Section 6

6 MARINE WATER QUALITY AND MARINE ECOLOGY

6.1 INTRODUCTION

The impacts of major developments on water quality in the Study Area have been of concern in Hong Kong for more than a decade. Thus, studies undertaken in the late 1970's to assess the potential impacts of the developments envisaged in the Study on Harbour Reclamation and Urban Growth (SHRUG) suggested that reclamations and their associated additional pollutant loads could give rise to significant detrimental effects on water quality in Victoria Harbour and its surrounds, with consequent impacts upon marine life. This conclusion was based upon data from mathematical modelling techniques, using an early version of the existing updated and extended Water and Hydraulic Model (WAHMO). Both these investigations and the extensive work which followed have revealed that the adverse effects on water quality may be reduced to acceptable levels by altering the shapes of the reclamations constructed, and by changes in wastewater/effluent disposal strategies.

This Section provides a general review of the existing water quality, marine ecology and fisheries in the Study Area (including relevant legislation), as a preface to consideration of the possible impacts of the construction and operation of the LAPH developments. Data from the WAHMO modelling investigations, which provide information on water quality impacts of this development are discussed in Section 7.

6.2 EXISTING WATER QUALITY AND RELEVANT LEGISLATION

6.2.1 Existing Water Quality

The present water quality in the Study Area is well-documented, having been the subject of regular monitoring since 1972. This report provides a background to the elements of water quality which are important in terms of the LAPH development.

The water quality in Hong Kong reflects the semi-estuarine nature of the Territory, the extent of the estuarine influence depending on the time of year.

- In summer (the wet season), Pearl River flows are predominant in the surface layers of much of the western and northern part of the Territory. A stratified water column is present in the west and north of the region for most of the time, salt waters derived from offshore oceanic water underlie the freshwater outflow from the Pearl River. Mixing occurs throughout the estuary, but particularly in the Western Harbour and to the south-east of Hong Kong Island.

- In winter (the dry season), the outflow from the Pearl River is much reduced, and vertical stratification is generally either absent or minor in its extent.

These seasonal changes are important with respect to protection of the Territorial waters from changes caused by developments. Thus, the modelling undertaken in the Port and Airport Development Strategy (PADS) study and other investigations has shown that the effects of development strategies should be ascertained in both the dry and wet seasons in Hong Kong to confirm their overall impacts.

6.2.2 Relevant Legislation

Gazetted Water Quality Objectives (WQOs) exist within the Study Area for the Southern Waters Water Control Zone (WCZ), with WQOs for Victoria Harbour being in draft (Table 6.1). There is no evidence of significant failure in compliance with the Southern Waters WQOs at present, with the possible exception of the Objective for nutrients, which states that annual mean depth-averaged inorganic nitrogen concentrations should not exceed 0.1mg/l, and that nutrients "shall not cause excessive algal growth".

The present concentrations of total nitrogen in Southern Waters of the Territory are generally slightly less than 0.1mg/l, and inorganic nitrogen levels will be lower than these. However, there is little scope for significant increases in these levels of nitrogenous compounds if WQOs are to be attained and maintained over the long term. In addition, it should be noted that the term *excessive* is not defined in the Objectives. However, algal blooms have apparently increased in incidence in the southern waters of Hong Kong over the last decade (Figure 6.1), and concern over their impacts continues.

The (ungazetted) WQOs for Victoria Harbour call for the maintenance of dissolved oxygen levels at greater than 50% throughout this area. Complete compliance with this Objective does not exist at present, at least transiently in certain of the enclosed parts of the Harbour, and particularly in some of the typhoon shelters. These same regions also exhibit episodic algal blooms under certain conditions, and it is clear from the database built up to date on existing water quality in Victoria Harbour that this water body is under considerable stress. The possibility of the diversion of a proportion of the present wastewater discharges arising from the main urban area to waters outside Victoria Harbour are relevant here, and the mathematical modelling undertaken within the LAPH investigations has included certain of the Strategic Sewage Disposal Study (SSDS) proposals to provide comparative data to assist in the interpretation of the model output (see Section 7).

Water quality in the area of Discovery Bay is of particular relevance to the proposals for the LAPH development. The proposed reclamation to support the Container Port (Figure 2.5) creates an embayment in this region, which becomes more extensive as the port-related development proceeds. At present, the water quality in Discovery Bay meets the WQOs (Table 6.1). It is clearly important that the future predicted water quality continues to attain WQOs in Discovery Bay and its surrounds, in all phases of the LAPH development. Plans exist to expand the residential population of Discovery Bay, and this may give rise to higher pollutant loads entering the Bay area from local sources.

6.3 EXISTING MARINE ECOLOGY AND THE FISHING INDUSTRY

6.3.1 Marine Ecology

Studies, including a marine ecology survey, have been undertaken as part of the LAPH studies to supplement the existing database relating to the marine ecology of the Study Area . The initial results of this study are detailed in Working Paper No. 12A *Environmental Baseline* and the results of the surveys are summarized in the Environmental Surveys Data Report (ESDR). Consequently, the previous studies are not exhaustively covered here, where a summary only is provided of marine ecological considerations.

The Study Area as a whole is characterised by an intertidal zone comprising a range of habitats varying from sandy embayments (e.g. Silver Mine Bay) to rocky shores, and including some regions of previous reclamation. The subtidal area is dominated (as is the rest of Hong Kong) by soft silty sediments in most areas, with only a few of the regions of coarser-grained sediment, where fast currents exist e.g. Kap Shui Mun. The sediment survey undertaken within the framework of the present studies involved the analysis of macrofaunal communities, trace contaminants (metals and persistent organic compounds), and particle size at 15 sites on two occasions (November 1991 and June 1992).

Partly because of their degree of exposure, rocky shores in the Study Area tend to exhibit a less diverse flora and fauna than do less exposed sandy or muddy zones. Reclaimed areas are generally impoverished compared to natural shores, which is a common finding throughout Hong Kong, even some years after reclamation takes place.

By comparison to the rest of Hong Kong, there is little of a particularly unique nature in either the intertidal or subtidal communities in the Study Area. Most notable with respect to the coastal habitats is the occasional nesting of the Green Sea turtle *Chelonia mydas* at Sham Wan on Lamma Island. This species is included in the Convention on the International Trading in Endangered Species of Wild Fauna and Flora (CITES) list, and is therefore protected in Hong Kong, which is a signatory to CITES. In addition, it should be noted that the Chinese White Dolphin (listed on the Bonn Convention on Migratory Species, and protected under the Wild Animals Ordinance) is occasionally spotted in the northern parts of the Study Area. Local fishermen report the seasonal presence of whales in the Study Area during March and April.

TABLE 6.1

WATER QUALITY OBJECTIVES FOR SOUTHERN WATERS & VICTORIA HARBOUR

WATER QUALITY PARAMETER	OBJECTIVE SOUTHERN WATERS	OBJECTIVE VICTORIA HARBOUR *	SUB-ZONE
Offensive odour,tints and colours	- Not to be present	- Not to extend natural by > 10%	- Whole zone
Visible foam, oil,grease scum, litter	- Not to be present	- Not to be present	- Whole zone
E.coli	- Not to exceed 1000/100ml in more than 60% samples	- Not to exceed 20,000/100ml in 90% of samples	- Secondary contact recreation subzone - Whole zone
D.O. within 2 m of bottom	- Not less than 2mg/l for 90% samples	- Not less than 4mg/l for 90% samples	- Whole zone
Depth average D.O.	- Not less than 4mg/l for 90% samples - Not less than 5mg/l for 90% samples		- Whole zone except fish culture zone - Fish culture zone;(BU-2)
pH	- To be in the range 6.5-8.5, change due to discharge not to exceed 0.2	- To be in the range 6.5-8.5, change due to discharge not to exceed 0.2	- Whole zone except bathing beaches
Salinity	- Change due to discharge not to exceed 10% of natural level	- Change due to discharge not to exceed 10% of natural level	- Whole zone
Temperature change	- Change due to discharge not to exceed 2°C	- Change due to discharge not to exceed 2°C	- Whole zone
Suspended solids	- Discharge not to raise the natural ambient level by 30% nor accumulation of SS.	- Discharge not to raise the natural ambient level by 30% nor accumulation of SS.	- Whole zone
Toxicants producing significant toxic effects	- Not to be present	- Not to be present	- Whole zone
Ammonia	- Annual mean not to exceed 0.021mg/l calculated as unionised form	- Annual mean not to exceed 0.021mg/l calculated as unionised form	- Whole zone
Nutrients	- Quantity shall not cause excessive algal growth - Annual mean depth average inorganic nitrogen not to exceed 0.1mg/l	- Total inorganic nitrogen not to exceed 0.5mg/l	- Whole zone

* - Objectives shown for Victoria Harbour are for Beneficial Use Criteria No. 3, (BU-3), except for *E.coli* which BU-6 criteria have been used. Below is a summary of the Beneficial Use Criteria.

BU-1; As a source of food for human consumption. WQOs apply to the food itself, not the waters.
BU-2: As a resource for commercial fisheries and shell fisheries (mariculture).
BU-3; As a habitat for marine life and a resource for human exploitation.
BU-4; For bathing (March to October).
BU-5; For secondary contact recreation including diving, sail-boarding and dinghy sailing.
BU-6; For domestic and industrial purposes, including cooling, toilet flushing and desalination.
BU-7; For navigation and shipping including the use of officially approved and endorsed sheltered harbours and typhoon shelters as temporary havens.
BU-8; For aesthetic enjoyment.

Marine Benthic Studies

Polychaetes were by far the dominant species recorded in the Study Area, comprising over 80% of the total species recorded. This species composition is typical of soft sediment faunal communities in Hong Kong waters. No particular environmentally sensitive species were noted. The dominant species including the polychaetes N.latericeus, *T.stroemi, G.chiori and P.pinnata* are ubiquitous in sediments with a high silt content.

From the two surveys undertaken it was apparent that there were more species and individuals recorded in the winter than in the summer survey. This is considered to be principally due to the influence of the Pearl River.

Annelid and mollusc species tend to predominate in the soft subtidal sediments, but diversity and abundance parameters suggest a quite impoverished community, which is probably due to the nature of the sediment and perhaps in part to fishing pressure.

6.3.2 Fishing Industry

Capture Fisheries

Through consultation with the Agriculture and Fisheries Department (AFD) and representatives from the local Fishermen's Associations a list of species commonly caught within the Study Area, has been compiled (Appendix A3). The Fisheries are fairly extensive with over 600 vessels operating within the Study Area.

Figure 6.2 sub-divides the fish catchment area in the Western Harbour into three sub-areas as follows:

- Northern Sub-Area;
- South-Western Sub-Area; and
- South-Eastern Sub-Area.

An estimate of the quantity and value of fish caught in these areas by small craft during 1989-90 is given in Table 6.2. Production totals some 4,140 tonnes of adult fish valued at approximately HK$60M and 3,587 thousand fish fry valued at HK$6.4M.

TABLE 6.2

1989-90 ESTIMATED FISHERIES PRODUCTION BY SMALL CRAFT

FISHING AREA	ADULT FISH		FISH FRY	
	QUANTITY (TONNES)	VALUE 000 HK$	QUANTITY 000 NO.	VALUE 000 HK$
Northern Sub-Area	2181	30,821	1,313	2,741
South-Western Sub-Area	782	14,342	262	758
South-Eastern Sub-Area	1,177	15,218	2,012	2,933
Total	4,140	60,381	3,587	6,432

Note: Data excludes fishing vessels larger than 15 m in length, recreational fishing, fish collected from the shore and fish farms.

Source: Agriculture and Fisheries Department

The fishing methods used include:

- gill netting;
- hand lining;
- purse seining;
- cage trapping;
- long lining;
- clam collecting;
- stern trawling; and
- shrimp trawling.

Gill netting is the most productive method of fishing used and employs the use of walls or compounds of nets set out in a particular pattern so that fish are gilled, tangled or trapped. The nets may be set anywhere between the surface and the seabed, and either anchored or allowed to drift freely with the current. The major fisheries relevant to the Study Area are discussed in further detail below.

The majority of fishing activity is carried out during all times of the day or night, depending on the tidal cycle. The shrimp fishery, however, is most commonly carried out at night, when the shrimp migrate to the surface waters and, as such, are easier to catch in the trawl nets. There is localised fishing for silver shrimp around Cheung Chau which operates from fairly small boats, and a commercial fishery for penaeid shrimp within the harbour, using beam trawls. Rocky substrate within the Study Area provides important areas for sheltering fish and support a fishery for groupers, this is primarily around Ma Wan and the west coast of Tsing Yi.

Fishing for fry using a number of the methods previously mentioned occurs in the sheltered bays as shown in Figure 6.3. The fishing is carried out in shallow, inshore waters and is of seasonal occurrence. The fry are concentrated within these areas between March and April, sometimes extending into June. Fry are also caught as part of an incidental catch when fishing for adults and are sold to local fish culture farms. In addition, the fish farmers also catch their own fry to replenish stocks.

Although it is unlikely that the LAPH developments will have any significant impact on the fish nursery and spawning grounds when viewed in isolation, however when the cumulative impacts of all the large scale infrastructure projects which are currently planned then there may be significant impacts on the fish nursery and spawning grounds. This is even likely given the relatively similar planning times for these projects. It is therefore recommended that further detailed studies are carried out to assess the cumulative impacts of all these projects. The scope of these studies would have to be agreed with AFD prior to their commencement

Fish Culture Zones (FCZ)

The establishment of fish culture zones (FCZs) is controlled under the Marine Fish Culture Ordinance 1980, and 26 zones are currently gazetted, (Tung Chung in northern Lantau having been degazetted recently, as a result of the impending Chek Lap Kok Airport development). The 'fish farms' are operated by private enterprises to produce a variety of fin-fish species, most of which are sold live to the local restaurant trade. The fish culture industry in Hong Kong is a significant source of seafood, producing a considerable percentage of the higher-priced species consumed locally. Current retail prices (August 1992) for live cultured fish range from about HK$70/kg for sea perch to about HK$250/kg for red grouper, and culture periods vary from 18 to 36 months. The estimated production in 1989 was 3,860 tonnes and was valued at HK$223 million.

Gazetted FCZs in the Study Area include those at Ma Wan and Cheung Sha Wan off Lantau Island, in addition to which there are two zones on eastern Lamma Island (Sok Kwu Wan [Picnic Bay] and Lo Tik Wan). Data from AFD on these zones suggest that the estimated total area of cage nets in each of these areas is as follows: Ma Wan, 11,000m^2; Cheung Sha Wan, 20,000m^2; Sok Kwu Wan, 24,000m^2, and Lo Tik Wan, 25,000m^2 (figures are rounded up to nearest 1000m^2. In each case, additional relatively minor areas are devoted to fish holding.

6.4 CONSTRUCTION IMPACTS

6.4.1 Introduction

This subsection considers the impacts on water quality and marine ecology from:

- the removal, transport and disposal of large quantities of marine mud;
- borrow and placement of fill activities;
- blasting; and
- general construction activities.

6.4.2 Dredging

Impacts on Marine Water Quality

Certain parts of the area to be reclaimed will require dredging prior to the placement of fill material (i.e. some sea walls; the base of the proposed Lamma Breakwater; also some of the access channels to the new port facilities). It is estimated that approximately 117Mm^3 of material will be dredged to support the development of the Container Port and its access channels. Significant amounts of this dredging are likely to arise in Phase III of the development, which will involve the formation of the new access channel to the west-facing container facilities (Figure 2.4). The access channel will also require maintenance dredging at regular intervals, in addition to the dredging for its initial formation. Smaller amounts of dredging (totalling approximately 12Mm^3) will be required to form the Lamma Breakwater; the Ship Repair Yard; the North Shore Development on Lantau Island; and the Hei Ling Chau Typhoon Shelter. In addition it is anticipated that, approximately 0.6Mm^3 of hard rock will be excavated to support the LAPH developments and this will necessitate further dredging.

The level of dredging activity outlined above, is considered to be very significant, particularly as Hong Kong is unusual as a port in that it is effectively self-cleansing in most areas and therefore requires very little, or no maintenance dredging for its access channels.

Dredging activities will increase suspended solid loadings with corresponding effects on dissolved oxygen levels. The degree to which dredging activities therefore affect turbidity is dependant on the methods of dredging, type of equipment, the physio-chemical characteristics of the material to be dredged, currents and the general working practices and procedures employed. The choice of dredging equipment is in turn dictated by a number of factors including the physical and chemical nature of sediments, water depth, cost, availability, wind, wave and sea conditions. In environmental terms, the total amount of material suspended in the water column is the important consideration. The non-mechanical dredgers, and in particular the trailing suction dredger is likely to resuspend less material, (as long as no 'Automatic Lean Mixture Overboard' (ALMOB) systems are used), than alternative mechanical equipment such as grab and bucket dredgers and is therefore favoured from an environmental point of view. However, as indicated earlier this will be affected by operating procedures and the implementation of good working practices. Details of some of the more common dredging techniques and associated impacts on water quality are presented in Appendix A2.

Contaminated Sediments

A number of previous and ongoing studies provide information on the quality of sediments within the LAPH Study Area, these include the Green Island Link (Preliminary Feasibility Study), and the Contaminated Spoil Management Study and the ongoing Territory wide sediment analysis carried out by EPD annually. Further information on sediment quality was also obtained from the marine ecology survey.

The results of these analyses are shown in Tables 6.3 to 6.6, presented in the following pages. From these results it can be seen that the majority of sediments within the LAPH Study Area are either clean or lightly contaminated, Class A sediments, however there are hot spots of medium and heavily contaminated sediments, Classes B and C respectively, located in the vicinity of the disused Kau Yi Chau dumping ground, Penny's Bay and east of the TCT peninsula. At these locations the contamination is due to elevated levels of heavy metals, namely Lead, Mercury and Copper.

Due to the construction method to be employed, where the majority of sediments are to be left in-situ, the quantity of contaminated sediment to be dredged is much reduced, and amounts to those areas located along the quay wall faces, those quay walls which are located at the east of a phase, and the areas to be dredged for the local breakwaters.

The quantity of contaminated sediment was estimated by using the results of the above studies and combining these with the areas requiring dredging gave a seabed area of about 984,000m^2. Assuming contamination is only present in the top one metre of sediment the total of contaminated material to be dredged and disposed of is estimated to be 984,250m^3, Table 6.7 gives the estimated quantity of contaminated sediment which will arise, on a phase by phase basis.

TABLE 6.7

ESTIMATED QUANTITIES OF CONTAMINATED SEDIMENT

Phase	Quantity m^3
I	275,000
II	96,000
III	45,500
IV	158,000
Sub-Total	**574,500**
Ultimate	409,750
Total	**984,250**

The total figure represents about 0.7% of the total to be dredged, totalling some 117Mm^3, and special precautions will be necessary when these sediments are removed and transported.

However, given the volumes of material to be removed (and disposed of elsewhere), the possibility of the remobilisation of contaminants and their subsequent adverse impacts must be viewed with some concern.

The international literature on the remobilisation of contaminants suggests that persistent contaminants such as pesticides are more likely to be remobilised than are trace elements when sediments are subjected to disturbance. Marine baseline studies indicate that there is no significant contamination with organochlorine pesticides, polychlorinated biphenyls (PCBs) or Polycyclic aromatic hydrocarbons (PAHs) in the sediments of the Western Harbour and its surrounds. While some trace metals will undoubtedly be remobilised from dredged sediments, it appears most unlikely that

TABLE 6.3

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY: SEDIMENT ANALYSIS

SAMPLE	ORGANIC PCB's mg/l	METAL mg/kg (dry weight)						
		Zn	Cu	Ni	Cr	Pb	Cd	Hg
DC3	0.006	41	7	9	11	23	0.7	0.07
DC4	<0.005	39	6	10	16	20	0.6	0.03
DC5	0.012	49	6	13	20	26	0.7	0.13
DC6	0.016	62	22	11	23	30	0.6	0.13
DC7	0.012	58	27	12	24	28	0.7	0.13
DC8	0.011	58	30	11	21	26	0.6	0.09
DC9	0.010	55	37	9	13	31	0.7	0.07
DC10	0.007	48	11	7	12	41	0.5	0.06
DC11	0.015	59	23	9	16	33	0.6	0.07
DC13	0.007	37	9	9	18	16	0.6	0.06
DC14	<0.005	40	9	10	15	19	0.6	0.03
DC15	0.021	67	28	10	18	31	0.7	0.04
DC16	0.011	61	19	10	19	32	0.5	0.14
DC17	0.008	59	19	10	19	27	0.7	0.14
DC18	0.007	24	5	3	7	32	0.4	0.10
DC19	0.007	27	12	2	2	13	0.5	0.04
DC20	<0.005	48	18	7	31	24	0.5	0.10

KEY :

WITHIN CLASS A LIMITS	EXCEEDS CLASS B LIMITS	EXCEEDS CLASS C LIMITS

TABLE 6.4

CONTAMINATED SPOIL MANAGEMENT STUDY: SEDIMENT ANALYSIS

METAL →	Zn		Cu		Ni		Cr		Pb		Cd		Hg	
SAMPLE ↓	bulk	< 63μm	bulk	< 63μm	bulk	< 63μm	bulk	< 63μm	bulk	< 63μm	bulk	< 63μm	bulk	< 63μm
68	108	-	43	-	23	-	26	-	61	-	0.51	-	0.70	-
69	119	139	43	42	16	24	20	29	57	70	0.66	0.68	1.00	-
70	104	129	34	39	21	25	23	27	57	61	0.54	0.51	0.98	0.66
120	110	114	33	38	23	24	24	30	71	66	0.66	0.52	0.72	1.00
121	32	-	8.9	-	8.6	-	10	-	24	-	0.57	-	0.17	-
122	64	-	18	-	13	-	15	-	40	-	0.61	-	0.31	-
123	73	-	17	-	16	-	18	-	44	-	0.54	-	0.35	-
124	86	107	22	23	21	24	20	29	48	48	0.71	0.48	0.32	0.16
125	78	-	17	-	23	-	21	-	39	-	0.53	-	0.42	-
126	88	-	21	-	22	-	21	-	47	-	0.54	-	0.54	-
127	84	-	17	-	22	-	18	-	41	-	0.73	-	0.84	-
128	79	-	17	-	24	-	18	-	39	-	0.57	-	0.93	-
129	60	80	10	11	20	23	16	24	29	31	0.48	0.44	0.02	0.04
130	74	82	13	16	19	22	18	24	36	39	0.49	0.48	0.11	0.11
131	44	-	10	-	13	-	10	-	25	-	0.57	-	0.23	-
132	52	-	33	-	11	-	12	-	25	-	0.26	-	0.27	-
141	96	134	47	46	24	24	20	32	35	46	0.63	0.66	0.55	0.89
142	72	77	31	35	18	22	25	30	35	44	0.54	0.54	0.12	0.15
143	36	-	17	-	11	-	7.5	-	23	-	0.68	-	0.08	-
144	97	97	34	30	19	21	16	30	35	51	0.64	0.55	0.11	0.21
Z2	83	-	22	-	17	-	23	-	50	-	0.55	-	0.38	-

KEY:

WITHIN CLASS A LIMITS | EXCEEDS CLASS B LIMITS | EXCEEDS CLASS C LIMITS

* results are mg/kg dry weight

TABLE 6.5

MARINE ECOLOGY SURVEY: SEDIMENT ANALYSIS

SAMPLE	METAL mg/kg dry weight													
SURVEY PHASE	Zn		Cu		Ni		Cr		Pb		Cd		Hg	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
1	93	-	24	-	27	-	23	-	39	-	<0.5	-	0.09	0.29
2	100	-	46	-	26	-	27	-	43	-	<0.5	-	0.57	
3	110	84	40	23	26	18	26	19	41	30	<0.5	<0.5	0.18	0.29
4	96	92	24	25	27	20	24	20	39	35	<0.5	<0.5	0.30	0.30
5	130	115	74	67	30	22	31	25	44	40	<0.5	<0.5	0.11	0.46
6	130	116	43	25	26	20	25	20	54	49	<0.5	<0.5	0.20	0.41
7	140	131	82	61	27	21	29	24	64	54	<0.5	<0.5	0.75	0.38
8	110	80	58	12	27	19	28	19	40	24	<0.5	<0.5	0.21	0.29
9	120	121	39	31	23	20	24	20	49	47	<0.5	<0.5	0.24	0.38
10	120	113	58	49	26	20	27	22	52	44	<0.5	<0.5	0.77	0.87
11	96	105	21	25	25	20	22	19	40	38	<0.5	<0.5	0.13	0.33
12	130	129	39	34	23	21	25	21	52	48	<0.5	<0.5	0.20	0.39
13	100	108	45	39	23	19	24	20	47	43	<0.5	<0.5	0.38	0.50
14	83	89	27	20	21	19	22	20	36	30	<0.5	<0.5	0.24	0.39
15	89	84	27	22	23	20	22	19	38	33	<0.5	<0.5	0.16	0.34
16	-	106	-	23	-	19	-	19	-	46	-	<0.5	-	0.41
17	-	107	-	46	-	20	-	23	-	36	-	<0.5	-	0.30

KEY :

WITHIN CLASS A LIMITS	EXCEEDS CLASS B LIMITS	EXCEEDS CLASS C LIMITS

Phase 1 : November 1991 survey **Phase 2 : June 1992 survey**

TABLE 6.6

PARTICLE SIZE ANALYSIS: MARINE ECOLOGY SURVEY

	Grading %								Average			
	Gravel		Sand		Silt		Clay					
Site	Nov '92	Jun '92	Nov '91	Jun '92	Nov '91	Jun '92	Nov '91	Jun '92	gravel	sand	silt	clay
1	0	n/a	8	n/a	73	n/a	19	n/a	0	8	73	19
2	4	n/a	24	n/a	51	n/a	21	n/a	4	24	51	21
3	5	1	30	19	46	61	19	19	3	24.5	53.5	19
4	2	0	18	3	58	71	22	26	1	10.5	59.5	24
5	0	0	4	5	65	68	31	27	0	4.5	66.5	29
6	2	1	15	5	52	62	30	32	1	10	57	31
7	3	18	42	48	43	24	12	10	10.5	45	33.5	11
8	5	0	42	11	34	64	19	25	2.5	26.5	49	22
9	3	2	25	16	46	59	26	23	2.5	20.5	52.5	24.5
10	2	0	12	7	56	69	30	24	1	9.5	62.5	27
11	1	1	33	24	47	53	19	22	1	28.5	50	20.5
12	3	0	13	4	56	66	28	30	1.5	8.5	61	29
13	1	2	12	20	64	59	18	19	1.5	16	61.5	18.5
14	3	2	40	20	39	60	18	18	2.5	30	49.5	18
15	1	2	26	16	51	64	22	18	1.5	21	57.5	20
16	n/a	4	n/a	13	n/a	61	n/a	22	4	13	61	22
17	n/a	1	n/a	39	n/a	44	n/a	16	1	39	44	16
							Average		2.42	19.9	55.4	21.9

Key : n/a no sample taken

this process could give rise to infringements of public health regulations for elements in seafood.

Impact on Marine Ecology and the Fishing Industry

The immediate and obvious impacts of dredging upon marine ecology in general, and on the local fisheries specifically, is the smothering of local benthic organisms, and the clogging of the gills of susceptible pelagic biota through the deposition and resuspension of suspended solids (from both reclamation and dredging activities).

If significant quantities of nutrients are released during dredging and if these are (or become) bio-available, an increase in algal productivity could eventuate in the Western Harbour and southern waters of the Territory, leading in severe cases to the formation of red tides through the blooming of species of dinoflagellates. These would exert adverse impacts on fisheries in the Study Area, and could even pose a threat to public health if species from the area which accumulate toxins produced by dinoflagellates (e.g. bivalve molluscs) are consumed by the local population. Alternatively, the release of significant amounts of bio-available forms of trace elements or other trace contaminants could threaten the fisheries industry through their uptake into species of commercial importance, possibly causing these to infringe public health limits for such substances laid down in the relevant Hong Kong legislation.

While such problems are conceivable (particularly given the scale of the development and its associated dredging and filling activities), it appears from studies elsewhere that they are unlikely to exert major impacts upon the receiving waters of the Study Area. At least in some areas of Hong Kong, such as Tolo Harbour, sediments may act as a reservoir for phosphates; thus, the concentrations of phosphorus-containing compounds could increase consequent to wide scale dredging activities. However, it is believed that under most conditions, algal productivity in local waters is nitrate-limited rather than phosphate-dependent, and the levels of nitrogen species are unlikely to rise as markedly as those of phosphate subsequent to dredging. Furthermore, no evidence exists to link algal blooms in Hong Kong to previous dredging events.

The removal of benthic organisms, which are entrained within the dredged muds, is not considered to be of major significance due to the impoverished nature of the fauna. The types of organisms found in the sediment are opportunistic species and as such will quickly recolonise a disturbed area. However, pelagic fish species (most of which are highly mobile) will generally avoid a cloud of high turbidity, although some do not exhibit such a response. Consequently mortalities of the local marine biota appear inevitable, but there is no adequate method of calculating the extent of such effects.

Less obvious but potentially more significant impacts may arise through disruption to the marine ecosystem and its intricate food webs. For example, increased levels of suspended solids may restrict light availability creating a stressed environment for simple photosynthetic plant life, the primary food source at the base of the food chain. In this indirect way dredging activities may have an impact on species of importance to the local fishing industry.

Fish Culture Zones within the Western Harbour Area are also potentially affected by the LAPH Development. Of the gazetted Fish Culture Zones, (FCZ) the most likely to be adversely affected by suspended particulates arising from the port reclamations and associated borrow areas is the FCZ at Ma Wan. This FCZ is relatively close to the TCT Mega Borrow Area and the planned areas of Port reclamation.

The other FCZs present in the Study Area are unlikely to be significantly impacted by the proposed LAPH development, at least in respect of possible effects from suspended particulates or any remobilised contaminants. All of these FCZs are situated at some considerable distance from the major areas of the intended works, and the dilution afforded by the receiving waters creates effective protection for the FCZs.

Other Impacts

Consideration should also be given to potential impacts on Lamma Power Station. The power station abstracts 6.5Mm^3 per day of seawater for cooling purposes, and considering the planned extension to the power station this figure is expected to increase to 8.5Mm^3 by 1997. Consequently, increased levels of suspended solids and incidences of algal blooms could if large enough hinder cooling water intake, and in extreme cases cause blockage.

The majority of the proposed dredging activities are unlikely to have an effect on the Lamma Power Station sea water intakes, as they are a sufficient distance from dredging activities to allow adequate dispersion and settling of suspended solids prior to abstraction. However, dredging activities for the Lamma Breakwater footprint are sufficiently close to the water intakes such that increased suspended solids may be a problem. Algal blooms will potentially cause impacts over greater distances and therefore could have an impact on the power station, for example, by affecting cooling water intakes.

6.4.3 Transport and Disposal of Dredged Material

The transport and disposal of the dredged spoil is likely to cause the dispersal of suspended particulates and the possible remobilisation of contaminants.

Quantification of spoil losses during transit is not possible, however from past experience this could be significant. The likelihood of this occurring is dependant on the mode of transport, vessel maintenance and working practices. With regard to disposal, several sites have been considered for the disposal of the contaminated spoil arising from the LAPH development, including pits at Urmston Road and close to Sha Chau. However, no final decision has been made on the most appropriate disposal site. The uncontaminated spoil (which constitutes the bulk of the arisings from the port-related dredging) could theoretically be disposed of to the existing gazetted disposal grounds to the south of Cheung Chau or at East Ninepins. However, it is understood that the theoretical capacity of both of these disposal areas has been allocated to other projects already. It appears that a further allocation (perhaps involving an extension of the existing grounds) will be required for LAPH, or that alternative areas for spoil disposal will have to be identified. Possibilities for the latter include sites outside the Territory's waters, perhaps in either the western Pearl River Estuary or the Lima Channel. However, the use of either of these would require agreement from the PRC. Any final decision on marine disposal locations will be made by the Fill Management Committee bearing in mind competing demands from other projects.

Mariculturists at Cheung Sha Wan have complained that barges carrying dredged mud for disposal at the Cheung Sha dumping ground pass close to the area and create high levels of suspended solids, causing increased fatalities. It is recommended that if the Cheung Chau dumping ground is to be used for the LAPH development then the barges should be required to use the shipping channel to the est of Peng Chau, Hei Ling Chau and Cheung Chau. This could be implemented by inclusion of a clause in the dumping works contract.

6.4.4 Borrow and Fill Impacts

The construction of the LAPH reclamation will be a major undertaking, involving the placement of up to some 202Mm^3 of fill material, about 75% of which will be employed to form the Container Port facilities on the existing seabed between north-east Lantau and Kau Yi Chau.

The development is planned to proceed in four phases (as illustrated in Figures 2.2 to 2.5), these being completed at the years 2000, 2003, 2007 and 2011 respectively. It is presently proposed that some of this fill should be provided through the excavation of the Tsing Chau Tsai (TCT) Mega Borrow Area on north-east Lantau Island. Both the borrow activities and the placement of the fill to form the reclamation may give rise to significant impacts in relation to water quality in the Study Area. Assuming that the fill to be employed is not contaminated (as will need to be ensured prior to development), such impacts will generally be restricted to the release and dispersion of suspended particulates to marine waters in the Study Area, with consequent plumes extending from the borrow area as a whole (driven largely by run-off) and also from the leading edge of the reclamation as the latter is formed.

6.4.5 Blasting Impacts

There is a possible need to use blasting techniques to remove existing obstructions to navigation in the approaches to the LAPH development. The two areas under consideration for removal are the Adamasta Rock between Cheung Chau and Lantau Island, and the Lamma Patch located to the north-east of Lamma Island.

Explosions in the marine environment will cause the death of marine fauna in close proximity to the blast (i.e. the "lethal zone"). The organisms which are killed or damaged over the longest range are those which possess an air bladder. When the explosion occurs a pressure wave is generated, which is reflected when it reaches the water surface and then descends as a negative pressure wave. It is thought that the negative pressure wave causes the air bladder to rupture which is fatal to fish. The mortality levels for marine fauna are therefore expressed in terms of pressure levels.

The lethal level for fish with an air bladder is between about 2.5 and 5.0 bar, whereas a crab can withstand a pressure of about 15 bar and a lobster up to 45 bar (estimated by Dredging Research Limited on the basis of a literature review). Experiments on the use of explosives and their effect on shrimps have been carried out using charges of up to 360kg. The results showed that shrimps at a distance of 15m were not harmed by the explosions (Sioblom, V. 1949). Laboratory experiments have indicated that susceptibility depends on age, species, and whether the air bladder is open or closed. It is thought that fish fry are particularly susceptible to blasting.

It should be noted in the case of fish culture areas even though they are outside the 'lethal zone', where immediate and acute fish kills occur, there is the potential for the blast shock waves to frighten the fish causing them to dash around the cages and smashing their bodies against the cage netting leading to wounds and bruises on the body, if these wounds become infected the fish would usually die.

The use of surface or suspended charges for underwater blasting is not recommended as the effects of the blast are significantly more damaging to the marine environment than if the charge is buried. It is therefore essential that drilling methods are used for placement of explosive charges. It is generally accepted that the water shock from the detonation of explosive buried in shotholes underwater is some 10 to 20% of that of a freely suspended charge of the same weight.

In order to assess the environmental impact of blasting it is necessary to know the amount of explosive charge to be used in each blast, along with several other variables related to the site, e.g. bathymetry, water depths etc.. With this information it is possible to calculate the peak overpressure and ground vibrations which will result from any particular blasting event. This will enable prediction of the lethal zone for fish and other marine fauna surrounding the blast.

The lethal blast zone resulting from an underwater explosion using a depth charge or rocket weighing 100kg is thought to be equal to a lethal radius of 77m for most marine fauna, and 309m for most fish (*Westing, 1978*). It is considered likely that the maximum explosive charge to be used in either blasting activity for the LAPH development requirement will be 100kg. The proposed blasting is therefore not likely to cause any impact on the local FCZs in terms of fish kills, the nearest FCZ being approximately 1500m from the blasting area.

In addition, the rocky areas surrounding the blast zone are not thought to be prime fishing grounds by the local Fishermen's Associations and therefore, are unlikely to support large populations of fish. The potential impact on local fish populations (outside the FCZs) is considered to be limited. However, consideration should be given to the potential disruption to fishing activity in the blasting area.

The potential effect of shock waves from blasting may also be fatal to humans, marine mammals and amphibians. It is therefore essential to ensure that at the time of the blast no human beings, and as far as possible no marine mammals are in the water. With regard to marine mammals, up-to-date information may be obtained from the World Wide Fund for Nature (WWF). Of particular concern is the possible location of breeding areas for the Green Sea Turtle and the presence of the Chinese White Dolphin. Also as previously mentioned, local fishermen have reported seasonal sightings of whales within the Study Area between March and April.

A potential impact also exists with regard to disturbance to birds during drilling and blasting operations. The area of sea to the west of Lamma Island is used as a night-time roost for gulls. The gulls use these areas as they are quiet and undisturbed. It is unlikely however that these roosting sites will be affected, particularly at the times when the birds are roosting.

The likely effect of blasting on marine ecology is not as well understood because the existing ecology for the particular rock patches in question is not known. It would therefore be beneficial to conduct subtidal visual assessments of the rocky areas in order to ascertain the potential for impact. The effect of rock removal on adjacent coastal habitats should also be reviewed prior to blasting to establish the potential impact.

At present the removal of the Lamma Patch and Adamasta Rock are not currently proposed, but if the submarine rock areas are to be removed then a detailed assessment of the impacts associated with the blasting should be carried out in addition to the measures identified above

6.4.6 General

It is envisaged that a major concrete batching plant will be required to provide material to form the roads and associated infrastructure of the port-related reclamation. Such plants are a common source of particulates, and are relevant to both air and marine pollution considerations. However, experience with the control of pollution from facilities of this type is widespread within Hong Kong, and no additional controls or treatment are envisaged to be necessary for the port-related work over those employed elsewhere.

Run-off from the advancing reclamation may contain not only suspended particulate material, but also contaminants arising from the reclamation process itself. Most notably, the latter include fuel derivatives from machinery employed in the reclamation. Given the magnitude of the reclamation, it is clear that a significant amount of machinery will be involved in its formation and that a fuel storage depot will be required in the area. The depot may also be moved to keep in step with the advancing edge of the land formed.

6.5 MITIGATION OF CONSTRUCTION IMPACTS

6.5.1 Dredging

Water Quality

The main impacts arising from dredging relate to increased turbidity and associated reduced levels of dissolved oxygen. A common occurrence during dredging operations is that water with a high suspended solids content is allowed to overflow from the barge. This polluting activity in particular should be minimised wherever practicable. In addition, there are further mitigatory measures that can be employed including :

- use of non-mechanical dredgers where practicable to reduce the levels of suspended solids; where mechanical dredgers are required measures such as adopting slower hoist speeds, and for example, using grabs which close tightly can reduce the release of sediments into the water column;
- slowing the rate of dredging activities generally;
- dredging at certain states of the tide when current flow is at its lowest;
- restricting the discharge of rest water in the hoppers of the training suction dredges;
- restricting the discharge of the 'rest water' contained inside the hoppers of the trailing suction hopper dredgers.
- with regard to the use of trailing suction dredgers, overflowing and degassing systems should be avoided. However, it is understood that there has been little need for the use of degassing systems in Hong Kong to date; and
- using silt curtains if considered necessary to prevent turbidity plume movement.

The use of silt curtains is recommended during dredging activities for the Lamma Breakwater footprint. Silt curtains fitted at the SRs could be appropriate if compliance monitoring detects unacceptable levels of suspended solids. The use of silt curtains around general dredging activities should be considered on a case by case basis since their use can hinder dredging progress.

The practicality of these and other measures, either individually or in combination will have to be assessed at the detailed design stage to enable inclusion in the construction contracts.

Marine Ecology and Fishing Industry

The construction of large areas of reclamation and the dredging of new channels will exert significant impacts upon the local marine ecology and on fisheries. Such impacts are largely unavoidable in many respects, however, particular methods of dredging and disposal of marine sediments may be selected in order to minimise the creation of plumes of suspended materials, which may smother benthic organisms or interfere with respiration in pelagic biota. In addition, marine baseline studies have shown that species diversity and number of individuals is greater during the winter months. Therefore, dredging during the summer months would have less impact on the marine benthic community.

The Ma Wan FCZ is considered to be sufficiently distant from the LAPH Development that any construction impacts on marine water quality and hence the FCZ are anticipated to be minimal. However, it should be noted that the accumulative impacts of PADS projects, on the Ma Wan FCZ are likely to be more significant.

6.5.2 Borrow and Fill

Mitigation of impacts arising from the borrow activities and fill placement can be achieved in several fashions, two of which require particular consideration here. Firstly, design of the TCT borrow area to minimise the quantities of run-off entering marine waters directly. Gullies and sediment traps of adequate hydraulic and physical capacity will need to be incorporated into the design of the works at TCT. Secondly, the Container Port reclamation could be formed by back-filling behind an initial sea wall extending along its perimeter, thereby avoiding the loss of material from the leading edge of the reclamation as it is formed. This work would be done in stages matching the various development phases for LAPH, and such an approach would not only reduce the overall loading of suspended solids to marine waters but would also maximise the effective use of borrow material, with associated cost savings.

6.5.3 Blasting

The effects of blasting can be reduced by using appropriate blasting techniques. As mentioned previously the use of surface charges for underwater blasting is not recommended. The charges should be placed in holes drilled into the rock which substantially reduces the resulting overpressure. It is essential that delay detonators are used either to confine instantaneous detonations to one or two holes at a time. Each charge should be fully buried in the rock and should no longer be live after 24 hrs if they fail to detonate. Explosives must not be detonated in the vicinity of vessels engaged in fishing, nor if shoals of fish or mammals are discovered near the shotpoint.

Mitigation measures used to reduce the water shock effect comprise the use of air curtains situated between the area of the blast and any sensitive areas. The curtain is produced by pumping air into a perforated tube which is placed on the seabed. The air bubbles rising form a curtain between the blast point and the sensitive zone. Shock wave reduction depends to a great extent on the amount of air used.

Although the two areas where blasting may occur are not considered to be areas of high fishing activity, liaison with local fishing associations should be established with regard to timing of drilling and blasting activities.

Finally, potential impact of blasting on fish fry can be substantially reduced by avoiding certain times of the year when fish fry are abundant such as between March and April, sometimes extending into June. This period should also be avoided as local fisherman have reported whale sightings in March and April.

6.5.4 General

It will be important to ensure that all fuel storage tanks are adequately lined and bunded and that the possibility of spillages from either these or major items of plant and equipment is reduced to a minimum. In order to minimize potential effects from the concrete batching plant it will be necessary to ensure the implementation of control and mitigation measures, such as the use of settlement tanks prior to discharge. As mentioned earlier environmental controls on this type of plant in Hong Kong are common place and it is not anticipated that additional mitigation would be required.

Mitigation of impacts arising from the reclamation run-off may be achieved by the use of interceptors and collection methods such as drainage channels and the use of settlement/degreasing tanks, prior to discharge.

6.6 OPERATIONAL IMPACTS AND MITIGATION

6.6.1 The Container Port

The operation of a major port facility involves inevitable risks with respect to marine pollution. While these will be more limited to some extent in container-dominated operations by comparison to multi purpose and bulk cargo handling ports, they are still potentially significant and need to be addressed. The following Section should be considered in the light of information provided by the Risk Appraisal for the planned port facilities, as described in Sections 12 and 13 of this Report.

Impacts to the marine environment from port operations can be conveniently separated into two main types: chronic, and acute.

Effects of Chronic Pollution

Chronic impacts arise from the day-to-day operations and involve the inevitable spillage of (generally small) amounts of polluting materials, with hydrocarbon-based fuels and oils being the most evident.

Studies elsewhere have amply demonstrated that port facilities constitute a major source of hydrocarbons to the marine environment. While the public perception of oil pollution is dominated by an awareness of major accidents involving oil tankers, in reality some 80% or more of the hydrocarbon load to coastal marine environments is derived from minor (but chronic) spills from day-to-day operations of coastal facilities (Whittle *et al.*, 1982). The types of hydrocarbons arising from port facilities vary from low molecular weight compounds present in cutting oils and similar mixtures, to PAHs of significant persistence and toxicity.

The discharge of such hydrocarbon-based contaminants into coastal environments may lead to a variety of consequences, affecting the marine food web as a whole, and potentially impacting on public health. With respect to the former issue, many hydrocarbons are taken up relatively rapidly by marine organisms and at least in certain cases are passed through aquatic food chains. Most vertebrates have developed detoxification mechanisms which hydroxylate and break down accumulated hydrocarbons. By contrast, however, primary producers and invertebrates possess either poorly developed or no systems of this type. Accumulated hydrocarbons can give rise to the tainting of seafood, or possibly to other types of effects involving cancer-like changes (neoplasia) in fish.

Few reported instances of tainted seafood exist consequent to the establishment of port facilities worldwide. Such taints (which may be evident by smell or by taste, or both) are generally caused by hydrocarbons of relatively low molecular weight (Connell and Miller, 1984), however the discharge to marine environments of sufficient amounts of these compounds to pass olfactory or taste thresholds is unusual. This does however remain a possibility, and has implications for both the capture fisheries and mariculture in the Study Area. With respect to neoplasia in fish, Malins *et al.*, (1983, 1984, 1988) have provided growing evidence for a link to hydrocarbon loading of coastal environments (PAHs being particularly implicated). However, specific data on the concentrations of PAHs in water, sediment or biota are either limited or not available for Hong Kong, and no information on the incidence of neoplastic changes in fish appear to be available. In the absence of such information, an informed view cannot be provided on the possible impacts of hydrocarbon releases from port-related operations.

No documented incidence exists of human intoxication through the consumption of seafood contaminated by hydrocarbons. It may be concluded that the LAPH development does not constitute a significant threat to public health in this respect.

Chronic pollution from the LAPH development will also occur as a consequence of additional wastewater discharges, these being derived from both sewage and industrial effluents associated with the Lantau Port operations. By comparison to the similar effluents already in existence in Victoria Harbour and its surrounds, such discharges are unlikely to create a major problem, particularly as the opportunity exists for their placement in waters of high receptive capacity to the south-east of the Lantau Port reclamation. The possibility exists of diverting a large proportion of the wastewater loading from the urban Kowloon area through the implementation of the Strategic Sewage Disposal Scheme (SSDS), and this would significantly alleviate any impacts of organic loading in the Victoria Harbour area and adjacent regions. Wastewater discharges are also relevant to nutrient loading in the waters of the Study Area. The WAHMO modelling has demonstrated that the discharge of untreated wastewater from Peng Chau, Discovery Bay and Yi Pak, (based on forecasted future pollutant loadings) would lead to a significant deterioration in water quality, this is discussed in detail in Section 7, Marine Water Quality Modelling.

In order to reduce vessel-derived pollution, reception facilities are also required for solid and liquid wastes produced within the framework of the LAPH development, this aspect is considered in detail in Section 11, Waste Management.

Given the distance between the likely points of discharge of any effluents arising from the port-related facilities and gazetted bathing beaches in Hong Kong, it is considered most unlikely that the proposals for the LAPH developments will affect microbiological quality at the beaches of the Study Area.

Antifouling Paints

The release of toxins from antifouling paints is likely to impact on the marine environment of the Study Area. Such paints commonly include either copper or tin compounds, which are selected for use due to their extreme toxicity to fouling organisms. The tin compounds include both tributyl tin (TBT) and triphenyl tin, these were developed in the early 1970s as an alternative to copper-based paints. These tin-based paints have generally longer periods of effectiveness. However, extensive research commencing in the late 1970s documented several specific adverse impacts of TBT in marine and estuarine environments, the major effects involved oysters and marine gastropod molluscs. Impacts on marine gastropod molluscs involve the creation of a so-called imposex condition (the imposition of male sexual characteristics on female gastropods), which leads to reproductive failure. In many areas of boating activity, gastropod mollusc populations have been reduced significantly and in some cases disappeared altogether due to the impacts of TBT. Concern over the adverse effects of tin-based antifouling paints in marine environments has given rise to the imposition of restrictions on their use in many western countries, although larger vessels are generally exempt from such regulations.

No surveys of TBT use or impacts are known for Hong Kong, although it appears likely (given the extent of local shipping) that significant effects of this type exist in the Territory. While the growth of the port operations as a whole in Hong Kong may be expected to increase the likelihood of such impacts, this will be balanced at least to some degree by the increasing effects over time of international restrictions or bans on the use of toxic-based paints and anti-fouling coatings.

The use of TBT-based antifouling paints in Hong Kong is regulated under the Pesticide Ordinance Chapter 133, February 1991. The following conditions apply:

- *'....all import, storage, formulation, distribution and use of TBT concentrate and paint must be done under permit';*
- *'....all TBT-based paints must be supplied in containers not less than 20l in size';* and
- *'....TBT-based paints can only be applied to boats over 25m in LOA (with the exception of aluminium hulled craft)'.*

The above conditions are enforced by the Agriculture and Fisheries Department (AFD).

The Ma Wan FCZ

The Ma Wan FCZ is the smallest of the four zones in the Study Area. It has been the cause of concern with respect to previous developments, and was considered in the PADS study to be potentially affected by the operation of the LAPH developments (as envisaged then). There appears no rationale to alter this view, and the long-term viability of the fish culture activities at Ma Wan requires thorough consideration. While the individual impacts presented by the developments involving the LAPH developments may not be significant in isolation, the presence of this FCZ in an area which will eventually be dominated by the port and airport activities is a potential problem. In particular, there may be concerns that these uses of the coastal waters are mutually incompatible

Floatables

Port-related operations also constitute a significant source of floatable materials (such as polystyrene, plastics wood, paper, cardboard etc.) the presence of which is unsightly in marine environments and may interfere with either marine life (e.g. through the ingestion of plastics by birds or mammals) or with shipping operations (e.g. by the blocking of cooling water intakes or the fouling of propellers). Such problems are already common in Hong Kong waters, as noted by an EPD report in the mid-1980s (EPD, 1985), and it is intended that the new port facility should not exacerbate these. It is possible through the implementation of correct waste disposal practices that the problem of floatable wastes would be reduced. It is however inevitable that some floatables will be present and these should be removed by equipment such as the 'Sea Witches' commonly used in Victoria Harbour.

Dangerous Goods Anchorage

It is not anticipated that any additional environmental impacts will occur as a consequence of moving the Pun Shan Dangerous Goods (DGs) anchorage area to a new area in the Western Harbour, this location does not present any significant change in circumstances.

Transportation of Dangerous Goods

Cargo manifests of ships arriving at and departing from Hong Kong carrying hazardous goods were reviewed for one week during December 1991. The cargoes are assumed to be typical of hazardous materials transported in Hong Kong waters and include a broad range of materials such as pesticides, solvents, paints, alcohols, oils and various other substances. Examples of the potential impacts on the marine environment from spillages, collisions etc., include the following:

- oil contamination;

- chronic effects on the marine ecosystem (long term damage to the marine ecosystem, carcinogenic effects, species loss etc.);

- acute effects on the marine ecosystem (fish kills etc); and

- the accumulation of heavy metals and pesticides in the food chain (damaging the shell fisheries industry and poisoning fish stocks).

A comprehensive list of the hazardous substances transported during the period of review is given in Appendix A5, Survey of Dangerous Goods in Ships Manifests in Hong Kong.

Effects of Acute Pollution

Acute pollution incidents may arise through spillages from the proposed port facilities, these being most likely to take place due to: (i) leakages from containers, some of which may contain Dangerous Goods (DGs); and (ii) the spillage of hydrocarbon-based fuels from ships, following incidents. The former source may involve a wide range of contaminants which are being imported, exported and trans-shipped through Hong Kong (Section 12), and will generally involve small amounts of materials (albeit of potentially high toxicity in certain cases). By contrast, ship-related accidents may lead to the spillage of relatively large amounts of hydrocarbon-based fuels, which are of a comparatively low (but nevertheless potentially significant) inherent toxicity.

Theoretically, either source of pollutants may affect a substantial part of the Study Area, perhaps even extending outside this region. However, given the small volume of potential spillage of DG materials, it is most unlikely that any significant damage to the marine environment could arise outside the port areas from this source (as dilution of the contaminants would occur in the wider area, rendering their impacts negligible). As noted in Section 12, it is considered that the possibility of a spillage of DGs is unlikely to exert measurable impacts on anything other than the local area of spillage.

Of more relevance is the possibility of a ship-related collision or other accident, releasing fuel oils or other hydrocarbon-based compounds to the approaches to the LAPH development, or to the area of the port itself. Oil spills are not only unsightly, but may be of significant toxicity to marine life, as well as affecting beaches and creating problems with seawater intakes (employed for cooling water and other purposes). Considerable effort has been expended by the Government Departments in Hong Kong on the development of a response capability to deal with oil spills in the marine environment, and this extends not only to the provision of booms and skimming or oil adsorbing equipment but also to the stockpiling of low-toxicity second generation dispersants. Such a response capability is already in place to deal with the existing port operations and with any other shipping-related (or indeed, terrestrial) source of oil contamination. It is considered that the planned expansion of the port facilities does not merit the installation of additional equipment of this type, as the eventual existence of the extended port merely increases the risk of the equipment being required, rather than fundamentally altering the amounts and type of equipment which is already available. However, the comments in Section 6.6.1 above regarding the possible effects of increased hydrocarbon loading to the marine environment in Hong Kong are relevant here.

Marine Habitat Creation

Possible mitigation for the loss of both coastal and marine habitats would be to create alternative habitats elsewhere in the Study Area. This might involve the use of modified engineering structures and habitat restoration and enhancement techniques. The use of boulders or similar type materials, such as large rock armour units, rather than smooth concrete structures will enhance the colonisation potential for marine organisms. A potential use for the rock from blasting could be to provide fishery enhancement areas which would provide alternative habitats following the disruption/destruction of other fishing grounds. Rocky areas provide ideal habitats for certain fish and shellfish species. The creation of artificial islands could also be considered perhaps in the vicinity of Sunshine Island. This has proved successful in a number of projects in the United States. Islands have been constructed to provide nature conservation, fishery enhancement, recreational and amenity areas.

Previous studies undertaken in Canada, (A. J. Jordon, 1992), have demonstrated marine habitat creation in the Port of Vancouver, using port structures where inter and sub-tidal benches, hollow areas of the caissons and a caisson mattress with angular rock fill, have been utilised for habitat creation to enhance the diversity of marine life. It is recommended that similar habitat enhancement techniques are considered for the LAPH development at the detailed design stage.

6.6.2 Maintenance Dredging

It is likely that regular maintenance dredging will be required in the proposed new access channel to the Container Port facilities to enable the safe passage of vessels through the channel. This will disrupt the fauna however it is likely to be of only limited significance in terms of marine ecology and fisheries, due in part to the generally impoverished nature of the benthos in the soft-sediment areas of the Western Harbour, but also to the fact that the capital dredging activity will have previously disturbed the area and any species which have recolonised the dredged channel will be those which are adaptable to disturbance.

6.6.3 Lamma Breakwater

Concern has been expressed by the local Fishermen's Associations, regarding the perceived impacts on marine ecology and fisheries of the proposed Lamma Breakwater. The Associations believe it would cause considerable disruption to fishing activity and that the breakwater would reduce tidal flushing within the Western Harbour area, which could have consequences for water quality and therefore impact upon marine ecology and fisheries.

The hydraulic modelling studies have not indicated problems with tidal flushing due to the imposition of the Lamma Breakwater. The construction and operational activities associated with the Lamma Breakwater would inevitably disrupt fishing in this area however as noted earlier no demand for the Lamma Breakwater or the associated reclamation has been identified.

The proposals for local breakwaters, which protect the initial stages of the Container Port development, will also cause disruption to fishing activity.

6.6.4 The North Shore Development

As described in Section 2, the North Shore will be developed in four phases and each phase will provide more quay face and back-up area for the RTTW and the floating docks.

Nearby SRs have been identified in the North Shore Development Working Paper 29A, and these include the FCZ at Kung Tsai Wan (on Ma Wan) the gazetted beaches in the Sham Tseng area, the two adjacent WCZ's and the fresh water streams and mangroves in the Yam O Wan area.

River Trade Transhipment Wharves

The operation of the RTTW will involve the handling of cargoes in both containerised and bulk forms, the potential for impacts on the marine environment from the handling of containerised cargo is considered to be much less than the handling of bulk cargo, i.e. the loss/spillage of cargo is more likely to happen when handling material in a bulk form.

Pollution incidents due to the spillage of cargo seems to be inevitable. It will therefore be necessary to ensure that appropriate modern, purpose designed equipment and methods for transfer of materials are provided, as well as good working practices to keep the occurrence of such incidents to a minimum and that suitably trained personnel are present at the RTTW so that any incident can be quickly and efficiently responded to.

The RTTW will create an embayed area of water at Yam O Wan. This will lead to reduced flushing rates within the embayed area and as a consequence the water quality can be expected to deteriorate. An increase in floatables, hydrocarbons and suspended solids, and a decrease in dissolved oxygen concentrations is anticipated.

Mitigation measures recommended include the rapid filling of the embayment and/or habitat preservation and creation. It is considered that a wetland habitat may be suitable for this location.

Floating Dock's and Back Up Areas

A number of the operations which will occur at the floating docks and the shore based back-up areas will produce wastes which have the potential to impact on the water quality an marine ecology of the Study Area. The types of wastes which will arise fall into the following two general categories:

- difficult and chemical wastes, including wastes such as asbestos, PCBs, solvents, oily bilge water, grease and TBT based compounds, (see Section 6.6.1); and

- general refuse, including wastes such as paint scrapings, paint, rust, timber, metal and domestic type waste.

These wastes if not properly disposed of could have a significant impact on the marine environment, this is especially so for the wastes containing toxic compounds such as TBT and PCB. However, it should be noted that due to the adverse impacts associated with these compounds their use is reducing/restricted worldwide.The Agriculture and Fisheries Department have taken steps to control the application, usage and labelling of TBT paints.Further, they are promoting the use of copolymer formulations which release less TBT into the water. Despite most control being directed at vessels less than 25m in length, the international trend is towards the development of non-TBT alternatives, for larger vessels as well. Waste derived from the floating docks and the onshore back-up area should be collected and disposed of properly. The waste arising and disposal options are discussed in more detail in Section 11, Waste Management.

6.6.5 Hei Ling Chau Typhoon Shelter

Concern has been expressed regarding the Hei Ling Chau typhoon shelter which will affect an inshore fishing ground. This fishing ground is of significance to the small scale fishermen from Mui Wo and Cheung Chau. It is possible that this will result in objections from local fishermen.

However, the currently proposed use of the Hei Ling Chau typhoon shelter will be limited to the period when a typhoon passes through Hong Kong and will not be a marine residential area. As a consequence of this together with the flushing characteristics of the shelter no water quality impacts are expected and the local small scale fishing activities which occur around this area should not be significantly affected apart from some temporary construction related impacts.

6.6.6 Marine Services Support Area & Ship Repair Yards

The MSSA and the dockyards are located to the east of the Container Port development, on the south side of the TCT peninsula. The MSSA will provide mooring facilities for the pilot boats and the tugs used within the Western Harbour. Workshops and offices for the tugging companies will also be provided. The design of the MSSA in Phase I has incorporated an opening in the seawall which will allow tidal flushing to disperse pollutants and prevent water quality within the basin deteriorating. The operation of the MSSA does not represent a significant source of pollutant loading to the marine environment at this stage as much of the waste producing activities will occur onshore within the workshop facilities. The waste produced from the workshops and offices would fall into the general and difficult waste categories and their collection and disposal method is outlined in Section 11, Waste Management.

In the later stages of development, (Phases II-IV), the MSSA will approximately double in size and also two ship repair yards are proposed. The development of the ship repair yards and to a lesser extent the additional MSSA facilities will have the potential to impact on the water quality and marine ecology of the area. The impact on the marine environment would be mainly derived from the wastes produced by the ship repair yards.

A variety of wastes will be produced by the ship repair yards including difficult, chemical and domestic type wastes. The wastes produced are similar to those produced by the floating dock facilities which are discussed above. Examples of the wastes which could be produced and methods of disposal are also given in Section 11 of this Report.

A major effect of the development of the MSSA second stage, and the ship repair yards is to close the channel which allowed water flushing of the MSSA. This flushing is important for preventing accumulation of pollutants and maintaining the water quality inside the MSSA basin. When the channel is closed it will be important to maintain flushing capability of the MSSA and dockyard basins. For example, the provision of culverts in the seawalls of the basins as a piled structure. It is recommended that this mitigation measure is incorporated in the detailed design. Physical removal of floatables on a frequent basis will also be essential.

6.6.7 Fishing Industry - Socio-Economic Impact

The commercial fishing industry in the Western Harbour area is of significant economic value. It is anticipated that fishing will be disrupted to some extent during both construction and operational phases of the LAPH Developments.

The Northern Sub-Area (Figure 6.2) accounting for approximately 50% of the fish caught and profits gained will be most affected by the LAPH Development. This is due principally to the sea area required for the port and associated reclamations, the increase in marine traffic in its vicinity and associated chronic and acute marine pollution. No significant impacts are anticipated on fishing activities in the Southern Sub-Areas.

However, given that many of the small fishing craft fish the combined areas in the Western Harbour there is a potential for overfishing in the Southern Sub-Areas.

Clearly, it is important in this situation that the Government amasses sufficient statistics on the existing (and potential future) fisheries in the Study Area to be in a position to adequately address any claims for compensation from the fishing industry sector. It is proposed that surveys of fish catches in the local waters should be undertaken by AFD in conjunction with EPD water quality monitoring to monitor the potentially complex ecological impacts on the marine environment.

6.7 ENVIRONMENTAL MONITORING AND FURTHER SURVEY WORK

The levels of turbidity and dissolved oxygen need to be compared to ambient levels and the appropriate WQOs. A baseline assessment would be required concentrating on the area to be dredged. Compliance monitoring of the affected area during dredging can then be carried out. Profile sampling should be undertaken for turbidity analysis with samples taken from surface water, mid-water and just above the seabed. Laboratory analysis can then be performed to measure the amount of suspended solids in the water, dissolved oxygen profiles are recorded *in situ* using a standard dissolved oxygen meter. Outline monitoring schedules are presented in Section 14.

Recommendations for Further Work

The following programme of further work is recommended if blasting of the Lamma Patch and the Adamasta Rock is to be carried out:

- recording of the species, composition and densities of marine life existing within the Study Area prior to the commencement of work, by underwater transecting and photography by divers;

- determination of the effects of the underwater blasts in relation to the total number and/or poundage of fish and invertebrates killed or injured, the total area affected by the blast centre to which fish kills were effected; and in order to establish the blast impact with distance it is recommended that fish of the same species as those kept in the nearby fish culture zones, are kept in cages at specified distances from the blast. This will act as a control for the lethal zone for fish. The cages should be placed at distances from the blast of 300m, 400m, 600m, 800m and 1000m and placed between the blast area and the fish culture zones. The fish should be checked for visual damage at regular intervals. The setting up, monitoring and post-analysis of the fish in cages should be carried out by a reliable, independent organisation. This will enable any verification of claims for compensation by local fish farmers. Test blasts using lower amounts of explosive charge should be carried out initially and any effects on fish in the cages should be observed and acted upon. Should the lower explosive charges cause the death of any fish in the cages, mitigatory measures must be taken (eg air bubble curtains). The fish from the cages should be retained for several weeks following the blast, for observation purposes.

- post-blasting visual assessment of the area to determine extent and effect of blasting and recolonisation potential.

6.8 CONCLUSIONS

It is anticipated that the most significant activity impacting on the marine environment would be dredging during the construction phase of the port development. The main impacts relate to increased turbidity and associated reduced levels of dissolved oxygen.

The mitigatory measures that may be adopted relate to the rate of dredging, the type of equipment employed, timing and the procedures utilised.

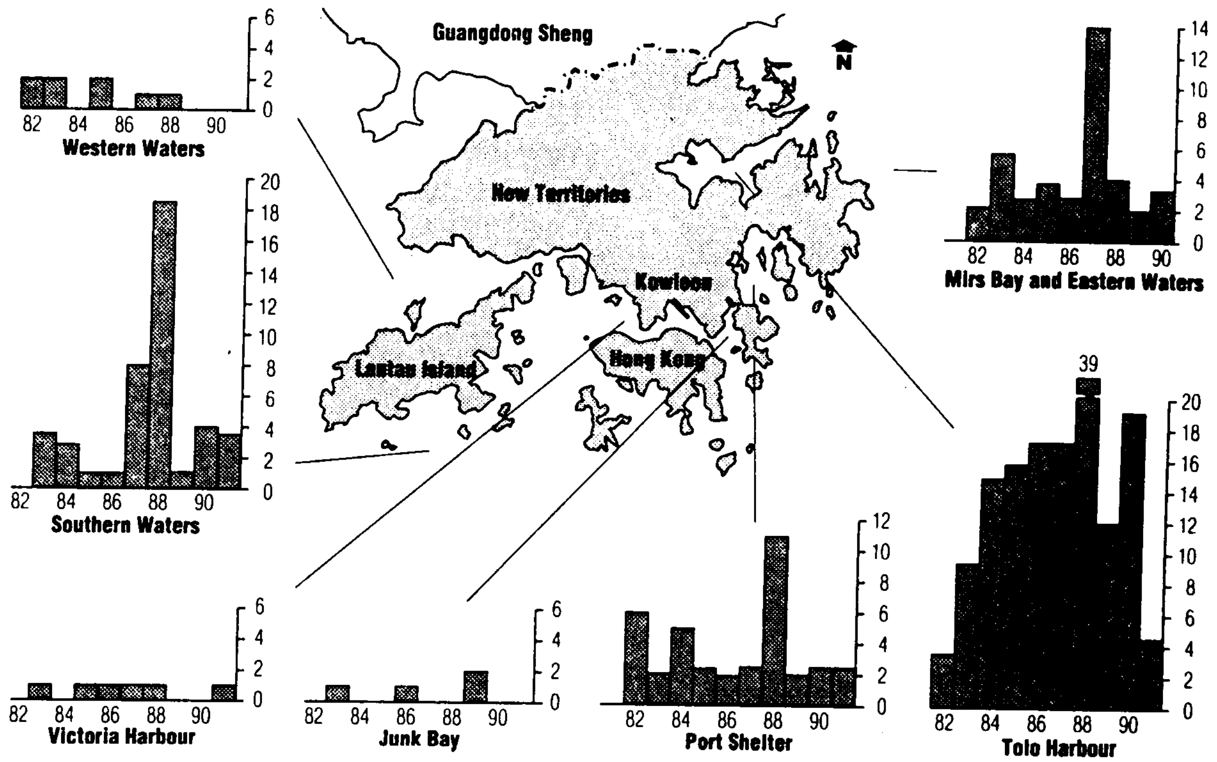
Operational impacts can be described as either chronic or acute. Chronic impacts would arise from the increased hydrocarbon load on the receiving waters. Hydrocarbons can persist in the marine food chain, the effects of which range from taste problems in seafood to carcinogenic effects. Although research is on-going in this area, no threat to public health is anticipated arising from chronic hydrocarbon contamination.

Acute impacts relate to accidental spillage of dangerous goods which may have toxic effects on the marine ecology and in particular oil spills. It is considered that a sufficient response capability already exists within Hong Kong to deal with oil contamination, no further precautions have been recommended.

The overall effects of the Container Port development will be to create an embayed area in the water body encompassing Discovery Bay, Peng Chau, north east Lantau. This would reduce tidal flushing and would possibly make the area susceptible to eutrophication. Consequently it will be very important not to permit significant pollutant loadings to be discharged into this water area.

The Port and its extensions and the associated increase in shipping traffic may lead to many fishing boats moving further south and consequently a greater level of fishing activity in the southern waters of the Western Harbour area. This potential situation should be monitored carefully to avoid over-fishing of economically valuable fish stocks. AFD should continue recording the volume and type of fish species caught throughout the year. The actual impacts on the fishing industry will depend on a large number of factors including the rate of development of the Port. There is currently insufficient data to enable a reliable and useful estimate of the loss to the fishing industry and further studies will be essential.

Given the large extent of dredging and potential for associated release of nutrients into the water column coupled with the identified sensitivity of the water body west of the port peninsula (see Section 7) a bio-monitoring programme to give early warning of red tide formation is recommended.



Source: Environment Hong Kong 1992, A Review of 1991, EPD

Note: Incidences of red tides, caused by massive blooms of microscopic plants called dinoflagellate algae, 1982-1991

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FIGURE 6.1

INCIDENCE OF ALGAL BLOOMS IN HONG KONG WATERS

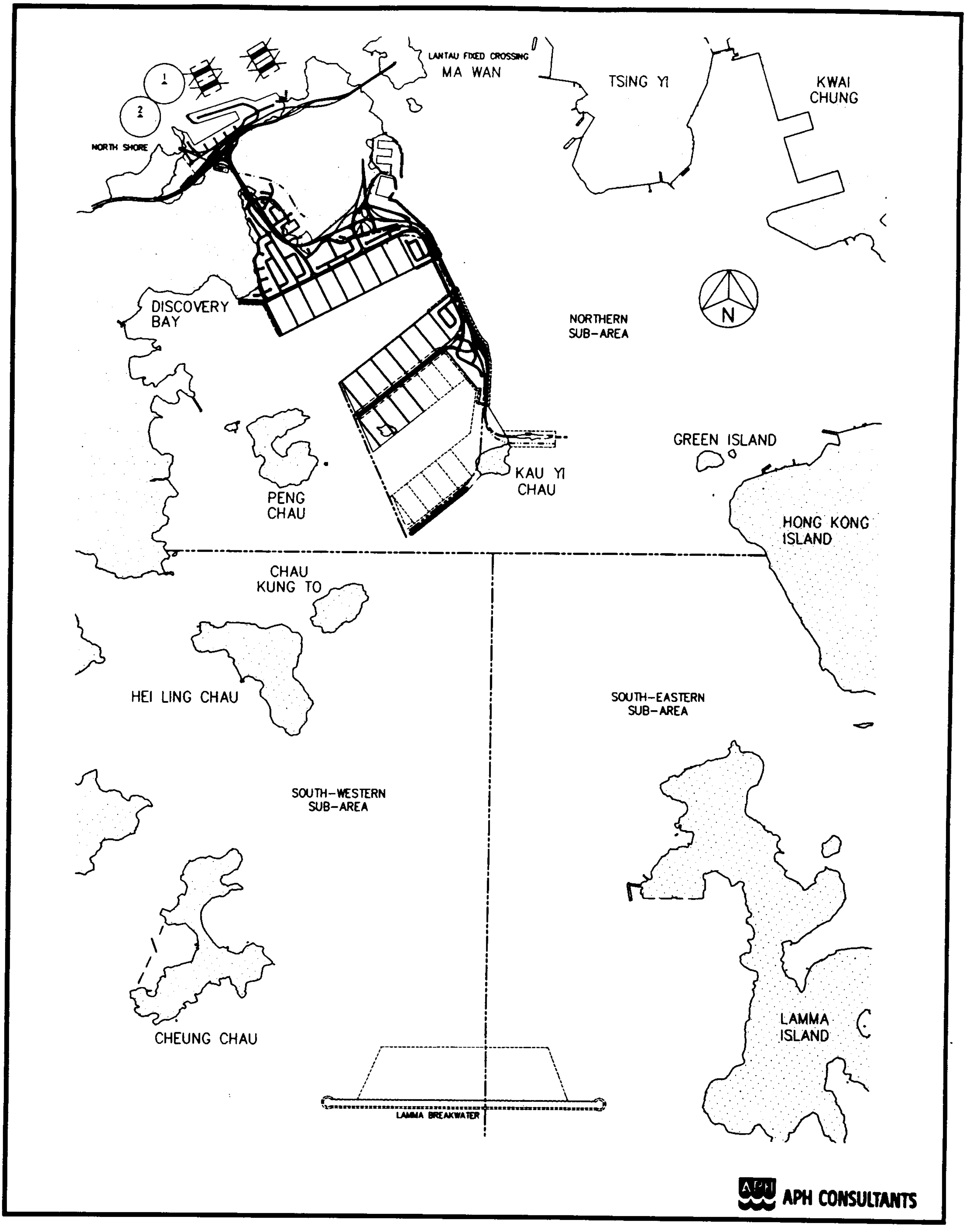

FIGURE 6.2

DELINEATION OF WESTERN HARBOUR INTO FISHING GROUNDS

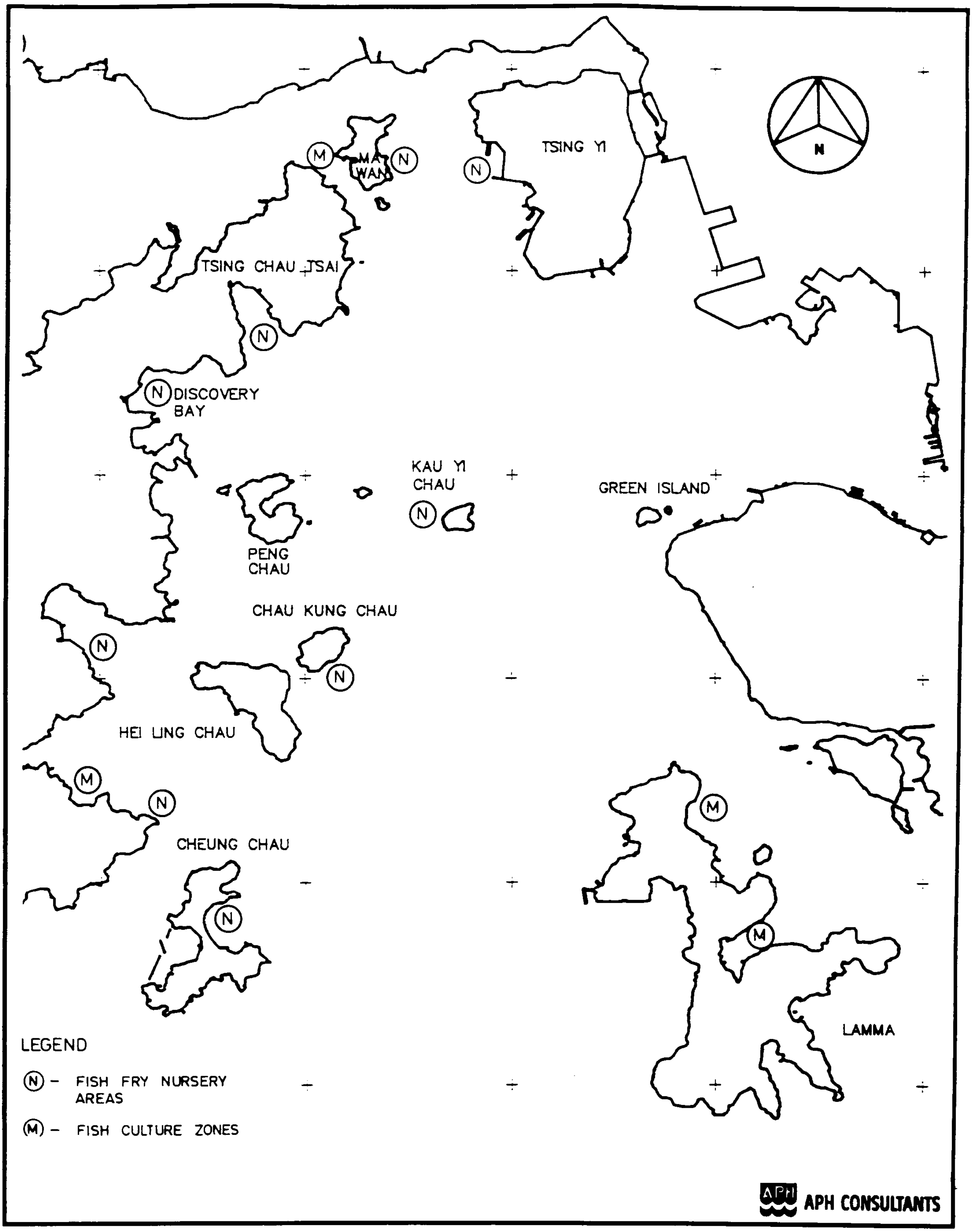

FIGURE 6.3

FISH FRY NURSERY AREAS AND FISH CULTURE ZONES