9 ECOLOGY

9.1 Introduction

Potential ecological impacts from the construction and operation of the TLCDGA are a key issue. There are fishing and nursery grounds as well as a fish culture zone in the vicinity of the TLCDGA. Chinese White Dolphin (*Sousa chinensis*) has been occasionally seen around Ma Wan and in the northern section of the Southern Waters. In addition, the rocky coastline of nearby islands may provide shelter for commercially important marine species. During construction dredging, in the event of a fuel spill, and during maintenance dredging, these sensitive receivers may be adversely affected. The objective of this ecological assessment is to determine the biological effects of dredging and fuel spillage on these ecological sensitive receivers.

9.2 Environmental Legislation and Standards

Hong Kong SAR Government ordinances and regulations relevant to the present project include the following:

The Wild Animals Protection Ordinance (Cap. 170), which protects listed species of wild animals, including cetaceans. Under this legislation, the disturbance, taking or removal of animals and/or their nests or eggs is prohibited.

The Animals and Plants (Protection of Endangered Species) Ordinance (Cap. 187), which bans import, export and possession of certain animals and plants including cetaceans.

The Marine Fish Culture Ordinance (Cap. 353), which designates and protects fish culture zones.

The Water Pollution Control Ordinance (Cap. 358), which defines Water Quality Objectives in various zones.

The Environmental Impact Assessment (EIA) Ordinance (Cap. 499), which provides guidance on the methodology for ecological and fisheries impact assessment in Hong Kong.

Planning, Environment & Lands Branch Technical Circular No. 1/97 - Works Branch Technical Circular No. 4/97, entitled *Guidelines for Implementing the Policy on Off-site Ecological Mitigation Measures*. The circular "sets out guidelines for the implementation of the Government's policy on off-site ecological mitigation measures which, in brief, requires that where such a measure is required, it would be provided to the extent that it is practicable, on a 'like for like' basis and within the boundaries of Hong Kong".

International conventions relevant to the study include the following:

Bonn Convention. Hong Kong is a Party to the Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention). The Bonn Convention has two major objectives:

- to provide strict protection for species listed in Appendix I of the Convention (migratory species in danger of extinction throughout all or a significant portion of their range); and
- to conclude agreements for the conservation and management of Appendix II species (migratory species which have an unfavourable conservation status and require international agreements for their conservation, or which have a conservation status which would significantly benefit from international cooperation). At present no such agreements are relevant to Hong Kong.

The first objective above includes obligations to conserve and restore those habitats which are important in removing the species from danger of extinction, and to prevent, remove, compensate for or minimize the adverse effects of activities or obstacles that impede or prevent migration of the species.

United Nations Convention on Biodiversity. China is a Contracting Party to the United Nations Convention on Biological Diversity of 1992. The Convention requires signatories to make active efforts to protect and manage their biodiversity resources. Article 10 of the Convention requires signatories to integrate consideration of biodiversity conservation and sustainable use into decision-making, and adopt measures to avoid or minimize adverse impacts on biodiversity. The Planning, Environment and Lands Bureau of the Hong Kong SAR Government has stated that it is "committed to meeting the environmental objectives" of the Convention.

IUCN Red List of Threatened Animals. The Species Survival Commission at IUCN are responsible for reviewing, updating and compiling a worldwide inventory of endangered species. *Sousa chinensis* is categorized under List 5 which includes species that lack the data needed to make an assessment of risk possible.

These ordinances, regulations, guidelines and conventions are the basis of the ecological impact assessment. Where species or conditions exist in the project area that meet any of the constraints outlined above, these will be noted and the consequences to the project would be assessed.

9.3 Assessment Methodology and Criteria

9.3.1 Review of Existing and Available Data

Assessment of the key issues for the identified sensitive receivers was completed primarily through literature reviews. A literature search was carried out to gather information on the biological effects of dredging and fuel spill on marine biota. Marine ecological surveys have been undertaken south of Ma Wan as part of the environmental baseline study for Lantau Port and Western Harbour Development Study (LAPH).

As part of the Lantau Port Development Studies for Container Terminals 10 & 11, CES carried out fisheries, fish fry and dolphin surveys from December 1995 to January 1997. Fish fry surveys were carried out at Fa Peng, Penny Bay, Discovery Bay, Peng Chau, Hei Ling Chau, Silvermine Bay and Kau Yi Chau. Fishery surveys by means of interviews with fishermen and observations of different fishing activities (e.g. shrimp trawl, longline and gillnet) off the northeast coast of Lantau Island were conducted. A 6-month dolphin monitoring programme was also carried out in the vicinity. These data have been reviewed and used to assess the status for the general area of this study.

Fisheries information appropriate to the area, including the fish culture zone, was obtained from discussion with representatives of the fishermen using the area and running the fish culture operations.

Information on dolphin use of the area was obtained from discussion with AFD, the Lantau Port Development Studies for Container Terminals 10 & 11 conducted by CES, and the study "Dolphins in East Lantau Waters of Hong Kong – Assessment of Potential Effects of Lantau Port Development" undertaken by Dr. Thomas Jefferson for CED in 1997.

9.3.2 Intertidal Habitat Survey

The proposed breakwater layout could potentially change the hydrodynamics of the area around the DGA. This may alter the coastal habitats in the immediate vicinity. An intertidal habitat survey was therefore carried out at Tang Lung Chau to describe the intertidal community inhabiting the area and assess the likely impacts of the breakwater configuration. The survey was conducted along the eastern shore of Tang Lung Chau in February 1998. General features of biota encountered along the profile were recorded.

Three replicate transects were run from the high-tide zone to the low-tide zone (at low tide). The locations of the transects are shown in Appendix E1. At regular intervals (about 5m apart) along each transect, 3 replicate quadrats of 1 x 1 m dimension were randomly placed on the substratum to sample the upper, middle and lower shores which were about 2m, 1.4m and 1m above Chart Datum.

Each quadrat was sectioned equally into 9 squares and the substratum, plants and animals under each of the 9 squares were recorded. Substratum and plant types included bare rock and algae (fleshy or encrusting, etc). Animal species encountered under each quadrat included limpets, molluscs, etc. Species identification was recorded to the lowest practicable taxon and if necessary, samples were retrieved and taken back to the laboratory for further taxonomic analysis.

Data were analyzed to provide a descriptive and quantitative picture of the various components of the shore community. Diversity and evenness were calculated and community structure was further analyzed where appropriate.

This analysis provides a general description of the baseline community and allows the shore to be placed into a Hong Kong context in terms of typicalness / rarity, significance and fragility. In the light of the results of this analysis, potential impacts of the proposed layout can be assessed.

9.3.3 Evaluation Criteria

The importance of ecological sensitive receivers has been based upon criteria normally applied during ecological assessment such as the rarity of the species (population numbers and global distribution), and species distribution within Hong Kong. Rarity may be officially recognized through regulatory protection, such as for marine mammals, including dolphins. The Chinese White Dolphin (*Sousa chinensis)* is a rare species of cetacean and is listed in the *IUCN Red List of Threatened Animals* as a species which lacks the data needed to make an assessment of risk possible. It should be noted that habitat conservation is as important as individual preservation. *Sousa chinensis* is protected locally under the Wild Animals Protection Ordinance (Cap. 170) and the Animals and Plants (Protection of Endangered Species) Ordinance (Cap. 187). The statutory requirements should be strictly observed.

As described in Section 3.4, fish culture zones have specific water quality criteria. According to the *ex-gratia* arrangements for mariculturists, at any one time the suspended solids (SS) concentration must not exceed 50 mg/L or exceed by 100% the highest level recorded at the fish culture zone during the five years before commencement of works in the vicinity.

The ecological importance and fisheries importance of the Project site has been determined based on the EIAOTM Annex 8 and Annex 9 respectively.

9.4 Baseline Conditions

CES has carried out fisheries, fish fry and dolphin surveys for the Lantau Port Development Studies for Container Terminals 10 & 11 from December 1995 to January 1997. The ecological baseline condition in this study was extracted from the Lantau Port Development Study. In addition, a report "Port Survey 96/97" from AFD and the study "Dolphins in East Lantau Waters of Hong Kong – Assessment of Potential Effects Lantau Port Development" were reviewed in this study. These field studies have provided data on marine biotic composition and abundance of the marine organisms around the Ma Wan area. The findings are summarized as follows:

9.4.1 Fisheries Resources Survey

According to the CES survey study, a total of 309 observations of fishers were recorded in the study. The location of the survey area is shown in **Figure 9.1**. Observations were carried out during morning and afternoon hours of each month. **Figure 9.2** shows that there was more vessel activity in this area during the morning hours. There were a couple of fishing gear types in the area. **Figure 9.3** shows how these observations were distributed across fishing gear types. Gillnet and handline technique consisted of 56% of the total number of observations, while trawling gear of shrimp and fish types comprised 32% of the observations. In terms of vessel type, 66% of all fishing activity in this area was conducted by sampans and speedboats (**Figure 9.4**). The remaining 34% of vessels were trawlers. 75% of the observed vessels were actively fishing. This showed that active exploitation of the resources occurred in this area. Monthly trends in observations of total fishing activity are shown in **Figure 9.5**. There were three peaks in fishing effort throughout the year, one in Spring (April), one in Summer (August) and the last in Autumn (October). The Autumn peak was the highest and is composed of the greatest diversity of gear and vessel type. Gillnet effort tended to be constant across all peak periods, while trawling tended to be concentrated in Summer and Autumn. **Figure 9.6** illustrates which gear types were mostly used in the survey area during the three peak periods of fishing effort. At the peaks in April (Spring) and August (Summer), fishing effort during these months was dominated by only 3-4 gear types – gillnet, hang, shrimp or stern trawling and a component of handline or longline fishing. In contrast, during the autumn period (October) when fishing effort in the survey area was at its greatest, a greater diversity of gear types was recorded. All six gear types were used during this single month.

From the AFD Port Survey 96/97 Study, the fishing area in Hong Kong Waters is divided into 189 parts (see **figure 9.7**). The fishing area of Ma Wan (code 25) is 418.82 ha, which belongs to the western harbour section. The total adult fish production in this area was 81,988.08 kg. Based on the result of the study, the rank (adult fish production per ha area) of Ma Wan fishing area among all other areas in Hong Kong was 48. In term of vessel type, vessels not exceeding 15m carried out all fishing activity in this area. This shows that only small size vessels were actively fishing in this area. The number of vessels in this fishing area was 254. There are some other fishing areas (code 1, 2, 3, 4, 24, 34) surrounding the proposed Tang Lung Chau DGA. The fishery information of these areas are summarized in Table 9.1. Also, Table 9.2 and 9.3 show that the top ten adult fish caught in these fishing areas. There are 38 homeports distributed in Hong Kong (see **figure 9.8**). The one nearest to the survey area is Ma Wan/Tsing Lung Tau/Yam O homeport (P009). According to the survey data, the total adult fish production in this homeport was 333,546.14 kg. There were 294 vessels recorded in this homeport. All of these were vessels not exceeding 15m, which was the same as the Ma Wan fishing area. Table 9.4 indicates the top ten adult fish caught by this homeport.

9.4.2 Fish Fry

According to the Lantau Port Development Studies for Container Terminals 10 & 11, it is believed that important habitats for fish fry are typically close inshore, sheltered waters in embayments.

Hence, four sampling locations for the study were selected at Fa Peng, Penny's Bay, Discovery Bay and Peng Chau in the first survey period (December 95 to May 96) and 3 new sites at Hei Ling Chau, Silvermine Bay and Kau Yi Chau were added in the extended survey period (August 1996 to January 1997). Each location excluded from Kau Yi Chau was sampled once a month and an average of 3 replicate tows for 15 minutes were taken within each site at the end of every month. The site, Kau Yi Chau was sampled only two times within six months at the same sampling time as the other six sites.

The total catch of fry collected from these sampling locations during the first survey was 217, while 12 fish fries were collected from August 96 to January 97 of the extension survey period. Table 9.5 provides summary data for the important commercial species of the fry fishery collected during the surveys in the first 6 months (i.e. Dec. 95 – May 96; indicated in the table as period I) and the extension period (i.e. Aug. 96 – Jan. 97; indicated in the table as period II). Four species of Sparidae were collected from December 1995 to May 1996 and two of these were collected from August 1996 to January 1997. From December to May, sparids accounted for 83% of the total catch for the entire survey, while they only made up 3.5% of the total catch in the latter part of the year. Among the 4 species of sparid collected in the survey, *A. Latus* was the most abundant, while only a single individual of *S.sarba* was collected during the survey. The relative abundance of *A. latus*, *P. major* and *E. cardinalis* is 51.0%, 19.2% and 29.3% of the total sparid catch respectively.

Regarding other species important to the fry fishery, the family Salangidae were the second important component of the fry fishery. Total numbers were relatively low compared to sparids collected in the survey and accounted for only 12% of the total fry catch. Besides this, two individuals of *P. maculatus*, one *L. russelli* and one *E. suillus* were caught in September and October of the extension survey.

Average weight and average standard length for fish collected during the survey are summarized in Table 9.5. Size comparison of fish collected in the survey and adult fish recorded in the literature are given in Table 9.6. In the spring survey, sparids occurred in different size groups. *A. latus* and *S. sarba* were the smallest and *E. cardinalis* were the largest fry. In the extension survey, all sparids collected were much larger than those found during earlier months and were most likely the older individuals of these earlier initial cohorts. Standard length of *S. ariakensis* indicated that these fishes were longer at collection than the majority of sparids. The average length of *S. ariakensis* was half of the maximum total length of adult fishes as reported in literature (Table 9.6), suggesting that these captured fishes were fast approaching maturity.

However, according to the 96/97 Port Survey Report, no fish fry productions are recorded in six of the sampling locations (Fa Peng, Penny's Bay, Discovery Bay, Peng Chau, Hei Ling Chau and Silvermine Bay). This implies that these areas do not have high density fish fry populations since fishermen do not prefer to go there for catching fish fry. Although the total fry(tails) production in Kau Yi Chau with an area of 1,620.87 ha was 22,983.87, the rank (fish fry production per ha area) of this fishing area was only 72 if comparing with the whole Hong Kong Waters. The total fish value (production per ha area) consisting of adult fish and fry was HK$3,949.61, and the corresponding rank of the production value was 63. Based on the comparison of CES survey results and AFD 96/97 Port Survey Report, these seven sampling locations selected from the CES survey study are not important nursery areas for fish fry.

From the result of AFD Port Survey 96/97, the total fry (tails) production in Ma Wan fishing area was 7,661.29. The rank (fish fry production per ha area) of this fishing area compared to other areas in Hong Kong was 68. However, the total fish value (production per ha area) including adult fish and fry was HK$10,672.14, for which the rank of the production value was 16. As described earlier under Section 9.4.1, the Ma Wan fishing area was ranked 48 out of 189 in terms of adult fish production per ha area. This showed that Ma Wan was a relatively high ranked fishing area with medium-to-high value adult fish among Hong Kong waters. The fry information of other fishing

areas (code 1, 2, 3, 4, 24, 34) surrounding the proposed Tang Lung Chau DGA are listed in Table 9.1. In addition, the total fish fry (tails) production in Ma Wan homeport (P009) was 91,935.48. The total fish value production (adult fish and fish fry) in this homeport was HK$16,793,467.73.

9.4.3 Ma Wan Fish Culture Zone

The Ma Wan fish culture zone is situated in three well sheltered areas on the north western coastline of Ma Wan. According to AFD data, the total area of cage nets in Ma Wan fish culture zone was estimated to be 11,000m^2. Bays on North Lantau to the west of the Kap Shui Mun channel are known to be nursery areas. Given the topography around Tang Lung Chau and parts of Ma Wan, it is also likely that some of these areas may provide shelter for juvenile fishes. Fish culture zone operators from Ma Wan collect some fry locally.

Table 9.1 : The fishery information of fishing areas surrounded by Tang Lung Chau DGA

Code	Name	Area (ha)	Total Production			Rank (Production/ha)			Vessels No.
			Adult fish (kg)	Fry (tails)	Value (HK$)	Adult fish	Fry	Value	
1	Fa Peng	296.50	12,383.64		492,411.02	131		118	48
2	Pa Tau Kwu	815.24	16,326.63		574,575.98	149		154	67
3	Penny's Bay	278.18	11,447.35		429,675.63	133		123	63
4	Discovery Bay	354.08	14,067.78		577,042.91	134		120	69
24	Tsing Chau Tsai	170.31	38,942.82	7,661.29	1,825,480.53	39	46	15	160
25	Ma Wan	418.82	81,988.08	7,661.29	4,469,689.80	48	68	16	254
34	Tsing Yi	1326.12	47,425.64		1,888,784.37	139		127	140

Table 9.2 : A list of fish species

Code	Family	Order	Species	English Name
ACETES	Sergestidae	Decapoda	Acetes spp.	Silver shrimp
ARGSPP	Sciaenidae	Perciformes	Argyrosomus spp.	Croaker
CHACRU	Portunidae	Decapoda	Charybdis cruciata	Red crab
CLUPUN	Clupeidae	Clupeiformes	Clupanodon punctatus	Gizzard shad
CYNSPP	Cynoglossidae	Pleuronectiforms	Cynoglossus spp.	Tongue sole
ILIELO	Clupeidae	Clupeiformes	Ilisha elongata	White herring
LATJAP	Serranidae	Perciformes	Lateolabrax japonicus	Sea bass/sea perch
LEIBRE	Leiognathidae	Perciformes	Leiognathus brevirostris	Pony fish
MCRAB		Decapoda	Mixed crab species	Crab
METAFF	Penaeidae	Decapoda	Metapenaeus affinis	Jinga shrimp
METJOY	Penaeidae	Decapoda	Metapenaeus joyneri	Prawn
MIXSPP				Mixed fish
MPRAWN	Penaeidae	Decapoda	Mixed prawn	Prawn
MURCIN	Muraenesocidae	Anguilliformes	Muraenosox cinereus	Conger pike eel
ORASPP	Squillidae	Stomatopoda	Oratosquilla spp.	Mantis shrimp
PLAIND	Platycephalidae	Scorpaeniformes	Platycephalus indicus	Flathead
PLEPIC	Haemulidae	Perciformes	Plectorhynchus pictus	Painted sweetlip
PORPEL	Portunidae	Decapoda	Portunus pelagicus	Blue crab
PORSAN	Portunidae	Decapoda	Portunus sanguinolentus	3-spot crab
PSECRO	Sciaenidae	Perciformes	Pseudosciaena crocea	Yellow croaker
SARJUS	Clupeidae	Clupeiformes	Sardinella Jussieu	Sardine
SEBMAR	Scorpaenidae	Scorpaeniforms	Sebasticus Marmoratus	Rockfish
SIGORA	Siganidae	Perciformes	Siganus oramin	Rabbitfish
SILSIH	Sillaginidae	Perciformes	Sillago spp.	Sand borer
TRYVAG	Gobiidae	Perciformes	Trypauchen vagina	

Table 9.3 : Top ten adult fish caught by fishing area

Code	Name	Ranked by Adult Fish Weight									
		1	2	3	4	5	6	7	8	9	10
1	Fa Peng	MURCIN	MIXSPP	SEBMAR	PLAIND	ORASPP	MPRAWN	CYNSPP	TRTVAG	ARGSPP	METJOY
2	Pa Tau Kwu	MIXSPP	PLAIND	ARGSPP	CYNSPP	ORASPP	MPRAWN	SEBMAR	PSECRO	ILIELO	TRYVAG
3	Penny's Bay	MIXSPP	ARGSPP	PROPEL	LEIBRE	SPARID	PSECRO	MCRAB	CLUPUN	PLEPIC	SEBMAR
4	Discovery Bay	MIXSPP	PORPEL	ARGSPP	LEIBRE	CHACRU	PORSAN	PLAIND	METAFF	SPARID	PSECRO
24	Tsing Chau Tsai	MIXSPP	SEBMAR	ARGSPP	MURCIN	SPARID	PSECRO	SIGORA	ILIELO	LATJAP	PLAIND
25	Ma Wan	SIGORA	SEBMAR	MIXSPP	ARGSPP	SPARID	CLUPUN	PSECRO	MURCIN	LATJAP	ILIELO
34	Tsing Yi	MIXSPP	ARGSPP	SIGORA	ACETES	MURCIN	PSECRO	SEBMAR	LEIBRE	PLAIND	SARJUS

Table 9.4 : Top ten adult fish caught by homeport

Code	Name	Ranked by Adult Fish Weight									
		1	2	3	4	5	6	7	8	9	10
P009	Ma Wan / Tsing Lung Tau / Yam O	MIXSPP	SEBMAR	ARGSPP	SIGORA	SPARID	PSECRO	LATJAP	PLEPIC	ILIELO	SILSIH

Table 9.5 : Breakdown of total catch statistics for fry at family and species level. Replaced synonyms (brackets) for some species are as follows: Acanthopagrus latus (Mylio latus); Sparus sarba (Rhabdosargus sarba); Pagrus major (Chrysophrys major). Text used for identification: The Fishes of The Japanese Archipelago (2 volumes; plates and text) edited by Masuda *et al*, Tokyo University Press, 1992; Taiwanese Fish Books (5 volumes in Chinese) and Fishes of Taiwan; symbol I, II and I&II means the first 6 month surveys, the extension survey and the 1 year whole survey respectively.

Family	Species	Abundance			Average Weight (g)			Average Standard Length (mm)		
		I	II	I&II	I	II	I&II	I	II	I&II
Sparidae	*Acanthopagrus latus*	99	2	101	0.15	22.6	0.56	19.3	75.8	20.4
	Pagrus major	32	6	38	11.2	32.3	14.6	67.9	91.3	71.6
	Evynnis cardinalis	58	-	58	4.82	-	4.82	47.2	-	47.2
	Sparus sarba	1	-	1	0.13	-	0.13	18.3	-	18.3
TOTAL		190	8	198						
Salangidae	*Salanx ariakensis*	27	-	27	0.64	-	0.64	67.1	-	67.1
Pomadasyidae	*Pomadasys maculatus*	-	2	2	-	4.7	4.7	-	53.9	53.9
Lutjanidae	*Lutjanus russelli*	-	1	1	-	6.23	6.23	-	57.1	57.1
Serranidae	*Epinephelus suillus*	-	1	1	-	1.09	1.09	-	36.9	36.9

Table 9.6 : Size Comparison (mm) of Fish Collected During Fish Fry Survey and Adult Fish Recorded in Literatures: The Fishes of The Japanese Archipelago (2 volumes; plates and text) edited by Masuda *et al*, Tokyo University Press, 1992 and Fishes of Taiwan edited by Shen, S.H., Press of Institute of Zoology, Academia Sinica, 1994.

Family	Species	Maximum Total Length - Literature	Average Standard Length - Fry Survey		
			I	II	I&II
Sparidae	*Acanthopagrus latus*	400	19.3	75.8	20.4
	Pagrus major	1000	67.9	91.3	71.6
	Evynnis cardinalis	205	47.2	-	47.2
	Sparus sarba	450	18.3	-	18.3
Salangidae	*Salanx ariakensis*	130	67.1	-	67.1
Pomadasyidae	*Pomadasys maculatus*	500	-	53.9	53.9
Lutjanidae	*Lutjanus russelli*	192	-	57.1	57.1
Serranidae	*Epinephelus suillus*	240	-	36.9	36.9

9.4.4 Benthic Communities

The comprehensive benthic community survey undertaken for the LAPH Study (December 1991 and June 1992) established grab sampling stations in the west-central waters and included one station near the proposed DGA. The results of the survey identified polychaetes as the dominant species group and noted that the infaunal benthic community in the area was generally represented by a single, large species assemblage. All species recorded in the survey area had been previously reported in Hong Kong and no environmentally sensitive or rare species were found.

9.4.5 Chinese White Dolphins (*Sousa chinensis*)

From the study of the Lantau Port Development in November 1995, dolphins were observed in the surveyed site on 2 of the 12 survey days. The results were different from the previous survey in October 1994 by Mott MacDonald. The incidence of dolphin sighting for that survey was 5 of the 21 surveys days, which was higher than that for the CES survey. The reason for the discrepancy may be due to the heavy rains in the Pearl Estuary during the Mott MacDonald survey, which probably caused the dolphins to move south. The Dolphin Research Group of SWIMS has postulated that decreasing salinity concentration in the marine water is correlated with the southward movement of dolphins, and thus more dolphins were observed in this area. This explanation could not be confirmed in this study. However, it was obvious that fewer dolphins were spotted at a similar time of the year. The low incidence of sightings and small number of individual dolphins indicated that dolphins did not substantially utilize this area as a habitat during the time of these two survey studies.

From the study "Dolphins in East Lantau Waters of Hong Kong – Assessment of Potential Effects of Lantau Port Development" prepared by Dr. Thomas Jefferson for CED in 1997, dolphins were sighted in the East Lantau study area in all four seasons of the year. Most sightings (57%) occurred in winter. Two sightings were made in spring, and four were made in summer months, but all of the latter were in the late summer season from late July to late August. The study estimated that about 22 dolphins occur in the East Lantau area in the autumn season, and about five in the winter. Dolphins did not normally appear to use the East Lantau area in spring or early summer months, although a few animals may use the area in late summer. Abundance and density were very low, compared to North Lantau. The highest East Lantau sighting rate (for autumn) was only 15% of the yearly average for North Lantau.

9.4.6 Intertidal Community

An intertidal habitat survey was carried out at Tang Lung Chau to describe the intertidal community inhabiting the area.

The surveyed shore on the eastern coast of Tang Lung Chau, where the 3 transects were placed, is composed of exposed granitic rocks, faces the prevailing winds and waves and is generally exposed. The strong wave action sends spray high up the shore and the flora and fauna have adapted to withstand the pounding of the waves. There were also some crevices containing some mud and sand in the bottom where other animals can shelter.

A total of 16 animal species were recorded during the rocky shore survey. Species identified and their abundance are given in Appendix E2. The Shannon diversity index (H) was found to be 1.82, while the Shannon equitability index (J) was found to be 0.66. The evenness of the intertidal community is not very high, because a few common species were dominant in abundance. These dominating species included *Nodilittorina trochoides, Nodilittorina vidua, Capitulum mitella, Cellana grata, Lunella coronata* and *Tetraclita* sp.

Two small herbivorous gastropods, *N. vidua* and *N. trochoides*, which are representatives of the littorine or periwinkle family, dominated the littoral fringe (upper shore). These are typical animals of the littoral fringe on many exposed rocky shores. The two gastropod species are very common, often found on rock surfaces well above mean high water mark where it appears to graze on terrestrial algae and lichens which normally grow in the spray zone. The large numbers of *N. vidua and N. trochoides* aggregating at this part of the shore explained the highest abundance of organisms recorded on the upper shore.

The eulittoral zone (middle shore), a broad stretch comprising most of the tidal shore, was covered by the sedentary animal, *Capitulum mitella*. This locally common species is normally found high on the shore, in bands wedged into crevices on exposed rocky shores. *N. vidua* also extended its range from the upper shore into the middle shore. In addition, another gastropod, *Lunella coronata*, was found in great abundance in this zone.

The lowest horizontal belt of the tidal shore, the sub-littoral fringe, is generally recognised from its algae. It was found that the percentage cover of algae increases with distance down the shore (see Appendix E3). In particular, great abundance of green algae comprising mostly *Ulva* sp. was recorded on the lower shore during the ecological survey. The blue-green alga *Kyrtuthrix maculans* was also noted inhabiting the lower and middle shores. The acorn barnacle, *Tetraclita* sp., was also widespread on the lower shore. This is the commonest and the first noticeable barnacle species found on exposed shores where wave action is violent. Lower down, amongst *Tetraclita*, lives the herbivorous limpet, *Cellana grata* which graze in the *Tetraclita* zone and is found very commonly on exposed rocky shores around Hong Kong. The carnivorous gastropod, *Thais spp.* was also observed on the lower shore. Their special habit is to feed upon barnacles or attached bivalves. Other molluscs of the algal zone on the lower shore included gastropods, namely *Monodonta labio* and *Lunella coronata*. Small mussels such as *Perna* sp. also settled here.

Sea anemones were found in small numbers in the rock pools on the lower and the middle shores. This animal type is commonly found in rock pools all around Hong Kong.

The vertical zonation pattern described above is typical of exposed rocky shores in Hong Kong (Morton, 1983). No rare or significant species were recorded in the survey. All the recorded species are common and widespread species of exposed rocky shores in Hong Kong.

9.5 Sensitive Receivers

There are four categories of sensitive receivers identified in this ecological impact assessment. The first group is the Ma Wan fish culture zone and fisheries resources. The Ma Wan fish culture zone is located in three sheltered areas to the northwest of Ma Wan island (Tam Shui Wan, Shek Tsai Wan and Kung Tsai Wan).

The second group of sensitive receivers is the Chinese White Dolphin (*Sousa chinensis*), which is protected under the Wild Animals Protection Ordinance, the Animals and Plants (Protection of Endangered Species) Ordinance and is listed in the IUCN Red List.

The third group of sensitive receivers is the beaches along the coastline of Ma Wan, southern North-West New Territories and Lantau. The closest one to the site is Tung Wan of Ma Wan, which is about one kilometre north of the proposed DGA.

The final sensitive receivers group is the intertidal habitat (or rocky shore habitat) which is situated along the south of Ma Wan, and the intertidal habitat of Tang Lung Chau. These rocky shore habitats are regarded as an important shelter for fisheries. Deterioration of this habitat may cause substantial ecological impact to the fisheries populations and fishing activities in this area.

9.6 Construction Phase Assessment

9.6.1 Potential Sources of Impact

Change of Hydrodynamics

The DGA breakwater configuration could alter the hydrodynamics which may affect the community structure of intertidal biota on Tang Lung Chau.

Impact on Water Quality

Dredging associated with the construction of the DGA may have local impacts on the marine ecosystem through changes in water quality at the DGA site. Dredging for the construction of the breakwaters will cause disturbance to marine biota in the surrounding area through dispersal of suspended sediments. Depending on the contamination level of the marine sediment, pollutants including heavy metals and nutrients, may be released. This may affect the food chain of the ecosystem in the vicinity and increase levels of organics which can cause de-oxygenation of local waters.

Resuspended sediment will cause an increase in suspended sediment (SS) concentrations in the water column and hence turbidity of the sea water. Indirect impacts may result as high SS concentrations can cause the smothering of filter feeders such as bivalves and clogging of gill filaments in fish and other organisms. One associated concern is the level of oxygen saturation within the water column as a number of effects produced by elevated SS levels combine to reduce dissolved oxygen (DO) concentrations. An increase in solids in the water column will reduce sunlight penetration, lowering the rate of photosynthesis of phytoplankton (primary productivity) and thus the rate at which oxygen is produced in the water column. Release of degradable organic matter into the water column would create an oxygen demand and could also locally lower DO concentrations.

It should be noted that the extent of impact on water quality in terms of the potential physical and chemical effects described above is related to the amount of material put into suspension. This is a function of the quantity and nature of the marine sediment, dispersion characteristics of the water receiving body at the site and dredging method employed.

The marine based construction activities also have the potential to cause water pollution from debris and refuse such as packaging and construction materials and spillages of fuel oil, diesel and solvents. Release of these potential pollutants into marine waters should thus not be permitted as introduction of polluted waters is likely to have detrimental effects on *Sousa chinensis* in this area. There may also be indirect effects on *Sousa chinensis* in terms of food availability, since fishing grounds would be adversely affected by poor water quality.

Loss of Habitat

Dredging for the construction of the breakwaters will result in a loss of approximately 335,800 m^2 of seabed habitat and thus inevitably remove or bury the associated benthic communities in the immediate work areas.

Underwater Construction Noise

Noise associated with the construction activities can have detrimental effects on *Sousa chinensis*.

9.6.2 Prediction and Evaluation of Impacts

The potential impacts of construction activity will mainly arise from the dredging works. As described in Section 9.6.1, sources of potential impacts include change of hydrodynamics, water quality deterioration, loss of habitat and underwater construction noise impact. The potential impacts upon the identified sensitive receivers are discussed below.

Subtidal Habitats

Dredging of marine sediment will result in the loss of approximately 335,800 m^2 of seabed and sublittoral habitats. This will cause a loss of the associated benthic communities in the immediate works area. Permanent losses of marine benthos will arise from the breakwater construction and from maintenance dredging requirements. The results of a benthic grab survey undertaken near the proposed DGA indicate the benthic community to be dominated by polychaetes. The community was found to be of a similar structure to others in Hong Kong and no rare or environmentally sensitive species were identified. Therefore the loss of benthos within the immediate area of dredging is not anticipated to result in significant adverse impacts. In addition, the benthos in the area to the south of Ma Wan are likely to be adapted to high suspended sediment concentrations as these waters will naturally be subject to higher sediment loadings as a result of the wet season Pearl River discharge. It is important that the recommended water quality mitigation measures are fully implemented during the dredging works, as detailed in Section 3.8, so as to reduce the amount of sediment resuspension.

Dredging works for the south-west breakwater may result in the release of heavy metals into the marine environment. (It should be noted that the marine sediments at the south-west breakwater were classified as Class C, seriously contaminated sediments, due to the exceedance of one heavy metal species only (i.e. copper) and that contaminated sediment was found at one depth interval only at the three vibrocore locations). As described in Section 3.6.2, however, adverse impacts on water quality arising from the release of heavy metals from the contaminated sediment are not anticipated during the dredging works. The impact upon marine biota through changes in water quality during the dredging works is therefore not anticipated to be significantly adverse and any impacts will be localized and short-term.

Fish Fry and Fisheries

Elevations in suspended sediment concentrations will also impact on mobile marine organisms, which will include commercial fish and shrimp fishing grounds, although the impacts are likely to be significantly less for free swimming species than sessile organisms. Impacts are likely to be localized and temporary.

As mentioned in Section 9.4.1 and Section 9.4.2, the results of the 96/97 Port Survey Study conducted by AFD show that the total adult fish and fry production were 81,988.08 kg and 7,661.29 tails respectively in the Ma Wan fishing area. Although the rank of fish fry production per ha area was low, the total fish value (production per ha area) including adult fish and fry was HK$10,672.14, for which the rank of the production value was 16. This showed that Ma Wan was a relatively high ranked fishing area with medium-to-high value adult fish among Hong Kong waters. The area is considered to have a certain value for the replenishment of "adult" populations targeted by the inshore fishery. The juvenile stage is the most vulnerable stage in the life cycle of a species. Any adverse impact on the juvenile stages of fish and shrimps may affect recruitment at population level and thus exert a long term adverse impact.

These fry are exploited by the fry fishery. Continual coastal development and pollution of the inshore waters will also add to the poor resource health through habitat degradation. This may be a prime factor causing the problems of the fry and adult fishery resources. Fish communities may be adversely affected by the dredging works by direct habitat loss, deposition of disturbed sediments and elevation of suspended solids. The resuspended sediment generated from the proposed construction works will cause an increase in SS concentrations in the water column and hence turbidity of the sea water. Indirect impacts may result as high SS concentrations can cause clogging of gill filaments in fish and other organisms. Smothering of filter feeders will indirectly pose threats to the fisheries by affecting the availability of food. Spawning and nursery grounds for commercial fish species will be disturbed during the construction phase of the Project. However, in view of other major developments in the study area, the extent of impact on fish communities from the relatively minor and short-term construction works for the DGA is anticipated to be relatively small in magnitude.

In a meeting with the Ma Wan fishermen held on 15 December 1997, the concern of high suspended solids levels from dredging clogging the gills of the fish in the fish culture zone was expressed. As described in Section 3.6.2, a maximum increase in SS concentrations of 4.5 mg/L above ambient levels is predicted for the dry season spring tide and up to 3.5 mg/L above ambient levels for the wet season neap tide. In terms of the WQO, the predicted increases in SS concentrations comply with the acceptable increase of 5.7 mg/L (depth-averaged value) and are well below the specific criterion for fish culture zones of 50 mg/L. However, to ensure that exceedances of the WQO do not occur, the mitigation measures recommended in Section 3.8 should be fully implemented to minimize the amount of sediment lost to suspension and thereby reduce impacts to the fish culture zone. With the implementation of the recommended measures, including the use of closed grab dredgers and the specification of an upper limit on the dredging rate, no adverse impacts from elevated SS concentrations are anticipated at the Ma Wan fish culture zone.

Chinese White Dolphin (Sousa chinensis)

Impacts from dredging on *Sousa chinensis* are not considered to be significant as the area does not comprise a core area for these species as revealed by the sighting records mentioned in Section 9.4.5.

Sousa chinensis as air breathing mammals will be less affected by high SS concentrations than fish. The significance of this potential impact would be dependent upon the size of the feeding range of the dolphin and the proportion of its range which would be affected by the construction works. Based on the AFD research study findings, [1] the feeding range of *Sousa chinensis* is believed to be large comprising estuarine areas west of Hong Kong, in Chinese waters.

The sighting records from AFD's *Sousa* research studies[1] show that the Dolphins' range extends to waters around Macau, which are subject to higher sediment loadings from the Pearl River. This suggests that *Sousa chinensis* may possibly be tolerant of naturally high background SS levels in the Pearl River Delta. Consequently, the potential dredging impacts on water quality could have less significant adverse impacts on *Sousa chinensis* based on its possible tolerance of silt laden waters. It is considered, however, that the potential exists for impacts to arise on *Sousa chinensis* through the associated indirect effects on food availability arising from sediment resuspension in the water column. High SS concentrations can cause the smothering of filter feeders such as bivalves and clogging of gill filaments in fish and other organisms. Thus there may be an indirect effect on *Sousa* in terms of food availability, since fish stocks and breeding grounds may be affected by a deterioration in water quality, resulting from the suspension of solids in the water column during

1 Population Biology of the Indo-Pacific Hump-backed Dolphin (*Sousa chinensis*) in Hong Kong Waters: Final Report. Jefferson, T.A., Submitted to the Agriculture & Fisheries Department under the Multi-disciplinary Research Program on the Indo-Pacific Hump-backed Dolphin Population, April 1998.

dredging. However, as impacts on water quality will be localized and short-term during the period of dredging works, it is not anticipated that *Sousa chinensis* will be adversely affected by a reduction in food availability.

Sound is transmitted very efficiently underwater and marine mammals rely chiefly on sound to communicate, sense food and understand their local environment. Thus, there has been a growing concern that as man-made facilities move offshore, noise associated with the operation and construction of these projects will negatively impact the lives and breeding of marine mammals.

As dolphins utilize echolocation to understand their local environment and locate food, and use sound to communicate and maintain stability in their social groups, increased noise levels due to marine based construction activities (generally below 1kHz) and vessel engines may interfere with such activities. In addition, long term exposure to high level noise may potentially lead to temporary or permanent reduction in hearing sensitivity. A precautionary measure would be to reduce the level of construction noise wherever practicable in order to minimize the potential scale, extent and severity of such noise impacts. Blasting of rock outcrops within the mooring anchorages will therefore not be carried out, thus significantly reducing the extent of noise disturbance on the dolphins. Since no major noisy construction activities will be required (such as blasting and marine piling), it is anticipated that the construction works are unlikely to have significant noise impacts on dolphins. Specific mitigation measures are therefore not required for noise attenuation during the construction works.

Intertidal Community

The proposed breakwater layout could potentially change the hydrodynamics of the area around the DGA. This may alter the coastal habitats in the immediate vicinity. In addition, the predicted elevations in SS concentrations during dredging works will affect sessile marine organisms near the area of dredging. However, effects from smothering are likely to be restricted to within the close vicinity of the dredger. Results from the intertidal habitat survey carried out at Tang Lung Chau indicate that species identified on the rocky shore in the Study Area are common intertidal species that might be expected for these types of habitats commonly found elsewhere in Hong Kong. No "rare species" or species of special scientific interest were found in these shore habitats. Therefore, the habitats and the associated biota are not of particular ecological importance. It is anticipated that the construction work will have minimal impacts upon the intertidal community.

Beaches along the coastline of Ma Wan, southern North-West New Territories and Lantau

The dredging works would result in slight increases in SS concentrations (less than 1 mg/L) at the beaches along the coastline of southern North-West New Territories and Lantau (Section 3.6.2). It is anticipated that such minimal elevations in sediment levels are unlikely to cause any adverse impacts on the associated biota.

As described in Section 3.6.2, the predicted maximum increase in SS concentrations at Tung Wan Tsai beach of 4.4 mg/L during the dredging works (with the adoption of the recommended additional mitigation measures) is well below the allowable increase under the WQO for SS at bottom water depth Thus, as no unacceptable impacts on water quality at Tung Wan Tsai beach are anticipated during these further mitigated dredging works, no resulting adverse impacts on the biota are anticipated.

9.7 Operational Phase Assessment

9.7.1 Potential Sources of Impact

During the operation of the DGA, the potential sources of impact upon marine ecology would be maintenance dredging, accidental fuel spillages or leakage of vessel fuel and vessel movements. These adverse impacts would result in direct and indirect impacts upon organisms and their habitats through changes in water quality.

However, the scale of maintenance dredging estimated to be required within the DGA is minor on comparison to the construction phase dredging, as described in Section 3.7.2. Impacts on marine biota during maintenance dredging would therefore be expected to be minimal and temporary. Nevertheless, spillage of vessel fuel could directly and indirectly impact upon the local marine and coastal ecology, including the fisheries around Ma Wan, Ma Wan fish culture zone and the Chinese White Dolphin (*Sousa chinensis*) through changes in water quality.

9.7.2 Prediction and Evaluation of Impact

Impact of Maintenance Dredging and Vessel Movement

Benthic communities

The maintenance dredging would result in the loss of benthic biota in the immediate works area (approximately 7,450 m^2 of seabed habitat will be lost). Some benthic species are sensitive to elevated suspended sediment concentations resulting from dredging. Loss of marine benthos can result from such habitat loss. However, as previously described, the benthic community was found to be very common in Hong Kong and no rare or environmentally sensitive species were identified. The loss of benthos within the immediate area of dredging is therefore not anticipated to result in significant adverse impacts. The recommended mitigation measures, as detailed in Section 3.8, will minimize the loss of sediment to the water column during maintenance dredging. This will further minimize the impacts on the benthos.

Fisheries

The movement of vessels to the DGA is unlikely to have direct impacts on free swimming biota. Thus, it is anticipated that the DGA will have minimal operational impact on the mobile marine biota around Ma Wan and Tang Lung Chau.

Fishing activities which may be interrupted during construction of the breakwaters will return to normal during operation. In addition, fish communities disturbed by the construction works are likely to return to the area. Due to the weak tidal currents within the DGA, sediment plumes generated during maintenance dredging will largely be contained by the breakwaters. Thus as adverse impacts on water quality are not anticipated in the vicinity of the DGA, no resulting adverse impacts on fish communities are anticipated.

Chinese White Dolphin (Sousa chinensis)

The movement of vessels to the DGA and maintenance dredging have the potential to result in direct and indirect impacts on *Sousa chinensis* through sediment resuspension, noise disturbance and physical harm potential.

Potential impacts associated with the disturbance of marine sediments are as given earlier in Section 9.7 for dredging activities during the construction phase. As described above, sediment plumes generated during maintenance dredging will largely be contained by the breakwaters and thus any resulting impacts on the dolphins are not anticipated to be significant. Dolphins may be exposed to increased noise disturbance resulting from vessel movements. Small boats may emit noise which are disturbing to dolphins due to the high frequency (>1000 Hz). Noise generated by vessels generally increases with a vessel's speed whether loaded or unloaded. The potential also exists for *Sousa chinensis* to be physically harmed from propellers and collisions with vessels. However, the infrequent sightings of dolphins in the vicinity of the DGA suggest minimal operational impacts from vessel movements and noise disturbance. Furthermore, the evaluation of the marine impact on vessel routes caused by the DGA relocation carried out in the Engineering Study[2] of the DGA concluded that the traffic generated by the TLCDGA is small. Thus, it is considered that there will be a low potential for the dolphins to be physically harmed from collisions with the vessels.

Impact of Fuel Spill

Fuel spillage can cause extensive adverse effects to marine ecology. The majority of ecological effects include physical and chemical changes in habitats, changes in growth, abnormal physiology and behaviour of individual organisms and species, toxicity and increase in mortality to organisms, and destruction or modification of entire ecological communities. Animals and plants would be affected by physical properties of floating fuel oil. This fuel oil surface prevents respiration, photosynthesis of phytoplankton, and feeding for marine organisms. Some marine mammals covered with fuel oil lose buoyancy and insulation. In addition, the ingestion of fuel oil is toxic to organisms, especially the water-soluble components of oil. The eggs and juvenile stages of organisms are more vulnerable. Moreover, emulsifiers, dispersants and surface-active agents used to remove oil are highly toxic and make membranes of organisms more permeable. Thus, these compounds enhance the penetration of toxic substances into organisms and can cause serious sublethal effects. The potential impacts of fuel spillage on the four groups of sensitive receivers identified, including Ma Wan fish culture zone and fisheries resources, Chinese White Dolphins, beaches and intertidal habitat, are summarized below:

Ma Wan Fish Culture Zone

Fuel spillage may cause direct harmful effects to fish as well as economic effects to fisheries resources. There is no definitive evidence, however, to show that oil pollution has significant impacts on natural fish populations. This is partly because fish can take avoiding action. When fish are placed in clean water, the hydrocarbon compounds from the oil disappear quickly. This indicates that fish have a metabolic capability for removing hydrocarbons. However, if oil has been emulsified or dispersed, it would coat the gills of fish and quickly kill them by suffocation. Moreover, contamination of fish may occur through bioaccumulation of dispersed or dissolved oil, or through physical contact with floating oil. Other adverse effects of fish to oil exposure include decrease in reproductive processes, inducing premature death through increased susceptible to predation or disease and also inducing carcinogenesis and mutagenesis.

Fish under oil exposure may acquire an objectionable, oily odour and flavour which is known as tainting. This results in serious economic loss to commercial fisheries because they lose their market value. These potential impacts are of particular concern at the TLCDGA due to its proximity to the Ma Wan fish culture zone. In addition, fishing equipments such as nets, traps, lines, fishing platforms

2 Tsuen Wan Bay Further Reclamation Area 35 Technical Report on Reprovisioning and Marine Impact of Dangerous Goods Anchorage at Tang Lung Chau Issue 2 September 1998 (Chapter 10).

and aquaculture cages may be contaminated with oil. Oiled equipment would need to be cleaned or replaced. Oil on the water may also affect the food supply to the fish culture zone.

As described in Section 4.6.2, the results of the fuel dispersion modelling indicate that the shortest time in which the fuel slick is shown to impact the Ma Wan fish culture zone (gazetted area at Kung Tsai Wan) is between 1 to 2 hours following a spill at the southern entrance of the DGA in the dry season. However, as discussed in Section 4.7, the event frequency of a fuel spill near the DGA is low and the frequency of a fuel slick reaching the fish culture zone in less than 2 hours is even lower. It is considered important that prompt response action be taken in the event of a major fuel spill near the southern entrance of the DGA so as to limit the spread of fuel at the source and to contain the slick. With the immediate implementation of the protocols and operational procedures defined in the Marine Department's Oil Pollution Contingency Plan (OPCP), it is anticipated that the potential for adverse environmental impacts would be kept to a minimum. The use of dispersants is not recommended at the Ma Wan fish culture zone in view of their toxic nature.

Chinese White Dolphin (Sousa chinensis)

Oil coatings may affect the normal swimming of dolphins and clog body openings. Dolphins rely on blubber and vascular constriction for controlling their body temperatures. Hence they are more resistant to the thermal effect of surface oiling (Doerffer, 1992). However, dolphins may inhale volatile fractions of petroleum hydrocarbons. Inhalation could cause mild irritation of mucous tissues, and prolonged inhalation of high vapour levels can result in death or damage to the nervous system. Dolphins may ingest floating or dispersed oil from the sea. They may also ingest petroleum hydrocarbons through feeding on fish which may have been contaminated by the oil. Short term ingestion of oil may not have serious effects. However, prolonged consumption may lead to organ damage or hormonal imbalances. Nevertheless, taking into consideration that the project site is not within a core area for dolphins, fuel spillage is unlikely to constitute a significant adverse impact on the dolphin population.

Beaches along the coastline of Ma Wan, southern North-West New Territories and Lantau

Fuel oil will generally accumulate on the sediment surface in the intertidal zone and further penetrate below the surface of beaches. The extent of penetration mostly depends on sediment grain size, the degree of waterlogging, the viscosity of the oil and the presence of burrows such as crab or worm burrows. Coarse sand allows more penetration than a beach comprising fine particles. Waterlogged sediment such as those in the lower intertidal zone allows less penetration than drier sediment. Light fuel oil penetrates easily, whereas viscous oil tends to remain on the surface. Oil may go down burrows and kill crabs or worms that live there. Furthermore, oil would also be buried by wind-blown sand. Oil which is near the surface or exposed to heavy wave action would not remain in the area for a long time. However, subsurface oil may persist for several years. After a period of time, it may be re-exposed during seasonal beach erosion and by wave action. Oiled sediment that is removed by wave action may be deposited offshore. This may affect sea-bed organisms.

In addition, the consequence of fuel spill on beaches along the coastline of Tsuen Wan and on Ma Wan could result in economic damage due to closure of the beaches in the event of fuel spillage. This would affect the coastal recreation businesses. As described in Section 4.6.2, the results of the fuel dispersion modelling for a spill near the northern entrance of the DGA indicate that the shortest time in which the slick is shown to impact the beaches on Ma Wan is within 1 hour following the initial spill in the dry season, and between 1 to 2 hours following the initial spill in the wet season. Impacts at the beaches along the southern coastline of the north-west New Territories occur first at around 7 hours after the initial spill in the wet season. The immediate implementation of the operational procedures defined in the Marine Department's OPCP will be required in the event of a major spill near the northern entrance of the DGA so as to minimize the potential for adverse

ecological impacts at the two beaches on Ma Wan.

Intertidal habitat

This habitat type is often colonized by many species of algae and invertebrate animals. The latter produces enormous numbers of eggs and larvae into nearshore waters. These eggs and larvae provide part of the food resource for juvenile fish. Algal debris also enters the food chain of nearshore water. Fish may feed directly on rocky shores at high tide and birds at low tide. When oil spill occurs, oil would cover the rocky shore and seriously affect ecological habitats there. As wave energy decreases, oil coating of the rocky shore would increase. The extent of oil adhered to the rocky shore depends on the slope of the shore, biological encrustations, tidal range and area of exposure. If wave energy increases, oil will return to the marine environment again and cause harmful effects to marine organisms.

Prompt response action will be required in the event of a major fuel spill near the northern and southern entrances of the TLCDGA so as to limit the spread of fuel at the source and thereby minimize the potential for adverse impacts on intertidal habitats. Provided that the protocols and operational procedures defined in the Marine Department's OPCP are implemented immediately, it is considered that the risk posed to the marine environment and ecological sensitive receivers would be minimized as far as possible.

It should be noted that if the fuel spill occurs within the DGA, the results of the fuel dispersion modelling indicate that the majority of the fuel slick is contained by the breakwaters and that only very small quantities of fuel can pass through the northern entrance of the DGA (Section 4.6.2). Therefore, provided that prompt response action is taken to limit the spread of fuel at the source and to contain the slick, it is considered unlikely that significant adverse impacts would result on ecological sensitive receivers.

9.8 Mitigation of Adverse Impacts

It is important to identify practical and cost-effective mitigation measures to minimize the scale, extent and severity of impacts caused by the construction and operation of the DGA. The following section gives recommendations on appropriate mitigation measures to be implemented during the construction and operation of the DGA to minimize impacts on the marine ecology, and to compensate for identified adverse effects.

Selection of Dredging Method and Equipment

Ecological impacts resulting from the dredging activities during construction and maintenance of the DGA can be effectively minimized provided the recommended mitigation measures, including the use of closed grabs for dredging, are included in construction contracts. The mitigation measures recommended to minimize sediment resuspension, as discussed in Section 3.8, shall be fully implemented. It is considered that with the employment of the recommended working methods and pollution avoidance measures, the potential for adverse impacts to arise on fisheries and *Sousa chinensis* through sediment resuspension and associated direct and indirect physical effects will be minimized. In addition, in the locations where sediment is found to be seriously contaminated, special care during dredging will be necessary so as to minimize the loss of pollutants either into solution or by resuspension. The special procedures for the avoidance of pollution during dredging of contaminated mud, as detailed in Section 3.8, shall be adopted.

Fuel Spill

Prompt response action will be required in the event of a major fuel spill near the northern and southern entrances of the TLCDGA so as to limit the spread of fuel at the source and thereby minimize the potential for adverse environmental impacts at the two beaches on eastern Ma Wan and at the Ma Wan fish culture zone. The immediate implementation of the Marine Department's Oil Pollution Contingency Plan would ensure impacts upon the marine environment and ecologically sensitive receivers would be minimized as far as possible. Furthermore, the use of chemical dispersants should be avoided in the vicinity of fish culture zones due to their toxic effects on marine life. Physical means to combat fuel oil pollution, for example the use of oil booms, are therefore recommended to be used in such areas. Anti-oil pollution equipment is available at gazetted bathing beaches and appropriate action should be taken by RSD in accordance with the OPCP in the event of a fuel spill.

Provision of New Habitat by the Breakwater

In the long term, after construction is complete, areas no longer subject to disturbance are likely to be recolonised by benthic fauna with similar communities developing in areas where substratum type is maintained. The breakwaters can also function as habitat enhancing devices by providing a surface area of 314,000 m^2. These habitats can serve as suitable hard substrates similar to artificial reefs for the colonisation and establishment of intertidal and subtidal faunal assemblages.

Waste Generation Control Measures

It is important that practices are employed to ensure that waste arisings do not enter surrounding marine waters in order to minimize impacts on *Sousa chinensis* and fishing grounds in the area. It is anticipated that with the appropriate handling, storage and removal of waste arisings during the construction period, the potential to result in detrimental effects on marine ecology will be minimized. Pollution control measures with respect to waste management are detailed in Section 7.8.

9.9 Definition and Evaluation of Residual Impacts

With the implementation of the recommended mitigation measures described above, it is anticipated that the residual ecological impacts would comprise a temporary minimal disturbance to the marine ecology resulting from the construction of the DGA and a permanent loss of 335,800 m^2 of subtidal habitat. These residual impacts are considered acceptable and in compliance with the relevant stipulated evaluation criteria.

It is considered that no adverse environmental effects will result from the employment of the recommended ecological mitigation measures for the construction and operational phases of the DGA. In the event of fuel spillage, the use of chemical dispersants is not recommended at the Ma Wan fish culture zone in view of their potential adverse ecological effects. Physical means to combat fuel oil pollution, for example the use of oil booms, are therefore preferred to the use of dispersants in the vicinity of fish culture zones.

9.10 Conclusions

The results of the marine ecological study indicate that the fish community of the Ma Wan area is of both ecological and fisheries interest. The area may serve as a medium-to-high important fishing area for adult fish in Hong Kong. The protected *Sousa chinensis* is also occasionally spotted in the area.

The sensitive ecological receivers identified are:

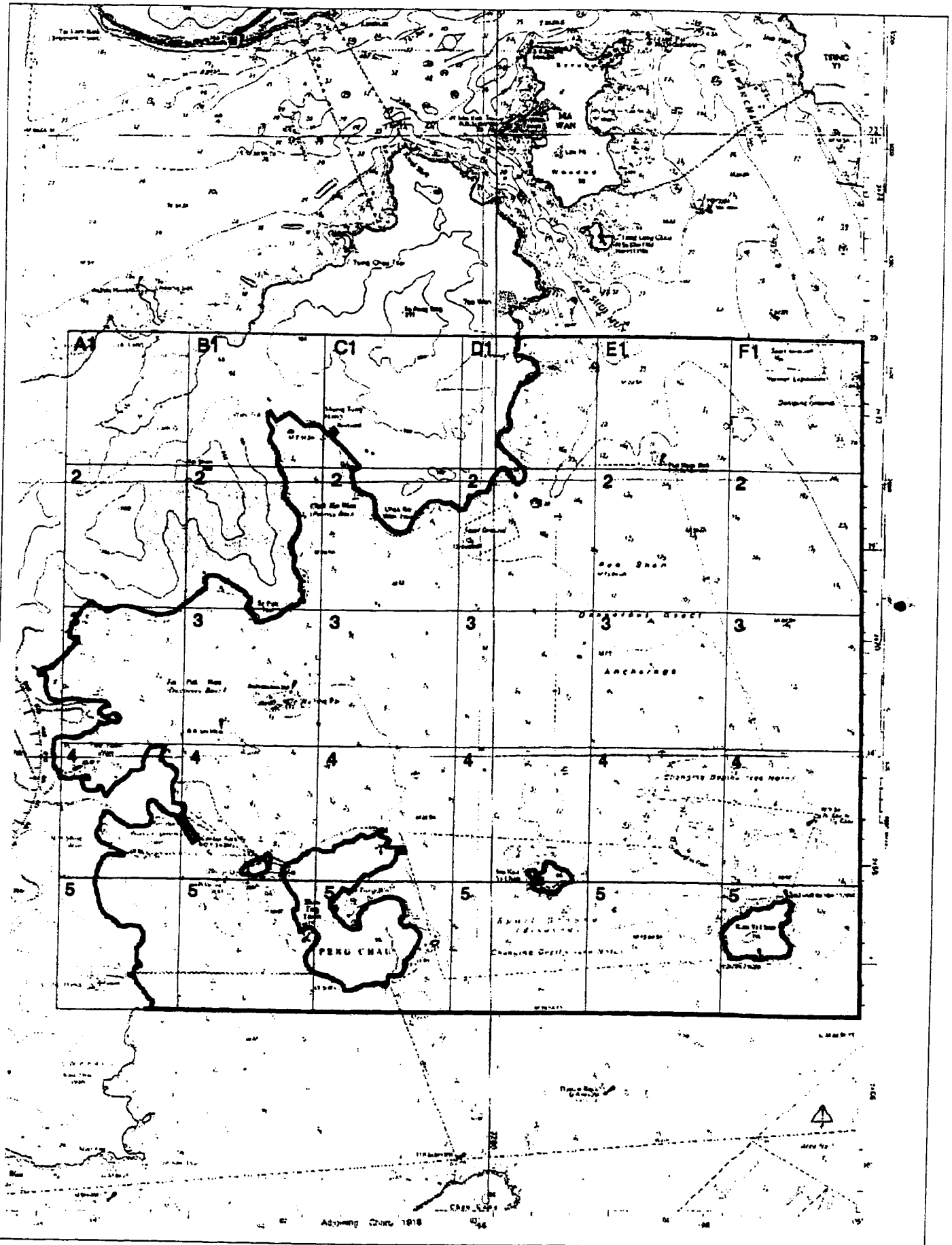
- the Ma Wan fish culture zone;
- the fishery resources in the vicinity;
- beaches along the coastline of Ma Wan, southern North-West New Territories and Lantau;
- intertidal organisms on Tang Lung Chau; and
- Chinese White Dolphins (*Sousa chinensis)* which may be present in the area.

Dredging activities during the construction phase of the DGA are likely to locally increase the turbidity of water, smother or disturb sensitive species and modify the bottom substratum, and hence potentially affect the sensitive receivers described above. The sediment plume modelling simulations, undertaken to simulate the fate of sediment lost to suspension during dredging, predicted an elevation of suspended solids levels which are in compliance with the WQO at the Ma Wan fish culture zone. Therefore, minimal impacts on the marine and coastal ecology are anticipated. The predicted impacts are considered acceptable in accordance with the evaluation criteria described in Section 9.3.3. It is considered that the loss of suspended solids to the marine environment and the resulting impacts on ecological sensitive receivers can be minimized, provided that the recommended mitigation measures for dredging works are fully implemented.

The dredging works can cause a permanent residual loss of approximately 335,800 m^2 of subtidal habitat. However, the breakwaters to be constructed can function as habitat enhancing devices by providing a surface area of 314,000 m^2. These habitats can serve as suitable hard substrates similar to artificial reefs for the colonisation and establishment of intertidal and subtidal faunal assemblages.

In the event of a major fuel spill near the entrances of the proposed DGA, the identified sensitive receptors may be adversely affected. However, as described in Section 4.7, the event frequency of a fuel spill near the DGA is low and the frequency of a fuel slick reaching the fish culture zone in less than 2 hours is even lower. Immediate action will be required in the event of a major fuel spill near the southern entrance of the TLCDGA so as to minimize the potential for adverse environmental impacts at the Ma Wan fish culture zone. The immediate implementation of the protocols and operational procedures defined in the MD's Oil Pollution Contingency Plan would ensure impacts upon the marine environment and ecological sensitive receivers would be minimized as far as possible.

Impacts from dredging on *Sousa chinensis* are not considered to be significant as the area does not comprise a core area for these species as revealed by the sighting records. Potential impacts to the dolphin are primarily indirect including effects on food availability arising from sediment resuspension in the water column, and less significant direct impacts from noise disturbance and physical harm potential from vessel movements. Practicable efforts should be taken to minimize potential impacts on dolphins arising from the construction works. It is considered that the full and strict implementation of the recommended water quality mitigation measures, such as working methods and pollution avoidance measures for dredging, as well as appropriate handling, removal and disposal of waste arisings during the construction period, is likely to minimize the potential for both direct and indirect impacts on dolphins from the DGA construction and operation.

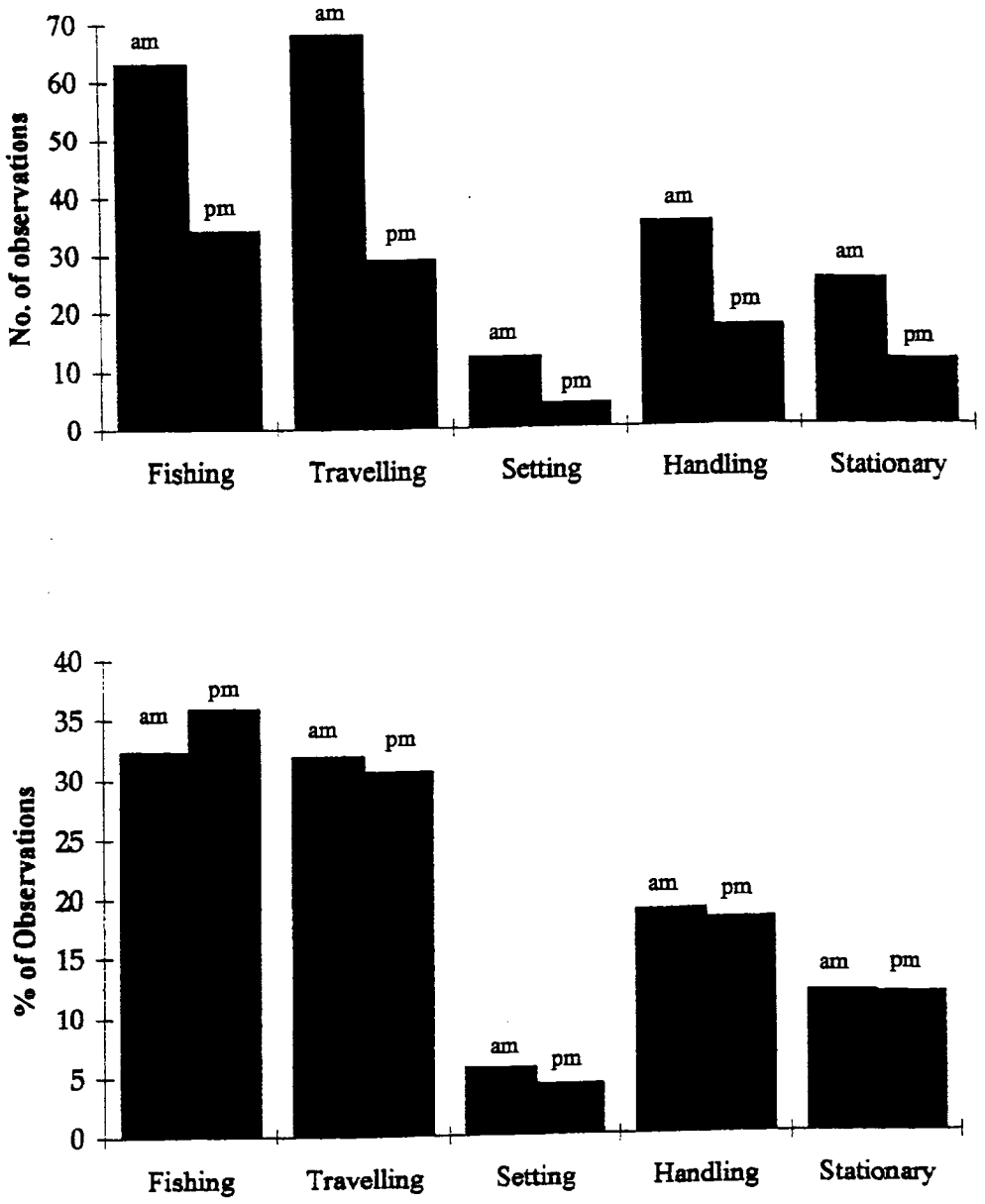


THE LOCATION OF CES SURVEY STUDY AREA

FIGURE 9.1

SCALE not to scale

C510

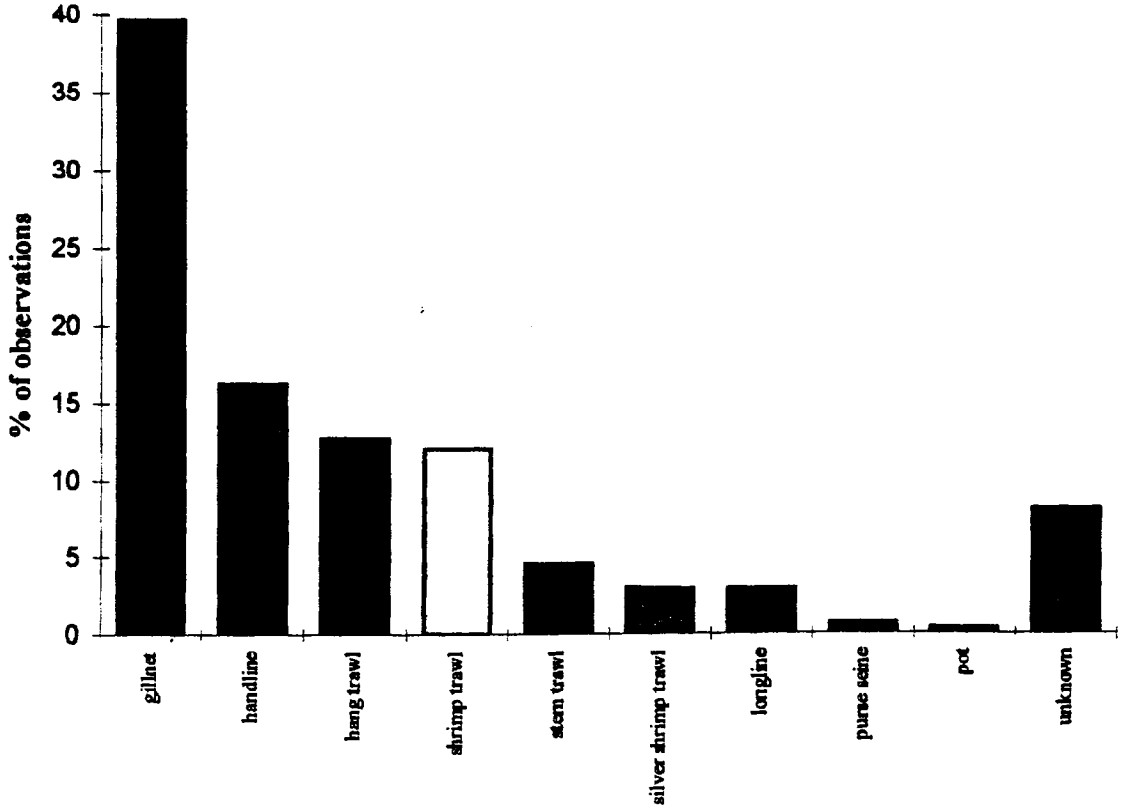


COMPARISON ACROSS ACTIVITY CATEGORIES FOR MORNING AND AFTERNOON OBSERVATION PERIODS (BY TOTAL NUMBER AND BY PROPORTION)

FIGURE 9.2

SCALE not to scale

C510

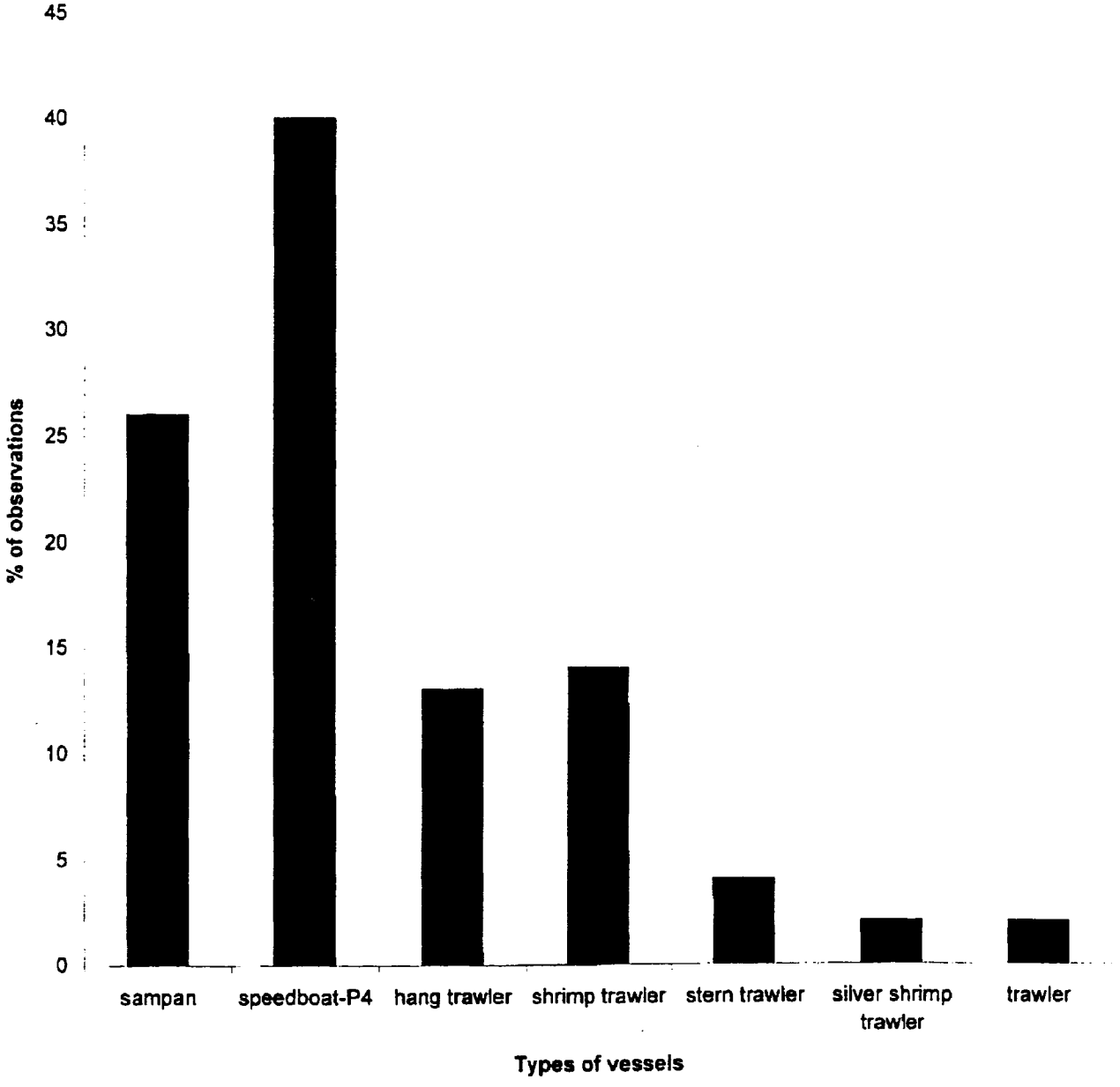


BREAKDOWN OF FISHING GEAR TYPES
OBSERVED IN THE AREA

FIGURE 9.3

SCALE not to scale

C510

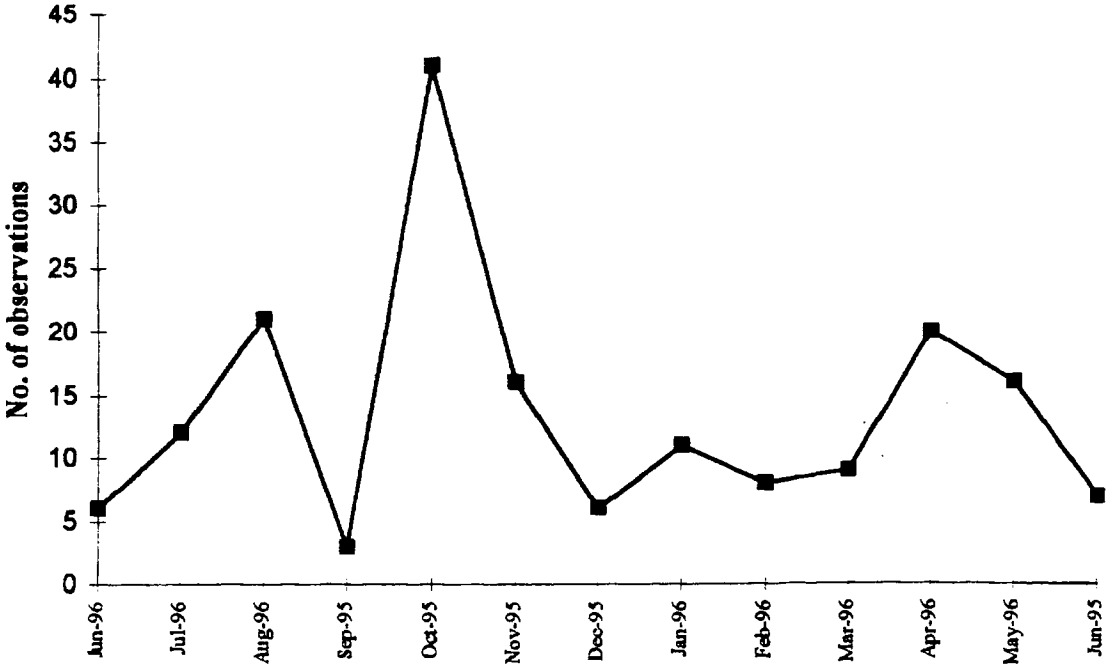


BREAKDOWN OF FISHING VESSELS OBSERVED IN THE AREA

FIGURE 9.4

SCALE not to scale

C510

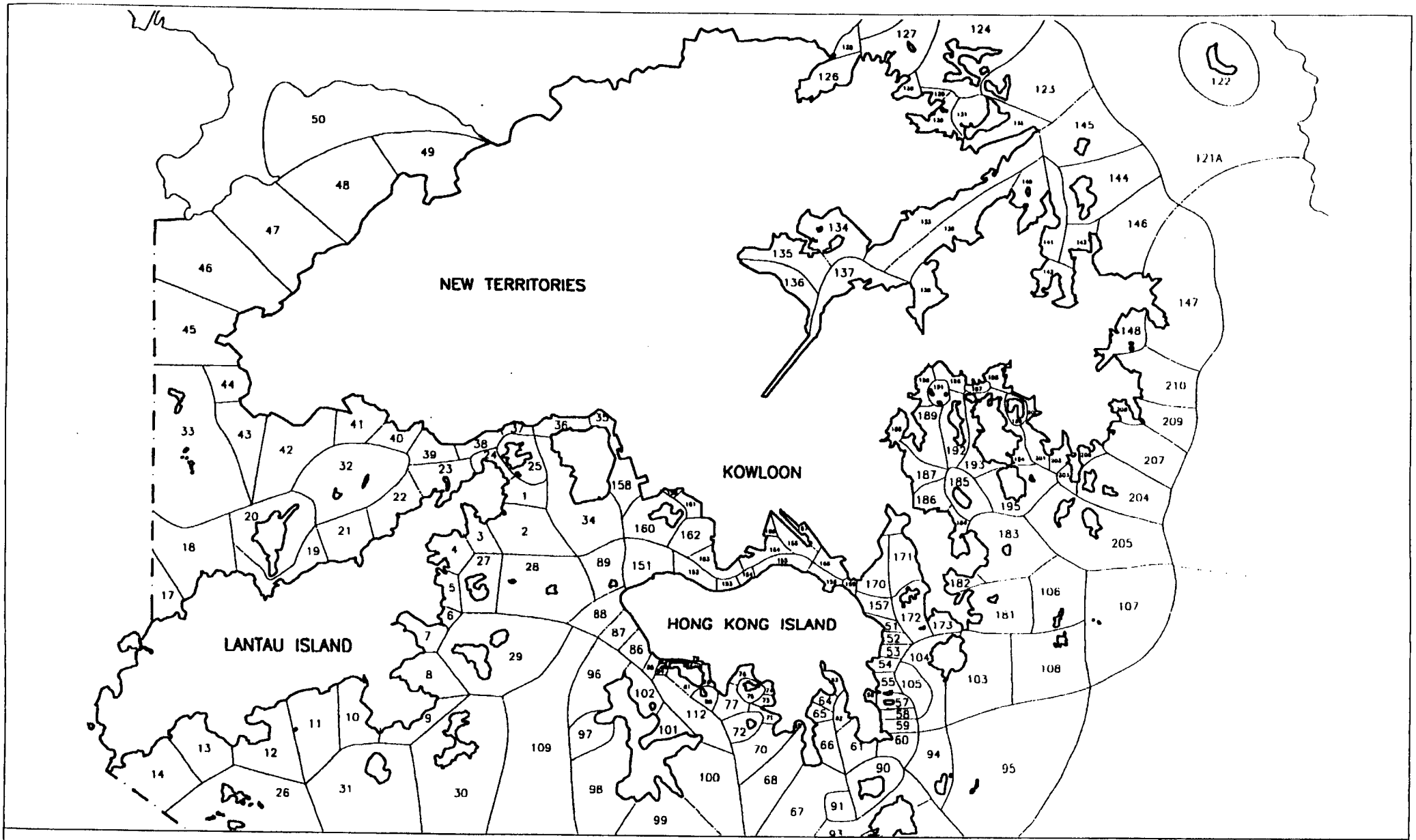


MONTHLY TRENDS IN TOTAL FISHING ACTIVITY

FIGURE 9.5

SCALE n/a

C510



DISTRIBUTION OF FISHING AREA IN HONG KONG WATERS

FIGURE 9.7

SCALE not to scale

C510