Southern Ocean Biogeochemistry: An Introduction

SOCCOM floats are unique because they carry sensors for ocean biogeochemistry as well as for salinity, pressure, and temperature. A SOCCOM float must have sensors for two of the following: dissolved oxygen, nitrate, and pH. Floats may also have bio-optical sensors such as chlorophyll fluorescence, backscatter, light transmission or light intensity, so scientists can assess biological activity at varying depths. All of this information helps inform scientists about carbon cycling and processes in the Southern Ocean — and, ultimately, how the Southern Ocean is responding to climate change.

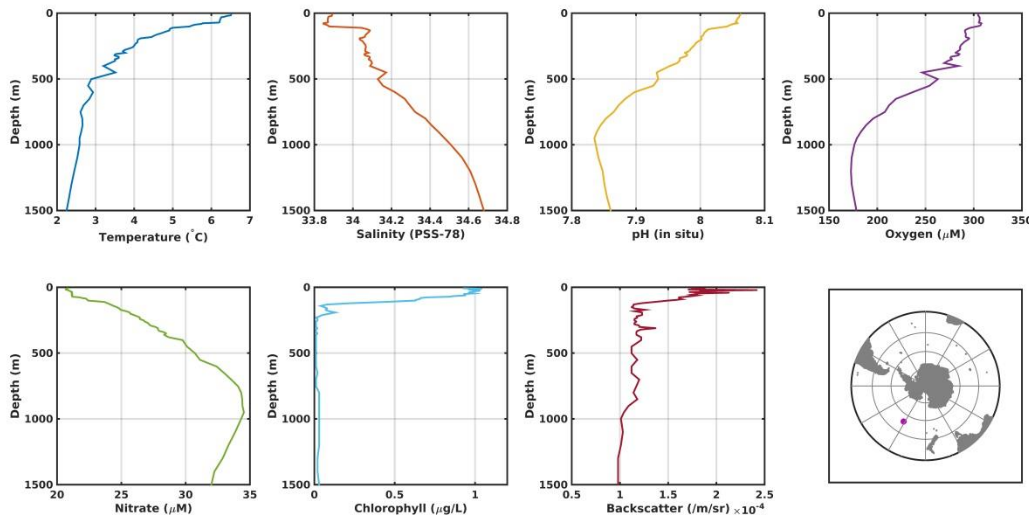

Figure 1. Simple depth profiles from a SOCCOM float. The purple dot indicates the location of the float when it took these measurements.

Ocean biogeochemical cycling is characterized by photosynthesis and respiration. Phytoplankton, the base of the ocean food web, require nutrients, light, and carbon dioxide to perform photosynthesis and produce organic matter. This reaction is described in equation form below:

$$Solar\ Energy + 106\ CO_2 + 16HNO_3 + H_3PO_4 + 122H_2O \rightarrow (CH_2O)_{106}(NH_3)_{16}H_3PO_4 + 138O_2$$

Photosynthesis can only occur in the light-filled surface waters of the ocean, because phytoplankton require solar energy to power the reaction. This can be seen in a depth profile of chlorophyll (see figure 1), which shows high levels of chlorophyll (and thus photosynthesizing phytoplankton) in the surface ocean, but very low values in the deep ocean. In contrast, respiration, the process by which organisms consume oxygen and organic matter to produce energy, can occur everywhere in the water column. Respiration is simply the reverse of photosynthesis (the reaction above, but proceeding from right to left).

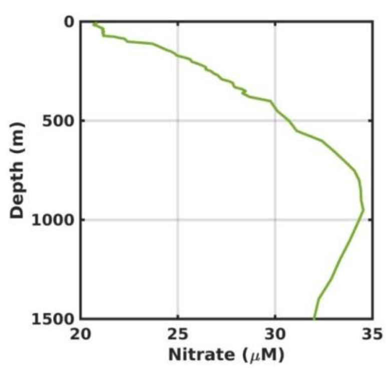

Figure 2. Nitrate depth profile.

Nitrate is a necessary nutrient for ocean primary production. Nitrate plays an essential role in the photosynthesis reaction (look again at the equation above). Because nitrate is consumed by photosynthesis and released through respiration, it is generally depleted in the surface ocean and enriched in the deep ocean (see Figure 2).

Dissolved oxygen is a product of photosynthesis. Dissolved oxygen profiles often look like mirror images of nutrient profiles (compare Figure 3 and Figure 2). This is because oxygen is released in photosynthesis reactions in the surface ocean, and consumed by respiration reactions in the deep ocean. The depth at which oxygen is lowest is called the oxygen minimum layer. It usually occurs at a depth of around 1 km (see Figure 3).

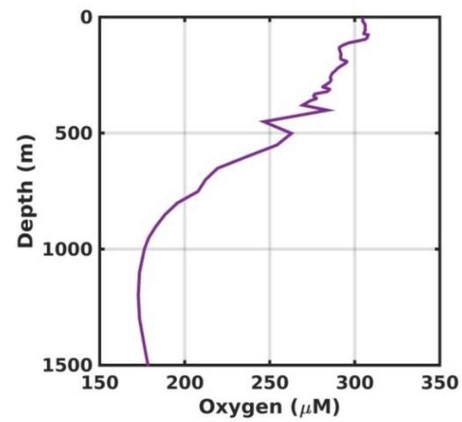

Figure 3. Dissolved oxygen profile.

PH is an indicator of carbon dioxide concentration. Total dissolved inorganic carbon (DIC) in the ocean is the sum of carbon dioxide [CO_2], carbonate ions [CO_3^{2-}], and bicarbonate ions [HCO_3^-]. As the proportion of dissolved inorganic carbon stored as carbon dioxide increases (i.e., as more carbon dioxide enters the ocean system), seawater pH *decreases* (see Figure 4). Carbon dioxide in the ocean is stored in the form of carbonic acid, or H_2CO_3. Therefore, increasing carbon dioxide can cause ocean pH to steadily decrease over time, a process called *ocean acidification*. Ocean acidification can be harmful to a variety of ocean lifeforms, especially corals. Figure 1 shows a profile of pH from the Southern Ocean. This profile looks very similar to the profile of dissolved oxygen — why is this? What process controls both of these parameters?

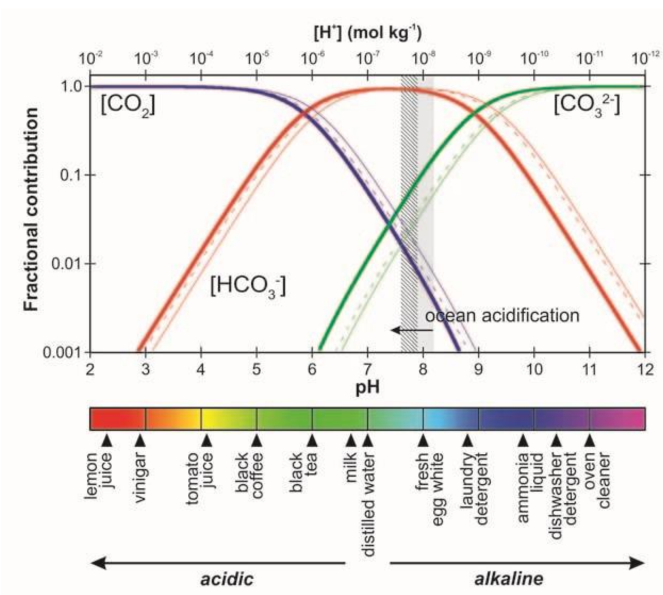

Figure 4. The pH of various forms of ocean dissolved inorganic carbon. Note how an increase in CO_2 moves ocean pH towards the acidic range.