Diversity and distribution of pico- and nano-eukaryotes in the coastal upwelling waters off Hainan (South China Sea)

Fahui Gong[1] Guihao Li[1,2] Kedong Yin[1]* & Jun Gong[1,2]*

1 School of Marine Sciences, Sun Yat-Sen University, Zhuhai 519082, China
2 Laboratory of Microbial Ecology and Matter Cycles, School of Marine Sciences, Sun Yat-Sen University, Zhuhai, China
*Corresponding authors. Email: gongj27@mail.sysu.edu.cn; yinkd@mail.sysu.edu.cn

Background

Coastal upwelling waters are highly productive regions, where small-sized eukaryotes contribute substantially to the standing stock of phytoplankton. Yet little is known about the diversity, abundance, and spatial distribution of these small eukaryotes in upwelling regions. In this study we investigated the pico- and nano-sized fractions of eukaryotes in a transect of the upwelling zone off Hainan (South China Sea) in summer of 2016, using multiple approaches (high throughput sequencing, flow cytometry, and quantitative PCR).
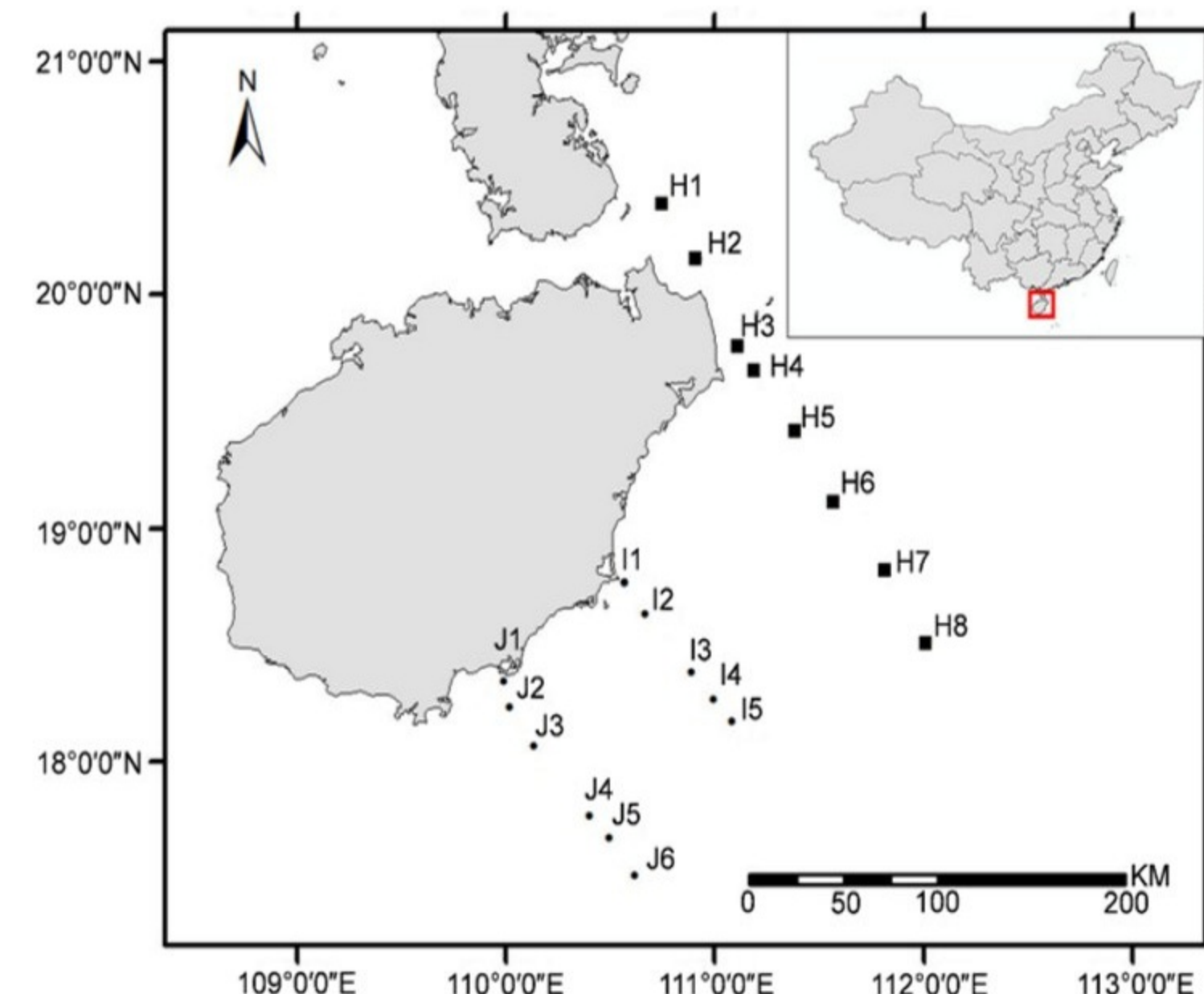
Fig. 1. Map of the investigated areas in the northern SCS and locations of sampling sites analyzed in this study, which was conducted from 19 July 2016 to 23 July 2016. Summer upwelling events within the Hainan Island continental shelf waters is commonly accepted to be induced mainly by the wind-driven Ekman effects.
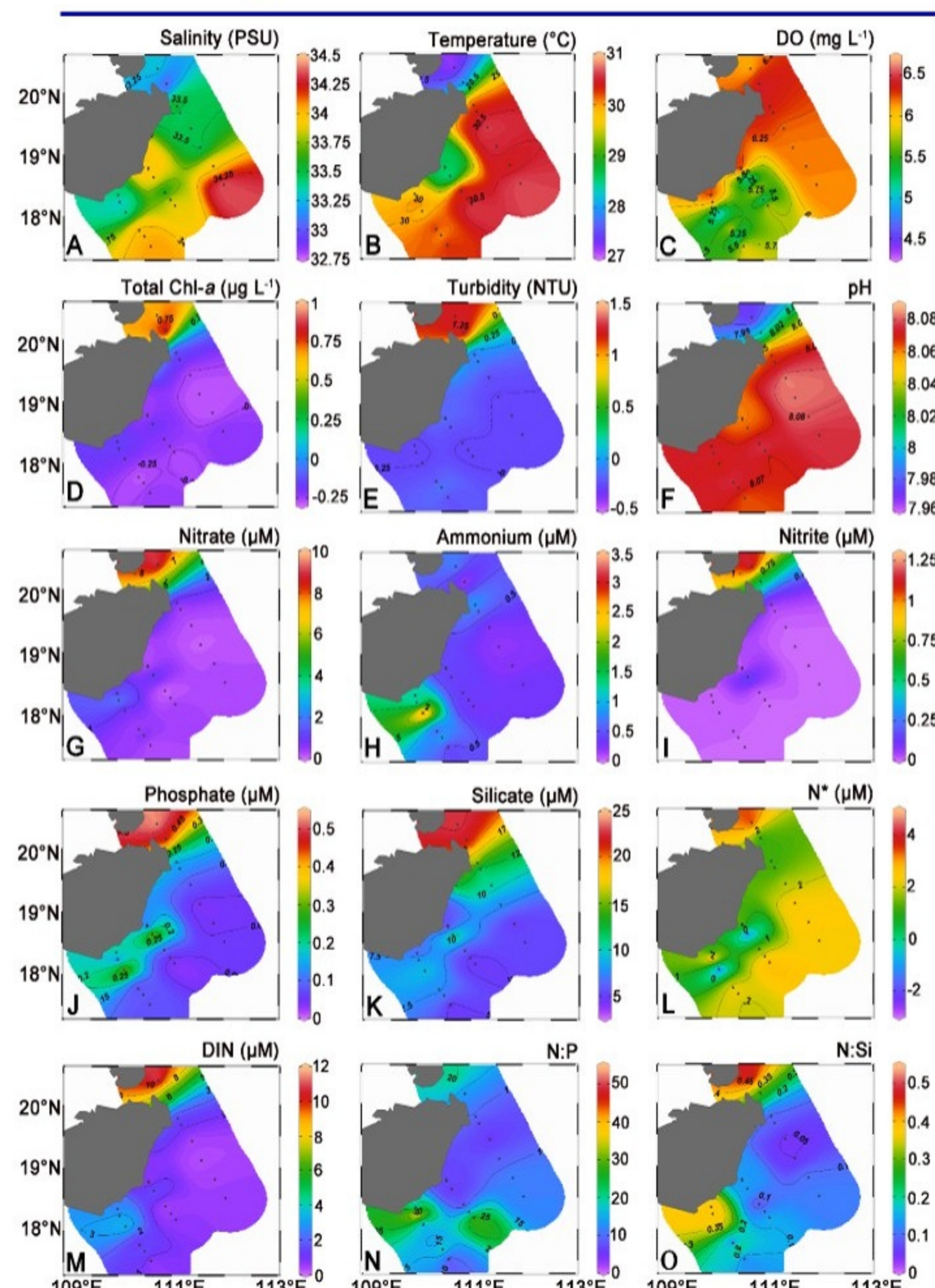
Physicochemical variables in the upwelling region

Fig. 2. Horizontal profiles of chemical and physical parameters in the H, I, J sections at the northeastern of the Hainan Island: (A) salinity; (B) temperature; (C) dissolved oxygen; (D) total Chl-a concentration; (E) turbidity; (F) pH; (G) nitrate concentration; (H) Ammonium concentration; (I) nitrite concentration; (J) phosphate concentration; (K) silicate concentration; (L) N* concentration; (M) DIN concentration; (N) N:P ratio; (O) N:Si ratio.
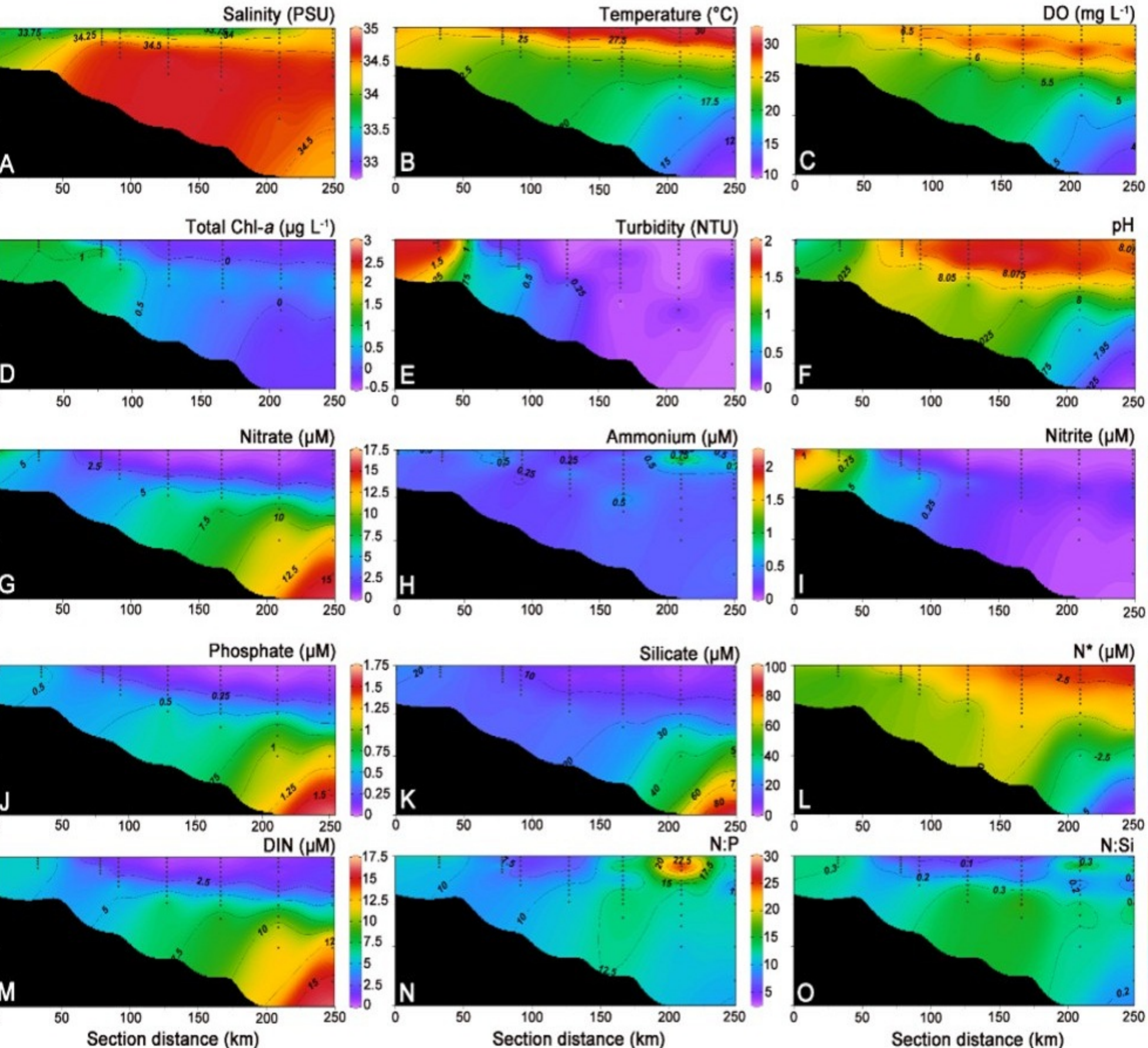
Fig. 3. Vertical profiles of chemical and physical parameters in the H section at the northeastern of the Hainan Island: (A) salinity; (B) temperature; (C) dissolved oxygen; (D) total Chl-a concentration; (E) turbidity; (F) pH; (G) nitrate concentration; (H) Ammonium concentration; (I) nitrite concentration; (J) phosphate concentration; (K) silicate concentration; (L) N* concentration; (M) DIN concentration; (N) N:P ratio; (O) N:Si ratio.

Fig. 4. Vertical and horizontal distribution of (A) 18S rRNA gene copy numbers; (B) OTU richness; (C) Shannon; (D) PPE and PNE; (E) PPE; (F) PNE in H section at the northeastern of the Hainan Island.
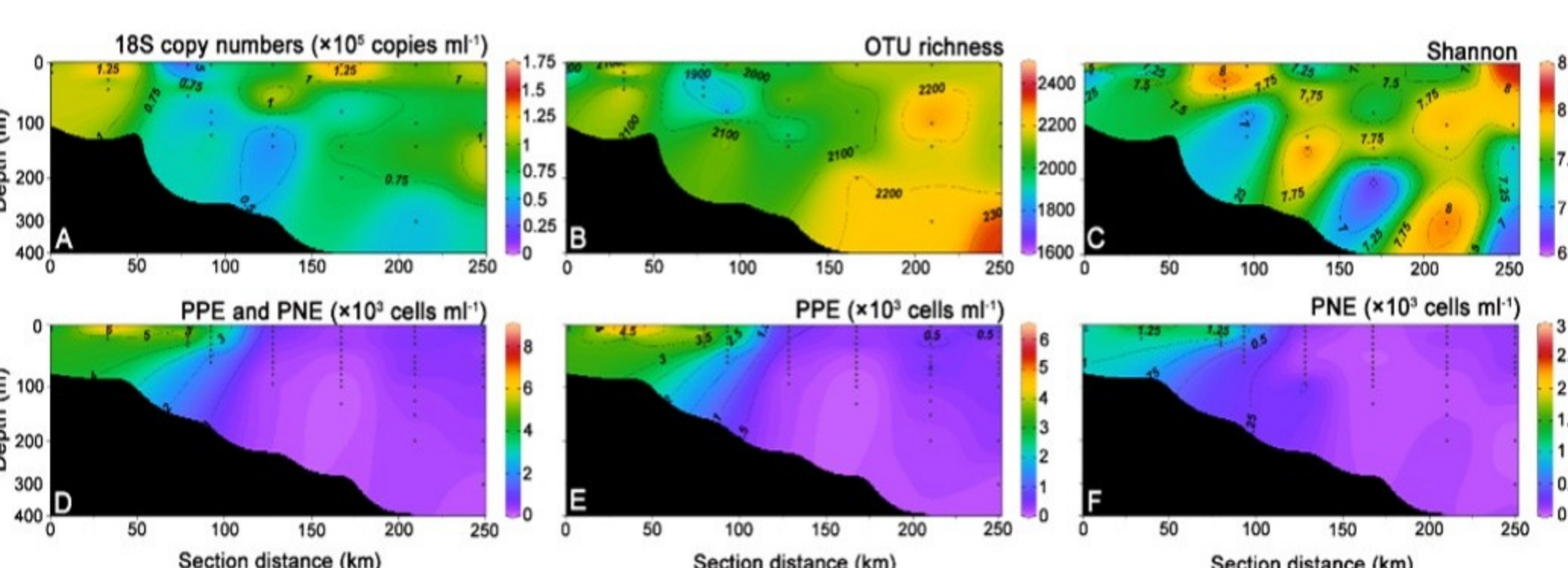
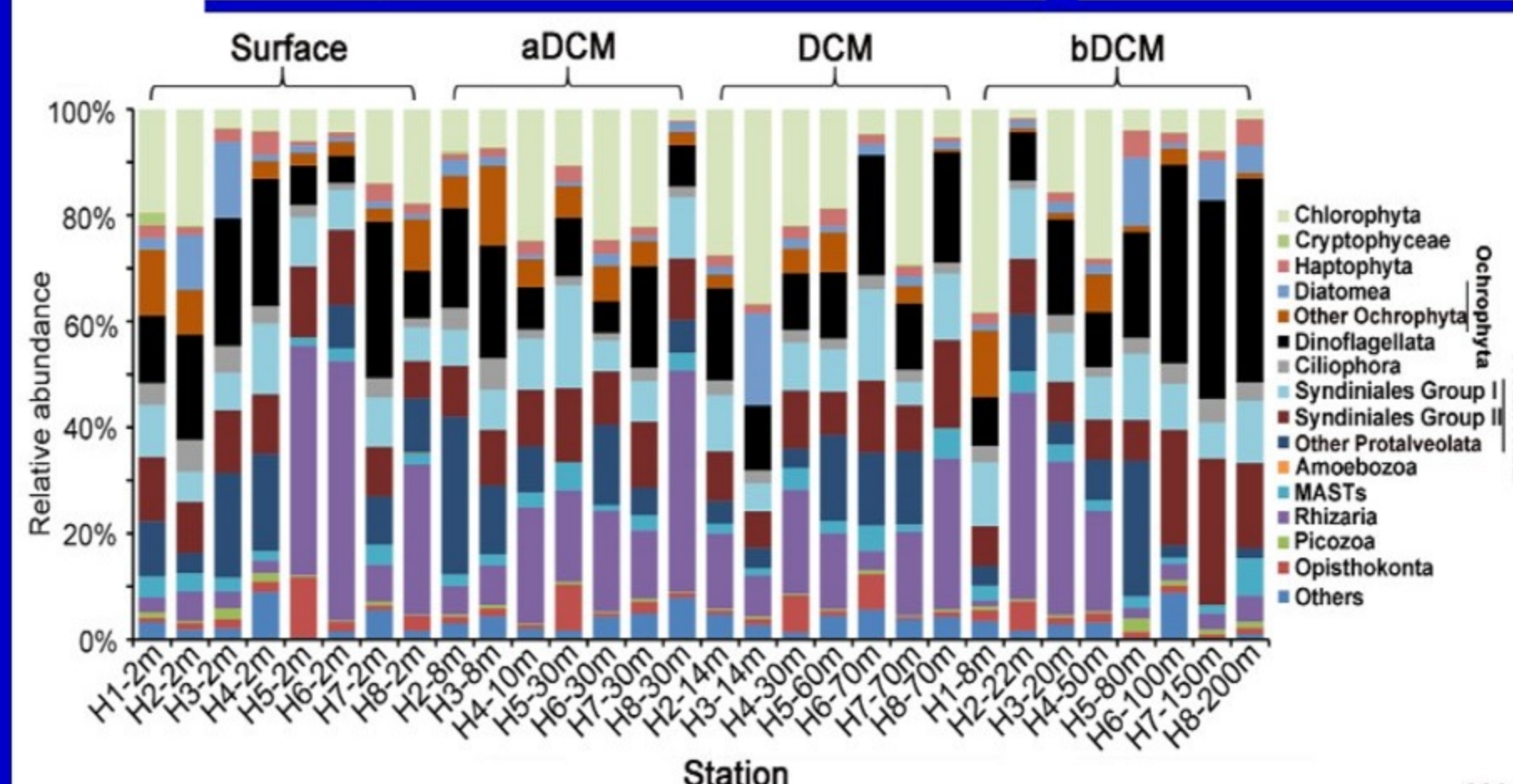## Quantitative assignment of main eukaryoteplankon

Fig. 5. Differences in community structure of major taxonomic groups (classes/subclasses) in H section as revealed by MiSeq sequencing of 18S rRNA genes.

Fig. 6. Spearman's correlations between environmental factors and relative abundances (A), absolute abundance (B) of the main eukaryote groups. The values of the correlation coefficients in e are indicated according to the color bar; insignificant ones ($P > 0.05$) are left blank.
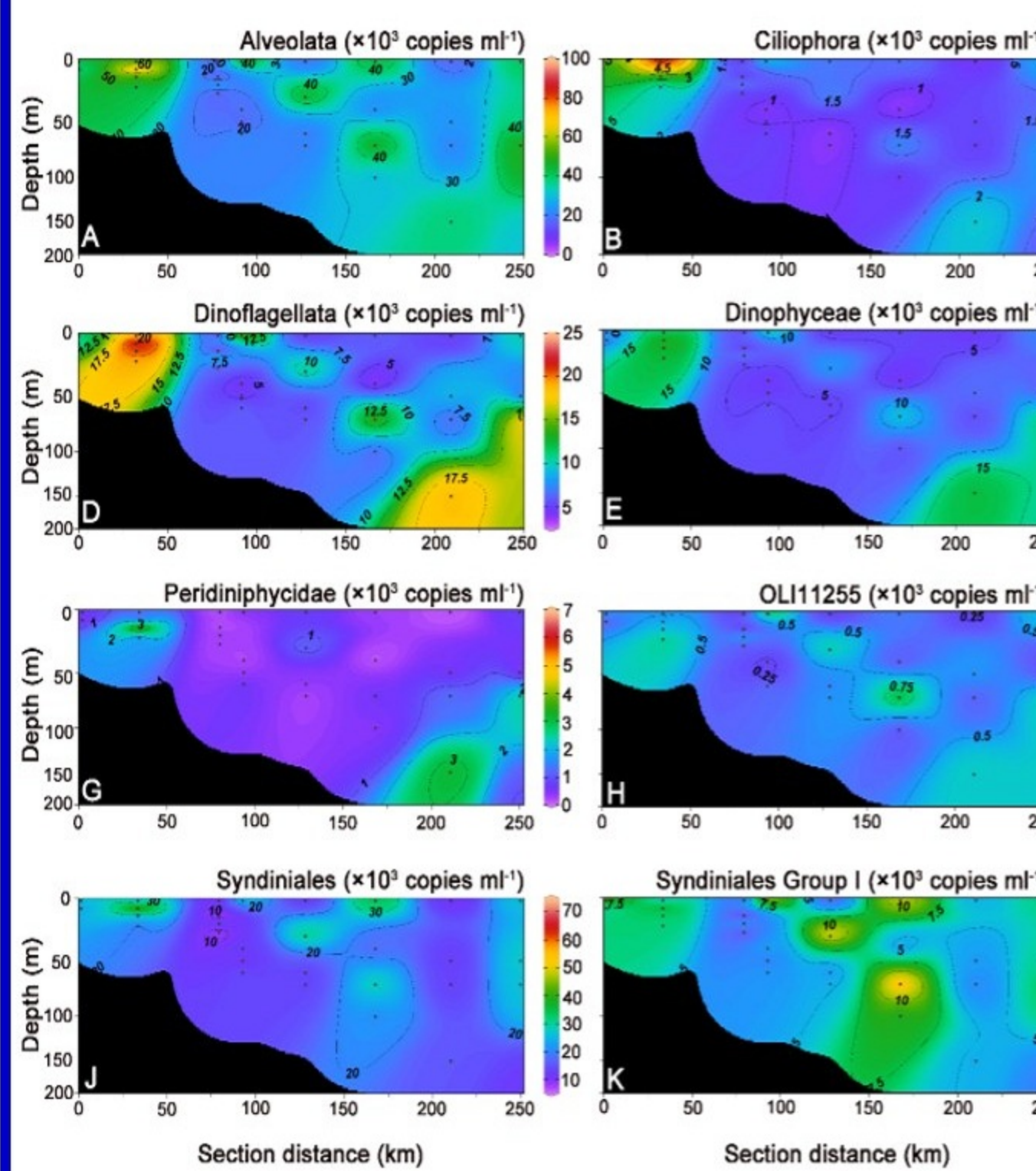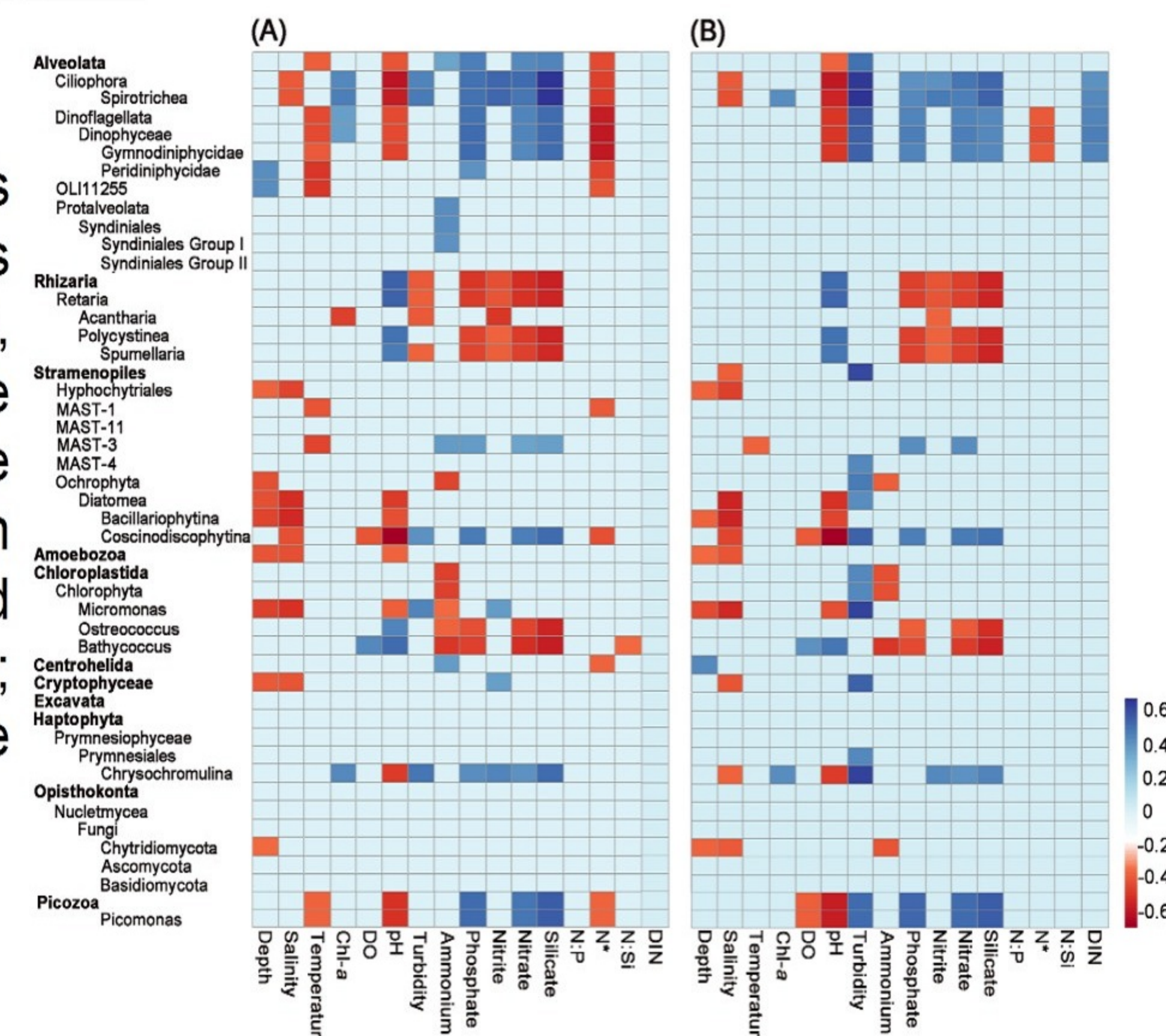
Fig.7. Vertical and horizontal distribution of 18S rRNA gene copy numbers of the main eukaryote species in H section at the northeastern of the Hainan Island: (A) Alveolata; (B) Ciliophora; (C) Spirotrichea; (D) Dinoflagellata; (E) Dinophyceae; (F) Gymnodiniphyceae; (G) Peridiniphyceae; (H) OLI11255; (I) Protalveolata; (J) Syndiniales; (K) Syndiniales Group I; (L) Syndiniales Group II.

Fig. 8. Vertical and horizontal distribution of 18S rRNA gene copy numbers of the main eukaryote species in H section at the northeastern of the Hainan Island: (A) Coscinodiscophytina; (B) Amoebozoa; (C) Chloroplastida; (D) Chlorophyta; (E) Micromonas; (F) Ostreococcus; (G) Bathycoccus; (H) Centrohelida; (I) Cryptophyceae; (J) Excavata; (K) Haptophyta; (L) Prymnesiophyceae.
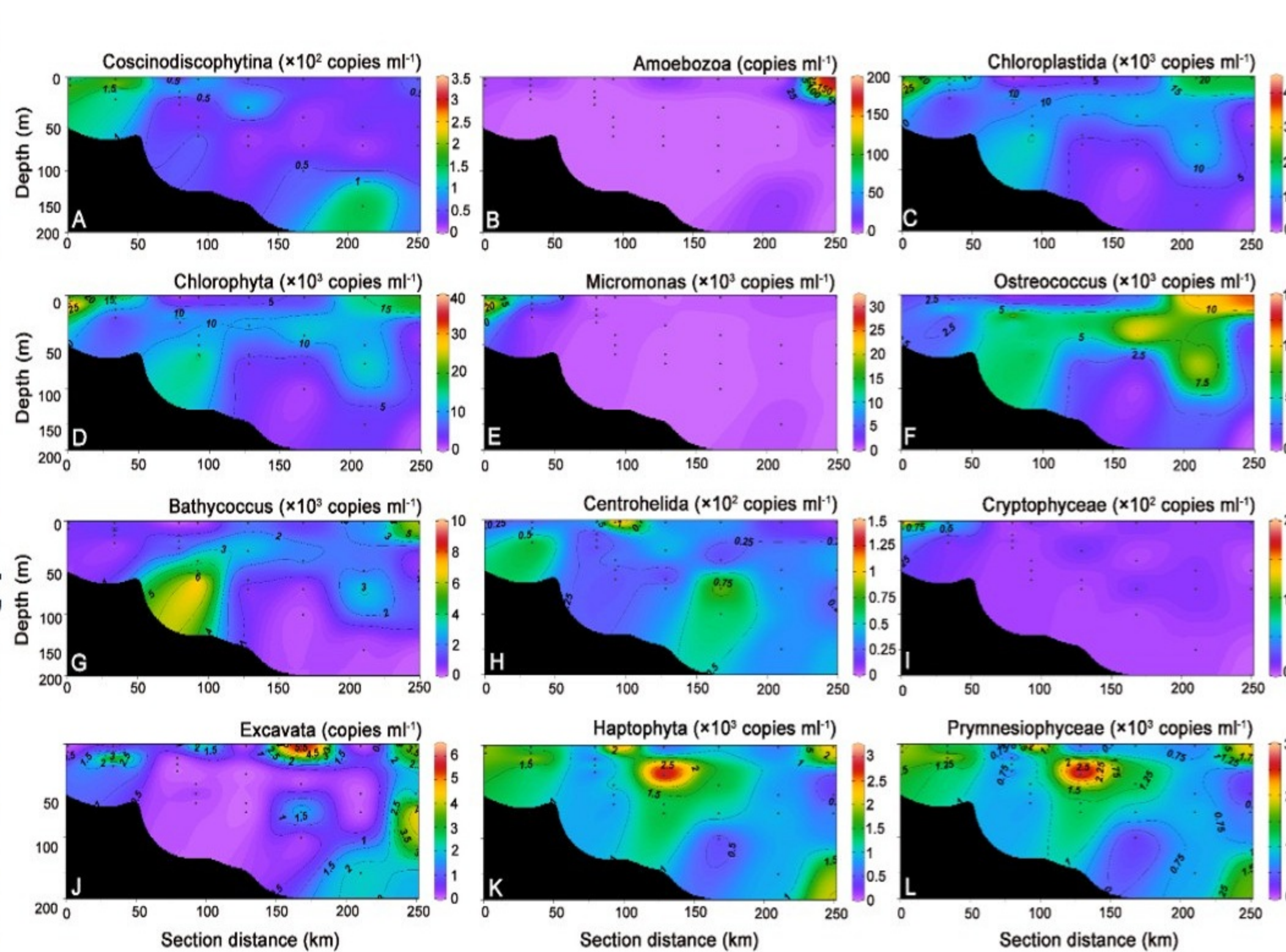
Conclusions and discussion

(1) Sized fractioned chl-a and FCM data showed that the pico- and nano-phytoplankton did dominate the total phytoplankton standing stock.

(2) MiSeq sequencing of 18S rDNA indicated that, the read proportions of Chlorophyta, Diatomea, Dinoflagellata, and some non-photosynthetic microbial eukaryotes such as Ciliophora and MAST groups, were significantly enhanced in the communities of upwelled water masses.

(3) Redundancy analysis revealed that water pH, salinity and NO3– concentration were the most important environmental parameters in structuring the pico-nano eukaryotic community.

References

1. Aktan, Y., Tufekci, V., Tufekci, H., Aykulu, G., 2005. Distribution patterns, biomass estimates and diversity of phytoplankton in Izmit Bay (Turkey). Estuarine Coastal And Shelf Science, 64, 372-384.