

3.3. Bottom Sediment Quality

The results of bottom sediment quality analyses are shown in Figure 3.3.1 to 3.3.6 and are summarized below.

3.3.1 Grain Composition

(1) Rainy Season

Fine grain (silt and clay) was the main component of the bottom sediment in the rainy season averaging 79% of the total samples. Gravel ranged 0 to 32%, sand 1 to 74%, silt 1 to 58%, and clay 4 to 68%. Fine grain component ranged from 5 to 99%.

Fine grain component was in greater proportion in the southwestern zone of the estuary (P14, P15, and P17) as well as in the eastern side of the central zone (P06 and P12). Coarse grains were abundant in the upper bay and in the surrounding area (P01, P05, P08, and P09). Exceptionally coarse grains were the major component at P01 and P05. Sand component was comparatively large in east part of the estuary mouth (P16, P18, P20, P22, and P23).

Grain compositions at P01 and P05 were distinctively different from other survey locations. This is evidently because these two locations were on the east-side navigation channel of the estuary where frequent dredging activity exposed the lower sediment layer. Many dredging vessels were seen near P05 during the survey. The large proportion of sand in the eastern side of the estuary mouth and the large proportion of fine grain in the southwestern zone of the estuary were both attributed to the influence of tidal currents. It is apparent that the ebb current exiting through the southwestern part of the estuary carried along fine grains originated in the river, and the flood current in the bottom layer entering through the eastern part of the estuary mouth prevented settling and accumulation of fine grain sediment.

(2) Dry Season

In the dry season survey, the bottom sediment was composed of sand, silt, and clay with the majority being fine grain (silt and clay). Particularly, at P14 and P24, the proportion of fine grain exceeded 90%. It was attributed to the weaker river currents in the dry season that permitted deposition of sediments. On the other hand, sand was the main component (82%) at P02, likely because of the dredging activity.

3.3.2. *Eh* (Oxidation-reduction potential)

(1) Rainy Season

Eh levels were positive at all the survey points ranging from 15 to 154 mV with an average of 62mV. The variation of *Eh* was narrow in the upper bay

area (P01, P02, P03, and P05) and was slightly wider in the southwestern part of the estuary (P13, P14, and P23).

(2) Dry Season

Eh levels were positive at most of the survey points. Comparatively high levels were recorded in the bottom sediment at P01, P02, and P14. Only P10 had negative potential, although the level was within the common range found in marine bottom sediment. Unlike the other survey points, it is evident that P10 had reducing environment as also indicated also by the higher-than-elsewhere level of sulfide. (See section 3.3.4).

3.3.3. Organic Matter

(1) Rainy Season

Organic matter contents ranged from 0.7 to 3.2% with an average of 2.2%. The organic contents were generally low at all the survey points. The distribution pattern showed the tendency that the levels of organic content were higher than average in Shenzhen bay (P10) and lower near the river mouths (P03, P04, and P05).

(2) Dry Season

The organic contents were also low in the dry season, well below the standard of the bottom sediment quality (3.4 %). Especially, P02 had a low level (0.4 %).

3.3.4. Sulfide

(1) Rainy Season

Sulfide contents ranged from 0 to 281 mg/kg with an average of 95 mg/kg. The sulfide levels were low at all the survey points, with no sign of pollution. The distribution pattern showed the tendency that the sulfide levels were higher than average at P06, P08 and P17, and lower near the river mouths (P01, P03, and P04).

The generation of sulfide was closely related to oceanic bacteria. Many of oceanic bacteria restore sulfate ion (SO_4^{2-}), and metabolize hydrogen-sulfide (H_2S). Metabolized hydrogen-sulfide bonds to metals contained in the bottom sediment and accumulates as sulfide. *Eh* as discussed in the previous section must be negative for activation of those bacteria. As the *Eh* potentials in the rainy season were positive at all the survey points, it was expected that sulfide generation was not wide-spread in the Pearl River Estuary.

(2) Dry Season

P10 had the highest level (489 mg/kg) exceeding the standard of the bottom sediment quality (300 mg/kg) and five to ten times higher than the levels

found at the other survey points. It was evident that the bottom sediment quality was polluted by sulfide at P10 in the dry season.

3.3.5. Total Nitrogen (T-N), Total Phosphorus (T-P)

(1) Rainy Season

T-N ranged from 55 to 167 mg/kg with an average of 109 mg/kg, not particularly higher than commonly found levels in marine sediments. The distribution pattern showed the tendency that the T-N level was higher than average at P10 and lower at P05, the same tendency as the organic contents.

T-P ranged from 22 to 104 mg/kg with an average of 74 mg/kg, also not particularly higher than common levels of marine sediments. The distribution pattern of T-P was similar to those of organic contents and T-N, higher at P06, P10 and P12 and lower at P05.

(2) Dry Season

The concentrations of T-N and T-P were generally low in the dry season.

3.3.6. COD

(1) Rainy Season

COD ranged from 1 to 15 mg/g with an average of 9 mg/g. The horizontal distribution had the tendency that the concentrations of COD level was lower than average in the upper bay area, especially at P05 (1 mg/L) and higher at P06 and P21.

COD of the bottom sediment was analyzed by the Japanese method only. It is one of the indicators for organic pollution, similar to the significance of organic content or ignition loss. The general rule of thumb for COD in sediments are:

- ≤ 10 mg/g : Not polluted
- 10 to 20 mg/g : Slightly polluted
- 20 to 30 mg/g : Moderately polluted, and
- ≥ 30 mg/g : Polluted.

The concentration of COD over 100 mg/g is uncommon even at the most polluted marine environment. The bottom sediment quality in the Pearl River Estuary was categorized by "slightly polluted".

(2) Dry Season

COD levels in the dry season were generally low. P10 had the highest level and P02 the lowest. The distribution pattern was similar to that of organic content.

3.3.7. Ignition Loss

(1) Rainy Season

Ignition loss ranged from 1.1 to 8.6 % with an average of 6.6 %. The horizontal distribution pattern had the tendency that the ignition loss was lower than average in the upper bay area (P01 and P05) and higher in the eastern side of the center of the estuary (P06 and P12) as well as in the southwestern zone (P14, P15, P17, and P21). The distribution pattern was similar to those of organic content and COD.

(2) Dry Season

The horizontal distribution had the tendency that the levels of ignition loss were lower than average at P01, P02 and P04 and higher at P14 and P24. The levels at P14 and P24 were, however, not alarming as the pollution index and were within the representative levels for bottom sediment mainly composed of fine grain.

3.3.8. Oil Contents

(1) Rainy Season

Oil content ranged from 26 to 942 mg/kg with an average of 313 mg/kg. The horizontal distribution showed comparatively high levels of oil content at P02, P06, and P15.

(2) Dry Season

Oil content ranged widely from 18 to 2,585 mg/kg. P10 had the maximum level far exceeding the standard of bottom sediment quality (1,000 mg/kg).

3.3.9. Heavy Metals (Hg, Cu, Zn, Pb, Cd, As)

Hg concentrations were generally low, well below the standard of the bottom sediment quality at the all survey points. P10, P14, and P24 had comparatively high values.

The levels of Cu were slightly higher than the standard of the bottom sediment quality at nearly half of the survey points. P10 and P14 had comparatively high levels.

The levels of Zn exceeded slightly the standard of bottom sediment quality (80 mg/kg) at most of the survey points. A high value was observed at P24 in the western part of the estuary mouth.

The levels of Pb were higher than the standard of the bottom sediment quality at all the survey points. Especially, high values about twice the standard of bottom sediment quality were observed at P10 in Shenzhen bay, P14 and P24 in the western part of the estuary mouth.

The levels of both Cd and Pb, exceeded the standard of bottom sediment quality (0.5 mg/kg) at the all survey points by 50% to 100%.

The levels of As were higher than the standard of bottom sediment quality at all the survey points. P10, in particular, had the level twice the standard.

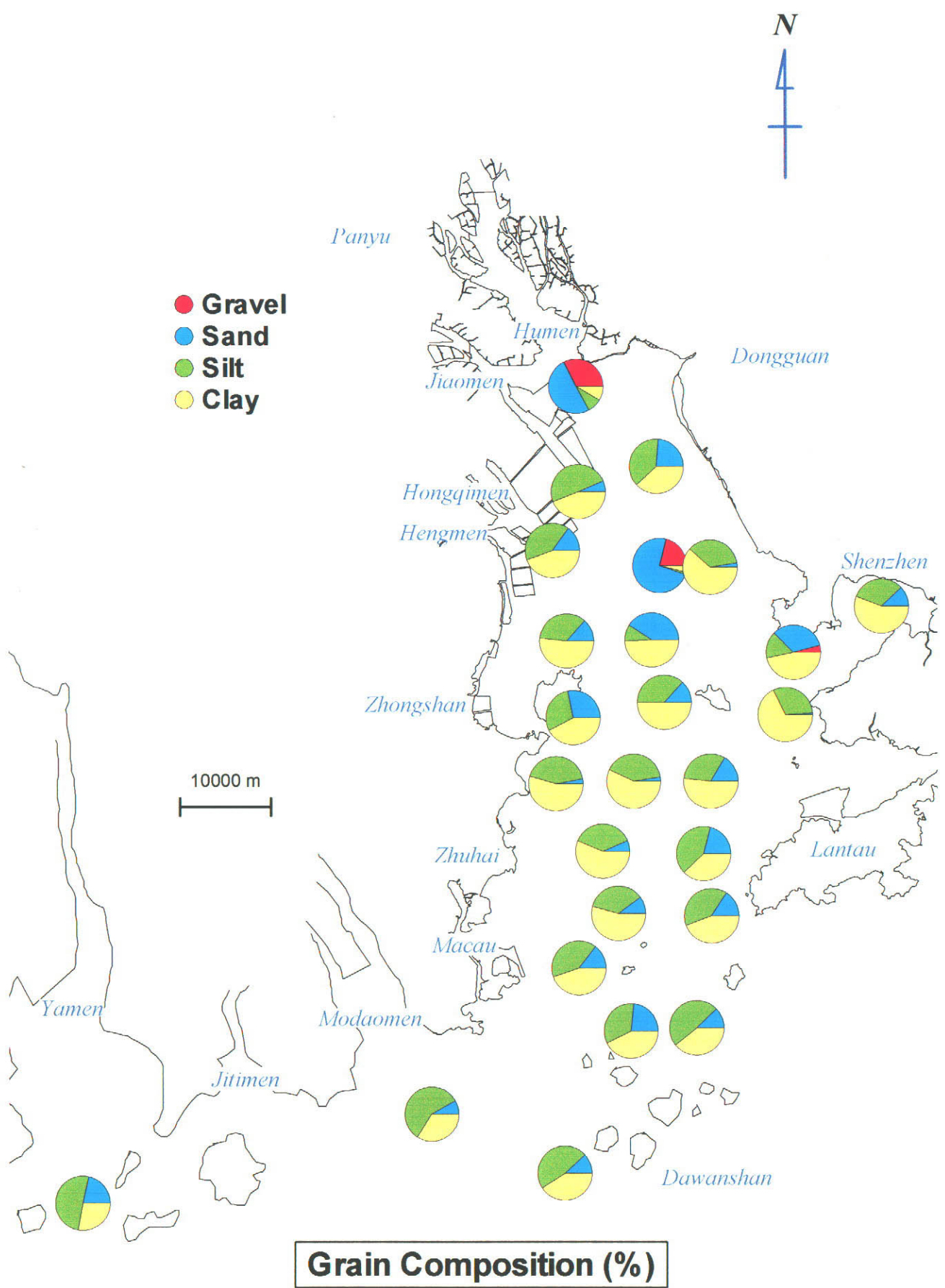


Figure 3.3.1 Result of the Survey on Sediment Quality (Grain Composition: Rainy Season)
July 31 - August 10, 2000

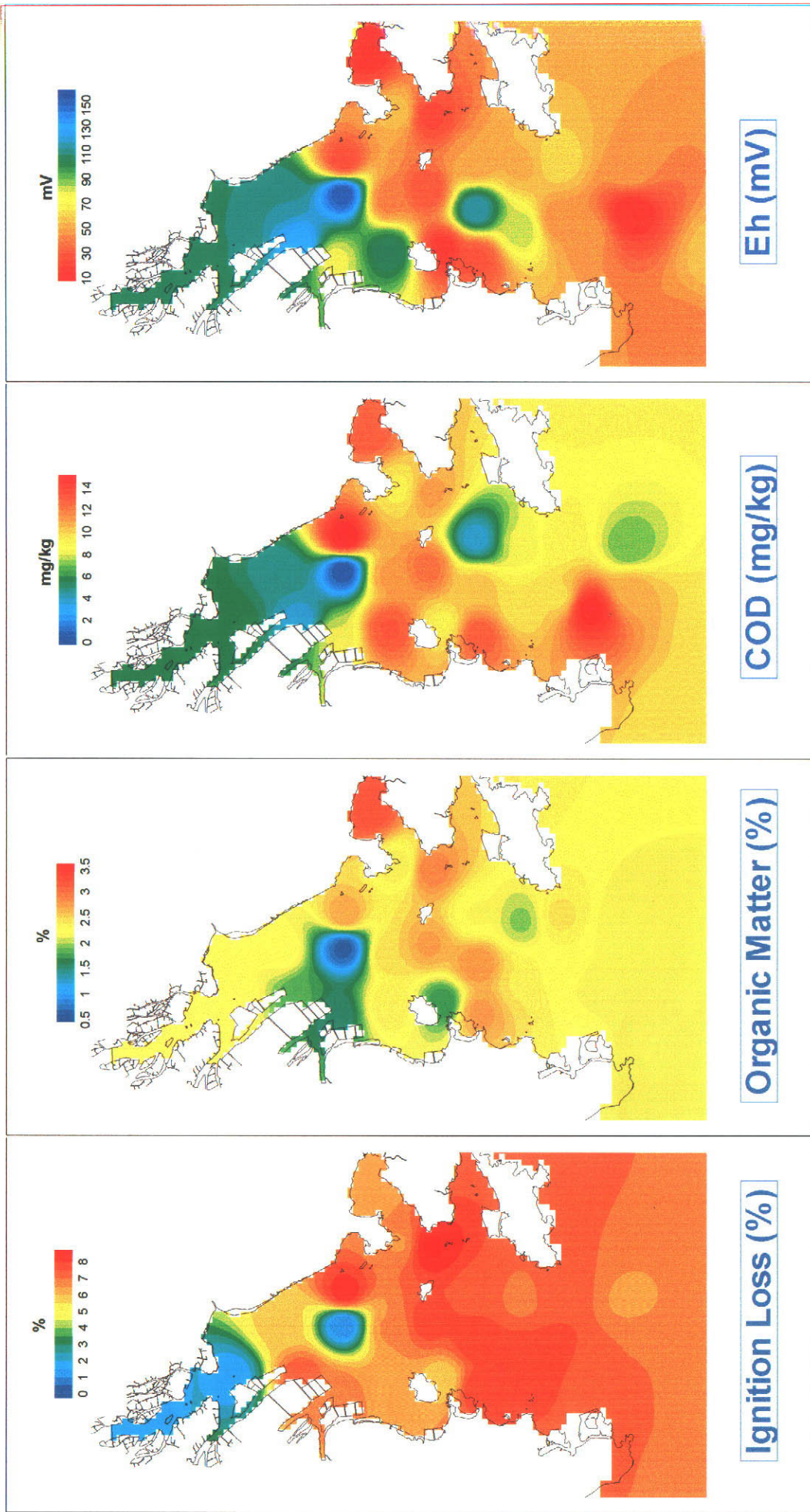


Figure 3.3.2 Result of the Survey on Sediment Quality (Ignition Loss, Organic Matter, COD, Eh: Rainy Season)

July 31 - August 10, 2000

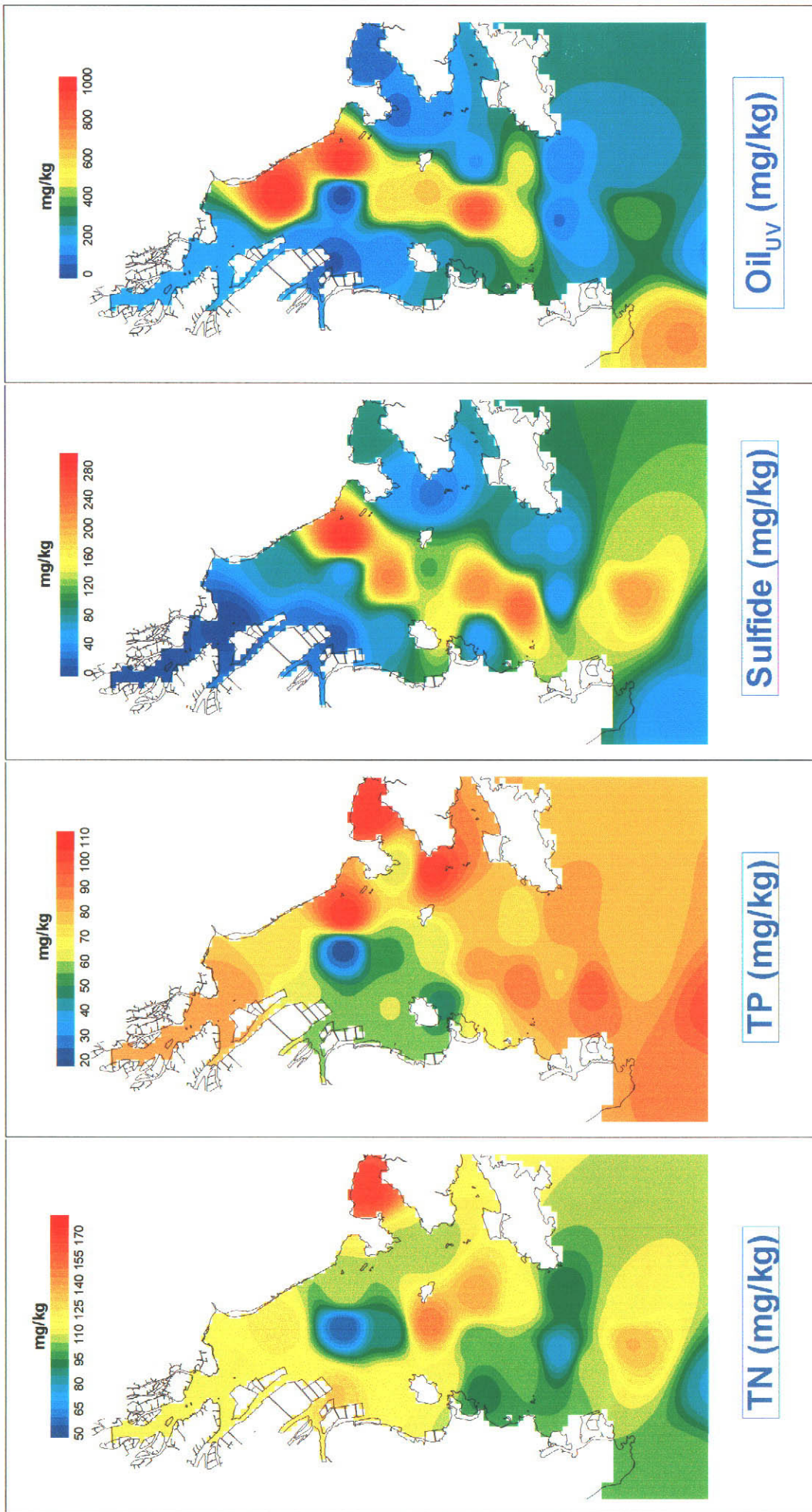


Figure 3.3.3 Result of the Survey on Sediment Quality (TN, TP, Sulfide, Oil_{UV}: Rainy Season)

July 31 - August 10, 2000

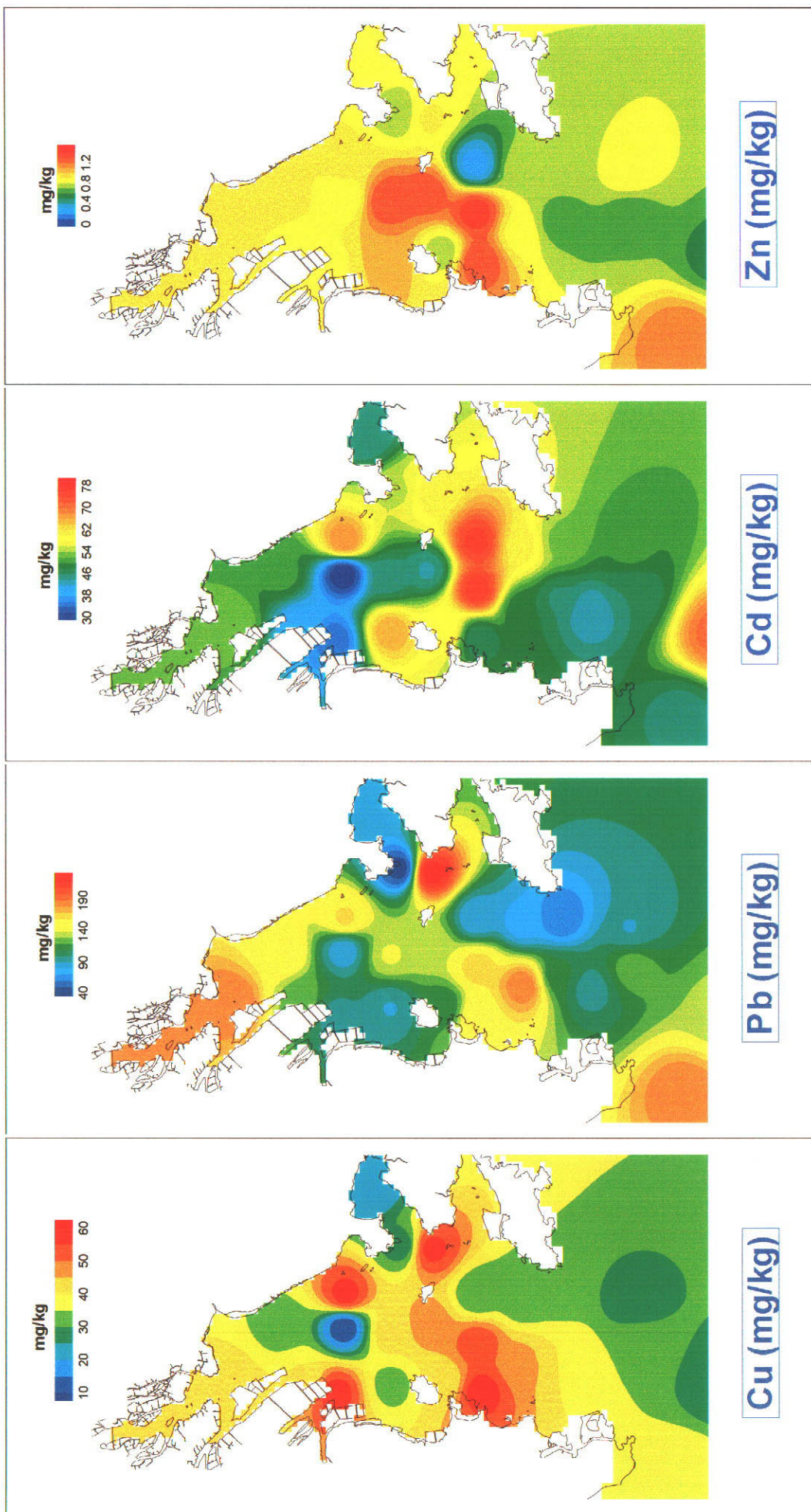


Figure 3.3.4 Result of the Survey on Sediment Quality (Cu, Pb, Cd, Zn: Rainy Season)

July 31 - August 10, 2000

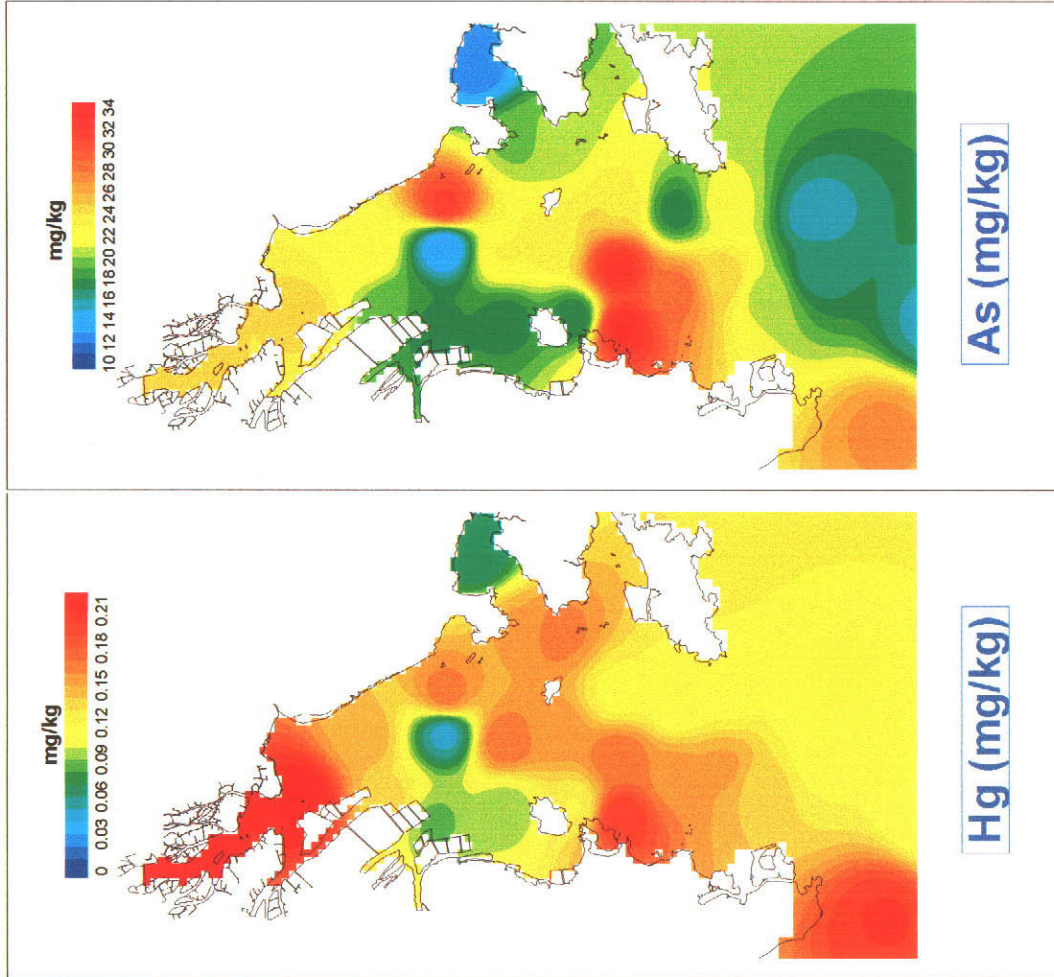


Figure 3.3.5 Result of the Survey on Sediment Quality (Hg, As: Rainy Season)

July 31 - August 10, 2000

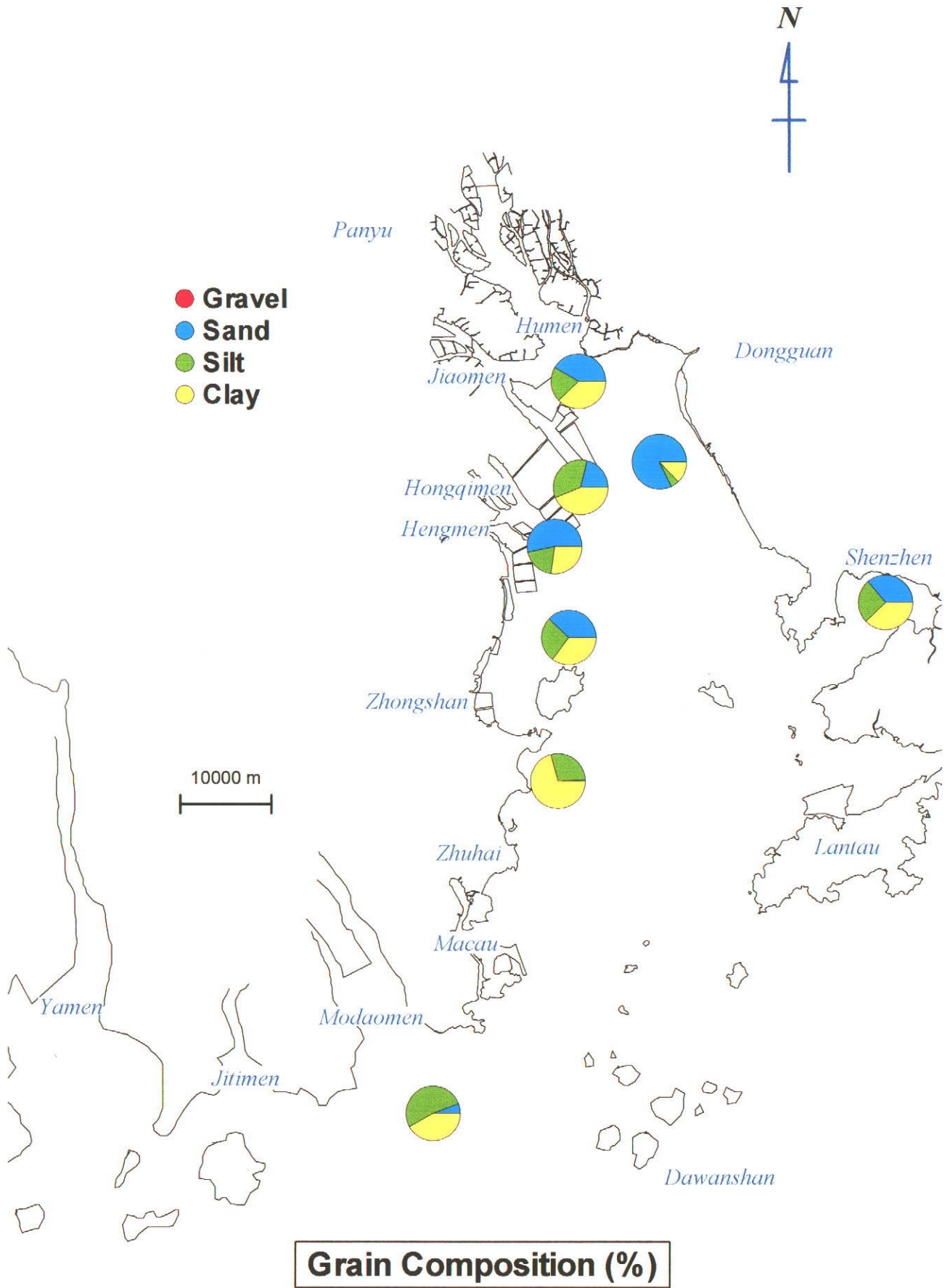


Figure 3.3.6 Result of the Survey on Sediment Quality (Grain Composition: Dry Season)

December 4 - 10, 2000