ALONGSHORE VARIABILITY OF THE CALIFORNIA CURRENT SYSTEM FROM CENTRAL TO BAJA CALIFORNIA IN WINTER AND SPRING 2003: PHYSICAL, CHEMICAL AND BIOLOGICAL PROPERTIES

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INTRODUCTION

Sixteen stations along the continental slope of western North America were occupied in February 18-27 and May 22-31, 2003, and form a meridional section from Monterey Bay, California (37º N, 122º W) to Cabo San Lucas, Mexico (23º N, 110º W). Our purpose was to compare trends in California Current (CC), Inshore Countercurrent (ICC) and California Undercurrent (CUC) properties with latitude, and between winter and spring conditions. In winter, coastal upwelling was near zero and the along-transect dynamic height was high and flat, allowing the ICC to advect tropical properties northward. In spring, coastal upwelling had commenced and surface flow along the transect presumably became equatorward. As a consequence of these dynamics, in winter the thermocline was deeper, SST was higher, macronutrients, chlorophyll and primary production were low along the entire transect, with most properties lacking strong latitudinal trends. In spring, the thermocline, macronutrients, chlorophyll and primary production rose along the entire section but most dramatically in the north where upwelling was stronger. Prochlorophytes and other small open-ocean phytoplankton were more abundant in winter along the entire transect and to the south in spring, whereas diatoms, a characteristic coastal group of phytoplankton, were more abundant in spring and in the north. Surface iron was higher in the north in winter, but lower there in spring, presumably reflecting drawdown by diatoms. These results are detailed in the figure captions.

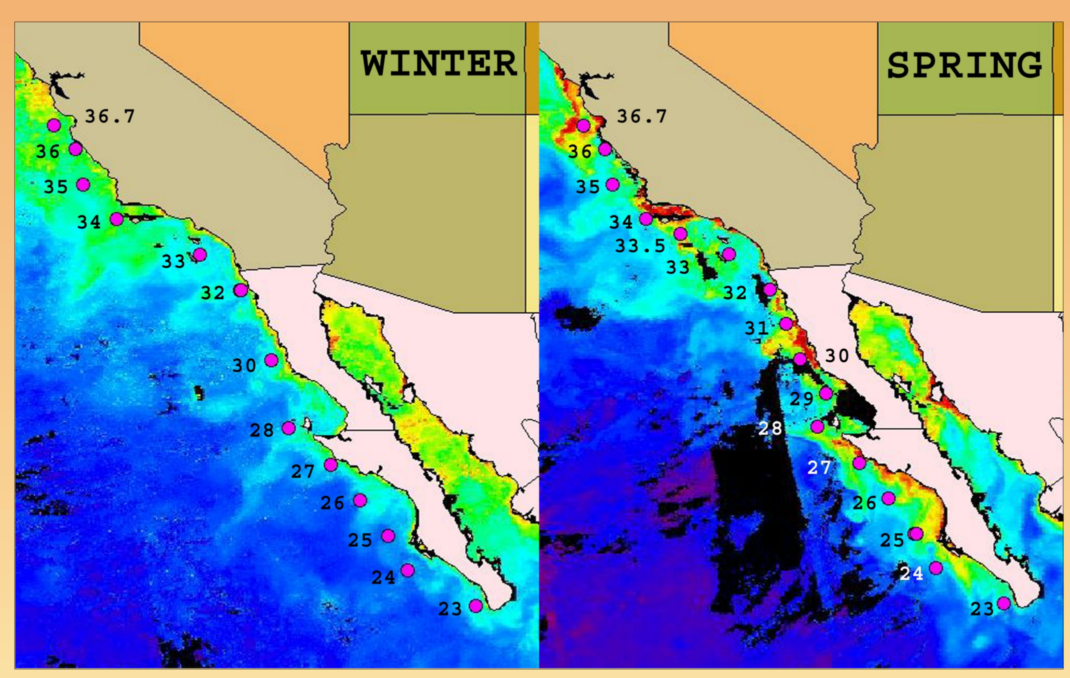

Figure 1. MODIS chlorophyll imagery, with stations and station latitudes overlain. The winter image is a weekly average for Feb 18-25, and the spring image is an average for May 17-24 (http://seawifs.gsfc.nasa.gov). Both images reveal considerable chlorophyll structure along the entire the section, but in spring chlorophyll levels were much higher nearshore.

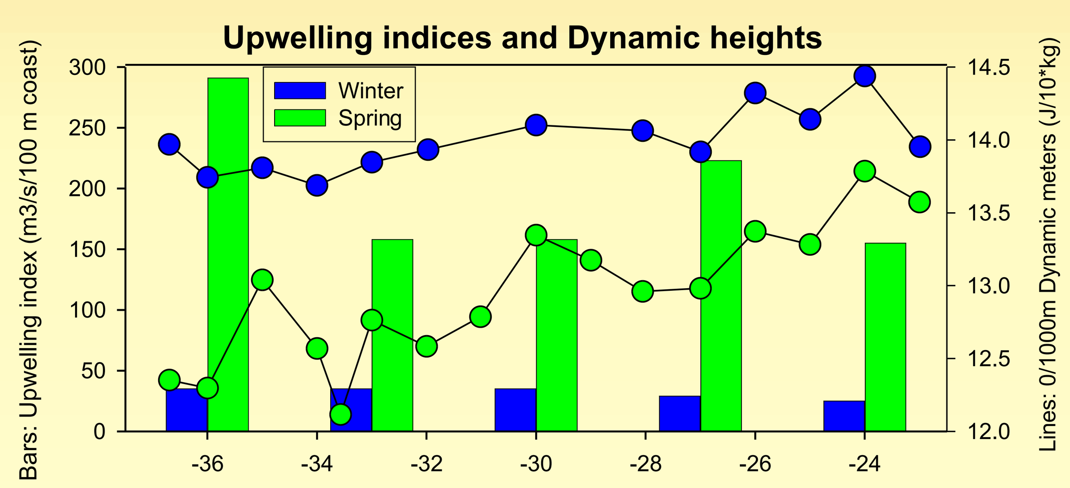

Figure 2. Upwelling indices and dynamic heights. UIs were neutral along the entire transect in Winter (Feb average; http://www.pfeg.noaa.gov), and increased dramatically in spring (May average). 0/1000m dynamic heights were high and flat in winter, but in spring were lower overall and sloped downwards to the north, reflecting northerly wind forcing, upwelling and a denser water column, and poleward subsurface flow of the CUC. Wind driven flow at the surface is equartorward in the spring.

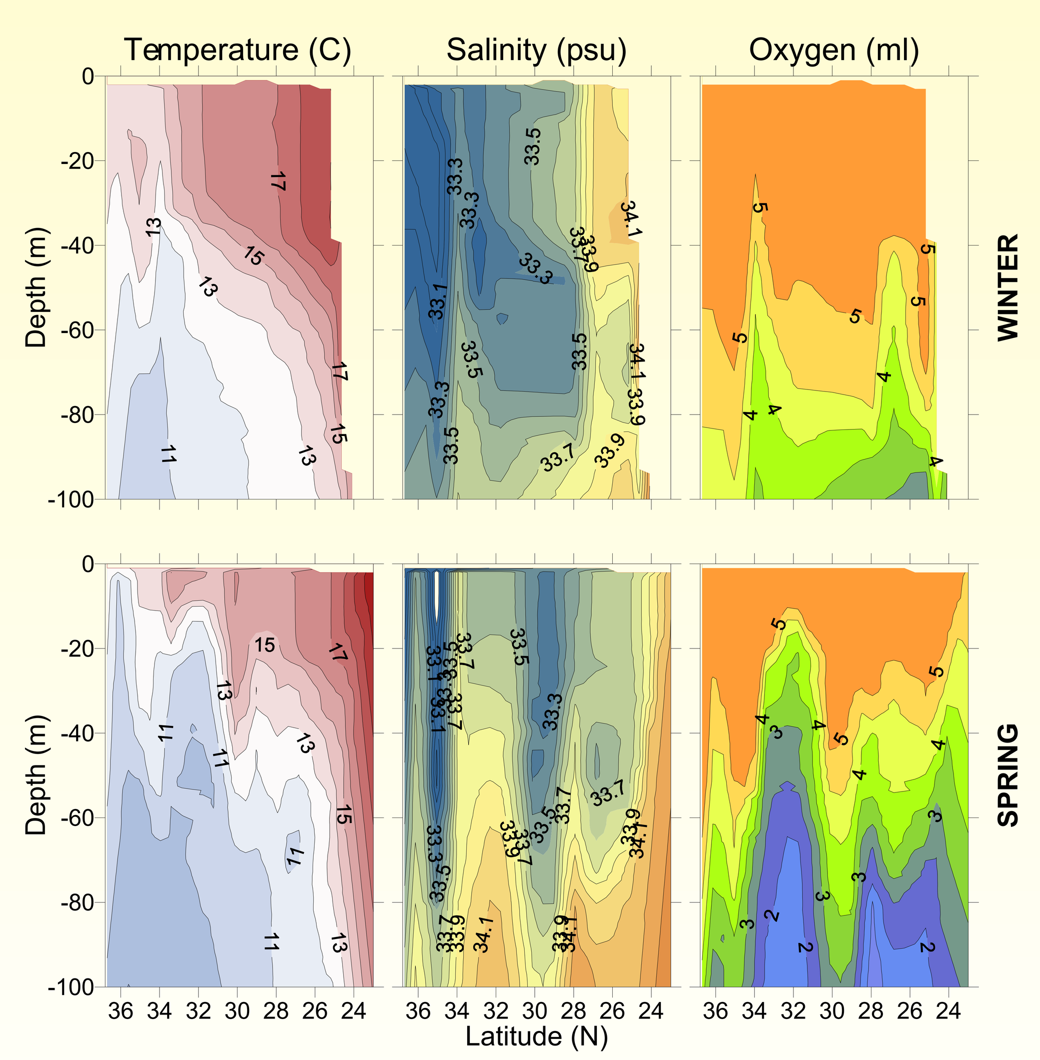

Figure 3. Temperature, salinity and oxygen contoured to 100 m, with top panels winter and bottom panels spring. Isolines of all properties rose at all depths and latitudes in spring. In both winter and spring, salinities were low in the California Current north of Point Conception (34° N). In winter, near surface salinity was high south of Punta Eugenia (28° N) but in spring, low salinity CC water was evident further south, to about 25° N, where the CC turns offshore as part of the north Pacific central gyre. Low oxygen waters below 100 m (not shown) shoaled from north to south indicative of (i) lessening influence of the fully-oxygenated CC and (ii) increasing influence of low-oxygen eastern tropical Pacific waters.

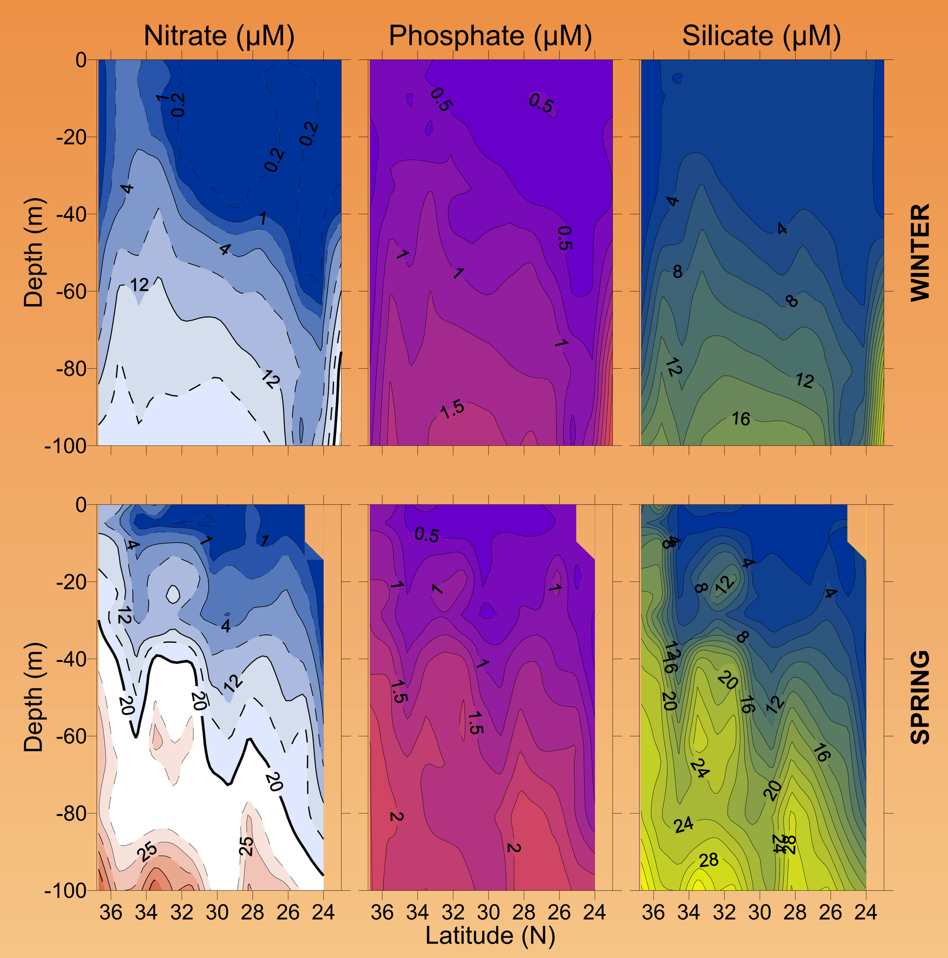

Figure 4. Nitrate, phosphate and silicate contoured to 100 m, with top panels winter and bottom panels spring. Nutrilines of all three properties were shallowest in the north in both seasons but shoaled at all depths and latitudes in spring. In winter, near surface nitrate was 2-4 uM north of Point Conception (34° N) but generally <0.2 uM further south. In spring, surface nitrate was 8-12 uM north of Point Conception but <1 uM further south. South of 35° N, near surface silicate was lower in spring than winter, possibly reflecting drawdown by diatoms

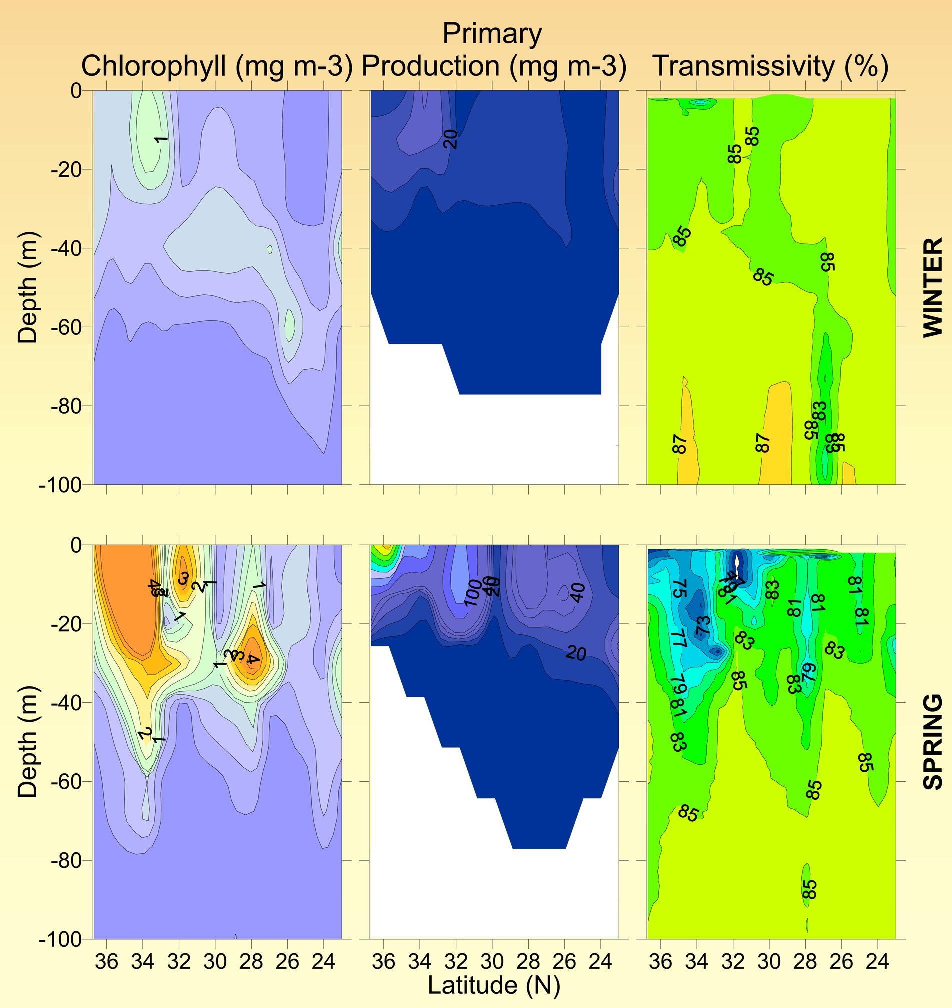

Figure 5. Chlorophyll, primary production and transmissivity as a proxy for POC, with top panels winter and bottom panels spring. All three properties were much higher both in spring and to the north. Chlorophyll maxima were at the surface in the north and subsided in the south to ~40 m on the 1 uM nitrate isoline. Primary production was also deeper in the south but subsurface maxima are not apparent. Areas of low transmissivity (high POC) did not subside nor develop subsurface maxima, indicating that the deep chlorophyll maximum reflects photoacclimation and increased chl/cell, not increased cell numbers at depth. Rates of primary production at the DCM are very low.

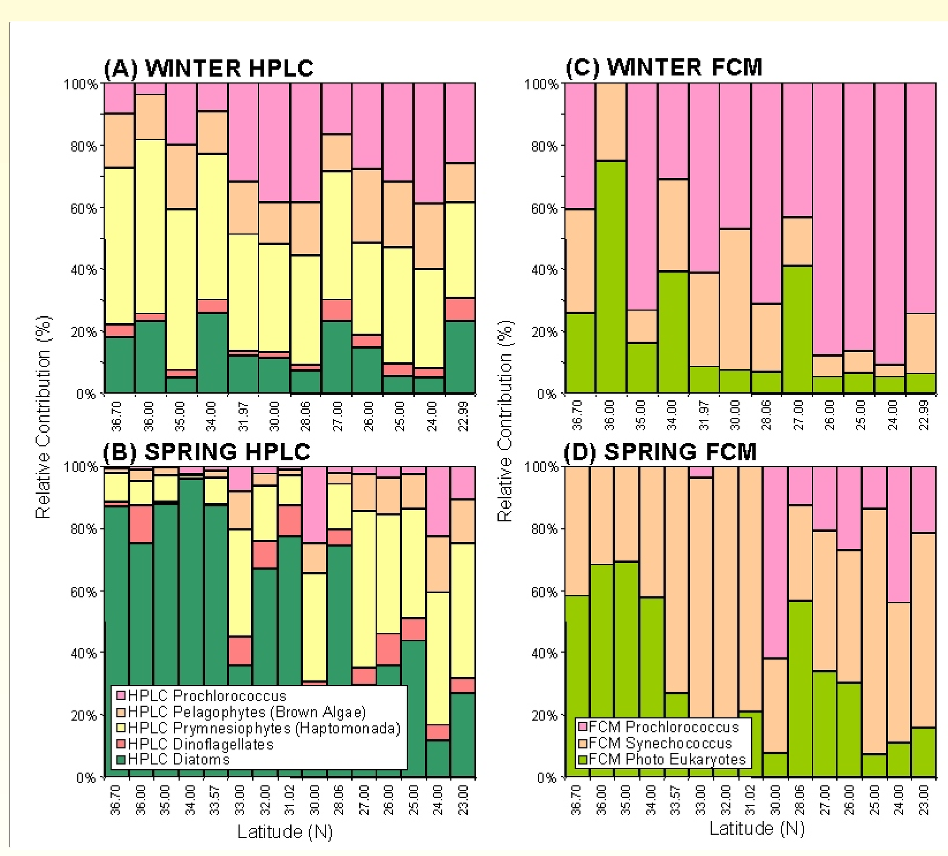

Figure 6. Percent of depth-integrated HPLC and FCM phytoplankton. HPLC and FCM *Prochlorococcus* (A-D) was most abundant in winter and in the south, whereas HPLC diatoms (A,B) were most abundant in spring and in the north. FCM *Synecococcus* (C,D) was most abundant in spring with little latitudinal trend. Several HPLC groups (A,B) were evenly distributed in winter but more abundant in the south in spring.

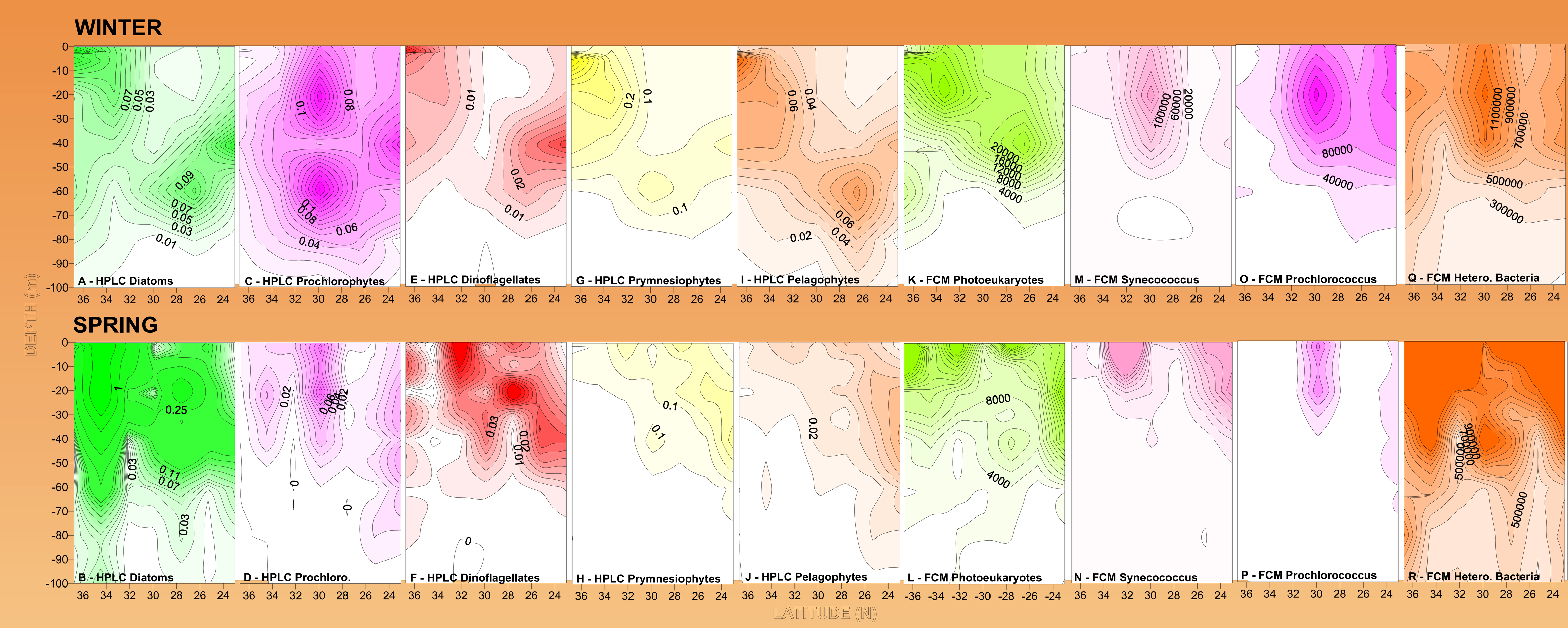

Figure 7. HPLC and FCM plankton. HPLC diatoms (A-B) were much more abundant in spring and subsided to the south, as did chlorophyll (Fig. 6); HPLC and FCM *Prochlorococcus* (C,D,O,P) were more abundant in winter and in the south. The pattern for FCM *Synecococcus* (M,N) is less clear. Several taxa (E,F,G,H,I,J) were rare in shallow tropical waters in the south in winter, but were also rare in springtime shallow upwelled waters in the north --- perhaps these are transitional groups. FCM heterotrophic bacteria (Q,R) were most abundant in spring, with little latitudinal trend.

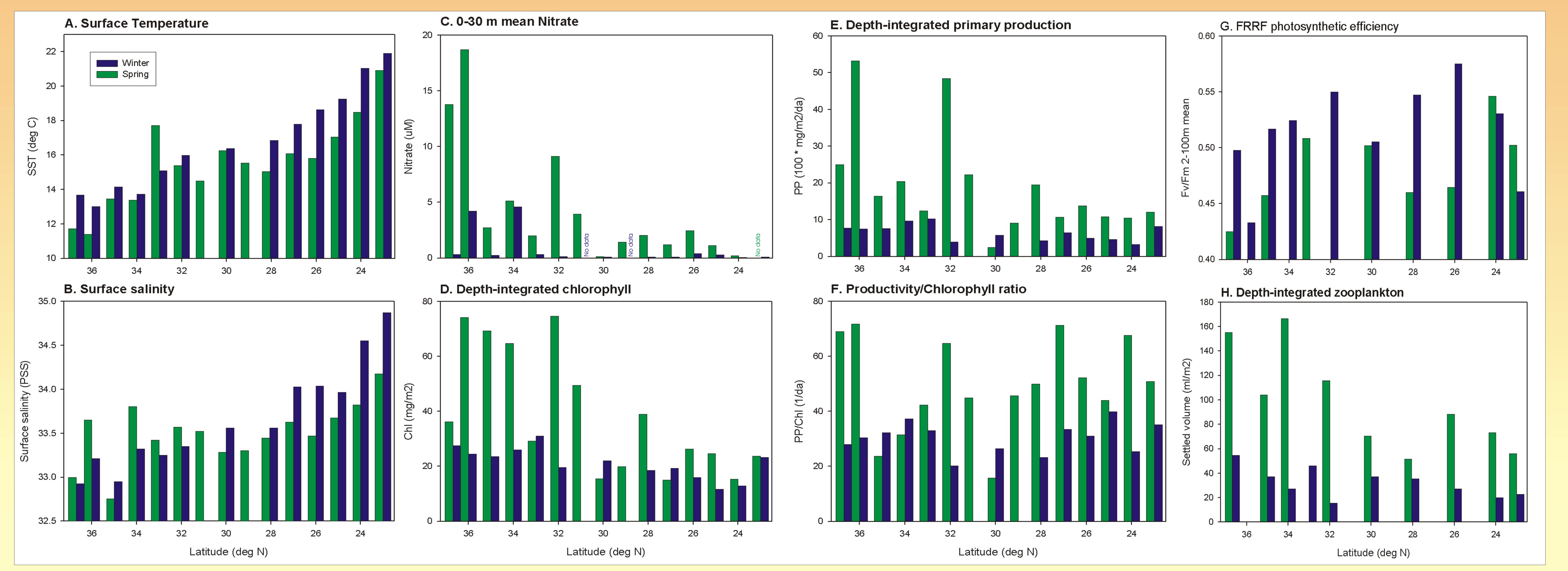

Figure 8. Summary bar graphs of selected properties. (A) SST was generally higher in winter. (B) Surface salinity was higher south of Punta Baja (30° N) in winter, reflecting poleward intrusion of tropical waters, whereas in spring, surface salinity was higher north of 30° due to coastal upwelling. These salinity changes appear coherent with the biological parameters as noted below. (C) 0-30 m mean nitrate was higher in the north in both seasons, but was much higher everywhere in spring. (D,E) Depth integrated chlorophyll and primary production were higher at all latitudes in spring versus winter, but were much higher N of Punta Baja in spring. (F) Primary production/chlorophyll ratios show no clear latitudinal trend, but are higher in spring. (G) Mean 2-100 m FRRF Fv/Fm ratios were higher in winter except at the two southernmost stations, possibly in relation to higher wintertime surface iron levels. (H) 0-200 m zooplankton settled volumes (Tucker Trawls, 500 um mesh net) were low with little latitudinal trend in winter and higher in spring and to the north.

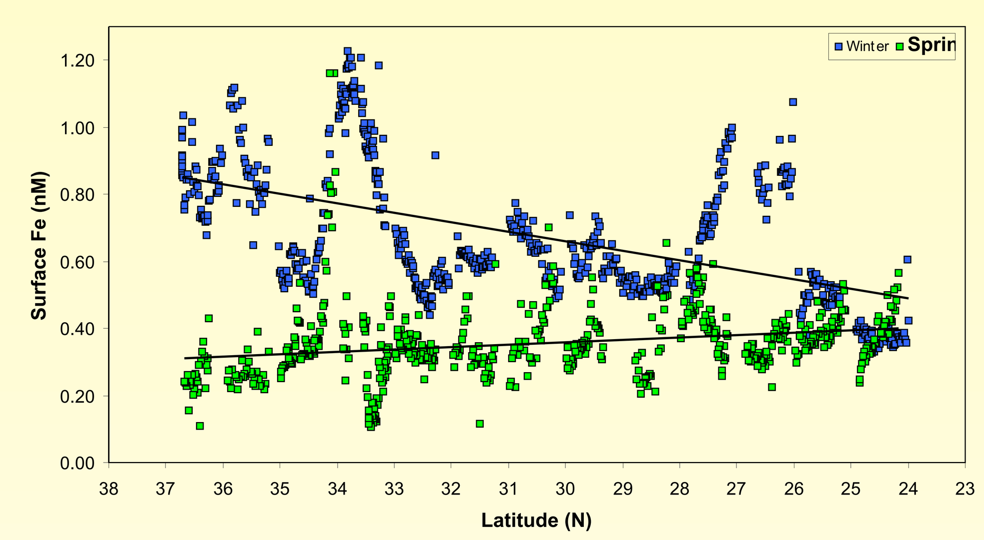

Figure 9. Surface iron levels were low overall (<1 nM) but highest in winter and to the north, perhaps reflecting increased wintertime mixing in the north. Levels were low in spring, probably due to biological drawdown. Iron spiked at Point Conception (34° N) in both seasons and just south of Punta Eugenia (27° N) in winter. Interaction of alongshore flow and bathymetry may elevate iron near these headlands.

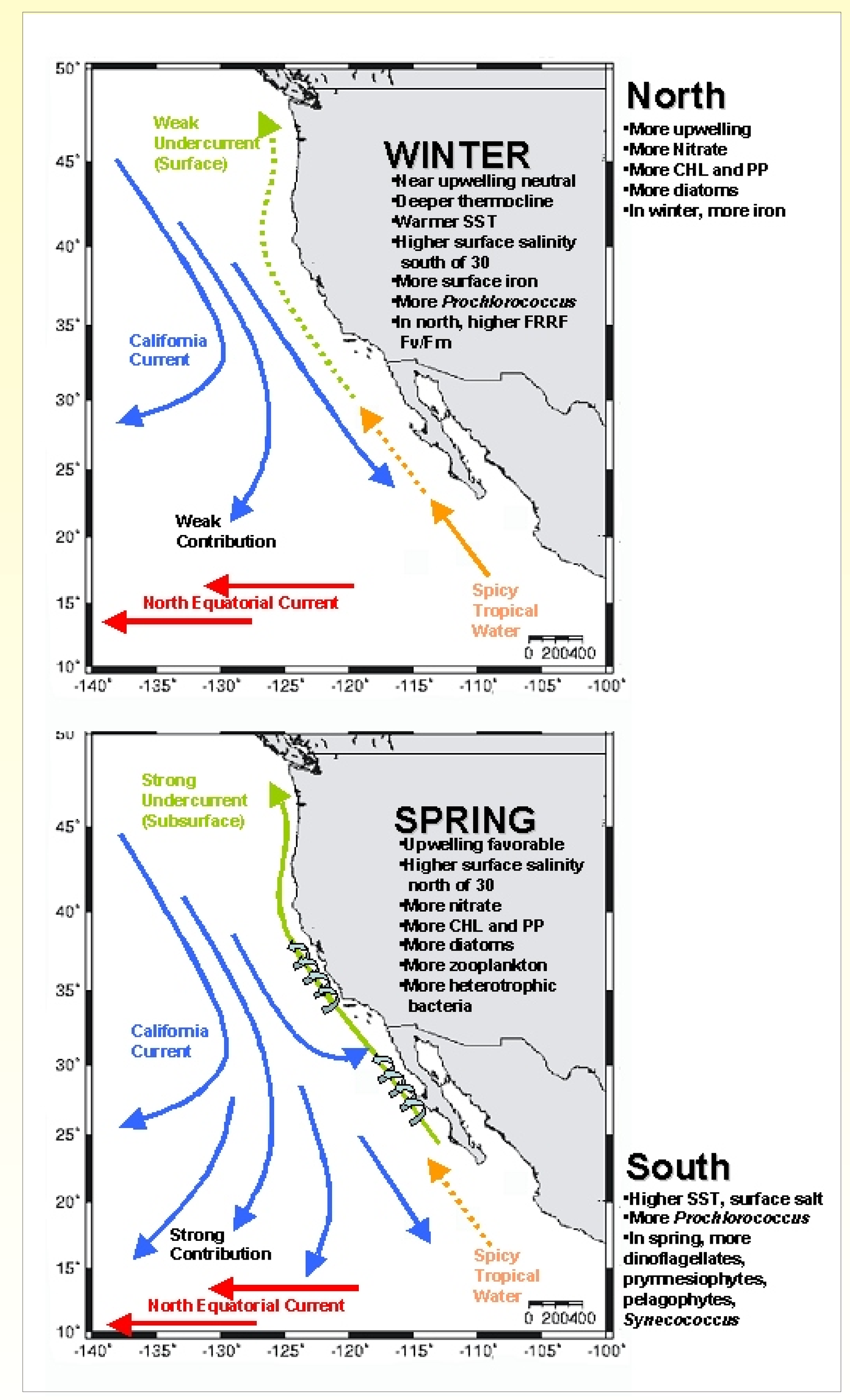

Figure 10. Summary view of currents and other properties com pared between winter and spring and north and south.

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