EXECUTIVE SUMMARY

BASELINE ECOLOGICAL MONITORING PROGRAMME FOR THE MAI PO INNER DEEP BAY RAMSAR SITE

MONITORING PERIOD: OCTOBER 2001 TO SEPTEMBER 2002

Tender Reference No. AFD/SQ/28/01

February 2004
1. INTRODUCTION

Agriculture, Fisheries and Conservation Department (AFCD) appointed the Laboratory of Environmental Toxicology of the University of Hong Kong to carry out the first annual Baseline Ecological Monitoring (BEM) Project of the Mai Po Inner Deep Bay Ramsar Site (the Ramsar Site) for a period of 12 months between October 2001 and September 2002 (BEMP 01-02).

2. MONITORING OBJECTIVES

The major objectives of the monitoring project were as follows:

- to carry out BEMP 01-02 in accordance with the Technical Manual (TM) so as to establish the trend of the ecological characters of the Ramsar Site;
- to determine whether the ecological characters of the Ramsar Site have changed, are changing or are likely to change as a result of technological development, pollution or other human interference; and
- to base on the experience gained in the implementation of BEMP 01-02 and from the data collected, to review the TM and make recommendations of practical modifications as appropriate to improve the robustness and effectiveness of the baseline ecological monitoring programme.

3. METHODS

The BEMP emphasizes on the ecological characters of the Ramsar Site. The major parameters comprised analysis of migratory bird counts, community structure of benthic fauna and the changes in extent and conditions of major habitat types. Furthermore, the monitoring project also collected supplementary data on water quality, sediment quality and sedimentation rate to support the analysis of ecological data. The monitoring schedule and sampling locations are attached in annexes 1 and 2, respectively.

4. RESULTS AND DISCUSSION

4.1 Water Quality

High concentration of organic and inorganic pollutants was detected in the open water of Inner Deep Bay as revealed by the low dissolved oxygen and high biological
oxygen demand, ammoniacal-N, total Kjeldahl-N, suspended solid and chlorophyll-a. High BOD and chlorophyll-a were also detected in gei wais 12 and 13. The changes of these parameters during the monitoring period are shown in Annex 3. The possible sources of pollutants in the Inner Deep Bay were mainly derived from the sewage discharges of Shenzhen River and Shan Pui River which flown into the mudflat of the Ramsar Site. The findings generally tallied with the trend as shown by data collected by Environmental Protection Department’s (EPD) Marine Water Quality Monitoring Programme during the same period in the Deep Bay Water Control Zone as shown in Annex 4. On the other hand, the abnormalities in gei wais were likely associated with the reduce frequency in the interchange of water with the open water.

4.2 Sediment Quality

High concentrations of mercury were found in the sediment as shown in Annex 5. Both are toxic even at very low concentrations and thus have potential ecological and toxicological impacts. In general, the organic pollutants in the sediment were in low concentration and were in line with those collected by EPD’s routine sediment quality monitoring in the Deep Bay Water Control Zone.

4.3 Mudflat Sedimentation

Mudflat elevation was measured in a separate hydrographic survey project using Real-time Kinematic Global Positioning System (RTK-GPS) with a precision of 15mm and 4 surveys between late 2001 and early 2003 were conducted. The first 3 surveys were conducted by a commercial surveying company while the last survey was conducted by the Civil Engineering Department (CED). Both the commercial surveying company and CED used the same RTK-GPS setup for the surveys. Although there was a high loading of suspended solid in the open water, the surveys revealed that the mudflat was a very dynamic environment and both erosion and sedimentation were observed over the mudflat at different time and location (see graphical presentation in Annexes 6 and 7).

4.4 Benthic Fauna

The Mai Po mudflat infauna community was characterized by low species richness and high dominance of a few pollution-tolerant opportunistic species - a typical feature of impacted community by organic pollution and/or other disturbance as shown
in Annex 8. As for the epifauna, the population sizes of crabs and mudskippers showed a decrease in February but recovered in May and afterwards (see graphs in Annex 9).

4.5 Habitat Extent and Conditions

Mangal: The mangal conditions ranged from fair to healthy. The expansion of mangal at 2 of the survey points (M1 and M4) exceeded the action level. It was estimated that the intertidal mangal increased by 18 ha from 262 ha to 280 ha during the monitoring period according to 2 IKONOS satellite images captured in February 2000 and January 2002. The major extension was located at the northern end of the mangal and was about 10 ha in size. In fact, dense mangrove seedlings and young trees were observed at this area and they blocked the access to the sampling site A. On the other hand, the Drainage Services Department undertook the pruning of about 7 ha of mangal at the outlet of Shan Pui River Channel from September 2001 to October 2001 and from April to October 2002 to control flooding. To maintain an unblocked sightline from the floating bird hides, WWF HK also cleared 6,000 mangrove seedlings in an area of 5 hectares in October 2001. The changes in the extent of mangal are shown in Annex 10.

Mudflat: Photographic records did not show any obvious changes of the mudflat conditions. Owing to the encroachment of mangal, the size of the major intertidal mudflat reduced from 342 ha to 324 ha during the monitoring period according to the satellite images. The changes in the extent of mudflat are shown in Annex 10.

Fishponds: Satellite images captured in January 2002 and photographic records did not show any obvious changes of fishpond conditions. The fishponds inside the Ramsar Site occupied an area about 540 hectares. The major species of fish cultured in the fishponds included Grass Carp, Silver Carp, Common Carp and Bighead. The total number of fish produced was estimated to be more than 2.57 million tails per year.

Gei wai and reed bed: Satellite images captured in January 2002 and photographic records did not show any obvious changes of gei wai and reed bed conditions. Gei wai occupied an area about 230 hectares. The occasional incidents of algal bloom observed in the gei wai tallied with the high chlorophyll-a concentration according to the water quality analyses. Owing to the cease of commercial shrimp production in gei wais inside the Ramsar Site, no productivity data were available.
4.6 Land-use Changes

There was no major land-use changes detected in the Ramsar Site, apart from those mentioned in section 4.5.

4.7 Avifauna

There were 54,720 birds recorded in Deep Bay during the winter of 2001-02. A peak count of 51,333 was made in January 2002 and 39,249 of them were found in the Ramsar Site. The figures are comparable to the records obtained in recent years.

4.8 Extent of Wetland Habitats

According to the analysis of an IKONOS satellite image captured in January 2002, the extents of the 6 major wetland habitats of the Mai Po Inner Deep Bay Ramsar Site are summarized as follows:

<table>
<thead>
<tr>
<th>Wetland Habitats</th>
<th>Approx. Size (Hectares)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intertidal mudflat</td>
<td>320</td>
</tr>
<tr>
<td>Mangal</td>
<td>280</td>
</tr>
<tr>
<td>Gei wai</td>
<td>230</td>
</tr>
<tr>
<td>Fishpond</td>
<td>540</td>
</tr>
<tr>
<td>River and channel</td>
<td>160</td>
</tr>
<tr>
<td>Woodland</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1540</strong></td>
</tr>
</tbody>
</table>

4.9 Exotic Plant Species

During the monitoring of BEMP 01-02, 3 exotic plant species, namely, *Sonneratia*, *Mikania micrantha* and *Spartina*, which were known to have weedy behaviour, were found inside or close to the Ramsar Site. *Sonneratia* was concentrated at the northern end of the intertidal mangal and was believed to originate from the mangrove afforestation in the Futian National Nature Reserve. *Mikania micrantha* was sparsely distributed in Ramsar Site and occupied about 8 hectare of land with other weeds and plants. There were 3 stands of *Spartina* in Sheung and Ha Pak Nai which were 6km away from the Ramsar Site (Annex 11). All of the 3 species were closely monitored for
their distribution inside or in close proximity to the Ramsar Site and clearance operation would be implemented if necessary.

5. RECOMMENDATIONS

In view of the experience gained from the first 12-month ecological monitoring project, a number of follow-up actions to improve the data collection are recommended as follows:

a) Mudflat sedimentation: A more comprehensive mapping of mudflat profile is recommended so that the dynamic pattern of sediment transport across the mudflat could be documented and monitored on a yearly basis.

b) Reference locations for the measurement of mangal encroachment: It was found at the beginning of the project that some of the reference locations for the measurement of mangal encroachment as set out in the TM had already been enclosed by the mangal. New reference points located at the fringe of the mangal were then determined for BEMP 01-02 so that the measurement could be taken place. Taking the rapid expansion of the mangal at some areas into consideration, it is recommended to review the locations of these reference points when a new monitoring project is commenced and revise them if necessary.

c) Size of sampling core for benthic infauna: It is recommended to reduce the diameter of the sediment collection core for benthic infauna from 20cm to 10cm so that the efficiency for sampling and sorting could be improved.

d) Revision of TM: Pilot studies have been conducted for recommendations b) & c) and statistical analyses indicated that the results obtained from the new approaches would be comparable to the first baseline dataset. It is recommended to revise relevant sections of the TM for recommendation b) and c) above accordingly.

6. WAY FORWARD

The first baseline ecological monitoring project covering the monitoring period between October 2001 and September 2002 was successful in general. From the results of the first monitoring, it becomes necessary that the following issues should be focused in the future:

a) source and intensity of pollution to the area.

b) mangal encroachment and strategies for intervention.
c) sedimentation rate and the future management of the reserve, particularly the mudflat area.

d) sediment quality, and relationship with the health of infauna community and the bird population.

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## Annex 1

### The monitoring schedule of BEMP 2001-02

<table>
<thead>
<tr>
<th>Monitoring Activities</th>
<th>Parameters</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Water Quality</td>
<td>i) <em>In Situ</em> Measurement: Temperature; Turbidity; Salinity; pH; Dissolved Oxygen</td>
<td>Monthly</td>
</tr>
<tr>
<td></td>
<td>ii) Laboratory Analysis: Suspended Solids; Biochemical Oxygen Demand; Nitrate Nitrogen; Nitrite Nitrogen; Ammoniacal Nitrogen; Total Kjedahl Nitrogen; Silica; Orthophosphate; Total Phosphorus; Chlorophyll-a</td>
<td></td>
</tr>
<tr>
<td>2. Sediment Quality</td>
<td>i) <em>In Situ</em> Measurement: Redox Potential</td>
<td>Quarterly</td>
</tr>
<tr>
<td></td>
<td>ii) <em>In Situ</em> Measurement: pH</td>
<td>Quarterly</td>
</tr>
<tr>
<td></td>
<td>iii) Laboratory Analysis: Particle Size Distribution (PSD)</td>
<td>Quarterly</td>
</tr>
<tr>
<td></td>
<td>iv) Laboratory Analysis: Ammoniacal Nitrogen; Total Kjeldahl Nitrogen; Total Nitrogen; Total Phosphorus; Total Sulphide; Copper; Lead; Cadmium; Mercury; Arsenic; Total Organic Carbon; Total PCBs; Total PAHs; DDT Isomers</td>
<td>Biannual</td>
</tr>
<tr>
<td>3. Mudflat Sedimentation*</td>
<td>Sedimentation Rate</td>
<td>Biannual</td>
</tr>
<tr>
<td>4. Benthic Infauna (Macroinvertebrates)</td>
<td>Species Identification; Species Abundance; Species Biomass</td>
<td>Quarterly</td>
</tr>
<tr>
<td>5. Benthic Epifauna (Mudskippers, Crabs)</td>
<td>Abundance of Mudskippers Abundance of Crabs</td>
<td>Quarterly</td>
</tr>
<tr>
<td></td>
<td>Number of Epifauna Burrows</td>
<td>Quarterly</td>
</tr>
<tr>
<td>6. Mudflat Extent and Condition</td>
<td>Photograph Record</td>
<td>Quarterly</td>
</tr>
<tr>
<td></td>
<td>Aerial Photograph/Satellite Image Interpretation**</td>
<td>2 times per 12-month period</td>
</tr>
<tr>
<td>7. Mangal Extent and Condition</td>
<td>Quadrat Survey; Species Identification; Growth Rate; Growth Condition; Photograph Record</td>
<td>Annually</td>
</tr>
<tr>
<td></td>
<td>Aerial Photograph/Satellite Image Interpretation**</td>
<td>2 times per 12-month period</td>
</tr>
<tr>
<td>8. Reed Bed Extent</td>
<td>Photograph Record</td>
<td>Annually</td>
</tr>
<tr>
<td></td>
<td>Aerial Photograph/Satellite Image Interpretation**</td>
<td>2 times per 12-month period</td>
</tr>
<tr>
<td>9. Fish Pond Extent</td>
<td>Aerial Photograph/Satellite Image Interpretation (within Wetland Buffer Area)**</td>
<td>2 times per 12-month period</td>
</tr>
<tr>
<td>10. Fish Pond Condition</td>
<td>Data Interpretation (Fish Ponds as Numbered in Hong Kong Bird Watching Society’s Surveys)**</td>
<td>2 times per 12-month period</td>
</tr>
<tr>
<td>11. Land Use Changes</td>
<td>Data Interpretation**</td>
<td>2 times per 12-month period</td>
</tr>
<tr>
<td>12. Avifauna</td>
<td>Data Interpretation***</td>
<td>2 times per 12-month period</td>
</tr>
</tbody>
</table>

Remarks: * : conducted by a private land surveying company and Civil Engineering Department.

** : data provided by AFCD.

*** : data provided by Hong Kong Bird Watching Society.
The major sampling/survey locations

Sediment quality -
All chemical parameters: A, B2, C, D, E, G12, G13.
Redox and pH: A, B2, C, D, E.
Particle Size distribution: A, B1-B3, C, D, E.
Sedimentation rate: A, B1-B4, D, E, F.
Mangal encroachment: M1-M5.
EPD’s water quality monitoring stations: DM1, DM2.

Benthic infauna: A, B1-B3, C.
Benthic epifauna: 1A-1C, 2A-2C, 3A-3C.
Burrow Counts: A, B2, C.
Annex 3

The changes of concentration of representative pollutants in water during the monitoring period

Limit level

Action level
Remarks: The sampling at G12 in Feb 2002 was not successful because the gei wai was drained at that time.
Annex 4

The clustering of measurement of selected parameters in water measured by BEMP01-02 and EPD during the monitoring period

Key of monitoring stations:
BEMP: W2 and W4
EPD: DM1 and DM 2
Annex 5

The changes of mercury concentration in sediment during the monitoring period

![Graph showing changes of mercury concentration in sediment during the monitoring period]
Annex 6

The changes of elevation at monitoring stations across the mudflat

Remarks:
Please refer to Annex 7 for the graphs showing the magnitude of elevation changes.
Remarks:
The first 3 surveys were conducted by a commercial surveying company while the last survey was conducted by the Civil Engineering Department (CED). Both the surveying company and CED used the same RTK-GPS model for the surveys. Owing to inclement weather and resource constrain, the elevation at points B3, E and F could not be measured during the survey conducted by CED.
Annex 8

The species diversity of benthic infauna at different survey locations during the monitoring period

Remarks:
1. H' refers to Shannon–Wiener Diversity Index. It measures the species richness and abundance of each survey locations.

2. J' refers to Evenness Index. It tells the degree to which species at each survey locations are evenly distributed.
Annex 9

The temporal and spatial changes of number of epifauna and their burrows during the monitoring period

[Graphs showing temporal and spatial changes of crab, mudskipper, and burrow numbers by sampling site over the monitoring period.]
Annex 10

The changes of extent of mudflat and intertidal mangal between 2000 and 2002

Remarks:
The extents of intertidal mangal and mudflat are derived from 2 IKONOS Satellite Images captured in February 2000 and January 2002.
Annex 11

The Distribution of *Spartina* in Sheung Pak Nai and Ha Pak Nai

Remarks:
Green – *Spartina* stands
Red – The Ramsar Site