| 35 | Invertebrate-eating seabirds | Sea and shore birds with invertebrates dominate in their diet, including Anatidae, Charadriidae, Gaviidae, Jacanidae, Laridae, Recurvirostridae and Scolopacidae |
| 36 | Marine mammals | Comprised of Indo-Pacific Hump-backed dolphins (*Sousa chinensis*) and Finless porpoises (*Neophocaena phocaenoides*) |
| 37 | Detritus | Comprised of particulate and dissolved organic matters |

## Appendix 3.1

Number of fishing boats that operate in Hong Kong waters (AFCD Fishing Vessel Database, unpublished). The average amount of time that each vessel type spent fishing in Hong Kong waters varies.

| Vessel Type | No of Vessels |
|---|---|
| Pair Trawler | 30 |
| Stern Trawler | 105 |
| Shrimp Trawler | 413 |
| Hang Trawler | 48 |
| Gill Netter | 285 |
| Long Liner | 165 |
| Hand Liner | 39 |
| Purse Seiner | 92 |
| Miscellaneous Craft[(1)] | 103 |
| Sampan | 2,745 |
| **Total** | **4,025** |

[1] Miscellaneous craft consist mainly of cage trappers and Mui Ha trawlers

## Appendix 3.2.

Estimated changes in number of fishing vessel from the *status quo* under each scenario in 5, 10 and 25 year. The numbers represent the state of fisheries independently from each time frame.

**5 years**

| | Predicted changes in fishing vessel number under each scenario | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Fleets** | **2a** | **2b** | **3a** | **3b** | **3c** | **3d** | **3d2** | **3e** | **3f** |
| **ST** | -1 | 9 | 0 | -121 | 1 | -121 | -1 | -121 | -121 |
| **SHT** | -27 | 15 | -28 | -198 | 0 | -197 | -27 | -244 | -195 |
| **PT** | 0 | -3 | 2 | -34 | 0 | -34 | 2 | -34 | -34 |
| **PS** | 0 | 1 | 2 | 35 | 1 | 36 | 1 | 13 | 38 |
| **P4/7** | 43 | 1053 | -26 | 1261 | 10 | 1281 | -24 | 442 | 1219 |
| **Misc.** | 2 | 41 | 1 | 44 | 1 | 45 | 1 | 13 | 43 |
| **HT** | 0 | 2 | 0 | 20 | 0 | 20 | 0 | 7 | 20 |
| **Sum** | 17 | 1118 | -48 | 1007 | 14 | 1030 | -48 | 76 | 969 |

**10 years**

| | Predicted changes in fishing vessel number under each scenario | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Fleets** | **2a** | **2b** | **3a** | **3b** | **3c** | **3d** | **3d2** | **3e** | **3f** |
| **ST** | 0 | 6 | 9 | -121 | 3 | -121 | 7 | -121 | -37 |
| **SHT** | -32 | 9 | -18 | -211 | 0 | -211 | -19 | -207 | 78 |
| **PT** | 0 | -5 | 7 | -35 | 1 | -35 | 6 | -35 | -11 |
| **PS** | 1 | -7 | 16 | 17 | 4 | 18 | 14 | 28 | 0 |
| **P4/7** | 32 | 903 | 306 | 961 | 71 | 997 | 263 | 1207 | 307 |
| **Misc.** | 2 | 39 | 12 | 38 | 3 | 39 | 10 | 45 | 11 |
| **HT** | 0 | -1 | 6 | 14 | 1 | 14 | 5 | 16 | 42 |
| **Sum** | 3 | 945 | 338 | 662 | 83 | 702 | 285 | 934 | 391 |

**25 years**

| | Predicted changes in fishing vessel number under each scenario | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Fleets** | **2a** | **2b** | **3a** | **3b** | **3c** | **3d** | **3d2** | **3e** | **3f** |
| **ST** | 6 | -36 | 6 | -121 | 6 | -121 | 7 | -121 | -121 |
| **SHT** | -33 | -149 | -40 | -201 | 0 | -198 | -38 | -201 | -228 |
| **PT** | 1 | -14 | 4 | -35 | 1 | -35 | 4 | -35 | -35 |
| **PS** | 7 | -39 | 11 | 26 | 5 | 35 | 12 | 35 | 25 |
| **P4/7** | 420 | 447 | 285 | 1050 | 339 | 1454 | 303 | 1393 | 1199 |
| **Misc.** | 15 | 20 | 10 | 40 | 11 | 49 | 11 | 51 | 40 |
| **HT** | 1 | -19 | 3 | 18 | 2 | 21 | 4 | 20 | 13 |
| **Sum** | 416 | 210 | 279 | 778 | 363 | 1206 | 303 | 1142 | 893 |

## Appendix 3.3.

Estimated *ex gratia* payment (HK$ million) to each fishing sector under the management scenarios estimated using: (a) the AFCD (i.e. potential loss in landed values x 7), (b) NPV method (i.e. sum of loss in net present value of benefits from each sector over 25 year timeframe using a discount rate for private sector of 7% per annum).

**(a)**

| Scenarios | ST | SHT | PT | PS | P4/7 | Misc. | HT |
|---|---|---|---|---|---|---|---|
| 1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2a | 11.2 | 12.0 | 16.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2b | 11.2 | 12.0 | 16.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3a | 11.2 | 12.0 | 16.0 | 52.1 | 346.5 | 25.4 | 4.7 |
| 3b | 213.3 | 706.3 | 52.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3c | 0.0 | 0.0 | 0.0 | 4.1 | 56.7 | 4.8 | 4.7 |
| 3d | 213.3 | 706.3 | 52.1 | 4.1 | 56.7 | 4.8 | 4.7 |
| 3d2 | 11.2 | 12.0 | 16.0 | 48.0 | 289.8 | 20.6 | 0.0 |
| 3e | 213.3 | 706.3 | 52.1 | 48.0 | 289.8 | 20.6 | 0.0 |
| 3f | 213.3 | 706.3 | 52.1 | 52.1 | 346.5 | 25.4 | 4.7 |

**(b)**

| Scenarios | ST | SHT | PT | PS | P4/7 | Misc. | HT |
|---|---|---|---|---|---|---|---|
| 1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2a | 0.0 | 23.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2b | 2.2 | 40.0 | 17.2 | 50.9 | 0.0 | 0.0 | 9.2 |
| 3a | 0.0 | 26.2 | 0.0 | 0.0 | 0.0 | 1.8 | 0.0 |
| 3b | 12.7 | 144.1 | 54.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3c | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3d | 12.7 | 141.8 | 54.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3d2 | 0.0 | 16.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3e | 12.7 | 145.0 | 54.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3f | 12.7 | 147.6 | 54.7 | 0.0 | 0.0 | 0.0 | 0.0 |

## Appendix 3.4

Buyback cost to each fishing sector under the management scenarios estimated using: (a) the AFCD method and (b) the NPV method.

**(a)**

| | Buyback cost to each fishing sectors (HK$ million) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Scenarios** | **ST** | **SHT** | **PT** | **PS** | **P4/7** | **Misc.** | **HT** |
| **1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2a** | 0 | -61.95 | 0 | 0 | 0 | 0 | 0 |
| **2b** | -72.37 | -283.09 | -24.23 | -122.33 | 0 | 0 | -77.61 |
| **3a** | 0 | -76.55 | 0 | 0 | 0 | 0 | 0 |
| **3b** | -245.57 | -381.47 | -60.47 | 0 | 0 | 0 | 0 |
| **3c** | 0 | -0.91 | 0 | 0 | 0 | 0 | 0 |
| **3d** | -245.57 | -375.53 | -60.47 | 0 | 0 | 0 | 0 |
| **3d2** | 0 | -71.61 | 0 | 0 | 0 | 0 | 0 |
| **3e** | -245.57 | -382.79 | -60.47 | 0 | 0 | 0 | 0 |
| **3f** | -245.57 | -434.09 | -60.47 | 0 | 0 | 0 | 0 |

**(b)**

| | Buyback cost to each fishing sectors (HK$ million) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Scenarios** | **ST** | **SHT** | **PT** | **PS** | **P4/7** | **Misc.** | **HT** |
| **1** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2a** | 0 | 15.32 | 0 | 0 | 0 | 0 | 0 |
| **2b** | 4.3 | 70 | 25.44 | 85.51 | 0 | 0 | 15.97 |
| **3a** | 0 | 18.93 | 0 | 0 | 0 | 0 | 0 |
| **3b** | 14.59 | 94.32 | 63.48 | 0 | 0 | 0 | 0 |
| **3c** | 0 | 0.23 | 0 | 0 | 0 | 0 | 0 |
| **3d** | 14.59 | 92.86 | 63.48 | 0 | 0 | 0 | 0 |
| **3d2** | 0 | 17.71 | 0 | 0 | 0 | 0 | 0 |
| **3e** | 14.59 | 94.65 | 63.48 | 0 | 0 | 0 | 0 |
| **3f** | 14.59 | 107.34 | 63.48 | 0 | 0 | 0 | 0 |