# CHAPTER IV

# DISCUSSION

## Heavy Metals in Seven Water Channels.

In this study, the concentrations of heavy metals in seven water channels discharge into the coastal zone were observed and the results are shown in Tables 3-1, 3-2, 3-3, 3-4, 3-5, 3-6, 3-7 and 3-8. During the sampling periods June-July 1989, November 1989 and May 1990 it was observed that the mouths of water channels were closed by sand. However, the concentrations of heavy metal in channel water were higher, both in particulate and dissolved forms, than in the seawater but no relationship exists because the water from those channels could not directly discharge into the sea due to sand blocks. Therefore, the discussion in this chapter will not consider the contribution of heavy metals and dissolved organic carbon from the channel waters.

## Distribution of Lead in Seawater.

The concentrations of particulate lead were found to vary during the four periods observed. The variations are shown in Figure 4-1. In October 1988 when no ship-breaking activity was under way, the concentrations observed should represent the background concentrations without the ship-breaking activity. The concentrations of particulate lead at nearshore and offshore of the ship-breaking plants were evenly distributed (0.02-0.18 µg/l)

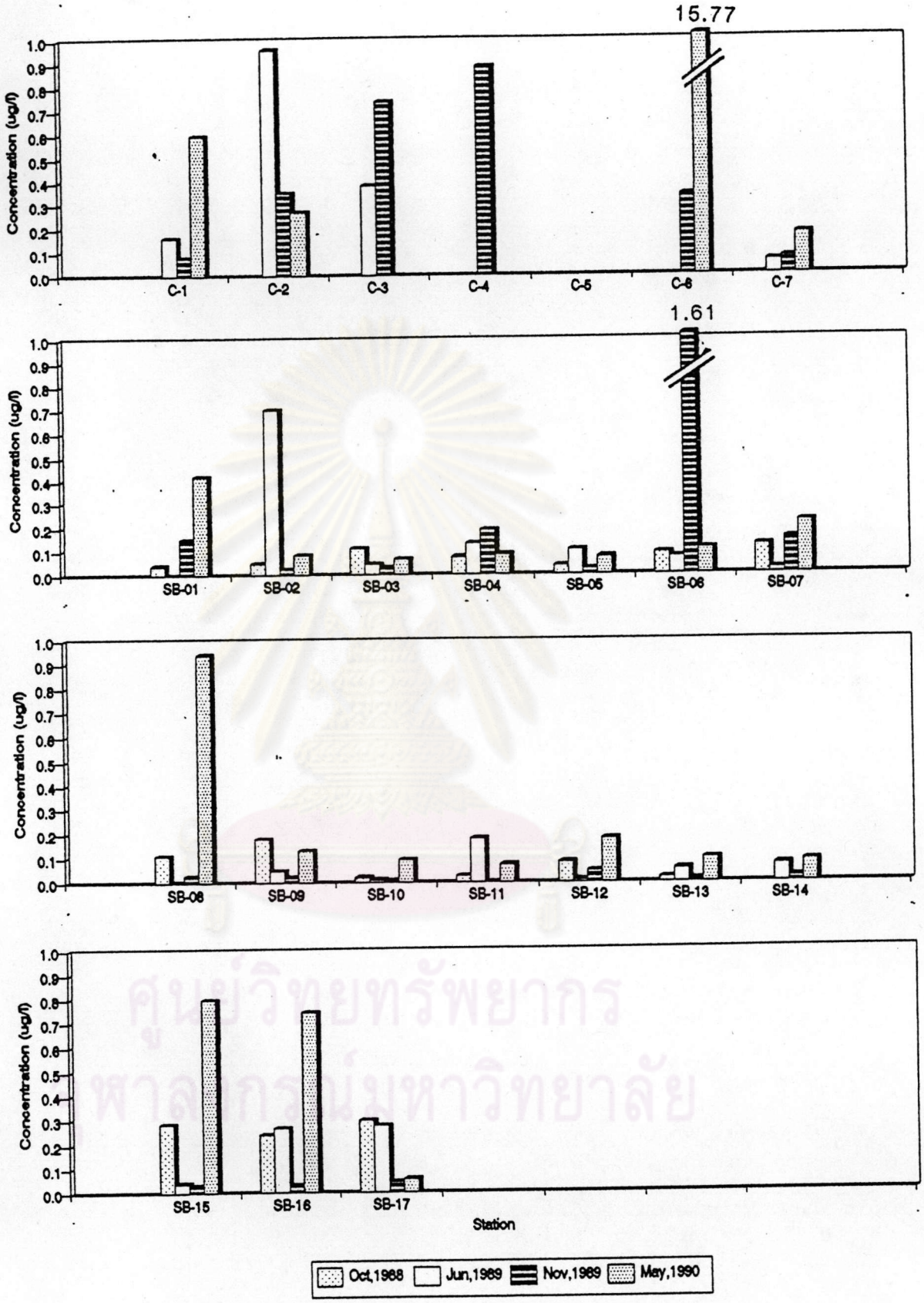


Figure 4-1 Concentration distribution of particulate lead in seawater at four sampling periods off Ban Nong Faeb, Mab Ta Phud, Rayong Province.

but were lower than the concentrations observed at the Rayong River mouth. High concentrations of particulate lead found at the Rayong River mouth are expected to be a contribution of river discharge.

During ship-breaking periods (June-July 1989 and November 1989), the concentrations of lead significantly increased at some stations observed. In June-July 1989, higher concentrations than in October 1988 were found at stations in the vicinity of the ship-breaking plants. Other stations were observed to possess low concentrations. In November 1989 the concentrations of particulate lead did not show any change from the concentrations observed in October 1988 (the background concentrations), except for nearshore stations; SB-04, SB-06, and SB-07 where the concentrations were slightly higher. In addition, the low concentrations of particulate lead observed were found at Rayong River mouth. It is expected that intense wave and wind prevailed during sampling cause a rapid mixing and dispersion of particulate lead in the seawater and the result was similar concentrations observed during the ship-breaking and no ship-breaking activities.

In May 1990, six months after the ship-breaking activity stopped, the concentrations of particulate lead increased from that found during the ship-breaking periods. The concentrations were about the same level as the background concentrations observed in October 1988.

The variation of dissolved lead concentrations in four periods observed were also found and are shown in Figure 4-2. In October 1988, the variation of dissolved lead concentrations in seawater shown the same trend as the particulate ones. The

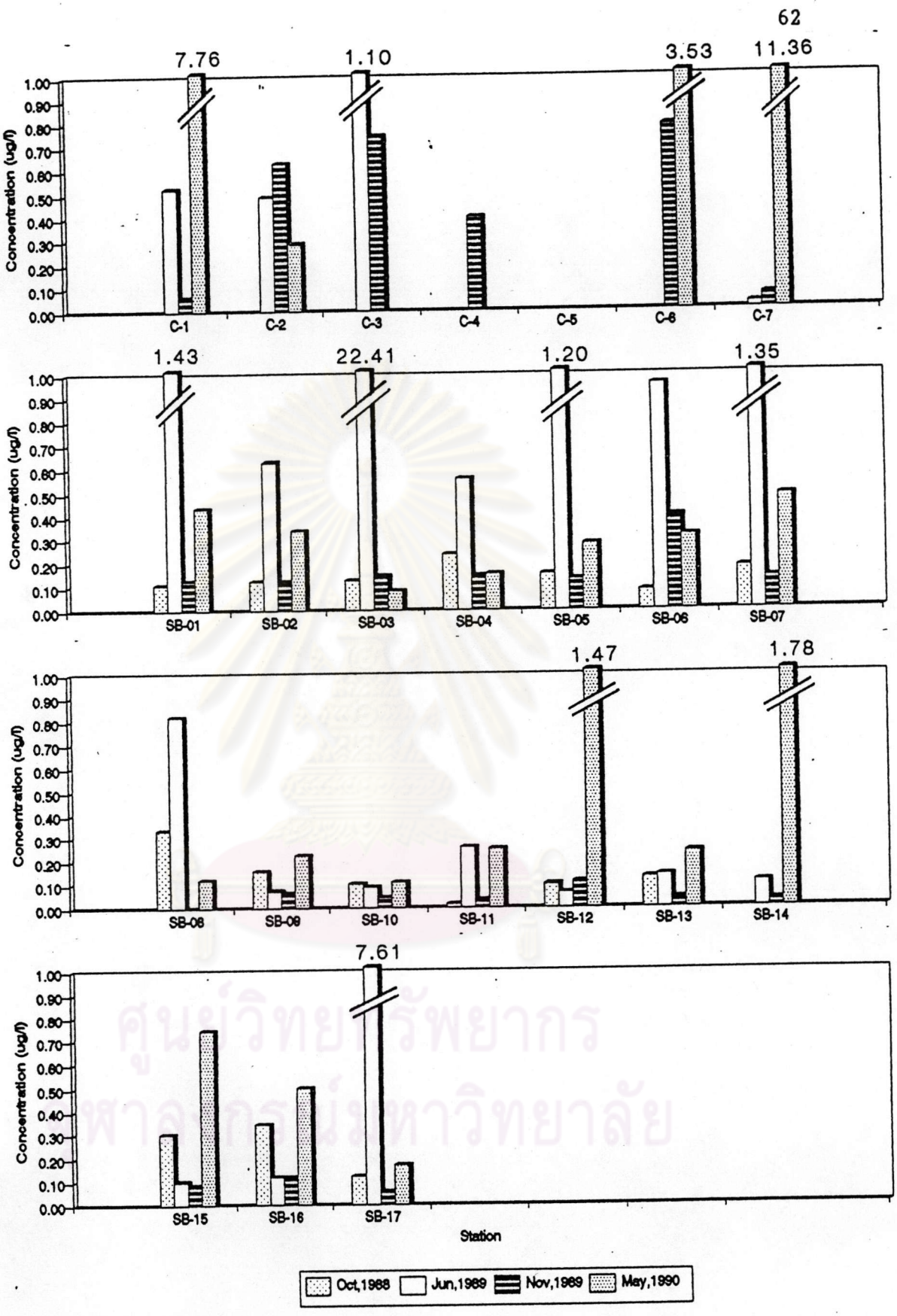


Figure 4-2 Concentration distribution of dissolved lead in seawater at four sampling periods off Ban Nong Faeb, Mab Ta Phud, Rayong Province.

concentrations near the plants were also evenly distributed but the concentrations observed at the Rayong River mouth stations were higher.

In June-July 1989, most of the concentrations observed at nearshore stations were obviously higher than the offshore stations which indicates a contamination caused by ship-breaking activity. The average concentrations for nearshore and offshore stations were 4.663 and 0.242 µg/l, respectively. In November 1989 the concentration of dissolved lead observed only at station SB-06 was significantly high (0.40 µg/l). Most of the concentrations observed were lower than that found in June-July 1989 but about the same level as concentrations found in October 1988.

When we consider the concentrations of dissolved lead in May 1990, the concentrations observed were relatively high when compared to previous periods. The concentrations were on the average two times higher than the background concentrations and even higher than the concentrations observed when the ship-breaking activity was under way. This is probably a result of leaching heavy metals from scrapping materials scattered around the ship-breaking plants vicinity. The effect of these materials was discussed in the following Section. In addition, Figure 4-6 indicates that during this May period, the dissolved lead concentrations were higher than the particulate lead. Figures 4-3, 4-4 and 4-5 also indicate that in the seawater for all periods, the dissolved lead was more abundant than the particulate one.

In conclusion it can be said that the ship-breaking activity

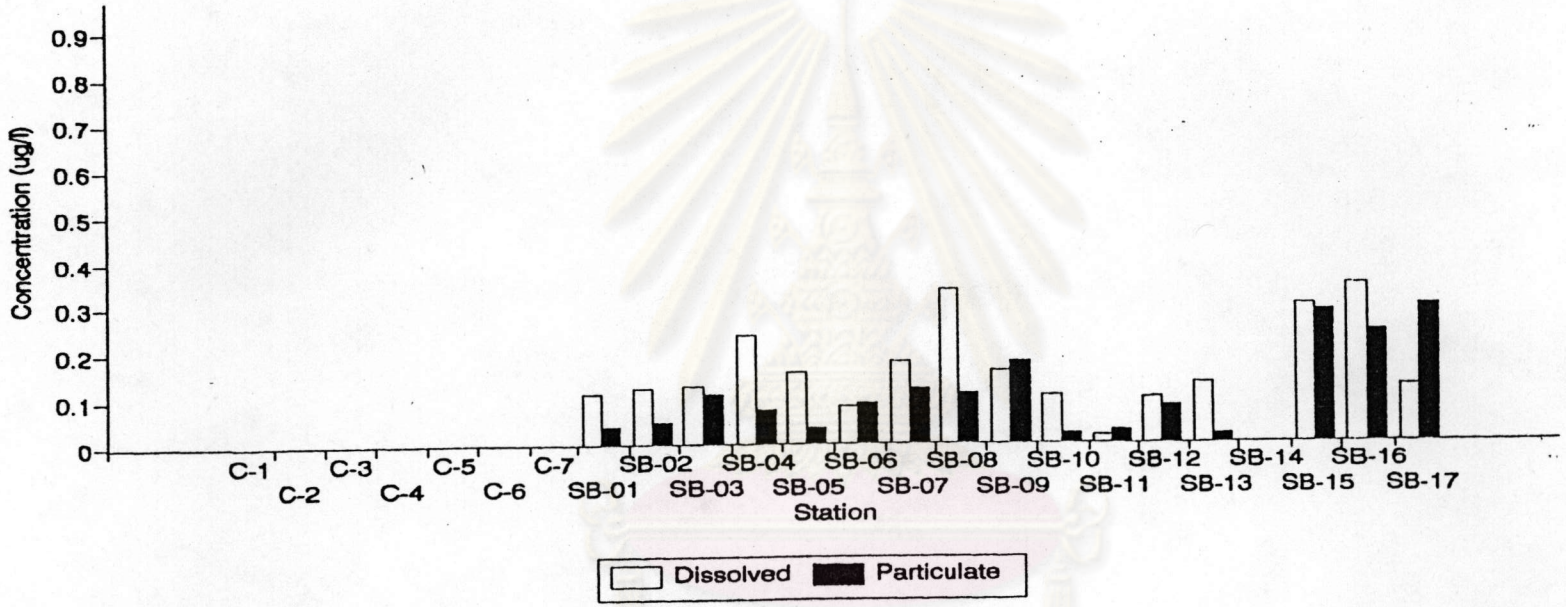


Figure 4-3 Concentrations of lead in particulate and dissolved forms in seawater on October 20-25, 1988.

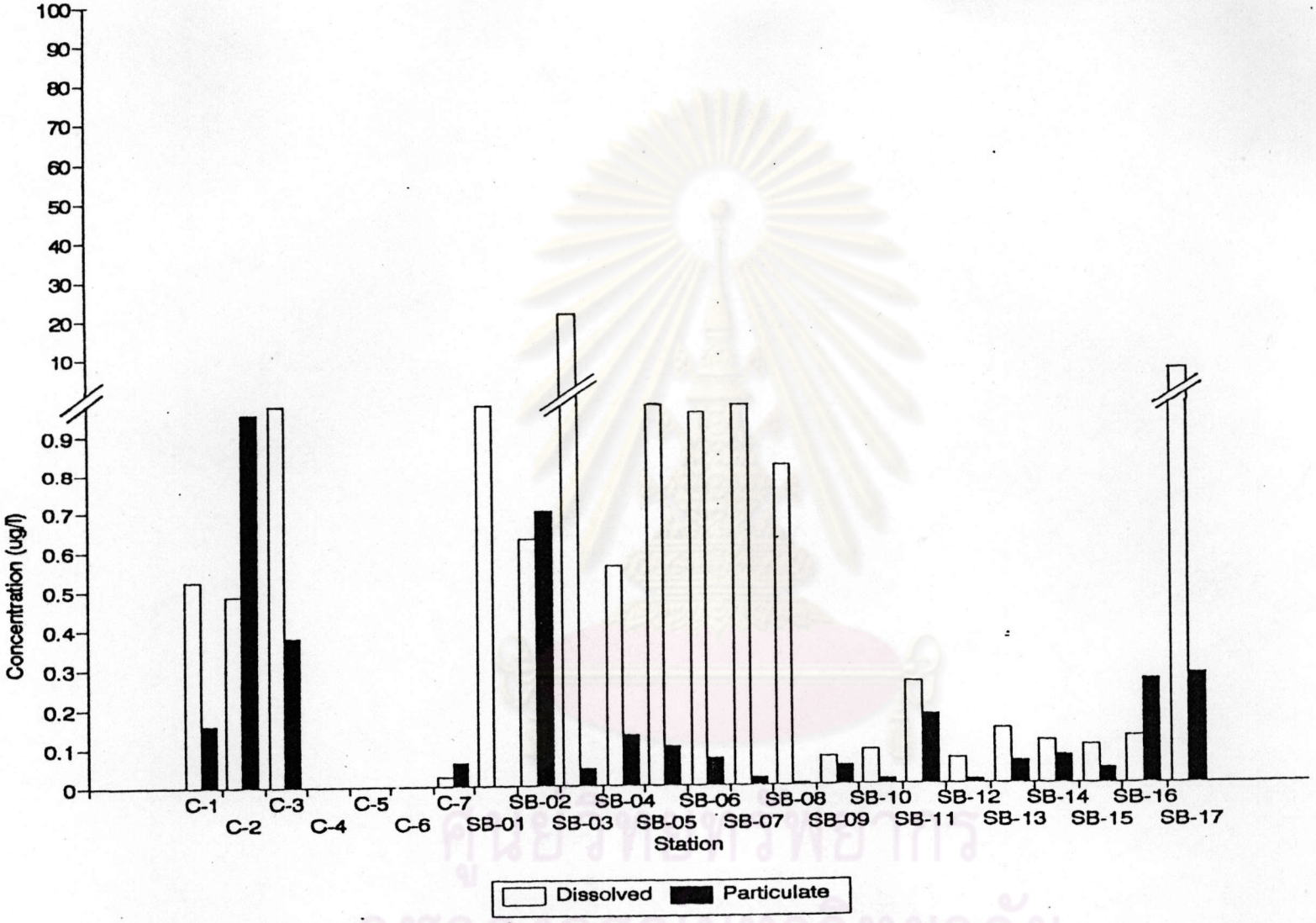


Figure 4-4 Concentrations of lead in particulate and dissolved forms in seawater on June 21-22 and July 11, 1989.

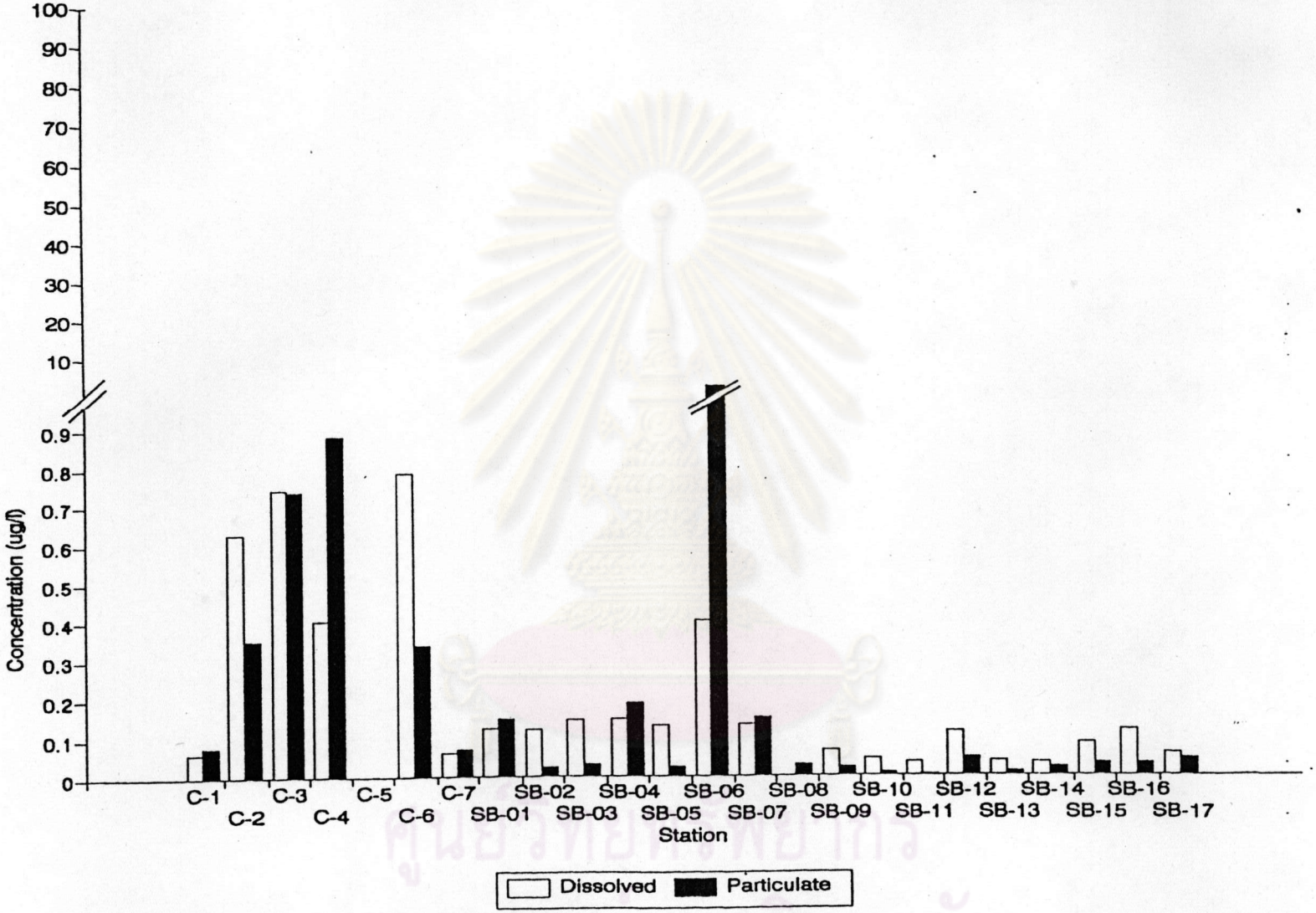


Figure 4-5 Concentrations of lead in particulate and dissolved forms in seawater on November 23-24, 1989.

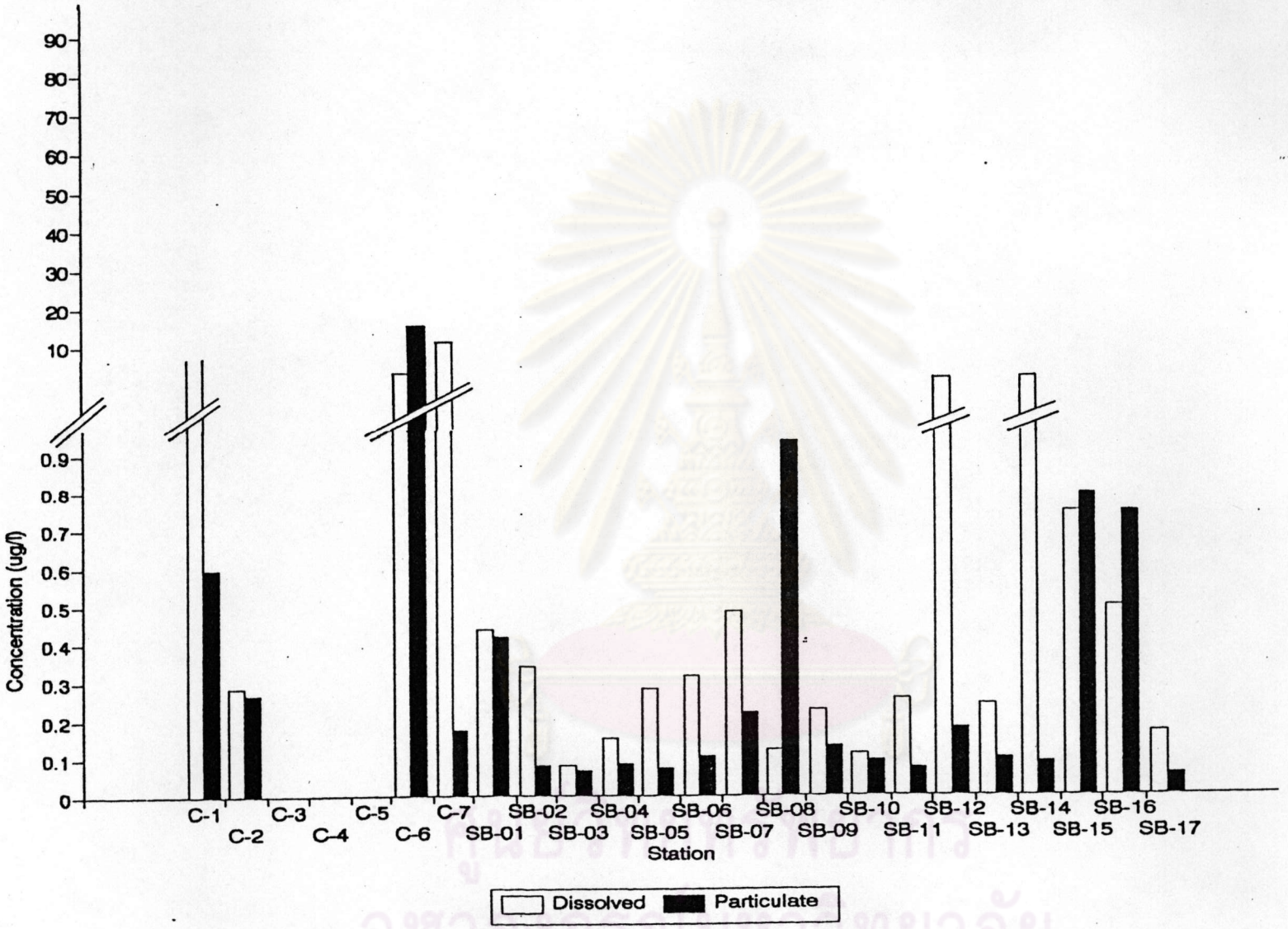


Figure 4-6 Concentrations of lead in particulate and dissolved forms in seawater on May 14-22, 1990.

causes a contamination of lead in seawater. Contaminated lead was found more in the form of dissolved than particulate and a discernible contamination occurred near the plants vicinity.

Although lead contamination due to ship-breaking activity was shown the concentrations observed were relatively low when compared to the Water Quality Standards, as shown in Tables 4-1 and 4-2.

Distribution of Copper in Seawater.

The concentrations of particulate copper were found to vary during the four periods observed. The variations are shown in Figure 4-7. The concentrations of particulate copper in October 1988 were very low concentrations (ND - 0.16 µg/l) at stations near the ship-breaking plants but were higher than concentrations observed (0.16 µg/l) at the Rayong River mouth.

During ship-breaking periods, June-July and November 1989, the concentrations significantly increased at some stations observed. The rest of the concentrations observed were very low and in the range of 0.0 - 0.2 µg/l. Therefore the variation of particulate copper concentrations was not significant.

However, the variation of dissolved copper concentrations in four periods observed were more pronounced as shown in Figure 4-8. In October 1988, the distributions of dissolved copper concentrations in seawater were evenly distributed (0.11-0.35 µg/l) and about the same level as concentrations found at the Rayong River mouth.

Table 4-1 Concentrations of particulate Pb, Cu, Zn and Fe in seawater from various coastal area and open ocean (in µg/l)

| Area | Pb | Cu | Zn | Fe | Reference |
|---|---|---|---|---|---|
| Open ocean average | 58 | 109 | 220 | - | Chester and Stoner, 1975. |
| New England Coast, USA. | 0.0023 | 0.0098 | 0.075 | 6.8 | Wallace, 1977. |
| Charting Coastal, Taiwan | - | 4.44 | - | - | Hung, 1989. |
| Mab Ta Phud,Rayong. | ND - 1.61 | ND-1.05 | ND-7.25 | 5.54-324.71 | The result of study |
| Water Quality Standard | <50 | <50 | <100 | <300 | ONEB, 1981 |

ND : not detected.

Table 4-2 Concentrations of dissolved Pb, Cu, Zn and Fe in seawater from various coastal area and open ocean (in µg/l)

| Area | Pb | Cu | Zn | Fe | Reference |
|---|---|---|---|---|---|
| Amphur Khlung, Chantaburi province | 6.1 | 2.7 | 4.4 | - | Hungspreugs, 1981 |
| Coastal line of Rayong-Trat Province | 2.50-19.95 | - | - | - | Vashrangsi,1981 |
| --- " --- | 0.79<br>0.20-1.82 | 1.90<br>0.72-3.99 | 15.01<br>2.70-49.32 | - | Petpiroon, 1988 |
| Coastal off Rayong province | 7.0 | 16.50 | 2.50 | -<br>- | The Office of National Environmental Board,1981 |
| Rayong Bay | 0.48<br>0.00-1.97 | 2.22<br>0.69-5.54 | 9.69<br>2.50-32.02 | - | Petpiroon, 1989 |
| Upper Gulf of Thailand (wet season) | 0.44<br>0.20-1.13 | 1.06<br>0.50-2.00 | 12.90<br>10.80-17.00 | -<br>- | Hungspreugs,1982 |
| Upper Gulf of Thailand (dry season) | 0.66<br>0.16-1.16 | 0.75<br>0.52-1.35 | 13.00<br>11.00-21.00 | -<br>- | -- " -- |
| Lower Gulf of Thailand | 0.04<br>0.01-0.06 | 1.40<br>0.70-2.10 | 7.10<br>4.00-12.00 | -<br>- | -- " -- |
| Near-shore average | - | 0.9 | 2.4 | 1.2 | Chester & Stoner,1974 |
| Open ocean average | - | 0.8 | 1.4 | 1.4 | -- " -- |
| Open ocean average | 0.03 | 0.50 | 4.90 | - | Brewer, 1975 |
| Mab Ta Phud, Rayong | ND-22.41 | 0.11-23.85 | ND-25.76 | ND-15.77 | The result of study |
| Water Quality Standard | <50 | <50 | <100 | <300 | ONEB, 1981 |

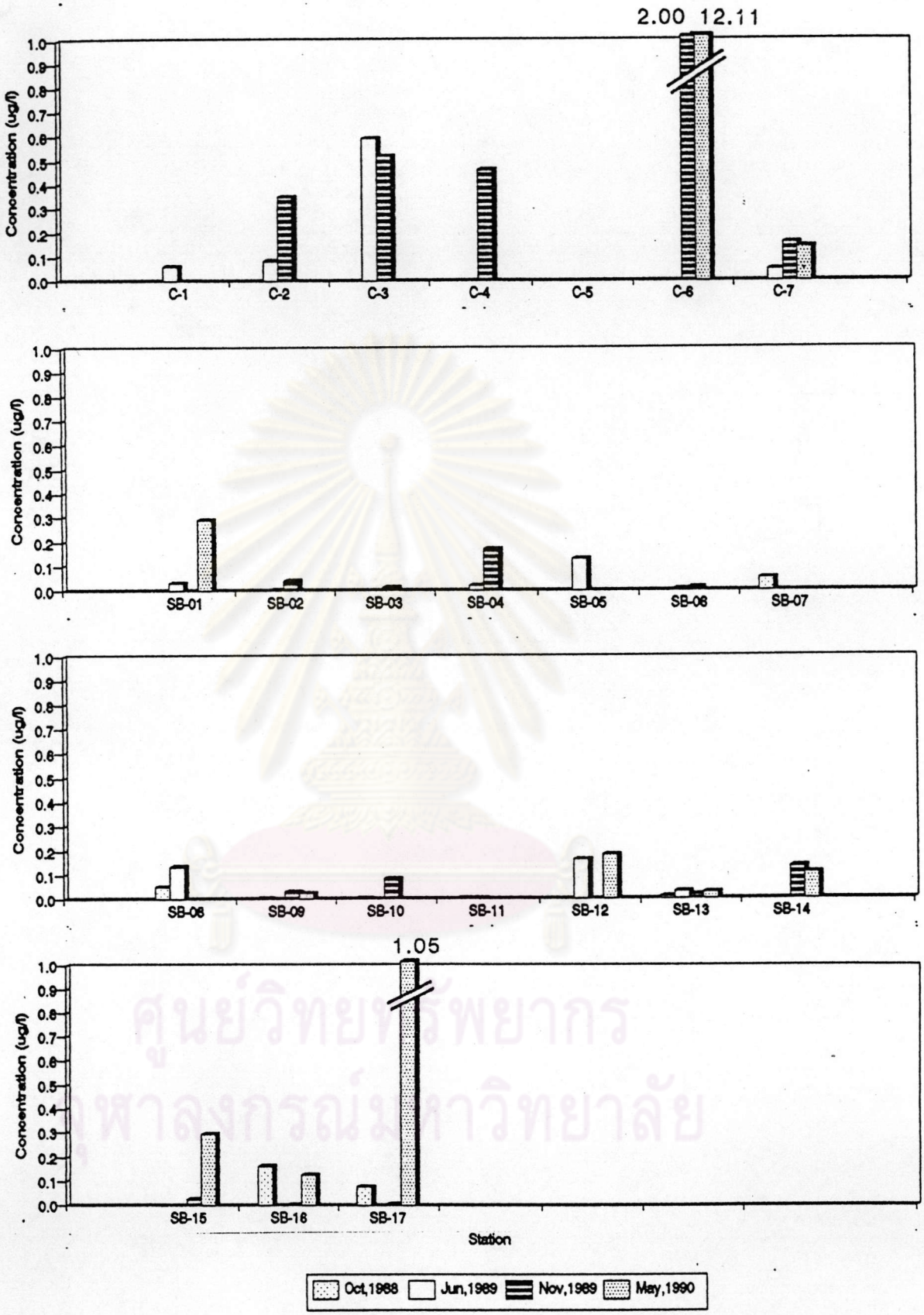


Figure 4-7 The concentration distribution of particulate copper in seawater at four sampling periods off Ban Nong Faeb, Mab Ta Phud, Rayong Province.

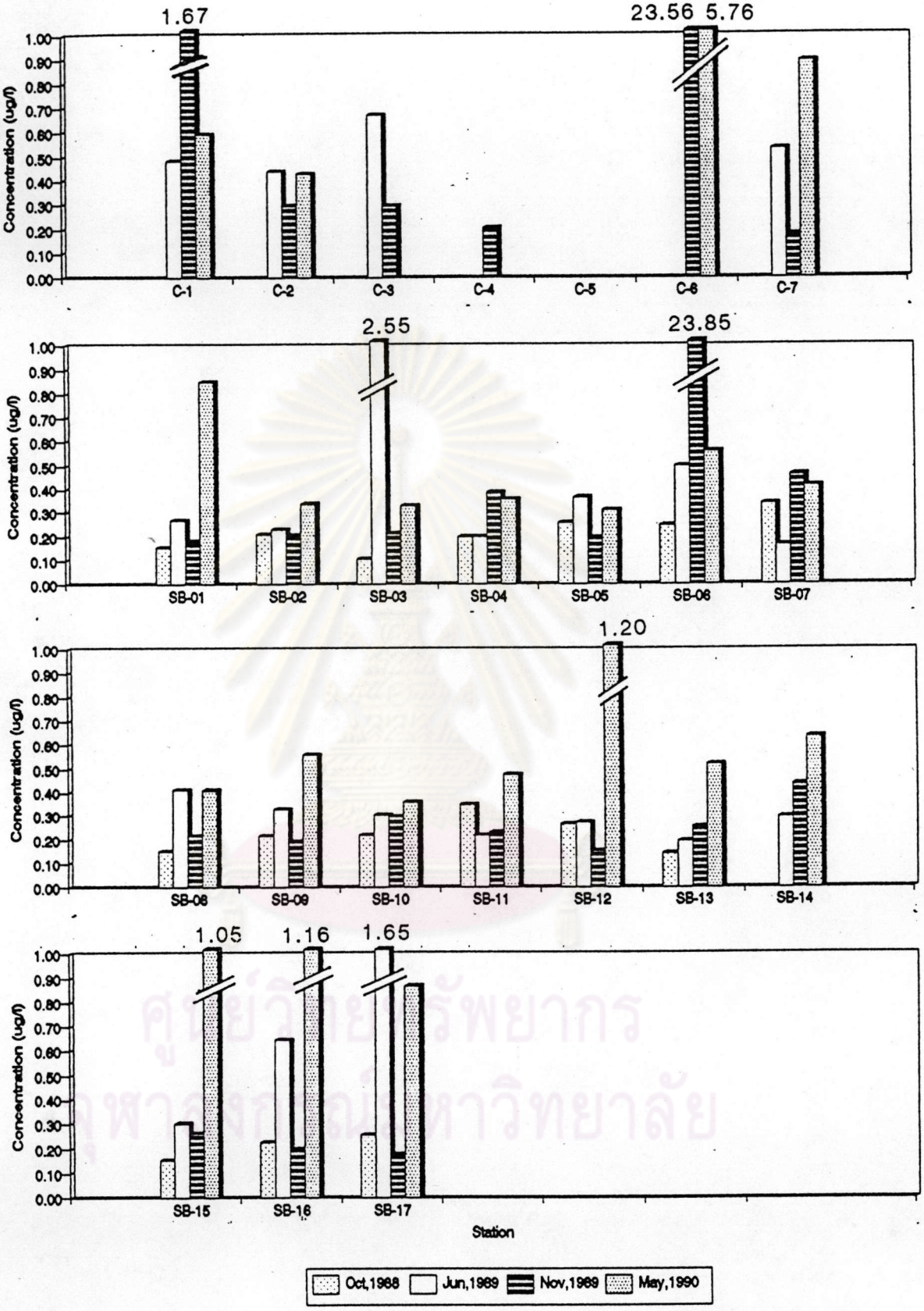


Figure 4-8 The concentration distribution of dissolved copper in seawater at four sampling periods off Ban Nong Faeb, Mab Ta Phud, Rayong Province.

In June-July and November 1989, most of the concentrations were higher. When consider the average concentrations of nearshore stations in June-July with the background concentrations in October 1988 a significant difference was observed. The average dissolved concentrations were 0.678 and 0.288 µg/l respectively. This strongly indicates a contamination of copper in a dissolved form due to ship-breaking activity at the nearshore area. However, the average concentration observed in November 1989 for the nearshore stations was also 0.27 µg/l which was slightly higher than the background one. This indicates a dissolved contamination due to rapid mixing caused by intense wave and wind prevailed during sampling.

In May,1990, the concentrations observed were high when compared to October 1988 period. The concentrations were by average two times higher than the background concentrations and even higher than the concentrations observed when the ship-breaking activity was under way.

When considering Figures 4-9, 4-10, 4-11 and 4-12 the dissolved copper concentrations were higher than the particulate ones for all periods. This indicates that copper in seawater was mostly in the dissolved form.

In conclusion it can be said that the ship-breaking activity causes copper contamination in seawater. Contaminated copper was found more in the form of dissolved than particulate.

Although the ship-breaking activity was shown to cause copper contamination, the concentrations observed were relatively

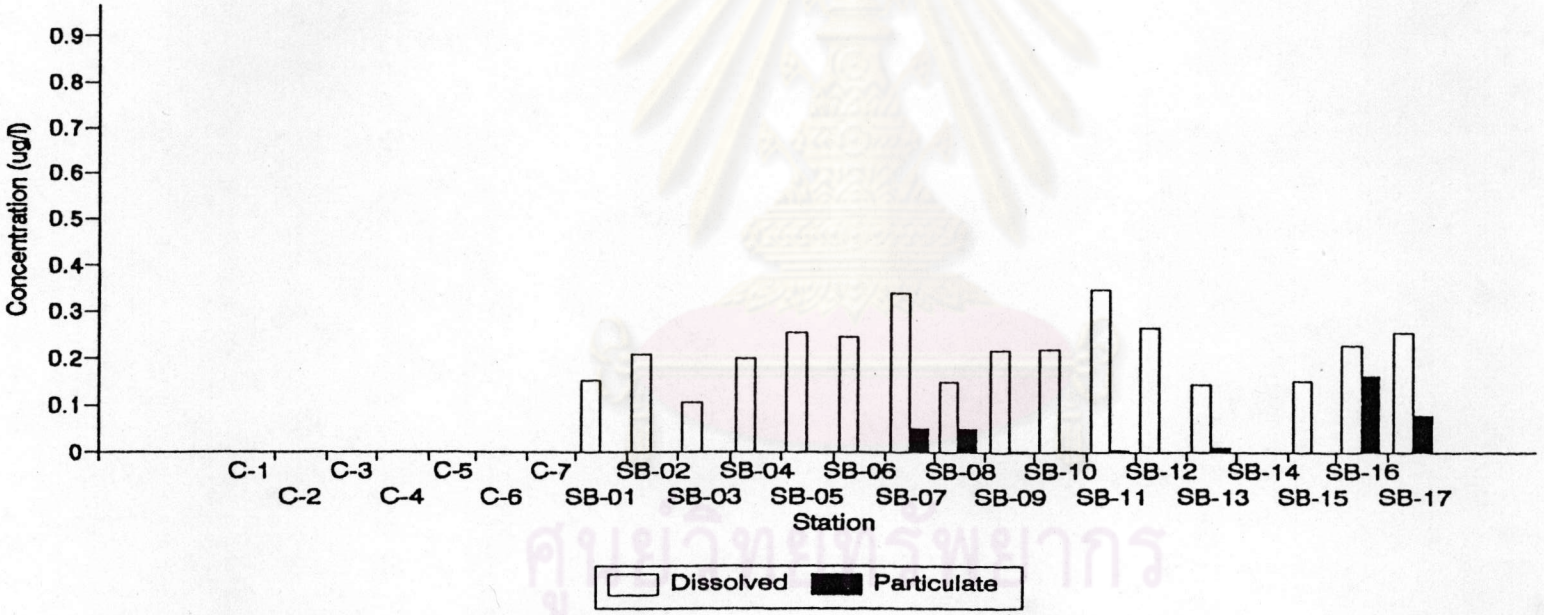


Figure 4-9 Concentrations of copper in particulate and dissolved in seawater on October 20-25, 1988.

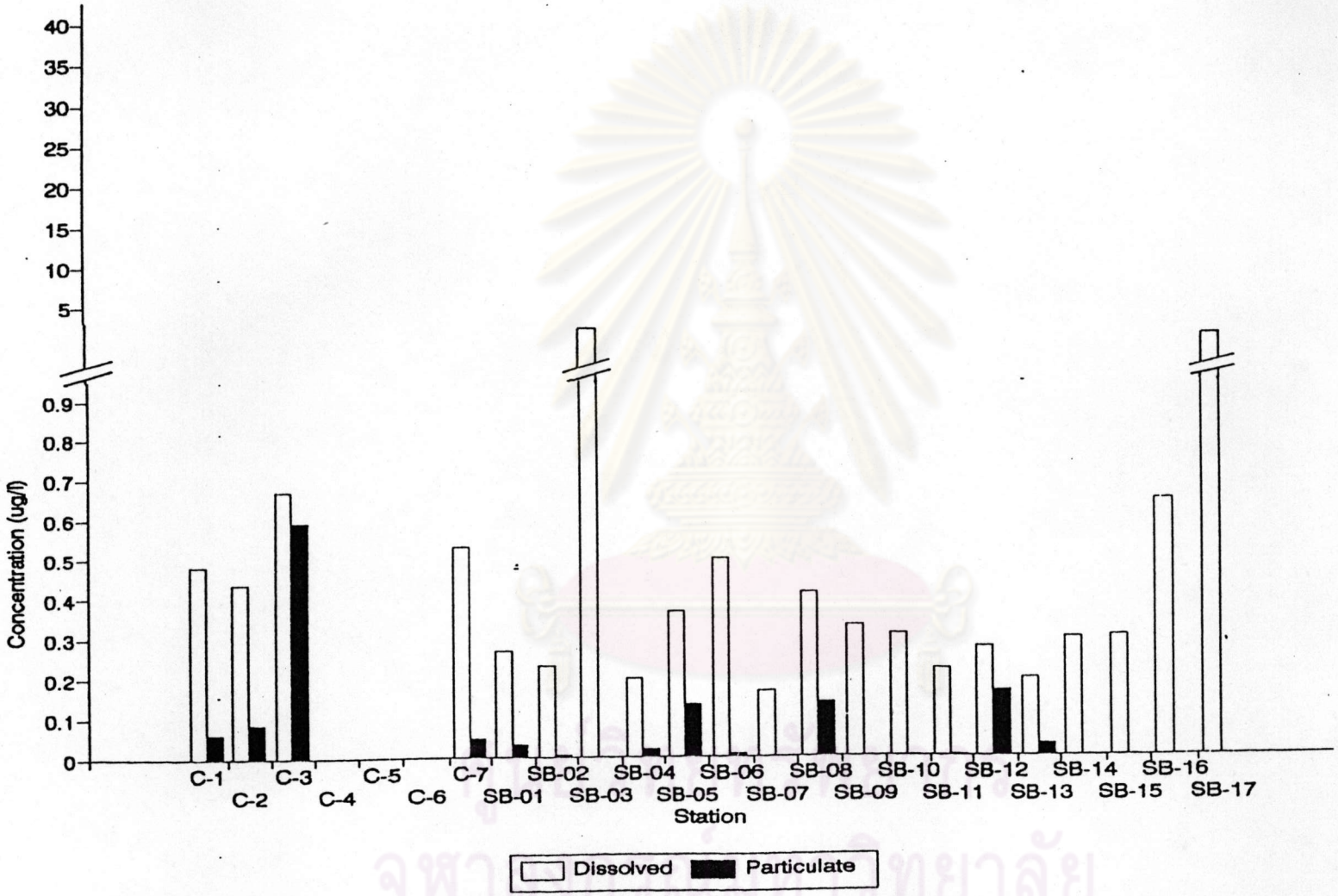


Figure 4-10 Concentrations of copper in particulate and dissolved forms in seawater on June 21-22 and July 11, 1989.

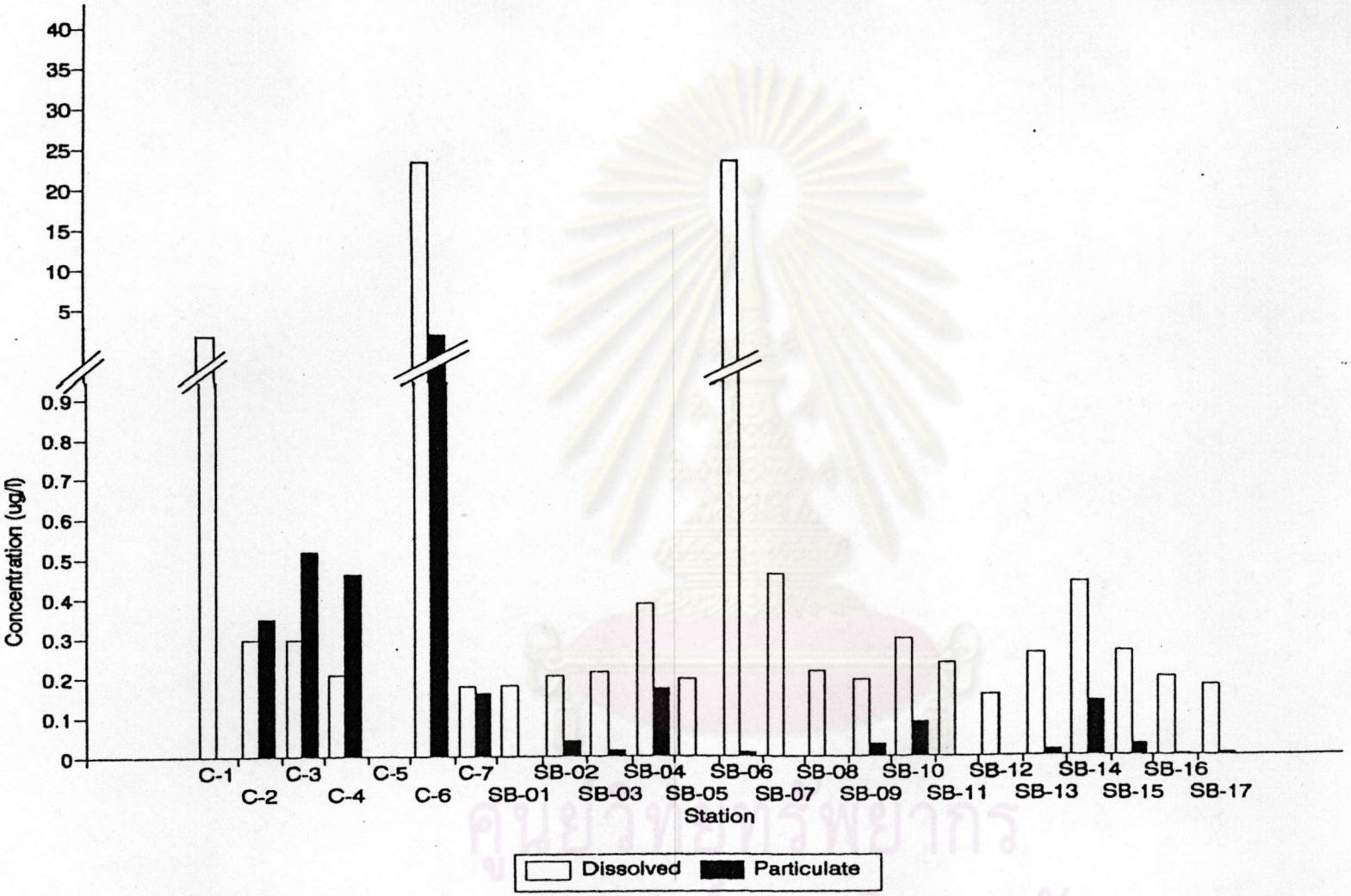


Figure 4-11 Concentrations of copper in particulate and dissolved forms in seawater on November 23-24, 1989.

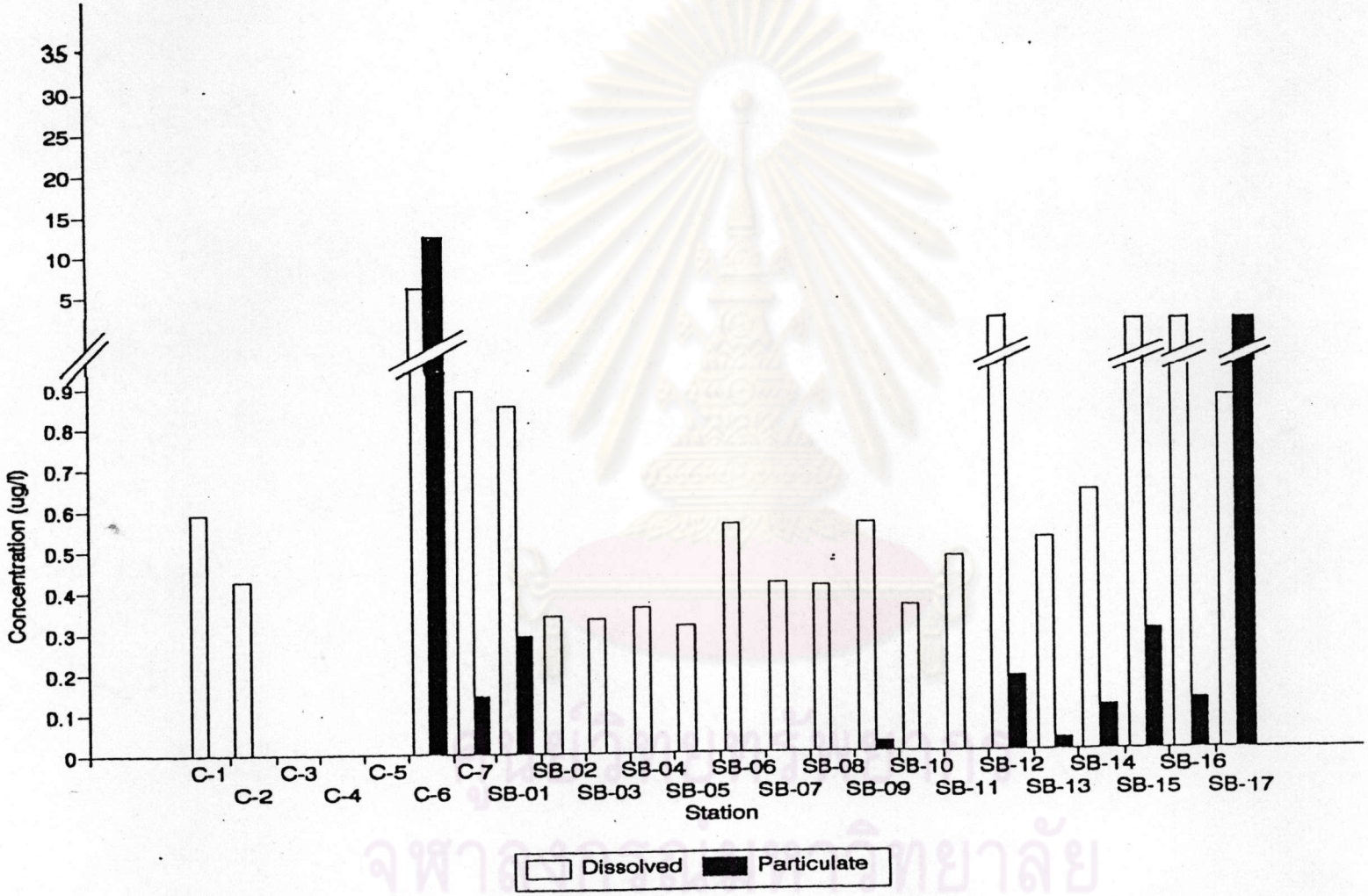


Figure 4-12 Concentrations of copper in particulate and dissolved forms in seawater on May 14-22, 1990.

low when compared to the Water Quality Standards, as shown in Tables 4-1 and 4-2.

Distribution of Zinc in Seawater.

The concentrations of particulate zinc were also found to vary during the four periods observed. The variations are shown in Figure 4-13. In October 1988, the concentrations of particulate zinc at nearshore and offshore of the ship-breaking plants were evenly distributed (0.26 - 1.79 µg/l) except for concentrations at SB-03 and SB-08 which were 2.39 and 2.70 µg/l, respectively. The concentrations at the Rayong River mouth were about the same level as the concentrations found at the vicinity of ship-breaking plants.

In June-July 1989, most of the particulate zinc concentrations at the nearshore and offshore stations were lower than concentrations found in October,1988. However, their concentrations were show the higher concentrations of the nearshore stations when compared to the offshore stations was also found. The average concentrations for nearshore and offshore stations were 1.812 and 0.230 µg/l, respectively. In November 1989 the variation of particulate zinc concentrations in seawater shown the same trend as the variation in June-July 1989.

In May 1990 the concentrations of particulate zinc decreased from what found during the ship-breaking periods and the background concentrations observed in October 1988.

The variation of dissolved zinc concentrations in four

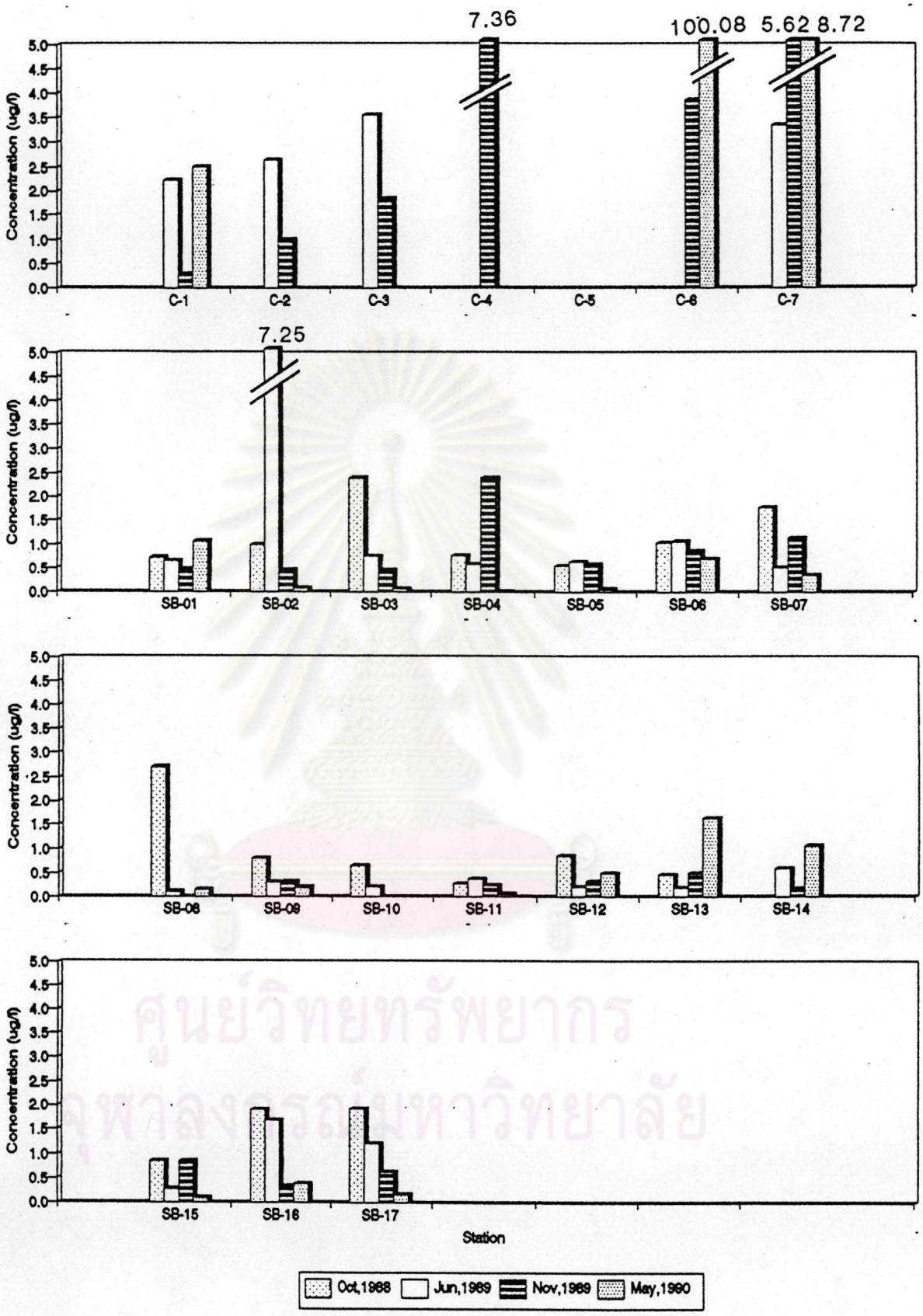


Figure 4-13 The concentration distribution of particulate zinc in seawater at the four sampling periods off Ban Nong Faeb, Mab Ta Phud, Rayong Province.

periods observed are shown in Figure 4-14. In October 1988, the dissolved zinc concentrations at the nearshore stations were higher than the offshore stations.

In June-July 1989, most of the nearshore stations concentrations were also higher than offshore stations. In November 1989 the concentration of dissolved zinc observed only at station SB-06 was significantly high ( 25.76 µg/l ). Most of the concentrations observed were lower than that found in June-July 1989 but the concentrations at nearshore stations were higher than offshore stations which indicates a contamination caused by a ship-breaking activity.

When consider the concentrations of dissolved zinc in May,1990, the concentrations observed were relatively less when compared to previous periods.

Figures 4-15, 4-16, 4-17 and 4-18 show that the dissolved zinc concentrations were higher than the particulate zinc for all periods. This indicates that zinc in seawater was mostly in the dissolved form.

In conclusion it can be said that the ship-breaking activity causes a contamination of zinc in seawater. Contaminated zinc was found more in the form of dissolved than particulate.

Although the ship-breaking activity was shown to cause zinc contamination, the concentrations observed were relatively low when compared to the Water Quality Standards, as shown in Tables 4-1 and 4-2.

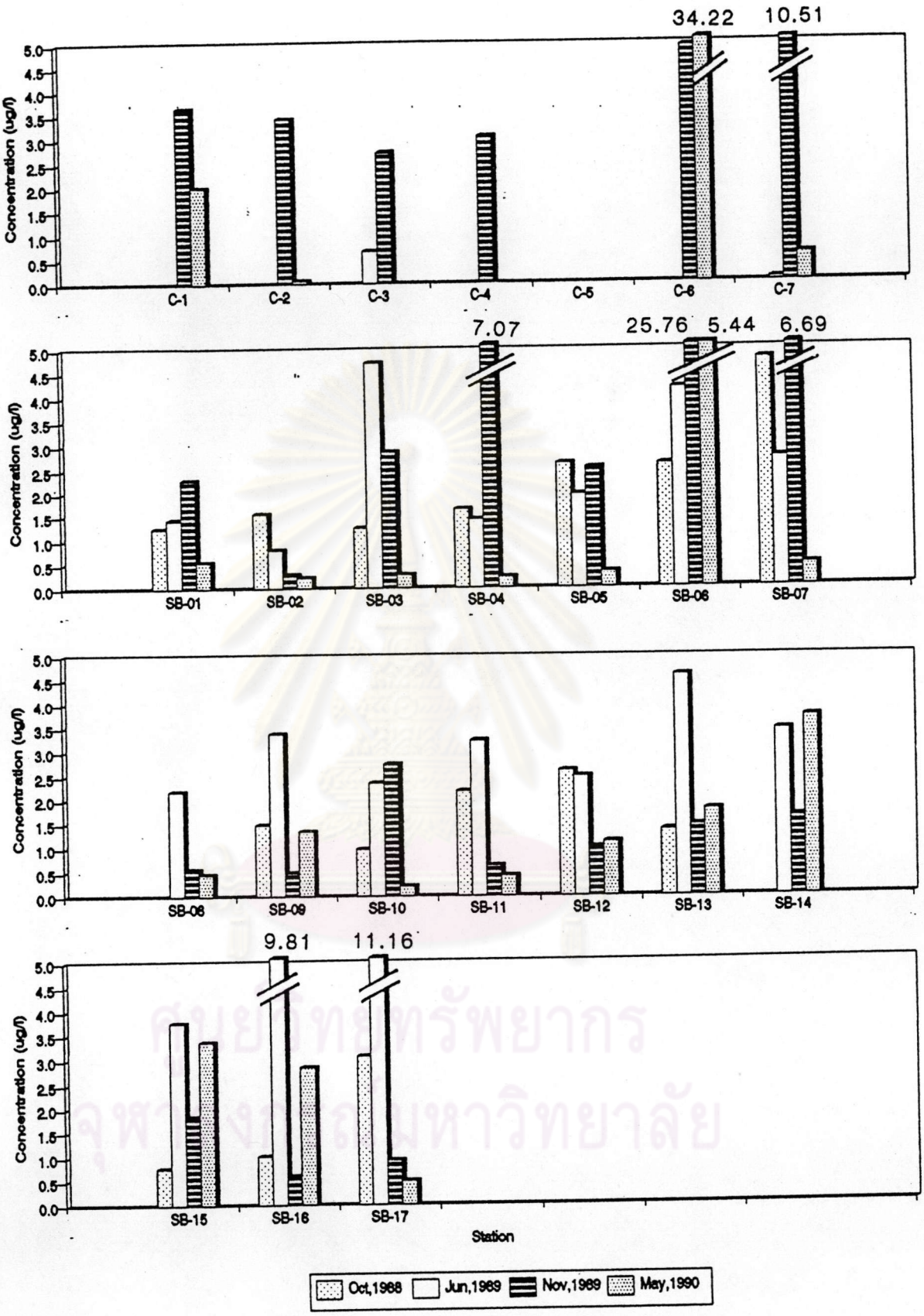


Figure 4-14 The concentration distribution of dissolved zinc in seawater at the four sampling periods off Ban Nong Faeb, Mab Ta Phud, Rayong Province.

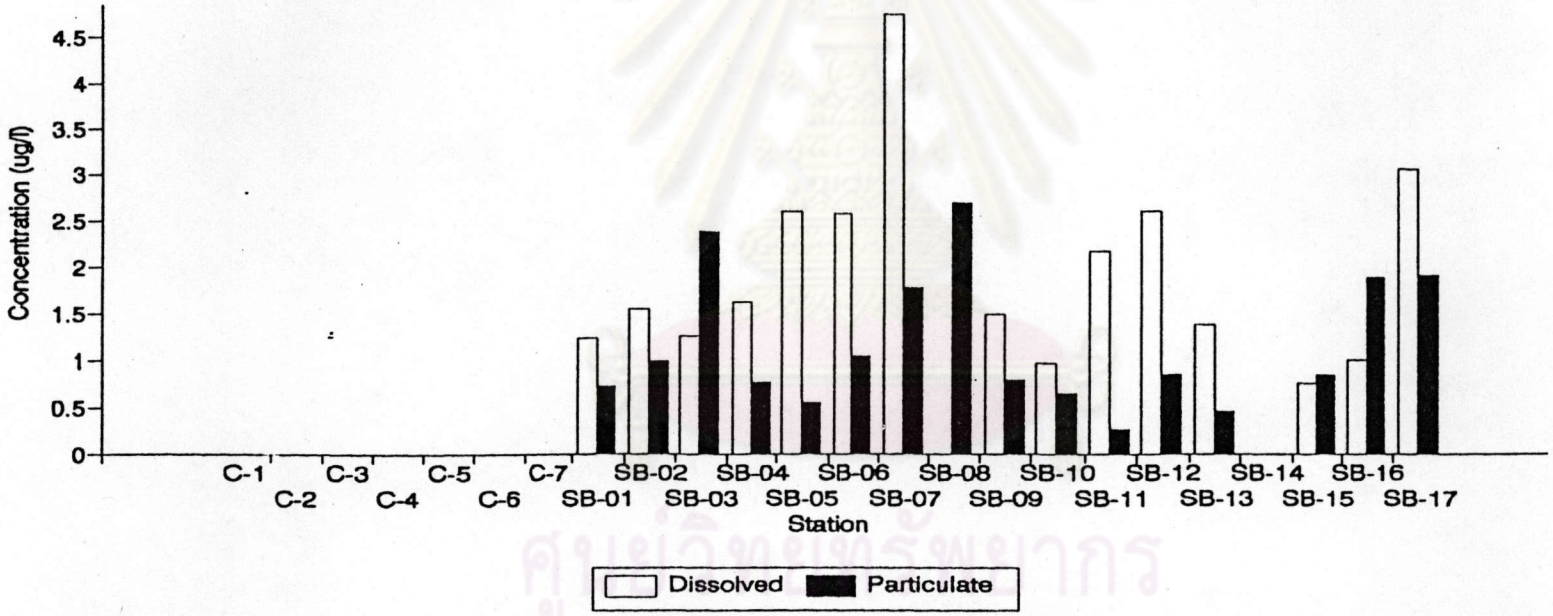


Figure 4-15 Concentrations of zinc in particulate and dissolved forms in seawater on October 20-25, 1988.

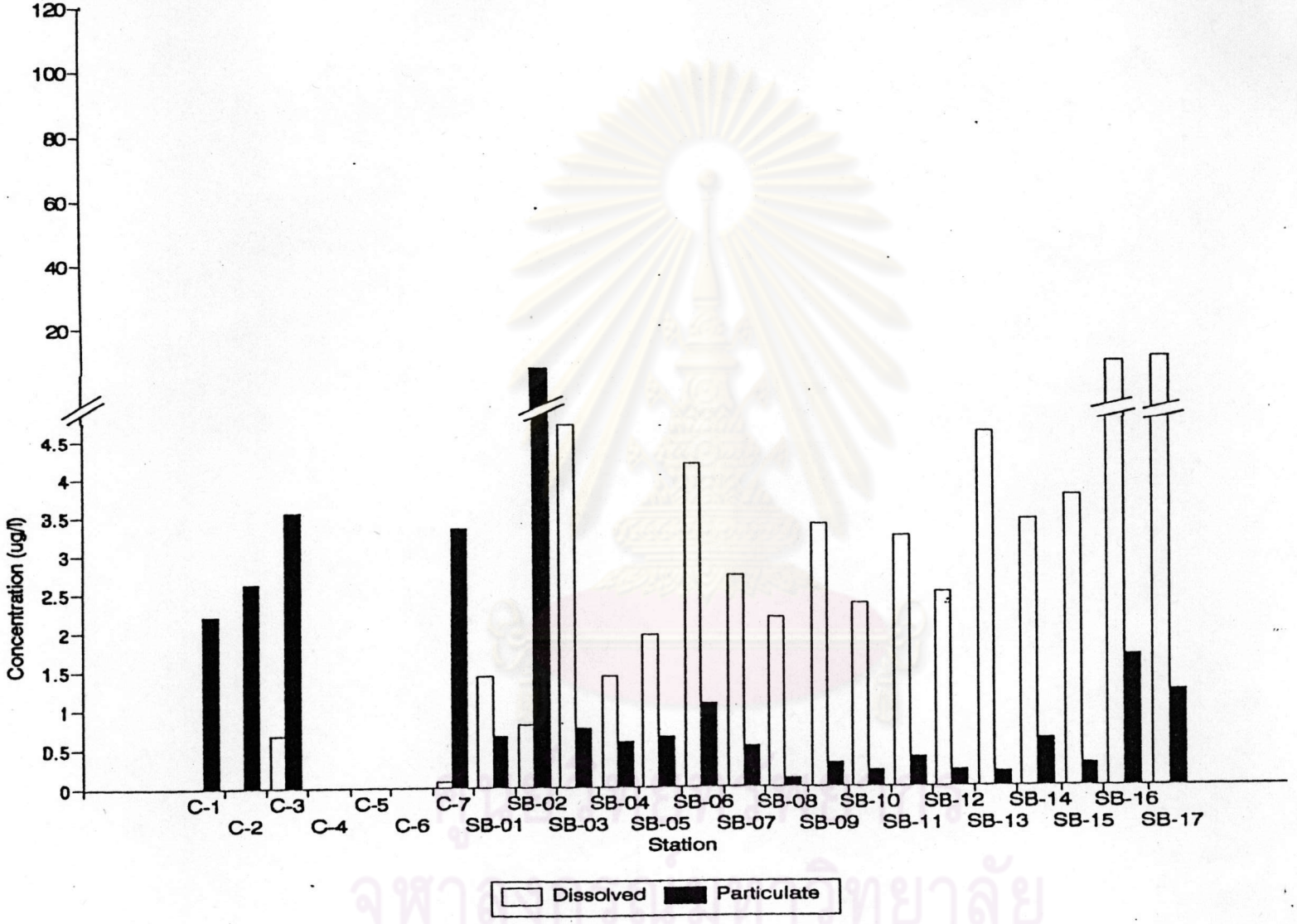


Figure 4-16 Concentrations of zinc in particulate and dissolved forms in seawater on June 21-22 and July 11, 1989.

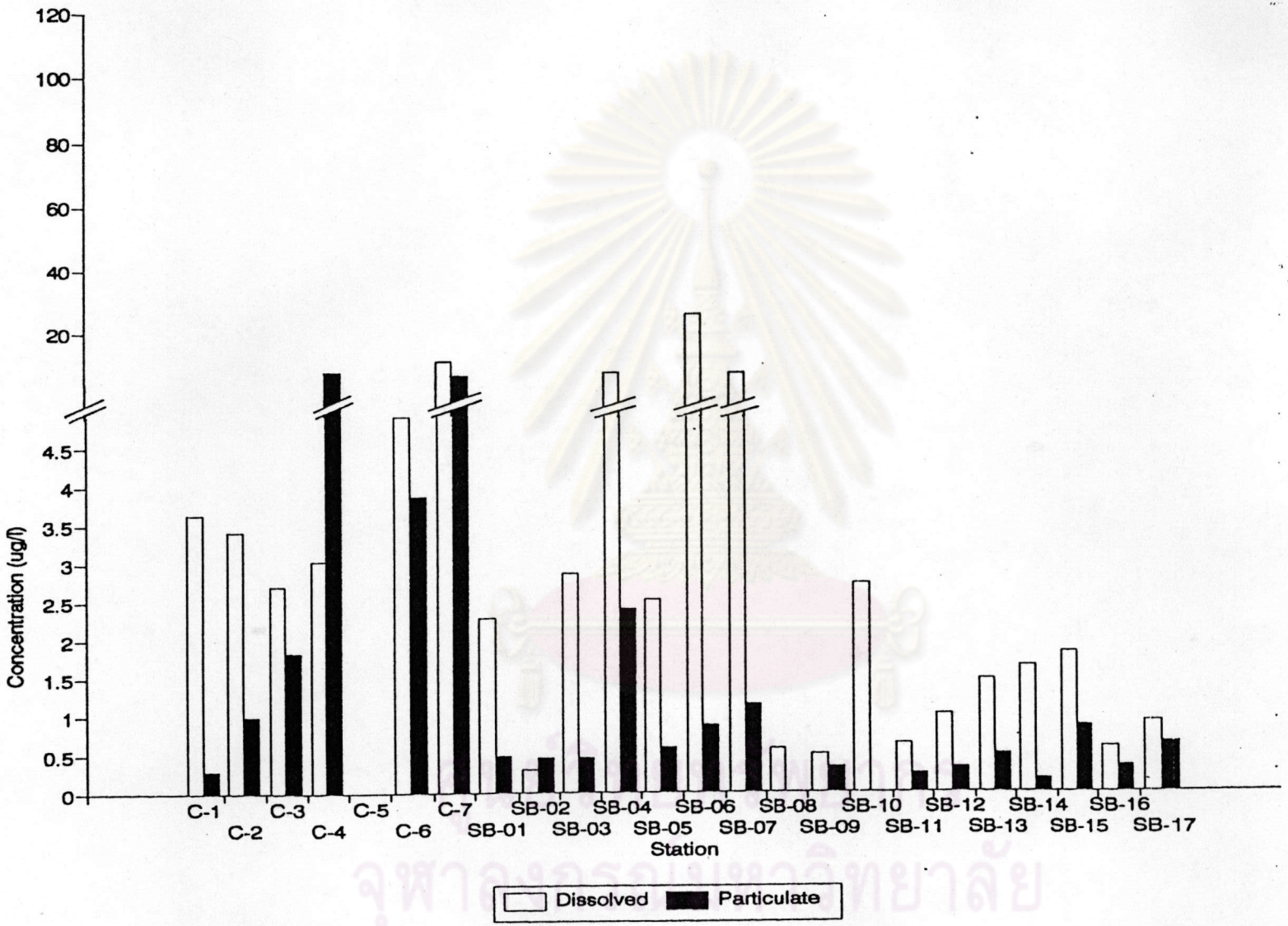


Figure 4-17 Concentrations of zinc in particulate and dissolved forms in seawater on November 23-24, 1989.

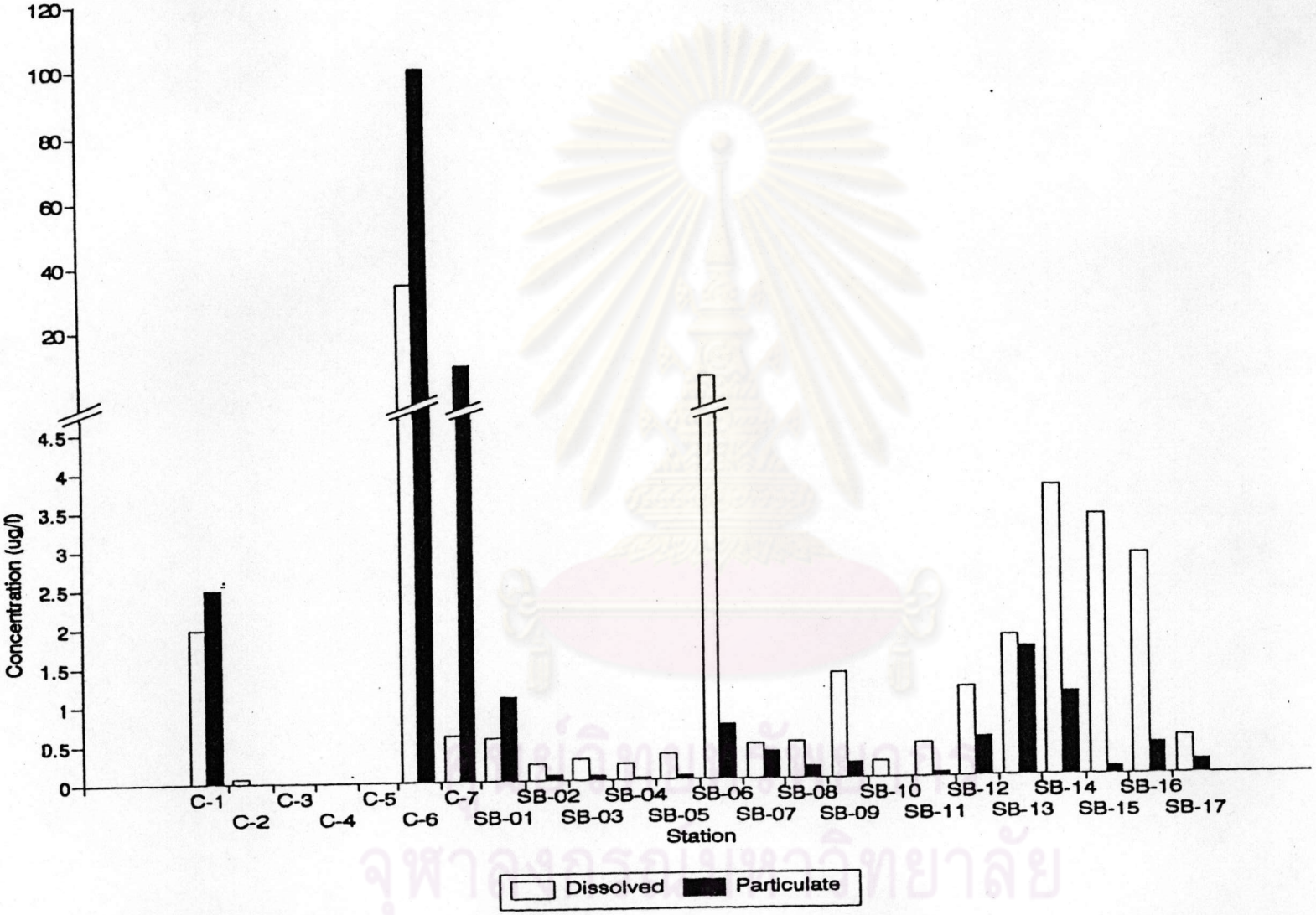


Figure 4-18 Concentrations of zinc in particulate and dissolved forms in seawater on May 14-22, 1990.

Distribution of Iron in Seawater.

The variations of particulate iron concentration are shown in Figure 4-19. In October 1988, higher concentrations of particulate iron than stations in vicinity of ship-breaking plants were found at Rayong River mouth. Most of the particulate iron concentrations at nearshore stations observed were higher than offshore stations. The average concentrations for nearshore and offshore stations were 25.53 and 14.80 µg/l respectively.

During the ship-breaking periods ( June-July 1989 and November 1989), the concentrations significantly increased at some stations. In June-July 1989, the higher concentrations than in October 1988 were found at stations in the vicinity of the ship-breaking plants. The concentrations of particulate iron were 50.76, 81.97, 35.38 and 41.03 µg/l at stations SB-01, SB-02, SB-04 and SB-06 respectively. In November 1989 the concentrations of particulate iron were the same as in June-July 1989.

In May 1990 the concentrations of particulate iron observed were relatively low when compared to June-July period but higher concentrations were observed at some stations. The concentrations of particulate iron at the vicinity of Rayong River mouth were lower than the previous periods.

The variation of dissolved iron concentrations during the four periods observed were also found as shown in Figure 4-20. In October 1988, the dissolved iron concentrations in seawater were very low ( ND - 6.19 µg/l ) at stations near the ship-breaking plants and Rayong River mouth except station SB-05 ( 13.37 µg/l ).

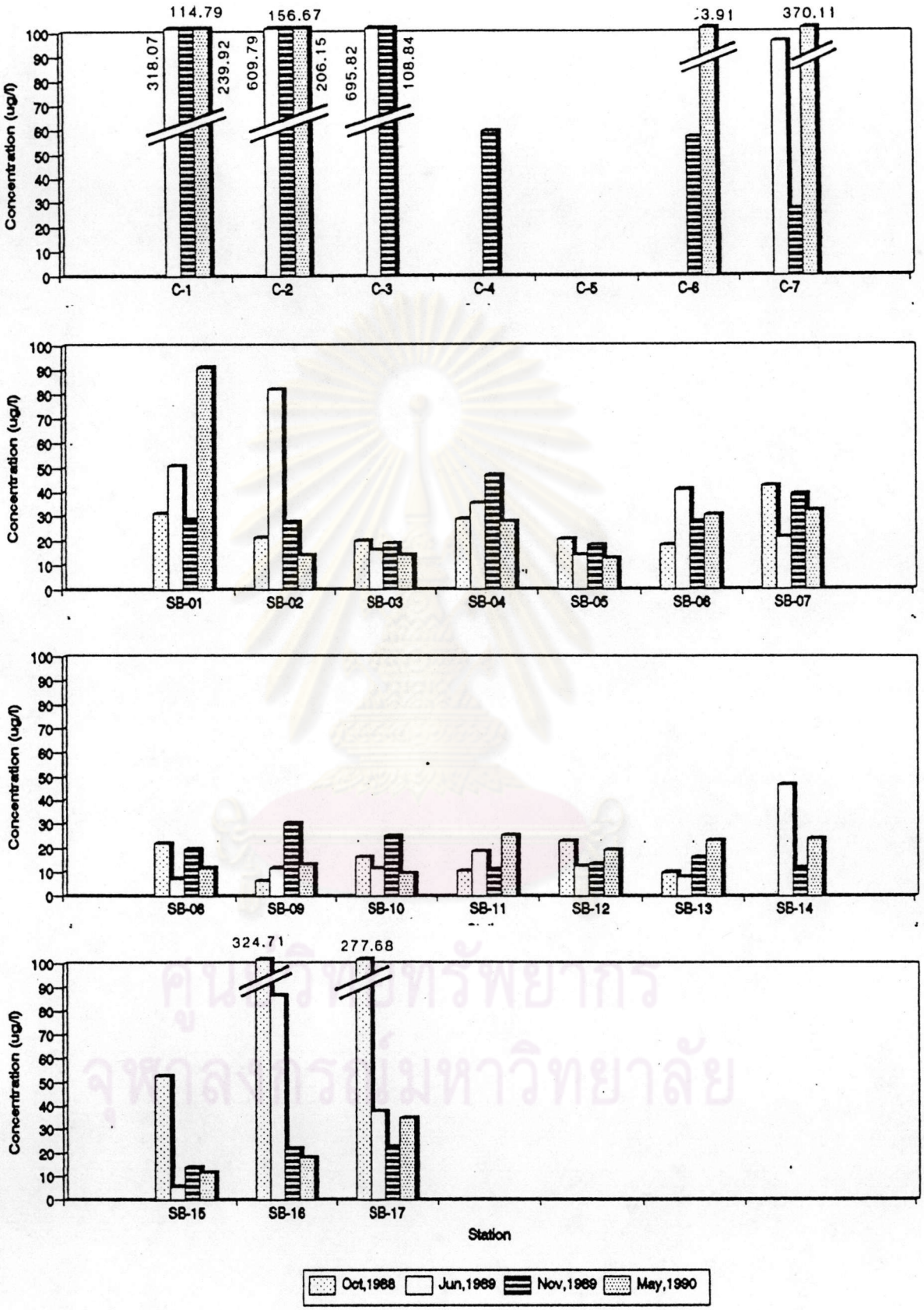


Figure 4-19 The concentration distribution of particulate iron in seawater at the four sampling periods off Ban Nong Faeb, Mab Ta Phud, Rayong Province.

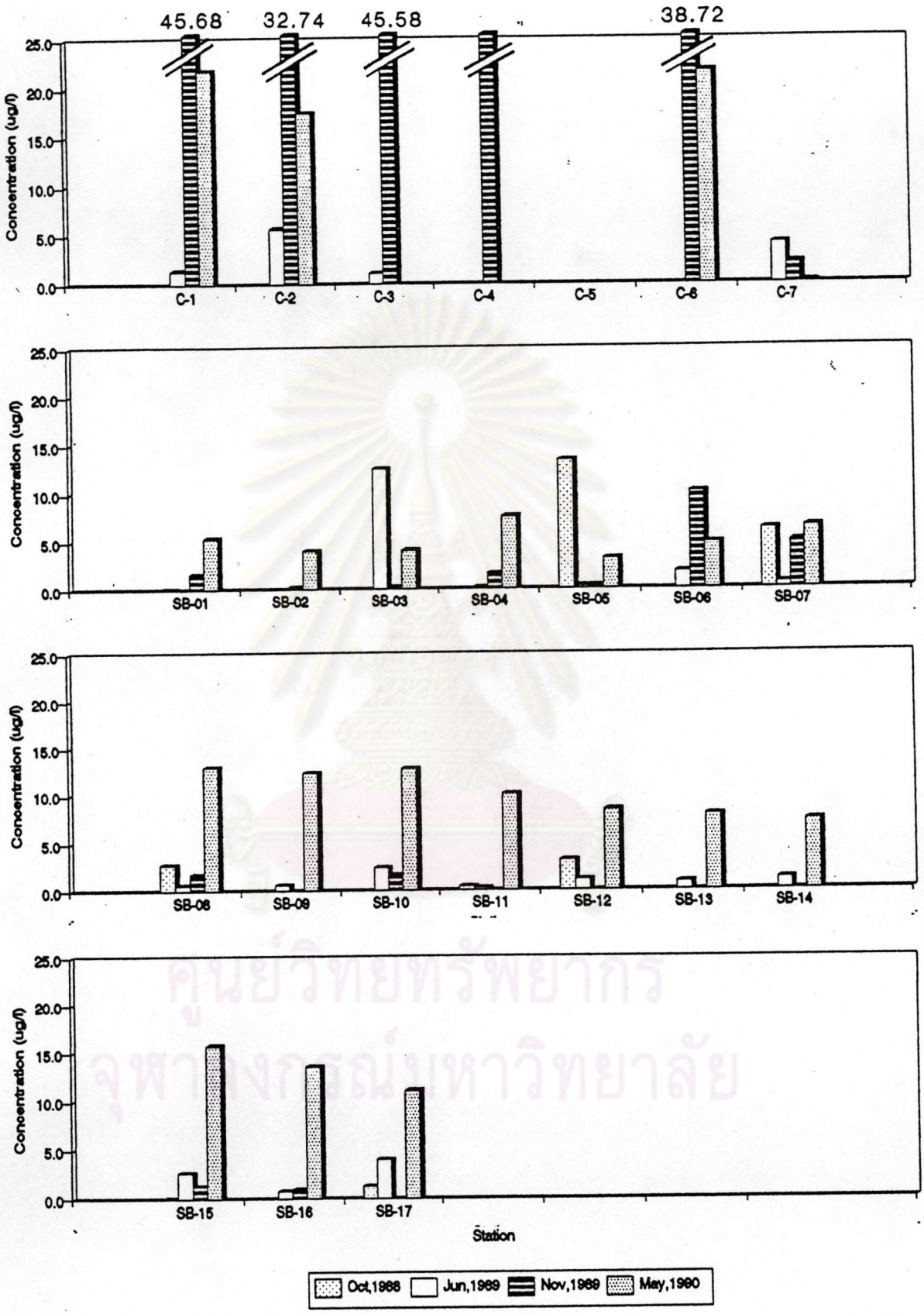


Figure 4-20 The concentration distribution of dissolved iron in seawater at four sampling periods off Ban Nong Faeb, Mab Ta Phud, Rayong Province.

The concentrations observed near the plants were evenly distributed and about the same as the concentrations observed at the Rayong River mouth.

During the ship-breaking activity, in June-July 1989 and November 1989, most of the concentrations observed at nearshore stations were the same level as in October 1988 and the rest of the concentrations observed were very low. The average concentrations found at nearshore and offshore stations were 2.52 and 0.96 µg/l, respectively. In November 1989 most of the concentrations observed were low and about the same level as concentrations found in June-July 1989.

In May 1990, the concentrations observed were relatively high when compared to the previous periods. High concentrations of dissolved iron observed may be caused by the sea port construction which was going on during the sampling period. The construction involved land reclamation where bottom sediments were excavated to form sea berth.

When considering Figures 4-21, 4-22, 4-23 and 4-24 the particulate iron concentrations were higher than the dissolved ones for all periods. This indicates that iron in seawater was mostly in the particulate form.

In conclusion it can be said that the ship-breaking activity causes a contamination of iron in seawater. Contaminated iron was found more in the form of particulate than dissolved.

Although the ship-breaking activity was shown to cause

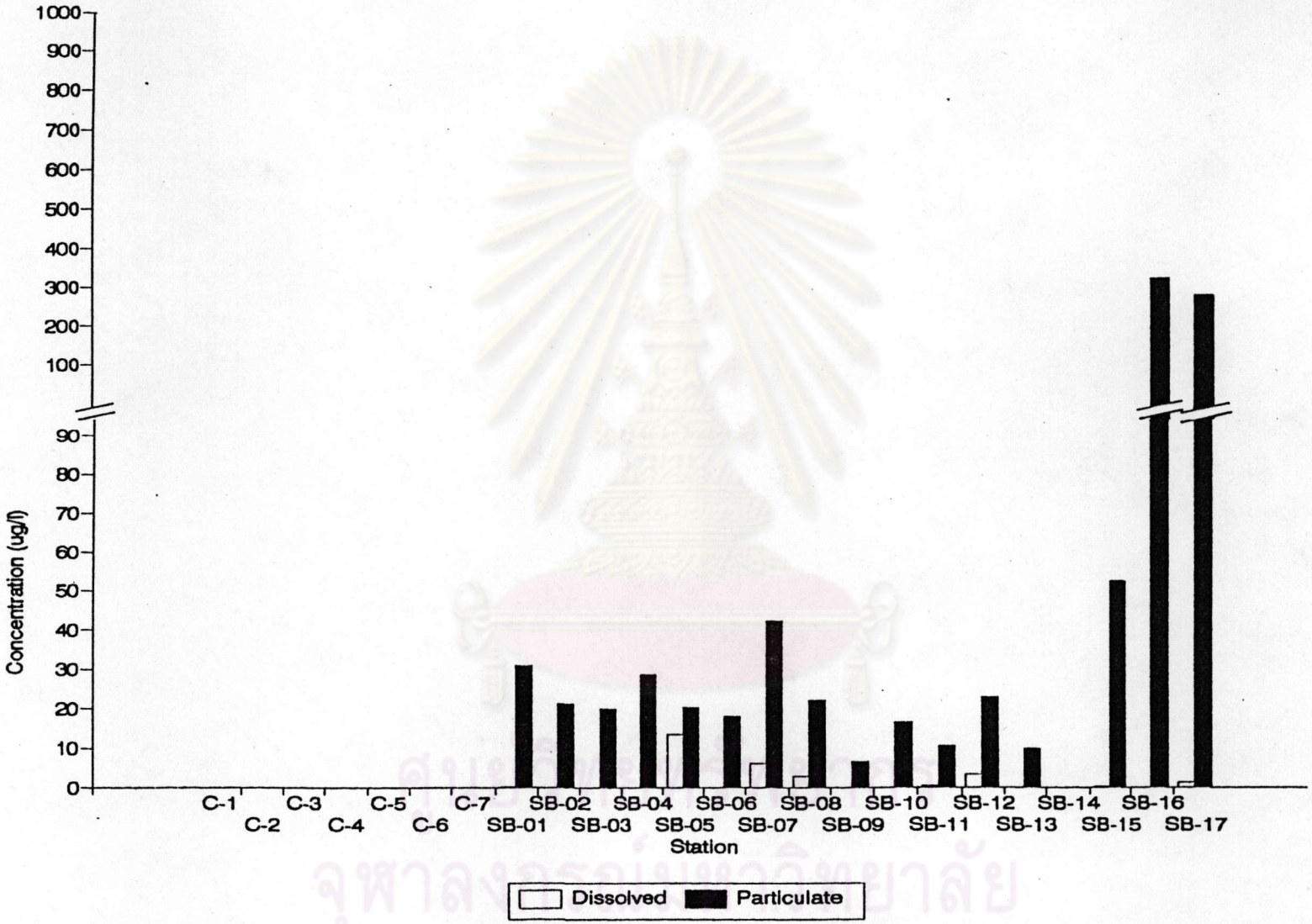


Figure 4-21 Concentrations of iron in particulate and dissolved forms in seawater on October 20-25, 1988.

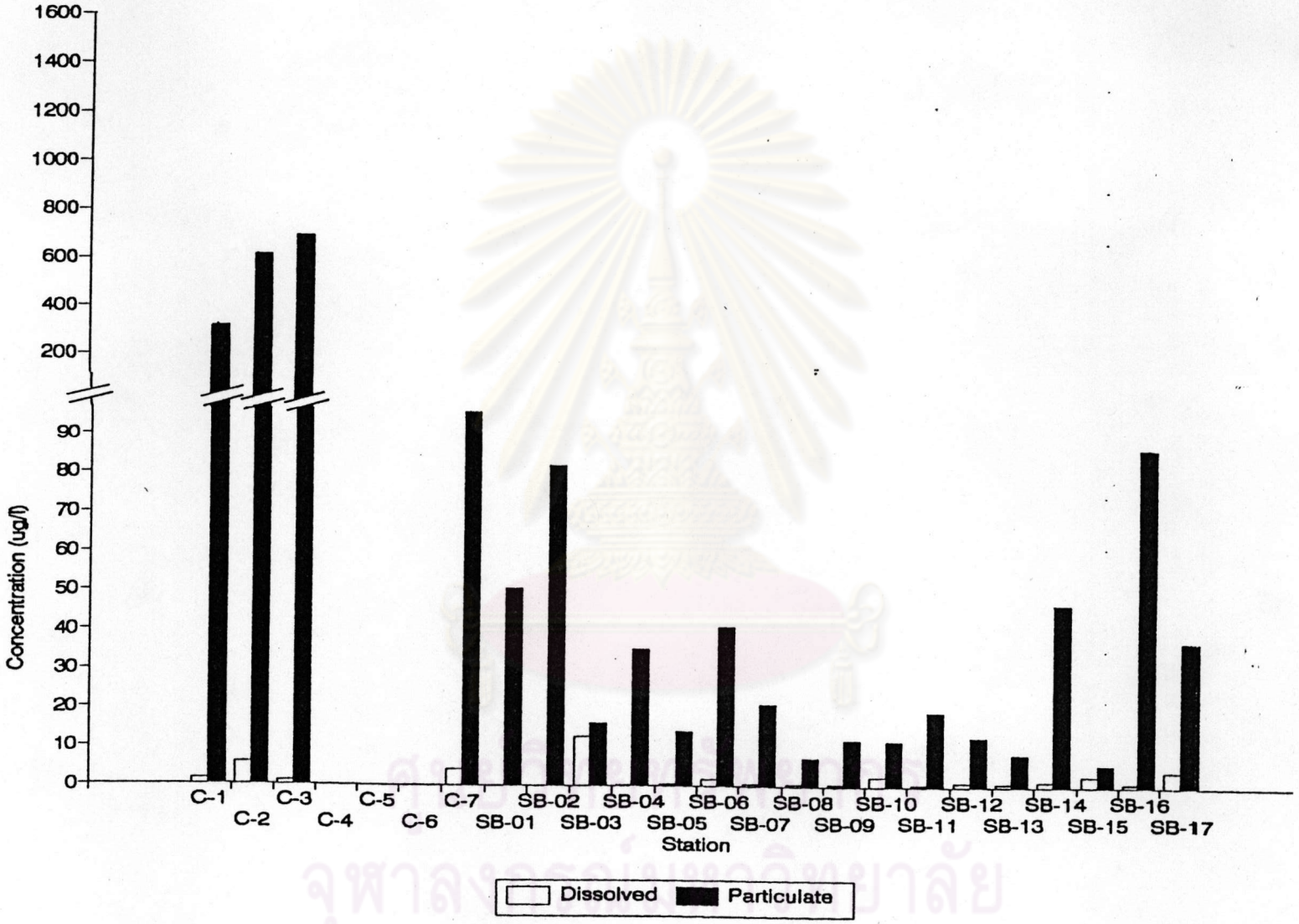


Figure 4-22 Concentrations of iron in particulate and dissolved forms in seawater on June 21-22 and July 11, 1989.

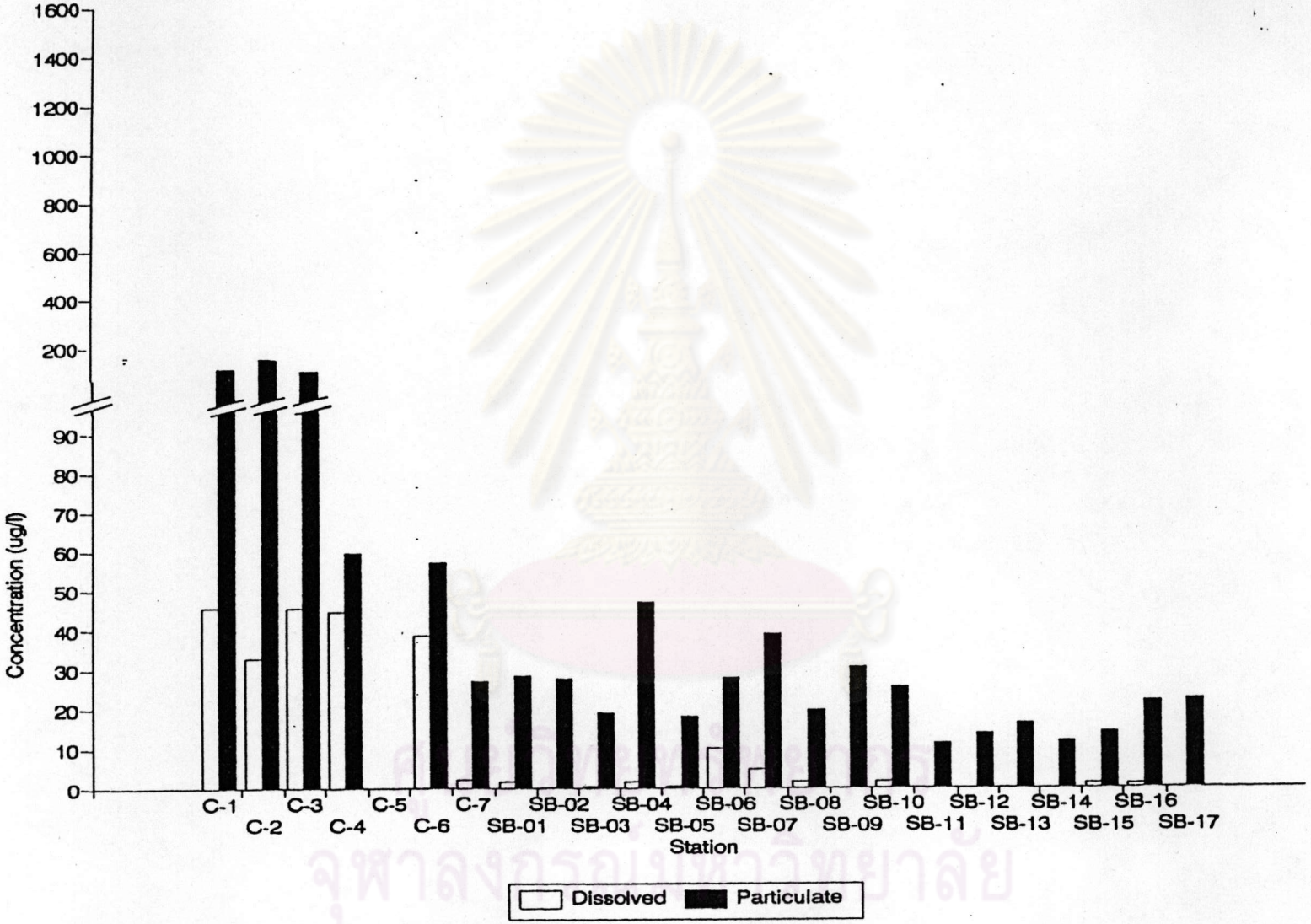


Figure 4-23 Concentrations of iron in particulate and dissolved forms in seawater on November 23-24, 1989.

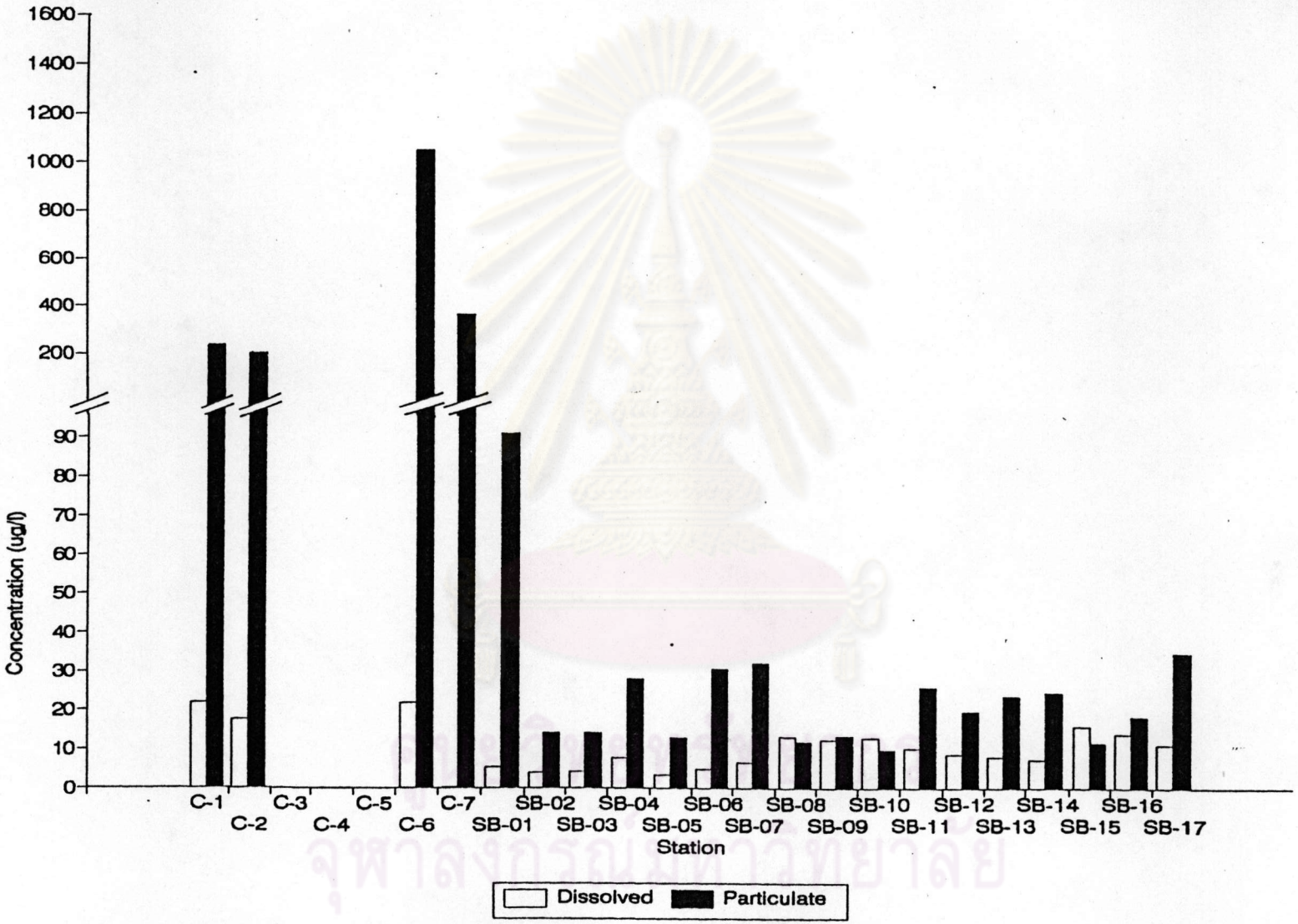


Figure 4-24 Concentrations of iron in particulate and dissolved forms in seawater on May 14-22, 1990.

iron contamination, the concentrations observed were relatively low when compared to the Water Quality Standards, as shown in Tables 4-1 and 4-2 except for the Rayong River mouth station.

Regarding the results of analysis of variance, the concentrations of particulate and dissolved lead, copper, zinc and iron were not significantly different at 95 % confidence level, except the dissolved iron concentration in May 1990.

Distribution of Dissolved Organic Carbon in Seawater

The concentration of dissolved organic carbon were found to vary during the four periods observed. The variations are shown in Figure 4-25. .From the results, the variation of dissolved organic carbon concentration in seawater shows the same trend as the dissolved copper. The high dissolved copper concentrations and high dissolved organic carbon were observed. A linear relationship between dissolved organic copper and dissolved organic carbon has been observed by Hung, Han and Wu, 1989. In addition, high concentrations of particulate organic copper and nonlabile organic copper indicated a high value of copper assimilative capacity. Therefore, low dissolved organic carbon concentrations in seawater during ship-breaking period indicates that the copper assimilative capacity value were low.

However, through the results the relationship between dissolved organic carbon concentrations and lead, zinc and iron concentrations was not observed.

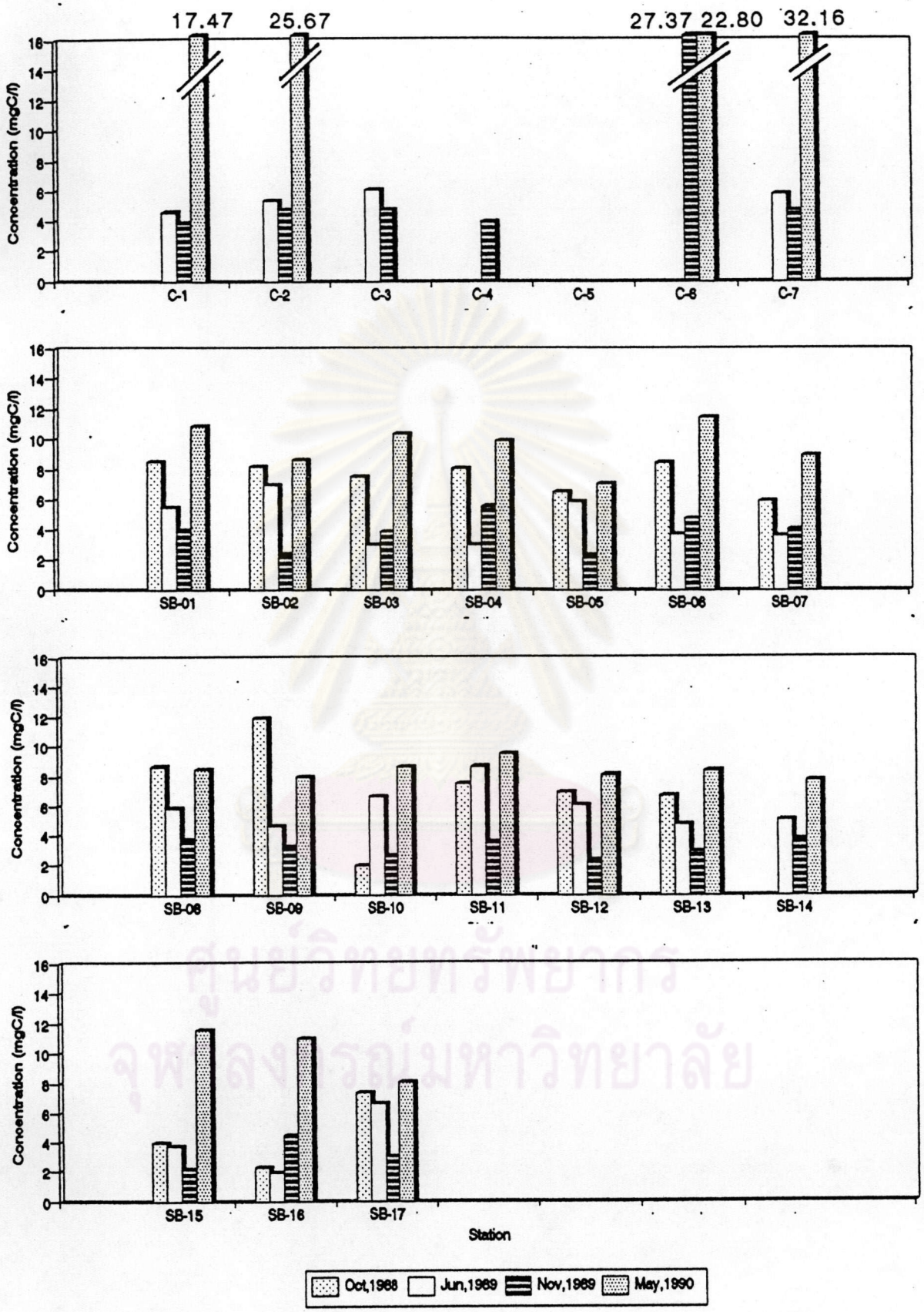


Figure 4-25 The concentration distribution of dissolved organic carbon in seawater at four sampling periods off Ban Nong Faeb, Mab ta Phud, Rayong Province.

Variation of Heavy Metals due to Tidal Cycle.

The variation of concentrations of lead, copper, zinc and iron both in particulate and dissolved forms in seawater within a tidal cycle was observed in June and November 1989. The variation patterns are shown in Figures 4-26, 4-27, 4-28 and 4-29.

On June 21-22, 1989 observation, the variations of particulate lead, copper, zinc and iron concentrations are shown in Figure 4-26. When considering the current direction, as shown in Figure 4-30, the concentration of particulate lead, copper, zinc and iron were dependent on the current direction. High concentrations were found while the current was in the east-west direction ( from Rayong River to the study area) and low concentrations were found while the current was in the west-east direction (from the study area to Rayong River mouth). It was expected that high concentrations of particulate lead, copper, zinc and iron were caused by the river water discharged.

The variations of dissolved lead, copper, zinc and iron concentrations are shown in Figure 4-27. When considering the current direction, as shown in Figure 4-30, the concentration of dissolved lead, copper, zinc and iron were not affected by the current direction except for the variation of dissolved copper.

On November 23-24, 1989 observation, the variations of particulate lead, copper, zinc and iron concentrations are shown in Figure 4-28. When considering the current direction, as shown in Figure 4-30, the concentration of particulate lead, copper, zinc and iron were related to the current direction. High concentrations

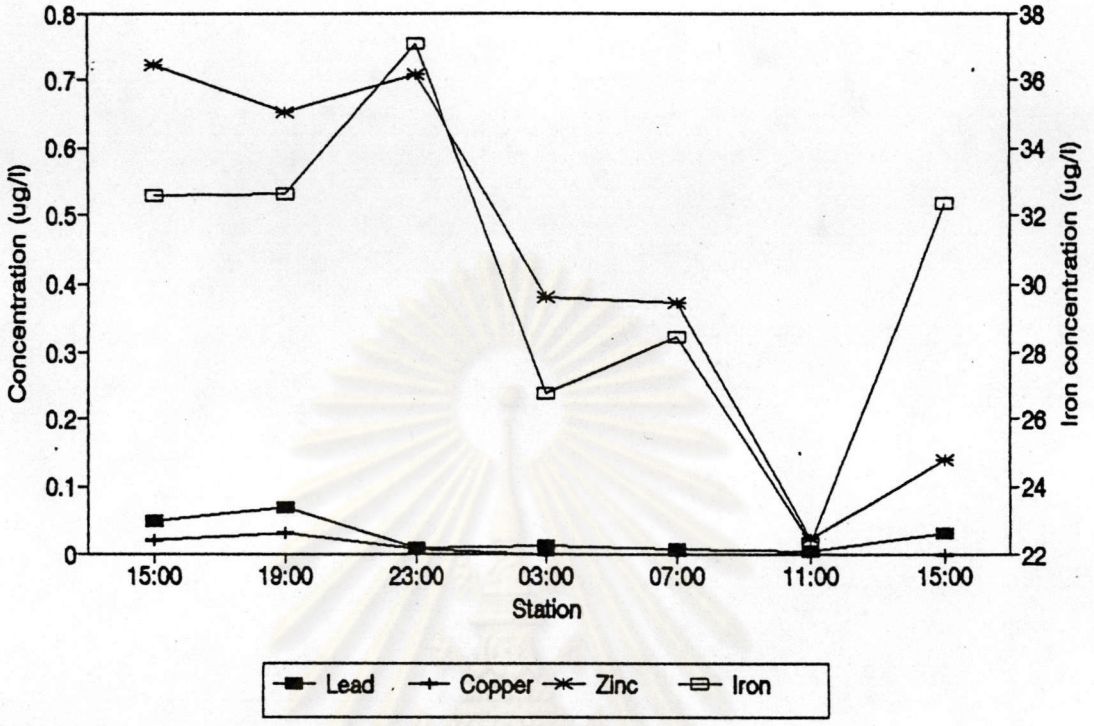


Figure 4-26 The variation of particulate lead, copper, zinc and iron concentrations within a tidal cycle at station SB-10 on June 21-22, 1989.

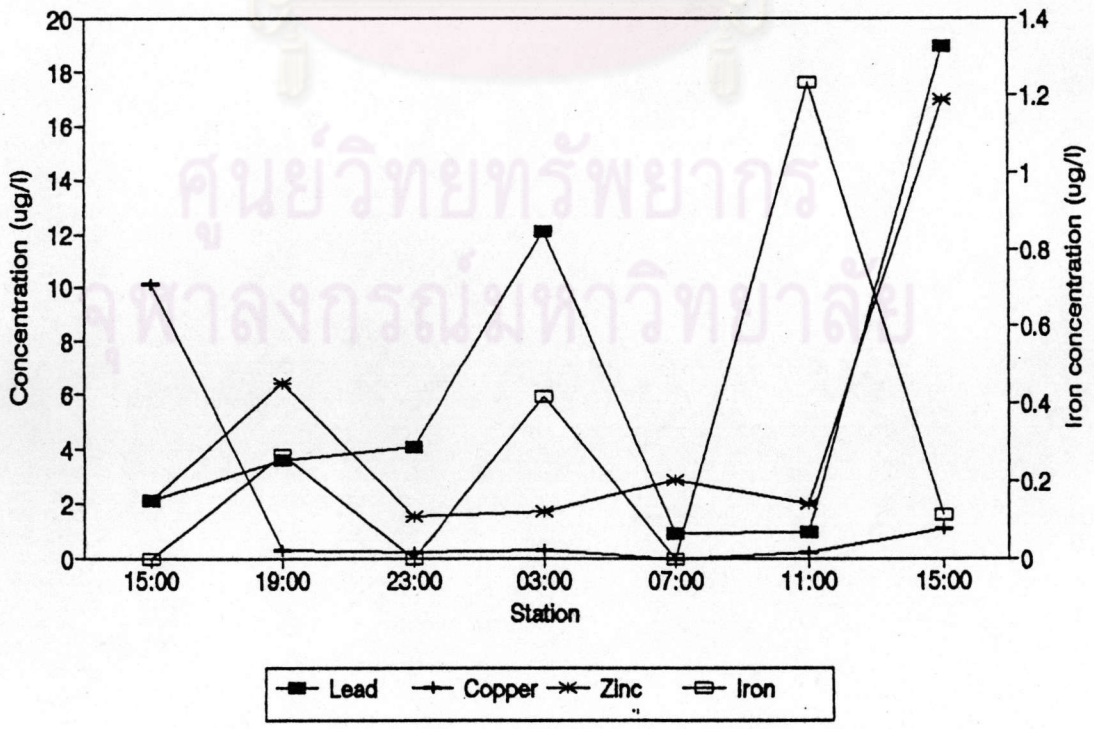


Figure 4-27 The variation of dissolved lead, copper, zinc and iron concentrations within a tidal cycle at station SB-10 on June 21-22, 1989.

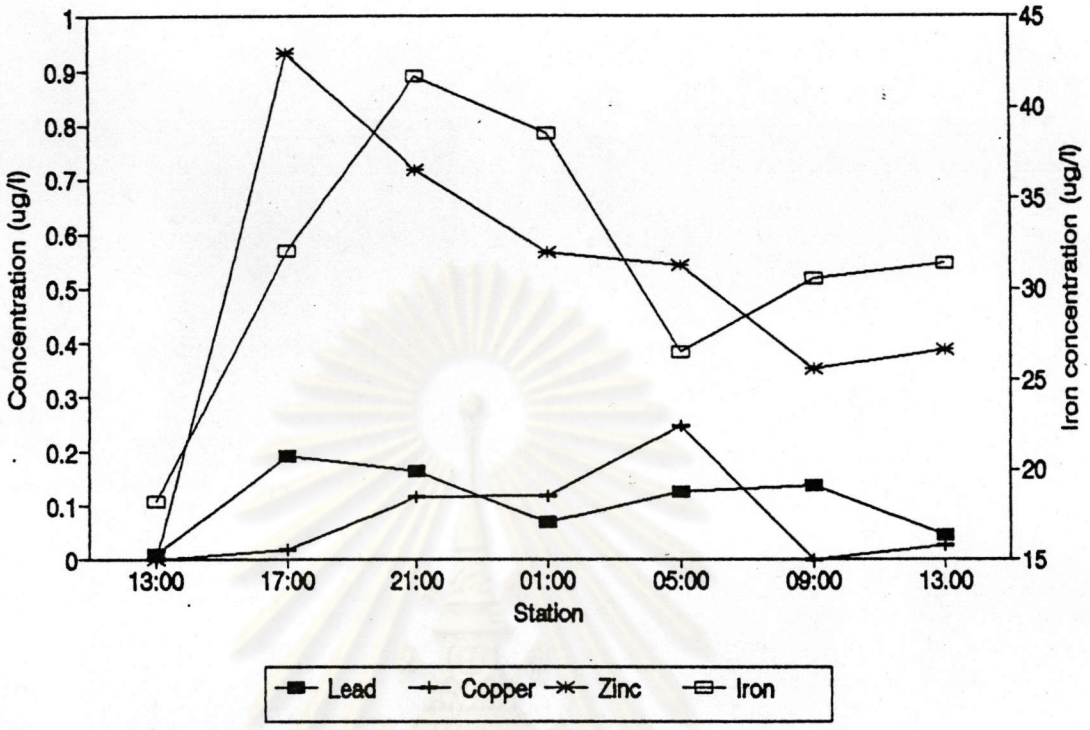


Figure 4-28 The variation of particulate lead, copper, zinc and iron concentrations within a tidal cycle at station SB-10 on November 23-24, 1989.

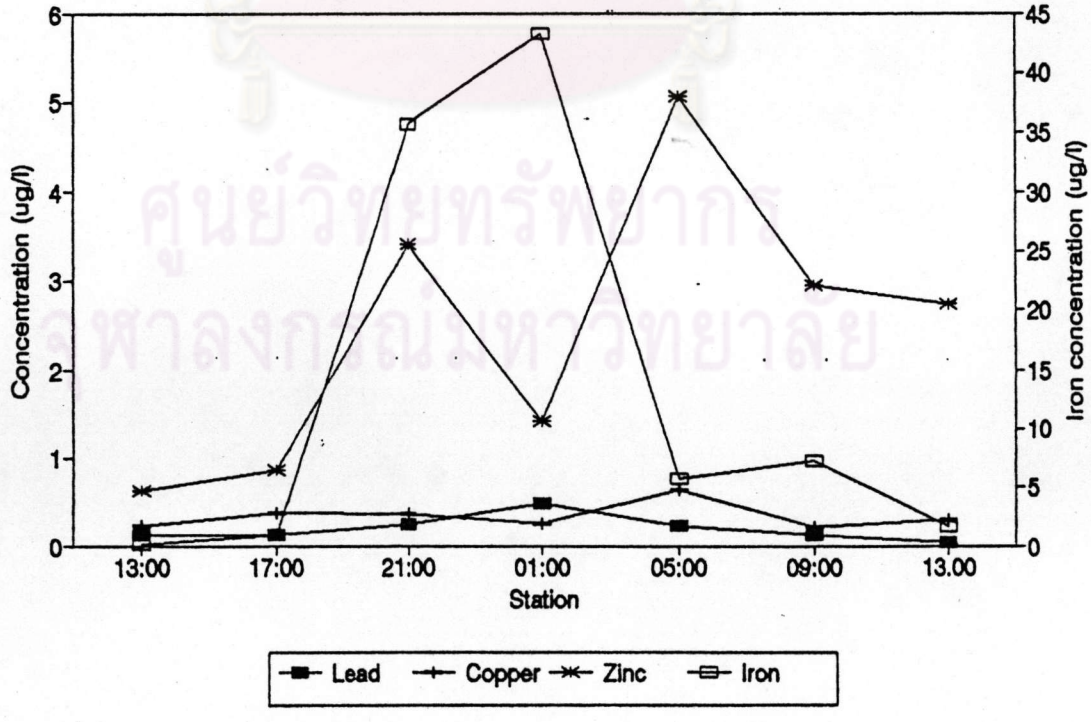


Figure 4-29 The variation of dissolved lead, copper, zinc and iron concentrations within a tidal cycle at station SB-10 on November 23-24, 1989.

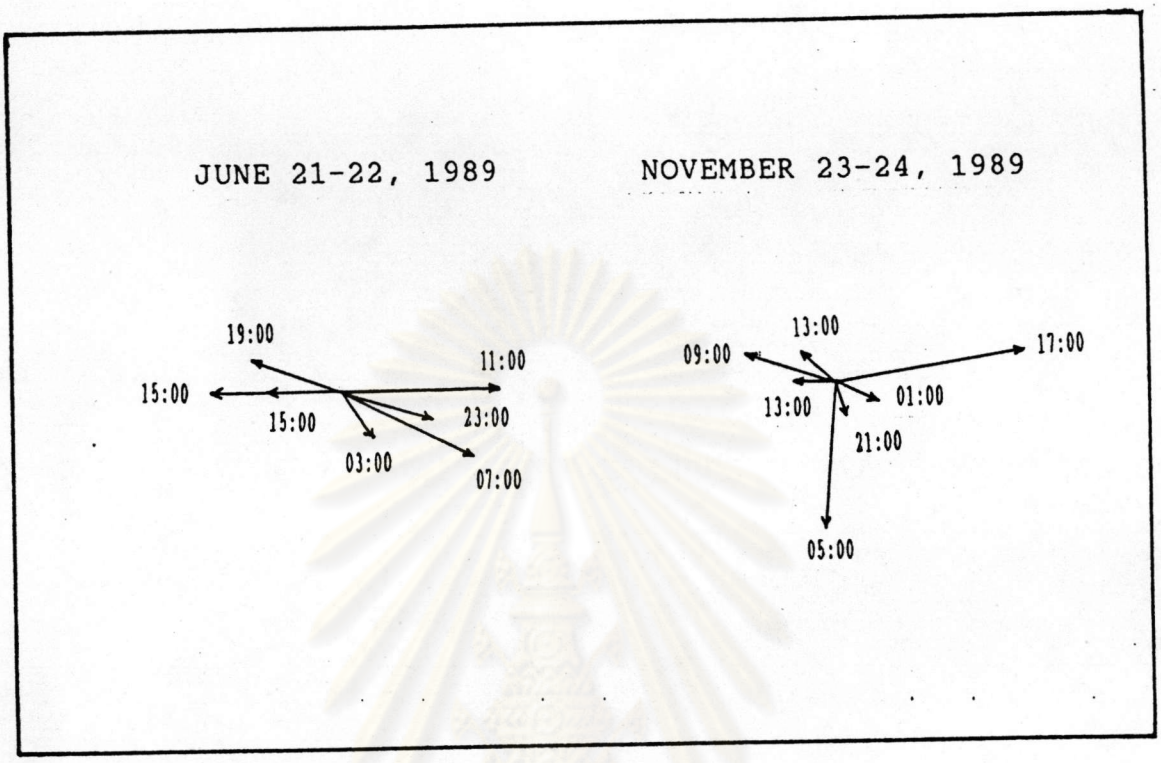


Figure 4-30 Speed and direction of current during sampling at SB-10 on June 21-22, 1989 and November 23-24, 1989. ( at 2 meter depth from surface)

were found while the current was in the west-east direction and low concentrations were found while the current was in the east-west direction. It is expected that intense wave and wind prevailed during sampling caused the rapid mixing and disturbed the suspended matter from bottom.

The variations of dissolved lead, copper, zinc and iron concentrations are shown in Figure 4-29. When considering the current direction, as shown in Figure 4-30, the concentration of dissolved lead, copper, zinc and iron shown similar relation to the current direction.

It should noted that the concentrations of copper and lead were lower than the concentrations of iron and zinc. This was due to their low solubility which was confirmed by the results of leaching experiments ( to be discussed in the following Section ).

Accumulation of Heavy Metals by Bivalves.

The total contents of heavy metal in soft tissues of pen shell, Atrina vexillum collected in June-July and November 1989 were observed to be widely varied. The concentrations of heavy metal in pen shell were 306.82 ± 43.65 and 184.85 ± 301.10 µg/g dry wt. for zinc and iron in June 1989, 266.17 ± 2.86 and 732.27 ± 254.73 µg/l for zinc and iron in November 1989, respectively.

In addition, it was found that the relatively high concentrations of lead, copper and zinc ( for the range of 0-24.08, 33.22-105.55 and 242.33-348.39 µg/g dry wt for lead, copper and zinc

respectively) was comparable to the results of Petpiroon (1989) ( for the range of 0.40-7.39, 25.00-156.39 and 59.18-199.60 µg/g dry wt for lead, copper and zinc respectively) as shown in Table 4-3. More over, the concentrations of heavy metals in other bivalves from the Gulf of Thailand were found to be lower than the results from this study. Therefore, the pen shell samples which were collected in ship-breaking periods were contaminated by heavy metals in the seawater.

Heavy Metals Leaching Experiment

The results of the leaching experiment (shown in Chapter III) indicate that heavy metals leached from scrap-paints, scrap-iron oxides, scrap-iron and scrap-iron on the beach. These materials were products of ship-breaking activity and commonly found in the vicinity of the ship-breaking plants. Therefore from this leaching experiment, it was obvious that ship-breaking activity can result in a heavy metal contamination in seawater.

Table 4-4 which was derived from Table 3-18 indicates that heavy metals leached out in both particulate and dissolved forms. The particulate irons and dissolved zinc were the important forms of leached heavy metal.

It can be concluded through this leaching experiment that product materials from ship-breaking activity can be sources of heavy metal contamination.

Table 4-3 Concentrations of heavy metal in bivalves from the Gulf of Thailand.

| Species | Cu | Pb | Zn | Authors |
|---|---|---|---|---|
| *Anadara granosa*[*] | 1.36-2.21 | 1.64-2.16 | 79.15-92.30 | Hungspreugs & Yuangthong(1983) |
| *Anadara granosa*[*] | 4.89-8.75 | 0.37-1.41 | 65.0-125.0 | Phillips & Muttarasin(1985) |
| *Anadara granosa*[+] | 5.6 | 0.18 | 16.2 | Huschenbeth & Harms(1975) |
| *Anadara granosa*[*] | 5.89-6.91 | 0.25-1.05 | 85.6-109.4 | Hungspreugs *et al.*(in press) |
| *Perna viridis*[*] | 0.66-17.92 | 0.19-3.80 | 58.27-285.7 | Hungspreugs & Yuangthong(1983) |
| *Perna viridis*[*] | 8.5 ± 2.4 | 0.73 ± 0.51 | | Hungspreugs *et al.*(1984) |
| *Perna viridis*[*] | 9.38-15.63 | 0.31-1.53 | 61.11-76.47 | Phillips & Muttarasin(1985) |
| *Perna viridis*[*] | 7.3 | 0.11 | 14.2 | Huschenbeth & Harms(1975) |
| *Crassostrea commercialis*[*] | 4.89-24.50 | 0.54-9.21 | 83.07-67.08 | Hungspreugs & Yuangthong(1983) |
| *Crassostrea commercialis*[*] | 100-180.9 | 0.20-0.53 | 571.4-1047.6 | Phillips & Muttarasin(1985) |
| *Crassostrea luqubris*[*] | 22.79-51.21 | 0.14-0.76 | 348.6-699.4 | Hungspreugs *et al.*(1987) |
| *Ostrea plicatula*[*] | 114 ± 50 | 0.24 ± 0.18 | | Hungspreugs *et al.*(1984) |
| *Paphia undulata*[*] | 0.26 | | | Hungspreugs & Yuangthong(1983) |
| *Paphia undulata*[*] | 4.55-7.37 | 0.55-1.39 | 42.0-57.9 | Phillips & Muttarasin(1985) |
| *Amusium pleuronectes*[*] | 0.21-0.79 (white meat) | | | Hungspreugs & Yuangthong(1983) |
| *Amusium pleuronectes*[*] | 3.0 ± 1.8 (white meat) | 0.01 ± 0.01 | | Hungspreugs *et al.*(1984) |
| *Atrina vexillum*[*] | 25.00-156.36 | 0.40-7.39 | 59.18 -199.60 | Petpiroon(1989) |
| *Atrina vexillum*[*] | 33.22-105.55 | 0.00-24.08 | 242.33-348.39 | The result of study |

[*] : $\mu g\ g^{-1}$ dry wt.
[+] : $\mu g\ g^{-1}$ wet wt.

Source : Hungspreugs *et al.*(1989).

Table 4-4 The order of leached four heavy metal concentrations.

| Material | Form | Ordering |
|---|---|---|
| scrap-paint | particulate<br>dissolved | Fe > Zn > Pb > Cu<br>Zn > Cu > Pb > Fe |
| iron oxide | particulate<br>dissolved | Fe > Zn > Pb > Cu<br>Zn > Fe > Cu > Pb |
| scrap-iron | particulate<br>dissolved | Fe > Pb > Zn > Cu<br>Zn > Fe > Pb > Cu |
| scrap-iron<br>on the beach | particulate<br>dissolved | Fe > Pb > Zn > Cu<br>Zn > Fe > Cu > Pb |