

Trace Metals in Seawater, Sediments and the Northern Neptune Whelk (*Neptunea heros*) from the Chukchi Sea, COMIDA Project

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1. Introduction

The COMIDA Project (Chukchi Sea Offshore Monitoring in the Drilling Area) was initiated by the U.S. Department of Interior, Minerals Management Service, to help identify areas of ecological importance in the Chukchi Sea and thereby minimize interference from offshore oil activities in areas with rich natural resources and native subsistence harvesting. Data collected from this project also will help assess whether changes in benthic flora, fauna and chemical composition may be linked to regional human activities or to global climate change and natural variability. A suite of 19 metals (Ag, Al, As, Ba, Be, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Sb, Se, Sn, Ti, V and Zn) are being studied in water, sediment and biota. Metals can be useful indicators of impacts from human activity because they are commonly enriched in the raw and finished materials used by modern society. Results presented here are from the first COMIDA cruise in August 2009 (Figure 1).

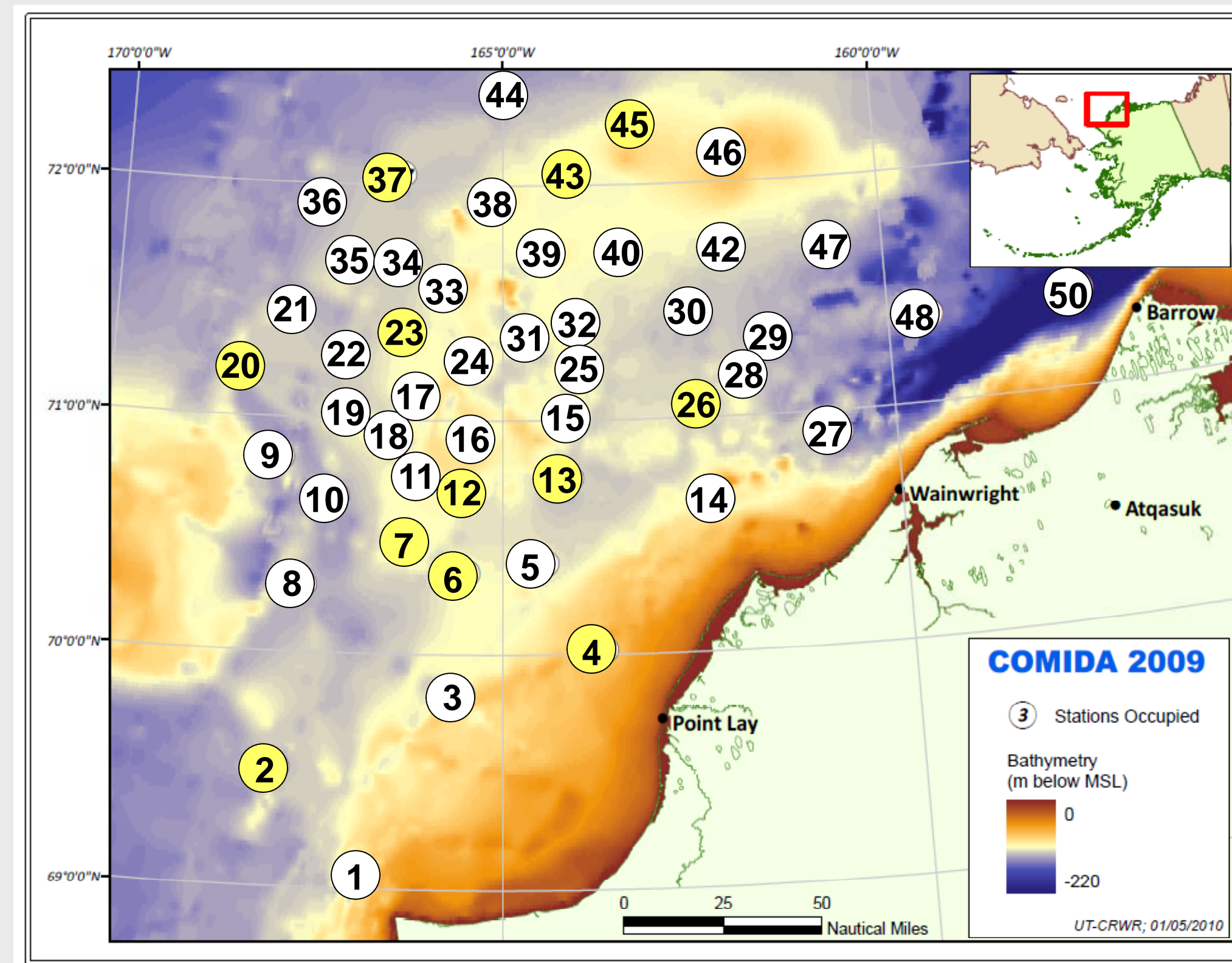


Figure 1. Map shows sampling sites in the Chukchi Sea during 2009 cruise; numbers in yellow circles are mentioned in figures and text.

2. Metals and Supporting Parameters in the Water Column

Concentrations of dissolved trace metals were relatively uniform as a function of depth and location in the COMIDA study area (Table 1). For example, the relative standard deviations [RSD = (std. dev./mean) x 100%] for average concentrations of dissolved As and Ni were only 3.4% and 11.3%, respectively, for samples analyzed to date (Table 1). Somewhat similarly, the bottom water salinity at the 48 locations identified in Figure 1 (water depths 26 to 56 m) averaged 32.5 ± 0.2 .

Vertical profiles show slightly fresher and much warmer water in the top 20 m of the water column (Figures 2a and 3a). Concentrations of dissolved As (as well as Cr, Sb and Se) did not vary significantly as function of depth; however, values for Zn and Cd (as well as Cu and Ni) showed slight stratification (Figures 2b and 3b). Furthermore, concentrations of nutrient-type metals such as Cd, Cu, Ni and Zn in the Chukchi Sea were more like values in deep water than surface water from the North Pacific (Table 1) and are probably linked to upwelling and northerly transport. Values for total suspended solids (TSS) averaged ~4 times higher at water depths >30 m than at depths <30 m (Figures 2c, 3c and 4). Similar vertical profiles were observed for TSS and particulate Al (wt. % basis) because particles in the lower portion of the water column were richer in aluminosilicates (clays). Concentrations of particulate organic carbon (POC) were ~3 times greater in the upper water column on a wt. % basis; however, net POC/L was two times greater in the lower water column due to high concentrations of TSS (Figure 4).

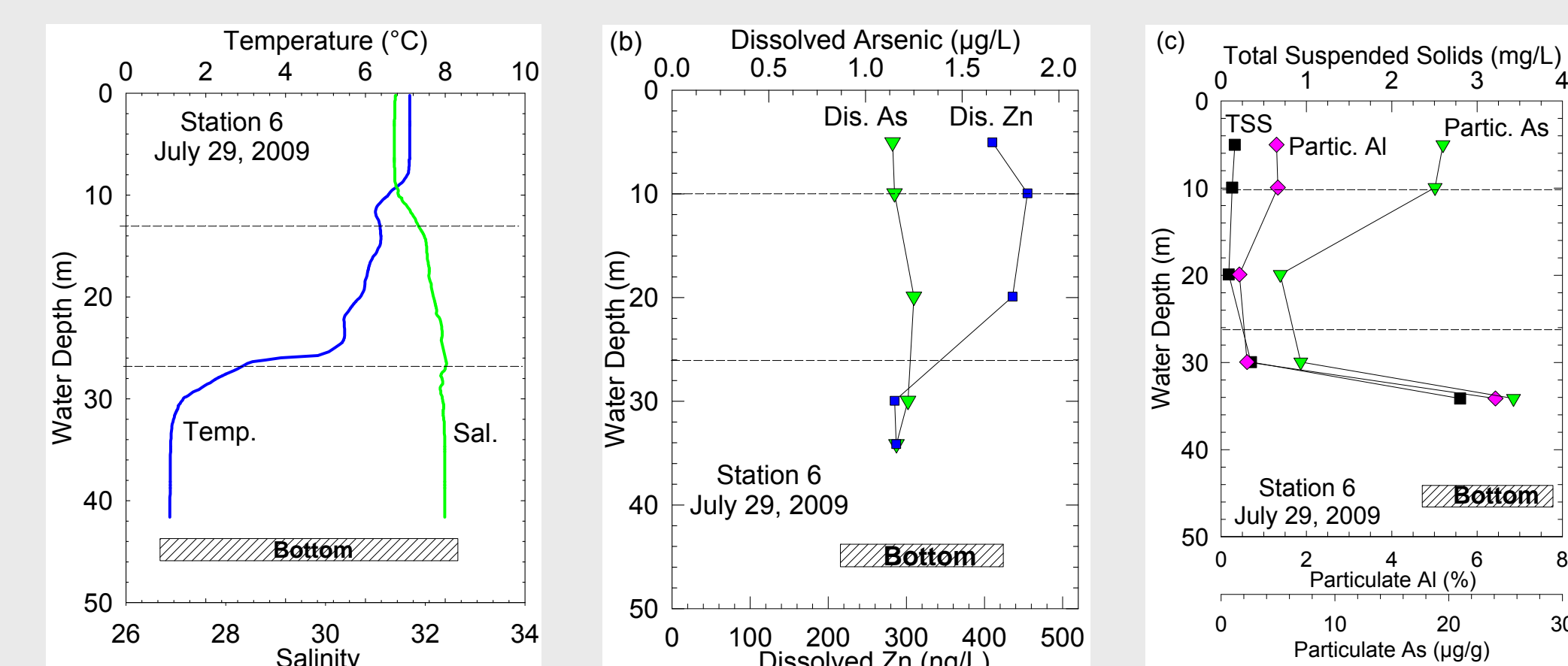


Figure 2. Vertical profiles for salinity, temperature, total suspended solids and selected dissolved and particulate metals for station 6.

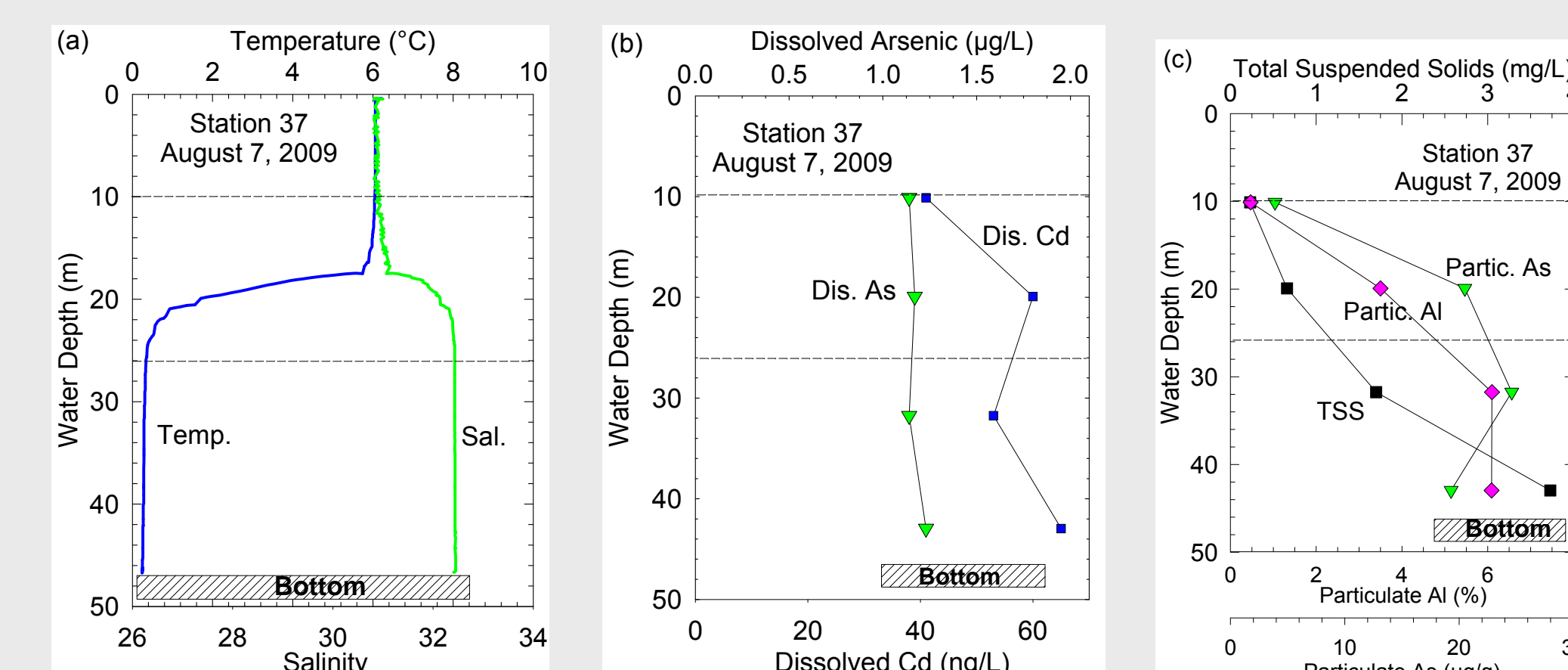


Figure 3. Vertical profiles for salinity, temperature, total suspended solids and selected dissolved and particulate metals for station 37.

3. Metals in Sediments

Concentrations of metals in surface sediments from the 2009 COMIDA sites were relatively uniform with all RSDs $\leq 25\%$ (Table 2). Mean values for metals in these sediments from the Chukchi Sea were generally similar to values for the Beaufort Sea and average marine sediments (Table 2). Observed variability in concentrations of trace metals usually can be explained by variations in mineralogy and grain size. In general, sediment metal values are positively correlated with Al because aluminosilicates are a dominant source for these elements (Figure 5).

Table 1. Concentrations of dissolved metals in the Chukchi Sea from the COMIDA Project (2009) and values for the North Pacific Ocean.

Dissolved Metal	Chukchi Sea This study (n = 17) Mean \pm SD (ng/L)	North Pacific (Donat & Bruland, 1995) (ng/L)	
		Surface	Deep
As	1,170 \pm 40	1,500	1,800
Cd	50 \pm 13	1	110
Cr	93 \pm 9	150	260
Cu	253 \pm 45	60	280
Ni	293 \pm 33	120	650
Pb	5 \pm 2	6	1
Sb	137 \pm 7	130	130
Se	40 \pm 4	40	180
Zn	294 \pm 87	13	500

At 0-30 m water depth:
TSS = 0.6 ± 0.7 mg/L (n = 42)
POC = 63 ± 26 µg/L (n = 29)
POC = $15 \pm 9\%$ (n = 29)

At >30 m water depth:
TSS = 2.5 ± 1.0 mg/L (n = 12)
POC = 130 ± 70 µg/L (n = 12)
POC = $5 \pm 3\%$ (n = 12)

COMIDA 2009
Avg. water depth: 43 m
Range: 26 to 56 m (n = 47)

Figure 4. Average values for TSS and POC at 0-30 m and at >30 m.



Box coring in the Chukchi Sea from the R/V Alpha Helix (August 2009).

3. Metals in Sediments (cont.) When data points for a metal plot above the 95% prediction interval on a metal versus Al plot, the anomalous points may indicate that the sediments contain an anthropogenic input of that metal. To date, no values for metals in sediments from the COMIDA sites have been identified as above background values.

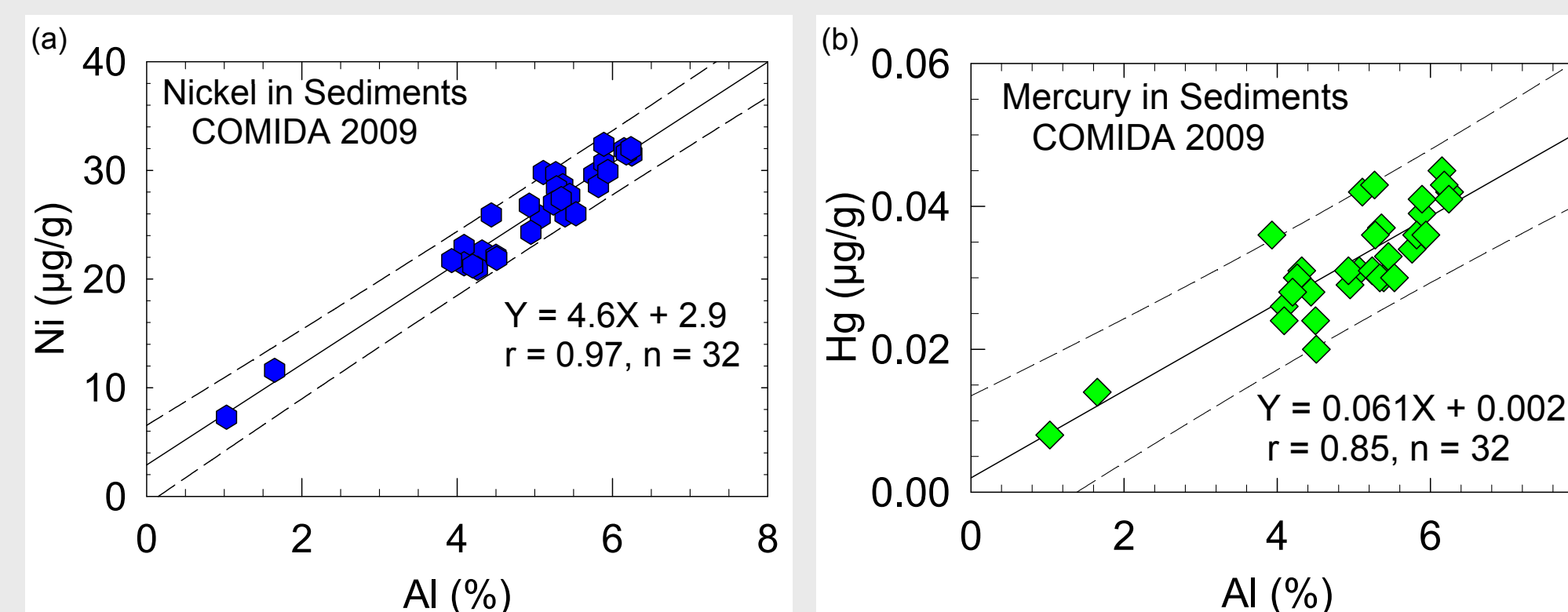


Figure 5. Plots of Al versus (a) Ni and (b) Hg for sediments. Equations, solid lines and dashed lines (95% prediction intervals) are from linear regressions.

Table 2. Average concentrations (\pm standard deviations) for selected metals in surface sediments from the Chukchi Sea (COMIDA 2009), the Beaufort Sea (Trefry et al., 2003) and typical marine environments (Salomons and Förstner, 1984).

Sample	Ag (µg/g)	Al (%)	As (µg/g)	Ba (µg/g)	Cd (µg/g)	Cr (µg/g)	Cu (µg/g)	Fe (µg/g)	Hg (µg/g)	Pb (µg/g)	V (µg/g)	Zn (µg/g)
Chukchi Sea (n=32)	0.11 \pm 0.01	4.9 \pm 1.2	14 \pm 3	590 \pm 54	0.16 \pm 0.03	75 \pm 17	13 \pm 3	2.8 \pm 0.7	0.03 \pm 0.01	11 \pm 2	100 \pm 23	71 \pm 17
Beaufort Sea (n=88)	0.11	4.5	11	394	0.22	57	19	2.2	0.04	10	93	100
Average Sediment	0.06	7.2	8	460	0.17	72	33	4.1	0.10	19	105	95

4. Metals in the Northern Neptune Whelk (*Neptunea heros*)

Concentrations of metals in clams (*Astarte sp.*) and the northern Neptune whelk (*Neptunea heros*) are being determined to provide data for contaminants in potential indicator organisms. Preliminary results for samples of pooled muscle (foot) from the whelk (Figure 6) show that Zn values were very uniform (RSD = 4.5%, Figure 7a) because Zn is an essential micro-nutrient that is tightly regulated by the organism. Arsenic values in *Neptunea* were high, relative to other molluscs, with an average >100 µg/g (dry wt., Figure 7b). Furthermore, an As value of 366 µg/g for the pooled sample from station 2 was ~3 times more than the mean for samples from the other 11 stations (Figure 7b). A similar observation was made for Hg with the sample from station 2 having a value that was ~8 times more than the low mean value of 0.15 ± 0.06 µg/g (dry wt.) for the other samples (Figure 7c). Concentrations of Pb and Ag also were very low, except for station 13 where values were ~8 and ~5 times greater, respectively, than at the other locations (Figures 7d and 7e). Higher values for Cd were determined for the sample from station 2 and to a lesser degree for station 13 (Figure 7f). Both stations 2 and 13 are in the southern, more coastal part of the COMIDA study area; however, water and sediments from these two locations had background values for As, Hg, Pb, Ag and Cd. Additional samples are needed from these and other parts of the COMIDA study area to help explain the observations.

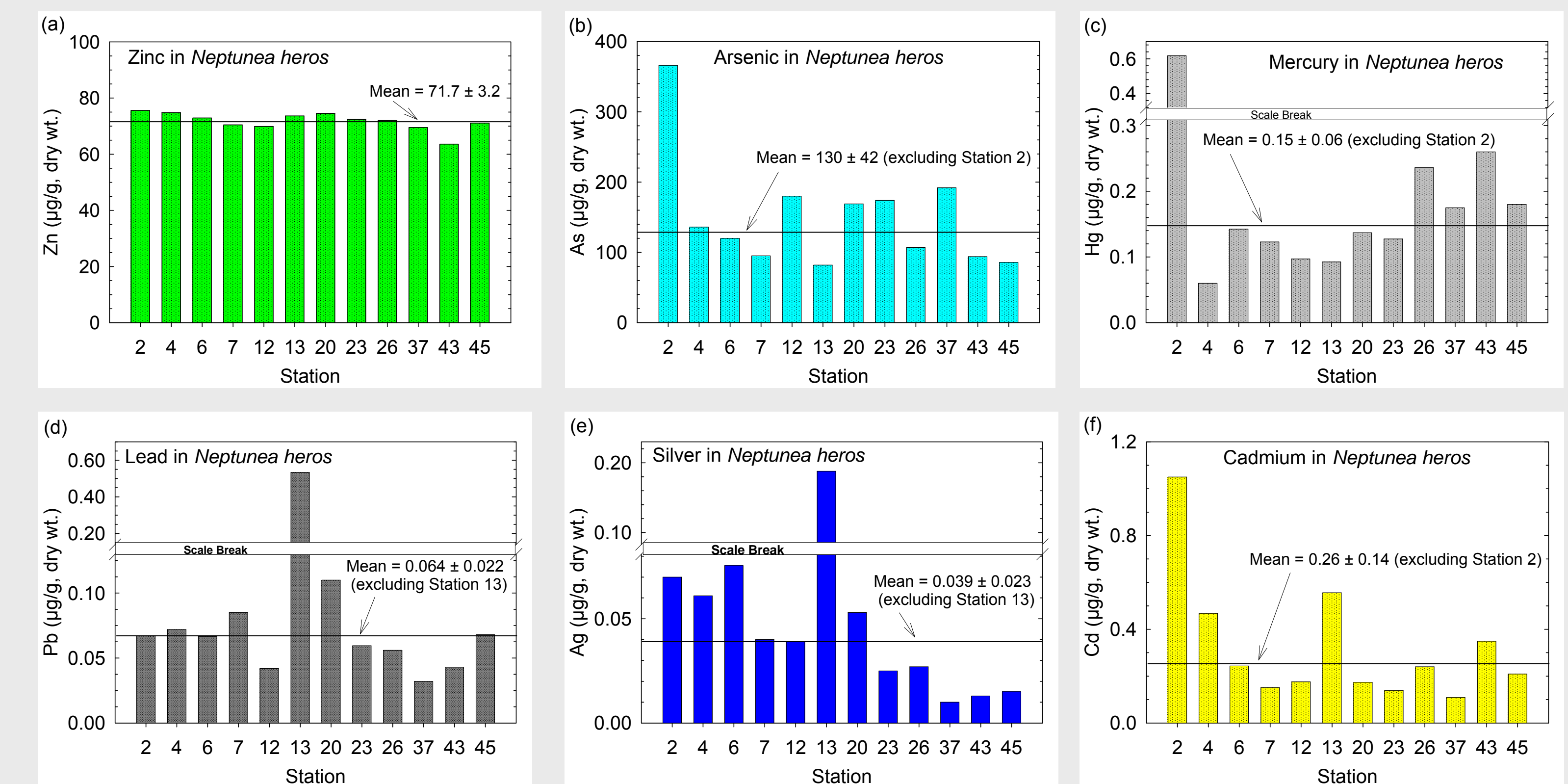


Figure 7. Concentrations of metals in samples of the northern Neptune whelk (*Neptunea heros*) that were collected during August 2009 from stations identified in Figure 1.

5. Conclusions

- Concentrations of metals in water and sediments from the COMIDA sites sampled in 2009, and analyzed to date, are at background levels and show no indication of anthropogenic inputs.
- Background values for As were high whereas values for Ag, Be, Cd, Cr, Hg, Pb, Sn and V were low in the whelk *Neptunea heros*. One anomalous value each for As, Hg, Pb, Ag and Cd from the southern COMIDA area suggest that more data are needed to determine whether the whelk could be a valuable indicator of metal contamination.

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Figure 6. Samples of the northern Neptune whelk (*Neptunea heros*) collected during August 2009.



Members of the Scientific Party for the August 2009 COMIDA cruise aboard the R/V Alpha Helix.