12. FISHERIES

12.1 Introduction

12.1.1 This section of the EIA presents details of the assessment of the potential impacts to fisheries resources within the study area and describes the sensitive receivers present, potential impacts from the project and recommends suitable mitigation measures. In order to achieve the aforementioned measures, the major objectives of the assessment are as follows:

- description of the physical environmental background;
- description and quantification as far as possible of the existing fisheries activities;
- identification of parameters and area that are important to fisheries;
- identification and quantification as far as possible of any direct or indirect and on-site or off-site impacts to fisheries; and
- proposals for any practicable alternatives or mitigation measures to prevent or minimise adverse impacts on fisheries.

12.2 Relevant Legislation and Assessment Criteria

12.2.1 Relevant legislation applicable to this Study includes:

- the Marine Fish Culture Ordinance (Cap. 353) 1983 which regulates and protects marine fish culture zones (FCZ) that are designated under the ordinance. It is a criminal offence to discharge polluting substances into an FCZ;

- the Fisheries Protection Ordinance (Cap. 171) 1987 which regulates fishing activities for the conservation of fisheries resources and other marine life; and

- reference was also made to Annexes 9 and 17 of the Technical Memorandum EIAO (Cap. 499) 1997 in order to determine the potential impacts to fisheries resources in the Study Area. The criteria include the following:

  - to prevent any significant impacts to sensitive fisheries areas particularly the nursery and spawning grounds of commercially important species of fish, crustaceans, molluscs and other marine life;
  - to prevent significant loss or interference with the use of fishing grounds and FCZ's; and
  - to prevent significant impacts to local fishery resources and fishing activities.

12.2.2 A review of relevant EIA's and reports has also been conducted in order to assist the assessment criteria. These reports include the following:

- New Airport Master Plan (Greiner-Maunsell, 1991);
- Feasibility Study & Environmental Impact Assessment for Aviation Fuel Pipeline (Montgomery Watson, 1996);
- Feasibility Study for Additional Cross-border Links Stage 2 (Mouchel, 1998);
- EIA for the Proposed Sand Extraction from The Brothers' Marine Borrow Area (Hyder Consulting, 1998);

- EIA Study for Disposal of Contaminated Mud in the East Sha Chau Marine Borrow Pit (ERM, 1997, 2005);
- EA Study for Backfilling of Marine Borrow Pits at North of the Brothers (Mouchel, 2002);
- Route 10 North Lantau to Yuen Long Highway Investigation and Preliminary Design EIA (Mott Connell, 1999);
- Hong Kong- Zhuhai- Macao Bridge: Hong Kong Section and the North Lantau Highway Connection: Ecological Baseline Survey (Mouchel, 2004); and
- Port Survey 96/97 and Port Survey 2001/2002, Fisheries Management Division, AFCD (AFCD, 1998, 2003).

12.2.3 Reports from the ongoing environmental monitoring and audit at the contaminated mud pits at East of Sha Chau (Mouchel, 2001a, 2005b; Meinhardt, 2006b) also provide a large amount of relevant fisheries data and have also been reviewed. The fisheries data provided in the aforementioned EM&A study provides the most up to date information on the fisheries resources of the study area.

12.3 Baseline Conditions

12.3.1 *Description of Physical Habitat*

12.3.1.1 A detailed description of the physical marine habitat is presented in Section 7.4.2 and the key aspects are summarised below. The PAFF is located within the western waters of Hong Kong that are highly influenced by the variable estuarine conditions of the Pearl River Delta and a well-scoured tidal channel running east-west (the Urmston Road). Thus, the seabed in the area is predominantly made up of soft muds, although the scouring of the tidal channel along the Urmston Road provides some coarser habitat containing muddy shelly sand. The benthic habitat in the study area is, therefore, highly sediment laden, both in suspension and on the seabed, and existing fauna are dominated by representatives that tolerate these high ambient loads (see Section 7.4). The soft-bottom sediments characteristic of the study area are predicted to be moderately contaminated in places (see Section 6.2.5). In terms of water quality, the Pearl River outputs significant nutrient loading resulting in generally eutrophic conditions (Section 6.2.4) and the predominantly estuarine fish inhabiting the study area are, therefore, already subjected to certain environmental stresses (notably relatively high suspended solid concentrations).

12.3.2 *Capture Fisheries*

12.3.2.1 Recent information on the capture fisheries is summarised in the Port Survey 96/97 (AFCD, 1998) and in the Report on Fisheries Resources and Fishing Operations in Hong Kong Waters (ERM, 1998). The PAFF pipeline and berthing jetty passes interfaces with two fishing areas, namely, the Tap Shek Kok and Lung Kwu Sha Chau fishing areas, as identified in the Port Survey 96/97 Report. The proposed 4.8km twin subsea pipeline is located approximately equally in each fishing area. The two fishing areas within the PAFF study area are significantly different in size and comprised the following:

- Area 33 - Lung Kwu Sha Chau comprising an area of 3,616.46 ha; and

- Area 43 – Tap Shek Kok comprising an area of 822.57 ha.

12.3.2.2 The total value and ranking of the fisheries resources in each of these fishing areas that lie within the study area are presented below in Table 12.1. The Lung Kwu Sha Chau fishing area is of reasonably high value and ranks quite highly in terms of adult fished biomass and overall value per hectare on a Hong Kong wide basis. The fishing area at Tap Shek Kok is ranked lower and in terms of adult fish production is ranked 105 out of 189 fishing areas in Hong Kong.

Table 12.1 Fisheries Production in Each Fishing Area (all fishing vessels)

Fishing Area (ha)	Total Production			Production (ha^{-1})			Rank Production (ha^{-1})		
	Adult Fish (kg)	Fry (tails)	Value (HK$)	Adult Fish (kg)	Fry (tails)	Value (HK$)	Adult Fish	Fry	Value
Lung Kwu Sha Chau 3,616.46	651,700.0	-	11,828,364.8	180.2	-	3,270.71	53	-	82
Tap Shek Kok 822.57	66,218.3	-	1,958,466.6	80.5	-	2,380.9	105	-	98

Note: Based on the 189 fishing areas in Hong Kong waters (AFCD, 1998).

12.3.2.3 The two fishing areas are subunits of a wider sector area that occupies the sea around North of Lantau. It is conceivable that impacts from the dredging operations could reach these wider regional areas and so a summary of the fishery for the region is included here. Thus, in terms of production by hectare the region ranks quite highly (4th out of 12 sectors) and is relatively valuable, however, the fry fishery is not nearly so productive (ranked 9 out of 12).

12.3.2.4 Apart from a category labelled as mixed fish, the AFCD Port Survey 96/97 identifies the top four species caught in the region as scad (*Caranx kalla*), gizzard shad (*Clupanodon punctatus*), sardine (*Sardinella jussieu*) and croaker (*Argyrosomus* spp.). These fish catches reflect the operations in the area, which are dominated by larger fishing vessels and notably hang trawlers fishing pelagic species. On a smaller scale, mixed fish species were also the most abundant fisheries resource in each of the fishing areas, followed by shrimp scad, gizzard shad and sardine (Lung Kwu Sha Chau) and gizzard shad, lionhead and croaker (Tap Shek Kok). A summary of the top ten adult fisheries resources caught in each fishing area is presented below in Table 12.2.

Table 12.2 Most Abundant Adult Fisheries Resources from the Study Area (by Biomass)

Rank by Biomass	Fishing Area	
	Lung Kwu Sha Chau	Tap Shek Kok
1	Mixed Species	Mixed Species
2	*Caranx kalla* (shrimp scad)	*ClupanodonPunctatus*(gizzard shad)
3	*Clupanodon Punctatus* (gizzard shad)	*Collichthys lucida* (lionhead)
4	*Sardinella jussieu* (sardine)	*Argyrosomus* spp. (croaker)
5	*Trichiurus haumela* (hairtail)	*Mugil affinis* (mullet)

Rank by Biomass	Fishing Area	
	Lung Kwu Sha Chau	Tap Shek Kok
6	*Mugil affinis* (mullet)	*Caranx kalla* (shrimp scad)
7	*Argyrosomus* spp. (croaker)	*Acetes* spp. (silver shrimp)
8	*Collichthys lucida* (lionhead)	*Platycephalus indicus* (flathead)
9	*Decapterus lajang* (scad)	*Ilisha elongata*(white herring)
10	*Stolephorus* spp. (anchovy)	*Eleutheronema tetradactylus* (threadfin)

Note: Mixed species is mixed fish considered of lower commercial value. Source: Based on Port Survey 96/87.

12.3.2.5 The more recent Port Survey 2001/2002 (AFCD, 2003) present the survey results in density grid, as shown in Figure 12.1, instead of fishing areas. With respect to Figure 12.1, essentially only cells B5 (Sha Chau) and C4 (Tak Shek Kok) would be affected by the proposed dredging works. The patterns revealed in Port Survey 2001/2002 were essentially the same as Port Survey 96/97 and in generally the Sha Chau area was more productive and the products were also more valuable compared to Tap Shek Kok. Although there were more small boats (<15m) operating in the two areas than the large vessel (>15m), the production of the small boat was low and ranked the second lowest across Hong Kong waters. Thus, impacts from the dredging operations to small boat operators are likely to be localised around the study area and are not likely to range wider. As the area is not the major operating area for the large trawling vessels (>15m), impacts to them would also be limited. The results of the Port Survey 2001/2002 are summarised in Table 12.3 below:

Table 12.3 Catch Statistics of Sha Chau and Tap Shek Kok, Port Survey 2001/2002

Cell[1](Area)	B5 (Sha Chau)	Rank[2]	C4 (Tap Shek Kok)	Rank[2]
No. of Vessels	100-400	3/6	100-400	3/6
Small Boat <15m)	100-400	3/6	100-400	3/6
Large Vessel (>15m)	50-100	4/6	10-50	5/6
Total Adult Fish Production	200-400 kg/ha	3/6	50-100	5/6
	5,000-10,000 $/kg	2/6	1,000 - 2,000 $/kg	4/6
By small boat (<15m)	50-100 kg/ha	5/6	0-50 kg /ha	5/6
By large vessel (>15m)	100-200 kg/ha	3/6	0-50 kg/ ha	6/6
Fry production	-	-	-	-
Main Catch	shrimp: 20-40 kg/ha	3/6	shrimp: 5-10 kg/ha	5/6
	sciaenidae: 20-40 kg/ha	3/6	Clupeidae: 5-10 kg/ha	5/6
			Siganidae: 5-10 kg/ha	5/6

Note: [1]Cell number refers to grid in Figure 12.1; [2]A scale of 1-6 was used in Port Survey 2001/2002 and the 1st is the highest rank.

12.3.2.6 Trawling is conducted as part of the ongoing EM&A programme for the contaminated mud pits in locations near the study area at sites around Lung Kwu Chau, off the airport and around the mud pits. The trawling locations are presented in Figure 12.2. The most recent fisheries data covering both the dry (January-February 2005; Mouchel, 2005b) and wet (October 2005; Meinhardt, 2006b) seasons from the Northwestern waters.

12.3.2.7 The January-February 2005 dry season survey recorded a total of 177 different species. Of these faunal groups, bivalves, crabs, fish, gastropods, shrimps (including mantis shrimp) and prawns were the most abundant. The gastropods were numerically

dominant and 3,163 individuals were trawled in January-February 2005. Crabs were the second most dominant species and 2,085 individuals were recorded in the dry season, although it should be noted that not all these crabs and gastropods are commercial species. Fish were also abundant and 2,638 individuals were recorded in the dry season and were the most diverse group represented by 66 different species. In terms of numerical dominance, the most common fish recorded were the croaker (*Johnius macrorhynus*), the gobies (*Trypauchen vagina*), Saddleback silver-biddy (*Gerres lucidus* (=*limbatus*)) and mullet (*Valamugil formosae*). The commercially important mantis shrimps (mostly Oratosquilla interrupta) and prawns (*Metapenaeus* spp. and *Penaeus* spp.) were also numerically abundant components of the trawls. The commercially important species (cephalopds, crabs, mantis shrimp, shrimp and fish) trawled from locations around Sha Chau during the January-February 2005 dry season are presented below in Table 12.4.

Table 12.4 Species Composition and Abundance of Individuals (Total Counts) from Trawling in Dry Season (January-February 2005)

Group	Species	FS1	FS2	FS3	FS4	FS5	FS6	Total
Cephalopod	*Loligo* sp.		2	7	3	4	5	21
	Octopus sp.			3		1	2	6
	Sepiella japonica						1	1
	Sepiella sp.			1	2		1	4
Cephalopod Total			**2**	**11**	**5**	**5**	**9**	**32**
Crab	*Charybdis acuta*	13		3		11	12	39
	Charybdis affinis	1	4	3		19	12	39
	Charybdis anisodon					1		1
	Charybdis cruciata	5	2	7	1	16	14	45
	Charybdis hellerii		3			4		7
	Charybdis japonica	111	151	85	50	510	222	1,129
	Charybdis truncata		7	7	1	9	21	45
	Charybdis variegata	5	9		3	2	12	31
	Clibanarius sp.	1	8	24	27	34	39	133
	Diogenes sp.		11		3	41		55
	Doclea ovis		2					2
	Dorippe polita		1					1
	Eriochier sp.	1						1
	Ethusa indica	4	1	14	19	6	10	54
	Eucrate costata	14	28	3	2	30	5	82
	Eucrate crenata	3	6		2	7	1	19
	Galene bispinosa	7		4	3	1		15
	Goniohellenus vadorum		11	40	35		3	89
	Leucosia vittata		6			3	21	30
	Macrophthalmus japonicus				1		1	2
	Macrophthalmus latreillei		1					1
	Platylambrus validus		4	9	9	4	50	76
	Portunus hastatoides		2	5	3	9	4	23
	Portunus pelagicus					9	14	23
	Procelain crab		2	1	2	28	91	124
	Scalopidia spinosipes						1	1
	Thalamita sima			2		2	2	6

Group	Species	FS1	FS2	FS3	FS4	FS5	FS6	Total
	Typhlocarcinops denticarpes			1				1
	Typhlocarcinus nudus	5	4					9
	Typhlocarcinus villosus	1			1			2
Crab Total		**171**	**263**	**208**	**162**	**746**	**535**	**2,085**
Fish	*Acentrogobius caninus*	5	3	14	11	83	25	141
	Ambassis gymnocephalus	23						23
	Amblychaeturichthys hexanema	6	10	1	2	3		22
	Apogon kiensis					2		2
	Apogon lineatus						1	1
	Apogon pseudotaeniatus		1					1
	Arnoglossus tenuis			1	1	9	5	16
	Chaeturichthys stigmatias	15	25	4	5	1		50
	Chrysochir aureus			1				1
	Coilia grayii	9	27	2			1	39
	Collichthys lucidus	2	8	2		6	1	19
	Cryptocentrus filifer					20	1	21
	Cynoglossus arel	20	15	6	5	47	26	119
	Cynoglossus gracilis						1	1
	Cynoglossus itinus						1	1
	Cynoglossus joyneri	21	18	13	7	10	1	70
	Cynoglossus puncticeps		2			2	2	6
	Cynoglossus semilaevis	10	6	1		8	6	31
	Dasyatis bennettii						4	4
	Dasyatis zugei			1				1
	Dendrophysa russelii	17	26	15	29	12	19	118
	Epinephelus bruneus					1		1
	Gerres lucidus			7	10	20	145	182
	Gymnothorax reevesii					1		1
	Ilisha elongata	2	5					7
	Inegocia japonica					4	3	7
	Inimicus japonicus					1	2	3
	Johnius belangerii	1	11	1		2	15	30
	Johnius macrorhynus	12	15	134	59	86	222	528
	Larimichthys polyactis			2				2
	Lateolabrax japonicus		1				1	2
	Leiognathus brevirostris	1	1	1	1	8	38	50
	Liza affinis				1			1
	Muraenesox cinereus		1		1	1		3
	Nemipterus japonicus			1	1	1		3
	Ophichthus celebicus					1		1
	Otolithes ruber			4	3	1	2	10
	Oxyurichthys tentacularis	4		8	13	7	3	35
	Parachaeturichthys polynema	8	50	4	3	13	2	80
	Pennahia argentata			1	2	3	2	8
	Pisodonophis cancrivorus					1		1
	Platycephalus indicus	4	4	16	14	23	24	85
	Plotosus lineatus			1			1	2
	Polydactylus sextarius		1	5	15	5	5	31
	Prionobutis koilomatodon						1	1
	Pseudorhombus arsius			1			1	2

Group	Species	FS1	FS2	FS3	FS4	FS5	FS6	Total
	Saurida elongata				2			2
	Scatophagus argus						4	4
	Sebastiscus albofasciatus						1	1
	Sebastiscus marmoratus						1	1
	Siganus canaliculatus		1	2			5	8
	Sillago sihama	1			1	9	27	38
	Solea ovata		3	3	2	43	68	119
	Syngnathus schlegeli	3	3	5	6	3		20
	Takifugu niphobles				1			1
	Takifugu oblongus						3	3
	Takifugu poecilonotus						1	1
	Takifugu xanthopterus						1	1
	Thryssa chefuensis						1	1
	Thryssa hamiltonii		4	3		10	2	19
	Trachycephalus uranoscopa	1	1	3	2	18	43	68
	Trichiurus lepturus	1					1	2
	Trypauchen vagina	155	122	10	20	66	54	427
	Uroconger lepturus			1	2			3
	Valamugil formosae			50	77	5	20	152
	Zebrias zebra	3	1					4
Fish Total		**324**	**365**	**324**	**296**	**536**	**793**	**2,638**
Mantis shrimp	*Clorida decorator*	1			1		1	3
	Dictyosquilla foveolata	6	2		1			9
	Harpiosquilla harpax	5	3	24	17	7	8	64
	Oratosquilla interrupta	90	46	31	41	29	11	248
	Oratosquilla oratoria	6	7	15	11	43	24	106
Mantis shrimp Total		**108**	**58**	**70**	**71**	**79**	**44**	**430**
Prawn or Shrimp	*Alpheus brevicristatus*	1	5		3	17	1	27
	Alpheus distinguendus	26	43	5	11	7		92
	Alpheus hoplocheles		5		1			6
	Exopalaemon carinicauda	25						25
	Metapenaeopsis barbata		1	1		9		11
	Metapenaeus affinis	48	6		2	2	36	94
	Metapenaeus burkenroadi	1	2	4	3		1	11
	Metapenaeus ensis	9	1		3	27	5	45
	Metapenaeus joyneri	18	20	7	33	7	7	92
	Parapenaeopsis hardwickii	177	36	1	6	18	2	240
	Parapenaeopsis hungerfordi	287	250	12	16	32	7	604
	Penaeus orientalis	3	3	7	8	29	143	193
	Penaeus penicillatus				3	3		6
	Scyllarus martensii				1		3	4
	Solenocera crassicornis	157	70	3	20	2	1	253
	Trachypenaeus curvirostris	1	2		1	1		5
	Trachypenaeus fulvus	12	10	1			2	25
Prawn or Shrimp Total		**765**	**454**	**41**	**111**	**154**	**208**	**1,733**

Note: Not all crab species are commercially important although they are important components of the marine system and are included for completeness. Source: Mouchel (2005b).

12.3.2.8 The October 2005 late wet season survey recorded a total of 165 different species. Of these faunal groups, bivalves, crabs, fish, gastropods, shrimps (including mantis shrimp) and prawns were also the most abundant. The gastropods were numerically dominant and 26,056 individuals were trawled in October 2005. Bivalves were the second most abundant species and 20,143 individuals were recorded while crabs were the third most dominant species and 4,644 individuals were recorded in the dry season. It should be noted that not all these bivalve, crabs and gastropods are commercial species and when compared to the results of the dry season surveys, blooming of molluscs (bivalve and gastropods) were often recorded in the area (Mouchel, 2005a). Fish were also abundant and 3,671 individuals were recorded in the wet season and were the most diverse group represented by 69 different species. In terms of numerical dominance, the most common fish recorded were the mullet (*Mugil cephalus*), the gobies (*Trypauchen vagina*), the pony fish (*Leiognathus brevirostris*), another gobies (*Oxyurichthys tentacularis*) and the Striped threadfin (*Polydactylus sextarius*). The commercially important mantis shrimps (mostly Oratosquilla interrupta) and prawns (*Metapenaeus* spp. and *Penaeus* spp.) were also numerically abundant components of the trawls. The commercially important species (cephalopds, crabs, mantis shrimp, shrimp and fish) trawled from locations around Sha Chau during the October 2005 wet season are presented below in Table 12.5.

Table 12.5 Species Composition and Abundance of Individuals (Total Counts) from Trawling in Wet Season (October 2005)

Group	Species	FS1	FS2	FS3	FS4	FS5	FS6	Total
Cephalopod	*Loligo* sp.				1		2	3
	Octopus sp.				1	7	2	10
	Sepiella sp.	2						2
Cephalopod Total		**2**			**2**	**7**	**4**	**15**
Crab	*Calappa philargius*		8				60	68
	Calappa sp.						2	2
	Charybdis acuta	19	116	9	8	112	35	299
	Charybdis affinis	80	273	59	74	165	81	732
	Charybdis callianassa						15	15
	Charybdis cruciata	1	18	52	20	53	26	170
	Charybdis hellerii					2	9	11
	Charybdis japonica	96	804	469	279	413	215	2,276
	Charybdis truncata			9		1	2	12
	Charybdis variegata		2			2	2	6
	Clibanarius sp.	27	148	31	23	16	45	290
	Diogenes sp.	5	20		2	13	2	42
	Doclea gracilipes	2	20	1	7		1	31
	Doclea ovis		6					6
	Dorippe polita		1					1
	Ethusa indica	2		81	85	13	47	228
	Eucrate costata					16		16
	Eucrate crenata		24	3		3		30
	Galene bispinosa	2	23	5		2	4	36
	Goniohellenus vadorum	7	1	24	40	30	16	118
	Halimede sp.						1	1
	Leucosia vittata		2	15	5		6	28
	Macrophthalmus japonicus			2				2

Group	Species	FS1	FS2	FS3	FS4	FS5	FS6	Total
	Platylambrus validus			2	3	4	8	17
	Porcelain crab			3		17	17	37
	Portunus hastatoides	2	6	4	28	1	8	49
	Portunus pelagicus	1	4		3	37	19	64
	Portunus sanguinolentus	8	2	2	8	11	6	37
	Portunus trituberculatus	1			1			2
	Scylla serrata						1	1
	Thalamita sima						1	1
	Typhlocarcinus nudus	4		5	7	1	1	18
Crab Total		**257**	**1478**	**774**	**593**	**912**	**630**	**4,644**
Fish	*Acentrogobius caninus*	11	7	20	26	49	11	124
	Ambassis gymnocephalus			2				2
	Amblychaeturichthys hexanema	7			1			8
	Apogon kiensis	5	24	5	7	40	18	99
	Apogon lineatus		1				1	2
	Arnoglossus tenuis	1			1	2	5	9
	Brachyamblyopus brachysoma				1			1
	Callionymus japonicus			2				2
	Cephalopholis boenak			1				1
	Chelonodon patoca					2		2
	Chrysochir aureus					4		4
	Coilia nasus	3	11					14
	Collichthys lucidus	4	31	1		2	2	40
	Cryptocentrus filifer			1		1		2
	Cynoglossus arel	6	12	12	21	19	14	84
	Cynoglossus joyneri	18	6	9	12	1		46
	Cynoglossus puncticeps			1		1	1	3
	Cynoglossus semilaevis	1		1	1			3
	Dasyatis akajei						2	2
	Dasyatis bennettii			1				1
	Dasyatis zugei						1	1
	Dendrophysa russelii	4	5	15	7		6	37
	Drepane punctata						2	2
	Epinephelus awoara					1	2	3
	Epinephelus bruneus					2	4	6
	Gerres lucidus			5	1	33	20	59
	Harpadon microchir		5					5
	Ilisha elongata	1	2	1	2			6
	Inegocia japonica	2	1			12	18	33
	Inimicus japonicus					1	1	2
	Johnius belangerii	8	6		1	66	93	174
	Johnius macrorhynus	8	17	11	17	103	28	184
	Lagocephalus gloveri					1		1
	Leiognathus brevirostris	11	1	47	154	55	16	284
	Leiognathus nuchalis	23						23
	Liza macrolepis				12			12
	Minous monodactylus						2	2
	Mugil cephalus	3		57	514	8		582
	Muraenesox bagio						1	1
	Muraenesox cinereus	1	2	3		4	1	11
	Nemipterus japonicus			1	2	9	9	21

Group	Species	FS1	FS2	FS3	FS4	FS5	FS6	Total
	Nibea albiflora					8		8
	Otolithes ruber				1			1
	Oxyurichthys tentacularis	8	23	82	97	3	9	222
	Parachaeturichthys polynema	4	53			1	1	59
	Pennahia argentata	11	29	2	2	1	4	49
	Pisodonophis boro					1	1	2
	Platycephalus indicus	9	5	44	30	53	49	190
	Polydactylus sextarius	88	12	26	15	47	27	215
	Pseudorhombus arsius						1	1
	Repomucenus richardsonii	1			1	1	5	8
	Rhynchopelates oxyrhynchus						1	1
	Saurida elongata	1		7	11	1	3	23
	Sebastiscus marmoratus					3	3	6
	Siganus canaliculatus	1		7	9	44	99	160
	Sillago sihama					3	11	14
	Solea ovata	2	10	1	4	41	8	66
	Syngnathus schlegeli			3	4			7
	Takifugu ocellatus	5		6		1	10	22
	Takifugu poecilonotus						2	2
	Terapon jarbua			1	3	6	35	45
	Terapon theraps					21		21
	Thryssa hamiltonii		1	3		1	2	7
	Thryssa sp.						2	2
	Trachycephalus uranoscopa	33	1	2	1	23	27	87
	Trypauchen vagina	255	65	30	28	56	27	461
	Upeneus japonicus				1			1
	Valamugil formosae	3		83	4			90
	Zebrias zebra		1		1		1	3
Fish Total		**538**	**331**	**493**	**992**	**731**	**586**	**3,671**
Mantis shrimp	*Clorida* sp.					1		1
	Dictyosquilla foveolata			5				5
	Harpiosquilla harpax	9	41	312	308	82	34	786
	Miyakea nepa	1		3	1			5
	Oratosquilla interrupta	271	263	34	28	42	13	651
	Oratosquilla oratoria	15	28	35	22	13	2	115
Mantis shrimp Total		**296**	**332**	**389**	**359**	**138**	**49**	**1,563**
Prawn or shrimp	*Alpheus brevicristatus*	4	1	1		5	1	12
	Alpheus distinguendus	5	3					8
	Alpheus hoplocheles		3					3
	Exopalaemon annandalei		1					1
	Metapenaeopsis barbata	1	1			3		5
	Metapenaeus affinis	630	120	114	199	28	22	1,113
	Metapenaeus ensis	7	1			7	5	20
	Metapenaeus joyneri	1	9	2	6		3	21
	Parapenaeopsis hardwickii	45	18	40	21	43	21	188
	Parapenaeopsis hungerfordi	63	31	33	23	35	19	204
	Penaeus monodon		1				1	2
	Penaeus orientalis		1	17	12	16	22	68
	Penaeus penicillatus	1		1	2		4	8
	Solenocera crassicornis	113	86	64	81	3	5	352

Group	Species	FS1	FS2	FS3	FS4	FS5	FS6	Total
Prawn or shrimp Total		**870**	**276**	**272**	**344**	**140**	**103**	**2,005**

Note: Not all crab species are commercially important although they are important components of the marine system and are included for completeness. Source: Meinhardt (2006b).

12.3.3 *Fisheries Resources*

12.3.3.1 The Report on Fisheries Resources and Fishing Operations in Hong Kong Waters (ERM, 1998) generally supports the information provided in the Port Survey data. The area is not identified as a primary nursery ground, however it is noted as a spawning ground for *Leiognathus brevirostris*, *Lateolabrax japonicus* and *Clupanodon punctatus*, which probably explains the general high catches recorded for the former species in the EM&A at East Sha Chau (e.g., Meinhardt, 2006b) and the latter species in the Port Survey 96/97 (AFCD, 1998).

12.3.4 *Culture Fisheries*

12.3.4.1 The nearest culture fishery is the mariculture zone at Ma Wan located approximately 14km to the east of Tuen Mun Area 38 (this represents the nearest point between the PAFF and the FCZ). This is the only FCZ in the area which may potentially be affected by construction and operation of the PAFF. The Ma Wan FCZ consists of 108 licensed floating rafts and the main species cultured are spotted grouper (*Epinephelus chlorostigma*), goldlined seabream (*Rhabdosargus sarba*), mangrove snapper (*Lutjanus argentimaculatus*) and pompano (*Trachinotus blochii*) (Mott Connell, 1999).

12.4 Sensitive Receivers

12.4.1 The sensitive receivers are the mariculture zone at Ma Wan and potentially operators of capture fisheries and the spawning grounds.

12.5 Key Issues

12.5.1 *Background*

12.5.1.1 The key potential issues associated with the PAFF project with respect to fisheries are associated with temporary alteration to the seabed, loss of habitat and suspension of sediments during the construction phase and the risk of an aviation fuel spill during the operational phase. A detailed account of the potential impacts attributed to alterations of the seabed and suspension of sediments to marine ecological receivers are presented in Section 7.6 and as such impacts are also applicable to fisheries resources, only a summary is provided below. Potential impacts associated with an aviation fuel spill to marine ecological receivers including fisheries species are presented in Section 11 and are not repeated fully in the foregoing sections.

12.5.2 *Potential Impacts*

Loss of Seabed Habitat

12.5.2.1 Temporary loss of the seabed due to the trenching of the 4.8km pipeline is estimated to require 340,000 m^3 of dredging that may lead to direct impacts on fisheries resources both through direct physical impacts and long-term loss of prey items. The habitat temporarily lost to the pipeline is, however, insignificant when compared to the size of the fishing areas it passes through. Furthermore, as discussed previously in Section 7.6.3, the area of seabed temporarily disturbed (12.5ha) during pipeline installation will following backfilling, likely return to a pre-dredged state rapidly as the relatively uncontaminated sediments of the study area are rapidly colonised by macroinvertebrates (Mouchel, 2001a; Meinhardt, 2006a).

12.5.2.2 In addition to the potentially negative impacts of seabed loss described above, there are also potential positive effects of dredging to fisheries resources within the immediate vicinity of the works. In the short-term, the disturbance to the seabed during dredging is likely to provide opportunities for feeding by fish as resident invertebrate prey populations are displaced from the sediments. Dredging has, for example, been known to attract dolphins (Hyder, 1998; Jefferson pers. comm.) that are presumably attracted to the vicinity of dredged areas to feed on fish similarly attracted by dislodged invertebrates.

Suspension of Sediments

12.5.2.3 Dredging operations may lead to localised high ambient concentrations of suspended sediments. The potential impacts of suspended solids on ecological receivers were described previously in Section 7.6.2 and are also applicable to fisheries resources. The potential direct and indirect impacts from suspended solids to fisheries resources are summarised below.

Direct Impacts

12.5.2.4 Direct impacts are associated with the following:

- physical abrasion and clogging of gills;
- interference with feeding apparatus;
- alteration of behaviour (especially in species that rely heavily on visual cues);
- higher susceptibility to diseases; and
- smothering of early-life stages particularly eggs.

Indirect Impacts

12.5.2.5 Indirect impacts comprise:

- suspended matter may reduce light penetration and alter primary productivity;
- large volumes of deposited suspended solids may alter the nature of the seabed; and

- suspended matter may contain organics that have an oxygen demand leading to reduced dissolved oxygen.

12.5.2.6 High suspended solid concentrations can have a lethal effect on adult fish through suffocation as gills clog and dysfunction. At lower concentrations, sub-lethal effects may be manifest as disruption to feeding, mating behaviour (loss of visual cues) and may also increase the susceptibility of the fish population to a range of chronic diseases including fungal, parasitic, bacterial and viral infections. The impacts from suspended solids are most notable to the younger stages such as larvae and eggs. The eggs of fisheries species are particularly vulnerable to sediment deposition as smothering prevents/impedes gaseous exchange inducing mortality to the developing embryo. Most adult fish are, however, adapted to the naturally-occurring sediment fluxes of the Northwestern waters and will respond to localised elevated concentrations of suspended solids by avoiding the area. Avoidance behaviour will not, however, be possible under mariculture conditions although it should be noted that elevated suspended solids are not predicted to reach the Ma Wan FCZ (see Section 6).

12.5.2.7 The indirect impacts from elevated suspended solid concentrations in the marine environment are difficult to quantify owing to numerous other confounding factors present. There is, however, evidence that elevated suspended solid concentrations can reduce photosynthesis (thereby interfering with primary productivity that may initially have implications for herbivorous fish); alter the seabed leading to losses of prey items; and, when suspended matter has a high organic content there is potential for an increased oxygen demand leading to localised hypoxia.

Suspension of Contaminated Sediments

12.5.2.8 Resuspension of highly contaminated sediments may lead to the desorption of contaminants into the water column that may eventually be taken-up into food chains that are linked to fisheries resources. The sediments in the study area are, however, relatively uncontaminated (Section 6.2.5); resuspension during dredging should be minimal (Section 6.4.6); and sediment re-suspension is not considered likely to cause significant elevation of potentially polluting naturally-bound constituents such as metals in ambient waters through desorption with the maximum short period elevations in contaminant concentrations were found to remain well below the environmental quality standards set for long term exposure (annual average) for the preservation of marine life (Section 6.4.6). There is, therefore, no predicted toxic impacts from resuspension of sediments to fisheries- resources and this potential impact is not considered further.

12.6 Impact Evaluation

12.6.1 *Construction and Operational Phases*

12.6.1.1 Annex 9 of the TMEIAO provides general criteria that can be applied in the assessment of impacts to fisheries due to developments. Construction phase impacts to fisheries associated with the PAFF project are mostly related to the potential for impacts from suspended solids and loss of habitat. Once constructed, the subsea pipeline will be backfilled with granular fill and amour rock on top. The rock armour protection would be level with the original seabed and there is no requirements for maintenance of the rock protection once place. The rest of the trench (on top of the amour rock) will be naturally filled up by sea mud as illustrated in Figure 3.3. Based upon this design,

fishing gear should not be affected and there will be no implications on capture fisheries. The only potential operational phase impact to fisheries resources is due to an aviation fuel spill. The risks of such a spill have, however, been shown to be of a very low frequency and for the spills to evaporate rapidly (Section 10 and 11) and the assessment of fuel spills on fisheries are also considered insignificant, as assessed in detail in Section 11.

12.6.2 *Impact from Suspended Solids on Fisheries Resources*

12.6.2.1 The PAFF study area is known to be an important spawning and nursery ground for many commercially important penaeid shrimp and fish species (AFCD, 1998; Figure 6.2 of sensitive receivers).

12.6.2.2 Fish are typically highly mobile and will generally avoid disturbed areas. On cessation of the construction phase activity, it is likely that fish will rapidly recolonise the area. Species inhabiting the areas adjacent to the dredging will be exposed to some localised elevated suspended solid levels although impacts from suspended material is likely to be minimal as it is likely that fish will either avoid the area or are adapted to local conditions (i.e., the high suspended sediment loads carried in the water column and/ or the re-suspension of soft-bottom sediments characteristic of the Northwestern waters). Furthermore, lethal impacts from suspended solids are not usually induced in fish until ambient concentrations reach 1,000 mg l^{-1} and it is notable that a recent study with a local fish species, the mangrove snapper (*Lutjanus argentimaculatus*) showed that extremely high suspended solid concentrations failed to induce toxicity. The mangrove snapper tolerated high total suspended solid loadings and the 48-h NOEC (no observable effect concentration) was 5,000 mg l^{-1} (AFCD, 2001).

12.6.2.3 The loss of some soft-bottom benthic habitat to dredging of the trench is only a localised temporary impact and the decrease of potential invertebrate food sources and impacts on fish and fisheries resources are considered insignificant. It is possible that detritus feeding species may be attracted through disturbance to sediments and construction may be beneficial to these species.

12.6.2.4 Dredging operations may result in some short lived plumes of sediment within the bottom layer. This bottom layer is naturally subject to large variability in suspended sediment conditions as a result of natural processes of sediment deposition and erosion. Demersal species inhabiting these waters are consequently tolerant to such variability in suspended sediment conditions. Suspended sediment concentrations within the middle and upper layers would generally not increase by more than about 5 mg/l across the study area. There would be a few transient plumes with slightly higher levels up to a maximum of about 10-15 mg/l above ambient which is within the natural variability experienced in the North Western waters. Thus pelagic species are also unlikely to be significantly impacted and are unlikely to move far from the dredging operation. Spawning activities are also unlikely to be disrupted. Fishing activities may be locally disrupted due to vessel movements and traffic restrictions, however, this will be short-term and given the high volume of marine traffic currently operating in the area, considered insignificant. The home-range of the fish involved will also generally be wider than the works area and opportunities will still exist to catch the fish elsewhere in the two fishing areas. The mariculture zone at Ma Wan is sufficiently distant from the works (>14km) that there will be no increase in suspended sediment concentrations as a

result of the project. Construction-phase dredging for the trench required to accommodate the pipeline is not, therefore, likely to be a factor influencing operations at the FCZ.

12.6.2.5 As the dredging work is highly localised and will be conducted to minimise sediment resuspension (Section 6.4), impacts due to suspended solids on fisheries resources are considered insignificant and acceptable. The mitigation measures described in Section 6.7 to protect water quality sensitive receivers from elevated suspended solid concentrations should prove adequate to prevent significant impacts of suspension of the seabed sediments to fisheries resources in the study area.

12.6.2.6 In summary, the PAFF construction will result in minimal loss of the seabed as the pipeline is located in a trench. The subsea pipeline will be backfilled with granular fill and rock armour placed on top. The rest of the trench above the rock armour will be naturally filled up by marine sediments as shown in Figure 3.3 and will not affect fishing gear. As such, the structure will have minimal impact to the benthic fish prey items inhabiting sediments and will also not interfere with fishing activities.

12.6.2.7 An evaluation of the PAFF project using criteria detailed in Annex 9 of the TMEIAO is provided below in Table 12.6.

Table 12.6 Impact Evaluation

Criteria	Predicted Impacts	Impact Evaluation/ Mitigation
Nature of impact	Dredging of a submarine trench for the PAFF Pipeline; and Temporary Seabed Loss and Potential Food Resources	Impacts are temporary (recolonisation of seabed is rapid as discussed in Section 7) and temporary loss of seabed insignificant as the seabed present is homogeneous throughout the study area. Provided that the good dredging practices recommended in Section 6.7 are adhered to, water quality impacts and hence impacts to fisheries are insignificant. No other mitigation measures are required.
Size of affected area	Pipeline is 4.8km and about 12.5ha of the fishing ground will be temporarily affected. This, however, represents a very small proportion (less than 0.3%) of the total fisheries habitat and fishing grounds in Hong Kong. The suspension of sediments during the construction phase (dredging required for laying of the pipeline in the trench) is predicted to be highly localised and elevated suspended solids are not predicted to extend more that about 100-200m from the dredger (see Section 6.4.6.7)	The area of direct impact is small and will only be temporarily affected The suspension of sediments during the construction phase (dredging required for laying of the pipeline in the trench) is predicted to be highly localised and elevated suspended solids are not predicted outside of a highly localised works area.
Loss of fisheries resources/ production	The pipeline and associated works is located in two fishing areas. Lung Kwu Sha Chau is of reasonably high value and ranks quite highly in terms of adult fished biomass and overall value per hectare on a Hong Kong wide basis. The fishing area at Tap Shek Kok is ranked lower and in terms of adult fish production is	The works will cause temporary loss of a very small percentage (<0.3%) of the fishing ground in the area. In the worse case where a short-lived sediment plume extended 200 m from either size of the pipeline, the overall area potentially affected will be about 192 ha. This, however, is a small percentage of the fishing ground (~4.3%) in the study area. The potential impact to fisheries resources/production is thus minimal. With the implementation of good dredging practices recommended

Criteria	Predicted Impacts	Impact Evaluation/ Mitigation
	ranked 105 out of 189 fishing areas in Hong Kong (AFCD, 1998).	in Section 6.7, water quality impacts and hence impacts to fisheries are could be further reduced and the impacts will be insignificant. No other mitigation measures are required.
Destruction and disturbance of nursery and spawning grounds	The study area is known to be a spawning ground for several important commercial fisheries.	Provided that the good dredging practices recommended in Section 6.7 are adhered to, water quality impacts and hence impacts (direct impacts attributable to elevated suspended solids and indirect impacts such as reduced dissolved oxygen) to fisheries are insignificant. No other mitigation measures are required.
Impact on fishing activity	A dredging vessel (s) will be required to dredge a trench for the pipeline and this vessel may interfere with fishing activity in the study area.	The study area has an extremely high volume of marine traffic (e.g., Urmston road major shipping channel; ~ 30 hydrofoil ferries pass through the area daily; river-going vessels to the RTT; and numerous trawl vessels) and (Jefferson pers. comm.) estimated that up to 200 vessels are present in the study area. The dredging is also likely to be completed in about 62 days (based upon the restriction to 12 hours per day outside the Urmston Road (Figure 7.5) and the revised dredging quantity) and predicted impact on fishing activity due to dredging vessels is, therefore, considered insignificant.
Impact on aquaculture activity	Dredging of the trench for the pipeline may lead to elevated suspended solids.	Insignificant elevated suspended solid concentrations are predicted and higher levels will be highly localised (i.e., within the works area/ dredging location). Elevated suspended solid concentrations are not predicted at the Ma Wan FCZ (see Section 6) which is located >14km from the PAFF and dredging operations on the FCZ are considered to represent an insignificant impact.

12.7 Conclusions

12.7.1 There are two fishing areas (Tap Shek Kok and Lung Kwu Sha Chau) directly within the study area, both of which support capture fisheries. The fishing area at Tap Shek Kok is ranked low in terms of adult fish production (ranked 105 out of 189 fishing areas in Hong Kong) although the Lung Kwu Sha Chau fishing area is of reasonably high value and ranks quite highly (ranked 53) in terms of adult fished biomass and overall value per hectare on a Hong Kong wide basis (Port Survey 96/97). The more recent Port Survey 2001/2002 (AFCD, 2003) suggests that the pattern of fishing operation in the area was similar to the Port Survey 96/97 (AFCD, 1998). Further afield, there are no predicted impacts attributable to the PAFF project at the Ma Wan FCZ.

12.7.2 The major impacts to fisheries resources are predicted to be due to the temporary loss of seabed and suspension of sediments during dredging. The temporary loss of seabed was, however, considered to be insignificant in relation to the amount of adjacent homogeneous benthic habitat available and it is notable that on cessation of pipeline laying operations, the overlying sediment is likely to be recolonised rapidly thereby restoring both habitat and prey items (note that construction phase activity will dislodge invertebrates that may prove beneficial to fisheries resources). Both direct and indirect impacts from suspended solids are known to have lethal and sublethal effects on fish. The suspended solid concentrations required to induce mortality in marine fish are however of the magnitude of 1,000 to > 5,000 mg l^{-1} and although more subtle sublethal impacts cannot be entirely discounted, it is likely that fish species resident in the study

area are (naturally) adapted to elevated suspended solid levels and have various physiological (such as mechanisms for clearing clogged gills) and behavioural (such as avoidance of highly impacted areas) adaptations to high sediment loadings. The suspension of solids due to dredging activity is also predicted to be highly localised and only of a transient nature as dredging is expected to be completed within about 62 days assuming all work is undertaken by the grab dredger. This timescale could be significantly reduced if the likely combination of TSHD and Grab dredging are applied.

12.7.3 In summary, the overall predicted impacts due to the PAFF on fisheries resources are insignificant and no specific monitoring and audit programme is required as the EM&A designed to detect unacceptable impacts to water quality will provide adequate for the protection of fisheries resources.

12.8 Mitigation Measures

12.8.1 The construction phase impacts due primarily to dredging activity were predicted to be highly localised, confined to the vicinity of the works area and represent an insignificant impact to fisheries resources in the study area. The mitigation measures recommended to protect water quality sensitive receivers presented in Section 6.7 are adequate to prevent adverse impacts to fisheries resources. Mitigation measures associated with the control, containment and cleanup of an oil spill are detailed in Section 11. These measures are also summarised in the Environmental Mitigation Implementation Schedule in Appendix B.

12.9 Residual Impacts

12.9.1 Significant impacts on fisheries are not predicted and thus, no adverse residual impacts are predicted.

12.10 Environmental Monitoring and Audit

12.10.1 The monitoring and audit programme designed to detect any unacceptable impacts to water quality (see Section 6.10) will provide adequate protection of fisheries resources in the study area. Predicted impacts to fisheries are insignificant and, therefore, no, EM&A programme designed specifically to assess impacts on commercial fisheries resources is required.

12.11 References

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