

ADVISORY COUNCIL ON THE ENVIRONMENT
(21.3.94)

(ACE 8/94)
(for advice)

**Territory-wide Measurement of the Physical
and Ecological Effects of Dredging and Dumping**

**Geotechnical Engineering Office
Civil Engineering Department
March 1994**

ADVISORY COUNCIL ON THE ENVIRONMENT

(21.3.94)

(ACE 8/94)

(for advice)

**Territory-wide Measurement of the Physical
and Ecological Effects of Dredging and Dumping**

PURPOSE

To update Members on the progress of studies into the overall effects of dredging and dumping activities in Hong Kong waters.

BACKGROUND

2. At the EPCOM meeting of 22 February 1993, members were briefed by the Geotechnical Engineering Office (GEO) of the Civil Engineering Department (CED) on the various sand dredging activities in Hong Kong waters. Members inquired whether any studies of the overall cumulative impacts of these works had been carried out. It was explained to Members that predictive computer modelling techniques could not be applied to the whole of Hong Kong, but that the Territory-wide situation was being monitored in order to provide the overall picture. Members asked to be regularly updated on the progress of these studies. The last update was in October 1993, when Paper FMC/110 was considered.

PHYSICAL STUDIES

3. The physical studies are designed to measure levels of suspended sediment throughout the water column, and to provide information on sea bed conditions and processes. A variety of survey methods are being used to gauge the effects that dredging and dumping are having on suspended solids levels and on the sea bed.

Remote sensing

4. Remote sensing is being used to study phenomena which are visible to satellites and survey aircraft. Satellite imagery has the advantage, given suitable cloud-free weather conditions, of providing an instantaneous "snapshot" of a large area, enabling large-scale visible phenomena to be examined. Surveys using aircraft provide more detail and are not quite so weather-dependant. Both types of survey provide good information on surface water turbidity and sediment movement in two dimensions, but are restricted in that they cannot "see" into the water and give data on mid-water and sea bed processes.

Satellite imagery

4.1 The French satellite SPOT was programmed to image Hong Kong during December 1993. Four images, covering Hong Kong and part of the Pearl estuary, have now been obtained from SPOT and are being examined. These images are in digital form and will be processed by the computerised Geographic Information System (GIS) operated by the GEO. The satellite data will be approximately "ground-truthed" (calibrated), using conventional water quality measurements, to give an overall picture of surface water turbidity. More SPOT images are planned.

Colour photography air surveys

4.2 The Air Survey unit of the Lands Department carried out vertical colour air photography of Hong Kong waters in August and December 1994. The surveys were shot with high resolution colour film which enables detailed observation of surface water turbidity. The August survey clearly distinguished dredging plumes, natural sediment entrainment and entrainment of sediment in ships' wakes. The December survey is currently being printed. Further surveys are planned at approximately three month intervals. As with the satellite data, approximate correlation of water appearance with suspended solids levels will be undertaken.

Water column suspended solids measurements

5. In order to measure suspended solids levels in the water column beneath the surface layer, GEO consultants Dredging Research Ltd (DRL) have been developing the use of the Acoustic Doppler Current Profiler (ADCP). The ADCP can now be used for obtaining continuous quantitative and semi-quantitative profiles of suspended solids concentration within the water column. The ADCP obtains a large amount of data very quickly and is proving to be excellent for obtaining information on suspended solids patterns over large areas. This equipment has certain limitations, however. The top one metre and bottom one metre of the water column cannot be measured, while air bubbles entrained by ships' wakes and certain dredging operations can lead to difficulties in interpretation. A survey of the South Cheung Chau marine disposal area was carried out in June 1993, and the conclusions derived by DRL from this work are presented in Appendix I. A Territory-wide ADCP survey was completed in August 1993. Elevated levels of suspended solids are apparent around active sand dredging sites while, perhaps surprisingly, levels are hardly affected by the marine disposal areas at South Cheung Chau and East of Ninepins. Extracts from the draft report of this survey are presented in Appendix II. Data from ADCP surveys of the East Ninepins marine disposal area and the West Po Toi sand borrow area are currently being processed. A further ADCP survey is planned for April 1994, and will examine the migration of suspended solids from active dredging sites in the Po Toi-Ninepins area.

Dredging plume surveys

6. Concern has been expressed that highly-visible dredging plumes are having an adverse effect on the environment. Until now, however, it has not been possible to relate the visual appearance of a plume to the approximate level of suspended solids contained within it, and this has made it difficult to assess the potential impacts. The first of a series of dredging plume surveys was carried out near the Ninepins Islands in November 1993 by DEMAS, dredging consultants to the GEO, and was designed to relate the appearance of a dredging plume to the actual measured level of suspended solids. Appendix III contains the Summary and Conclusions of the DEMAS report on this first survey, together with some examples of the relation between appearance and suspended solids levels. The key findings of the survey were that, for the plume in question, surface suspended solids levels within about 100m of the dredger ranged from 75mg/l to 150mg/l, and decreased by about 50% in the first ten minutes, while within 30 minutes the surface concentration had reduced to 20 to 30mg/l. A second dredging plume survey took place in late February 1994. This second survey provided a large amount of quantitative data on the dredger overflow (i.e. the rate of solids overboard) and the development and decay of the dredging plume. The results of the second survey are currently being processed.

ECOLOGICAL STUDIES

7. Surveys and investigations of the various habitats within Hong Kong waters are designed to provide data on existing conditions and to detect any changes which may indicate potential problem areas. These studies complement the physical investigations by monitoring the general health of the ecosystem and the ways in which it responds to physical processes. By documenting the locations of sensitive and high diversity ecological communities in Hong Kong waters, Government will be able to take account of their value at an early stage in project planning. For the purposes of these studies it has proved convenient to subdivide the sea bottom ecosystem into coastal (nearshore, hard substrate) and sea bed (offshore, soft substrate), as these areas are quite distinct and require different survey methods.

Coastal ecology

8. The Territory's land masses are surrounded by a submarine coastal strip which slopes down to the flatter offshore sea bed. The sea floor in the coastal strip may be quite complex and is frequently rocky. It is within this habitat that corals are found. The coastal strip is best surveyed by marine biologists who are also qualified scuba divers. Underwater ecological surveys, which started in 1991, are being carried out by GEO's consultant Binnie Consultants Ltd (BCL). After initial qualitative baseline surveys in eastern waters, areas were selected for quantitative ecological work including the establishment of permanent monitoring stations at some high-risk, high-value locations. Coral loss became of concern in the spring of 1992 when 25% of the hard corals and some gorgonians were killed along the west side of North Ninepin Island due to "smothering" by fine sediment settling from dredging plumes generated in close proximity to the island. Losses of approximately 10% of the hard corals on the west side of South Ninepin Island, due to the same cause, were also noted at this time. Ongoing surveys have not found any other dredging related damage to corals. Continuing dive surveys in the Ninepins area showed that the corals had begun the slow process of recolonisation, although during the summer of 1993 a sequence of typhoons caused additional coral loss. Coral loss from the physical impact of storm waves generated by the typhoons of summer 1993 was widespread throughout Hong Kong waters. The areas covered by the now extensive, weekly, dive surveys are shown in Appendix V.

Sea bed ecology

9. The sea bed area comprises the generally flat-lying, muddy sea bottom which is found in the majority of Hong Kong waters. Burrowing and browsing animals prevail, and dive surveys are of limited value in documenting this habitat. Two types of survey have been undertaken, comprising traditional grab sampling/taxonomic classification techniques and an innovative sea bed camera/computer image interpretation system known as REMOTS.

REMOTS survey

9.1 A sea bed survey was carried out in October 1993 using a specialised sediment profiling camera. The work was carried out by Science Applications International Corporation (SAIC) of the USA, who also interpreted the data obtained using computer scanning techniques. This technique of camera survey and computerised interpretation is known as the REMOTS system (Remote Ecological Monitoring Of The Seafloor). REMOTS was developed by SAIC and has been used worldwide for over 15 years. SAIC have reached the preliminary conclusion that the offshore environment in Hong Kong is fairly dynamic, with sea bed processes being influenced by the Pearl River and by regular typhoons (which appear to cause significant sediment entrainment and movement). Benthic

ecologists have long speculated that Hong Kong organisms would be well adapted to periodic seabed disturbances such as are caused by typhoons, and would be quick to recolonise disturbed areas. SAIC state that it appears that natural disturbance processes are of greater regional significance than local perturbations related to dredging and disposal. The Executive Summary of the SAIC draft report on this work is reproduced in Appendix IV, together with summary figures showing derived benthic habitat quality, which is generally high throughout the area surveyed. The REMOTS system has shown itself to be very well suited to documenting the sea bed conditions in Hong Kong, and further work is planned for February/March 1994 to examine the dry season conditions, to extend the area covered by the first survey and to test the preliminary conclusions.

Grab surveys

9.2 Grab sampling and taxonomy complement the REMOTS work by enabling traditional identification and classification of the sea bed organisms to be carried out. While the REMOTS technique allows the collection of a large number of samples and gives a rapid indication of the ecological health of the seabed, the slower grab sampling technique provides a more detailed assessment of the ecology of an area. Pilot grab sampling surveys have been carried out in the East Lamma Channel, the Ninepins area and at the South Cheung Chau marine disposal area (see Appendix V), and taxonomic analyses of the specimens obtained are now in progress. Further surveys are planned.

Trawl surveys

10. Trawl surveys, using a local fishing boat, are being used to assess both the ecological and the socio-economic status of commercial fisheries in the inshore waters of Hong Kong. To date, surveys have been carried out in the East Lamma Channel and in the South Ninepins area (see Appendix V). Study and identification of the fish and invertebrates caught during these trawl surveys is in progress. Further surveys are planned.

DATA MANAGEMENT

11. Data from all the above studies are being collated in the computerised Geographic Information System (GIS) operated by the GEO. In addition, water quality data from EPD and AFD will also be entered into the GIS.

INITIAL FINDINGS

12. The continued use of Hong Kong marine sand resources will depend on the level of environmental impact caused. The GEO and its consultants have been undertaking a wide range of physical and ecological surveys to assess any territory-wide cumulative effects arising from the large number of dredging operations currently underway. The results obtained to date are currently being examined within the government, but the various consultants have indicated that the preliminary findings are as follows:-

- (a) Most of Hong Kong's marine life is well adapted to the irregular large inputs of sediment and energy caused by the Pearl River, typhoons, strong winter monsoons and localised strong tidal currents. The hard corals prevalent in clearer eastern waters, however, are less hardy and are periodically damaged or killed by waves and low temperatures, as well as

being subject to predators such as sea urchins, which in turn are present in unnatural abundance due to the removal of their predators by fishing. The impact of dredging and dumping activities on marine life needs to be viewed in this context.

- (b) The health of the sea bed and the coastal habitats is generally good apart from around the heavily urbanised areas, where significant environmental degradation has occurred over many years due to processes unconnected with today's dredging and dumping activities.
- (c) Plumes of suspended solids around sand dredging operations are transitory and are more visually intrusive than environmentally damaging. Site-specific problems can nevertheless arise if the dredging takes place close to sensitive receivers such as mariculture sites and areas of coral growth. So far, the only recorded loss of hard corals has been at the Ninepins Islands. While this is regrettable, it should be noted that the affected corals did not have a high rarity or diversity value. Recent surveys have shown that no further damage has occurred and the slow process of recolonisation has already started.
- (d) The main impact of mud dumping is the disruption of habitat in the active dumping area. Recolonisation of mud-dumping grounds by bottom-dwelling organisms has been demonstrated to take place very soon after dumping. A secondary effect of mud dumping is the generation of fluid mud that tends to migrate downslope. The effects of this are being studied.

NEXT REPORT

13. The next report to ACE is expected to be in May/June 1994, when the collation of the various physical and ecological datasets will be further advanced..

LIST OF ATTACHMENTS

- Appendix I: Discussion and Summary of Conclusions, DRL Report on Suspended Sediment Data Collection and South Cheung Chau Marine Disposal Area.
- Appendix II: SAIC REMOTS Survey, Executive Summary and Organism Sediment Index plans/distributions.
- Appendix III: Locations of Trawl Surveys, Grab Samples and Coastal Ecology Dive Surveys.
- Appendix IV: Summary and Conclusions, and example photographs, DEMAS plume trial report.