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A Treasure from the Deep

Using sediment traps to understand deep-sea biodiversity and carbon flux

By Svenja Halfter, Institute for Marine and Antarctic Studies, University of Tasmania

Rough weather makes data collection in the Southern Ocean a difficult task. Ship-based observations are usually restricted from spring to autumn and do not cover the winter months. However, year-round data are urgently needed to understand the ocean's impact on our climate. Even though the Southern Ocean represents only 22 percent of the world ocean's surface, it is responsible for ~40 percent of the total uptake of anthropogenic carbon dioxide and 75 percent of the additional heat. Water masses form in the subantarctic zone and transport gases and heat down to the deep ocean basins of the Atlantic, Indian, and Pacific Ocean. Additionally, biological processes drive carbon transport as part of the so-called Biological Carbon Pump, in which carbon is taken up by photosynthetic phytoplankton and transported to the deep ocean as sinking particles (known as marine snow) when the plankton cells die. Higher trophic levels, such as zooplankton and fish, ingest, fragment, and produce particles themselves, which add to the particle rain into the deep sea. Both physical and biological processes remove carbon from surface waters and counteract climate change.

Sustained mooring sites can help overcome the seasonal gaps in ocean observations. Unlike research vessels, they collect data continuously over a long period of time. The Southern Ocean Time Series Site, or SOTS, at 47˚S south of Australia, is a sub-facility of the Australian Integrated Marine Observing System (IMOS) and has provided these important ocean data since 1997. The moorings are equipped with autonomous sensors and sample collectors to observe air-sea flux and surface biogeochemistry and include deep ocean sediment traps. Sediment traps are devices that collect sinking particles from the water column, typically every two weeks throughout the year. They provide information on the inter-seasonal changes in carbon flux, but also help to understand long-term trends in carbon transport to the deep ocean. Before processing the collected samples back in the laboratory, larger organisms such as zooplankton swimmers are usually removed as they bias the carbon flux estimates.

A rough day on the Southern Ocean © Robert Strzepek

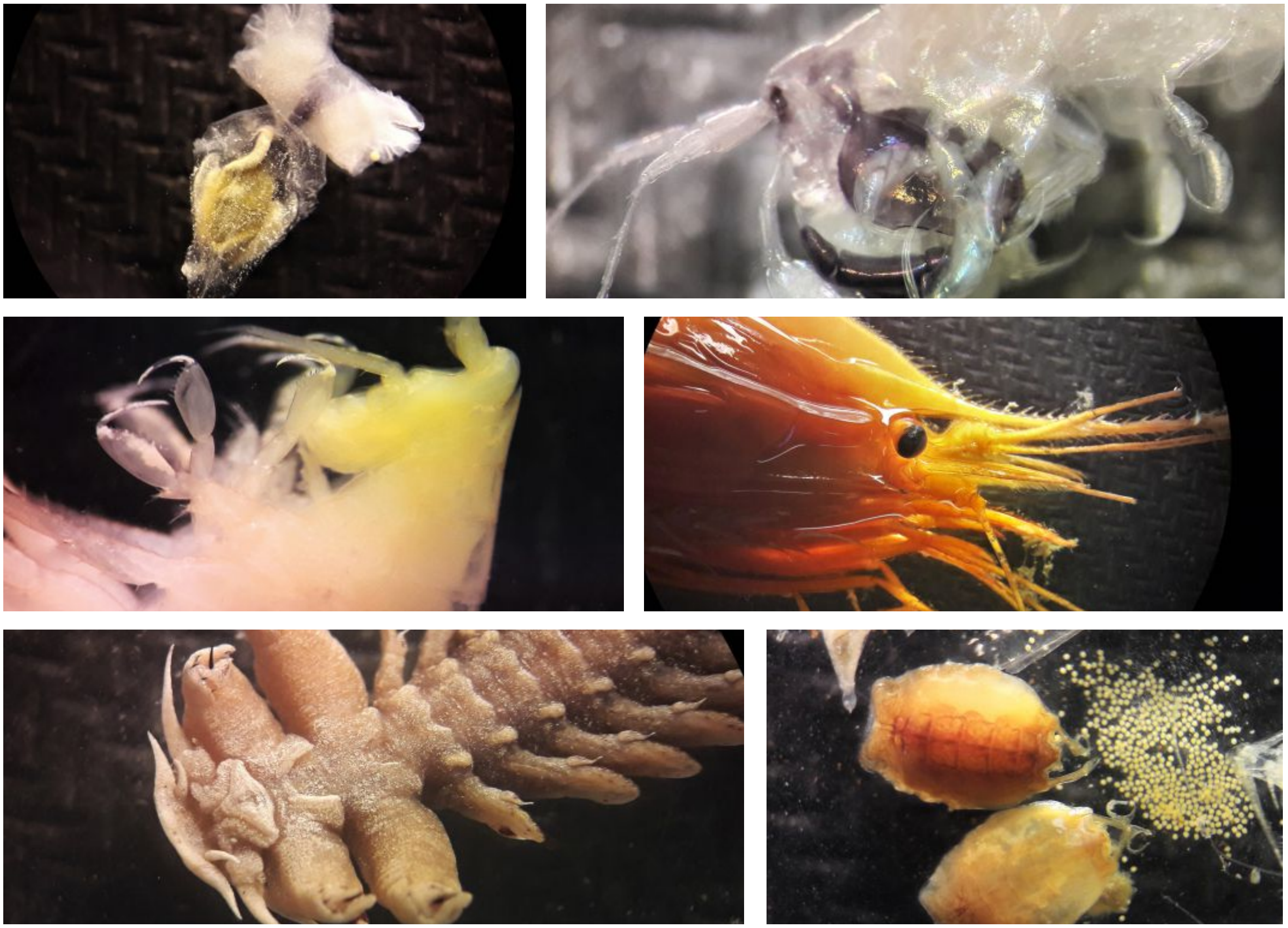
Recovery of the sediment traps after a year of sampling the deep ocean.

Swimmer communities sampled in the shallowest sediment trap at SOTS (1000 m water depth).

Swimmers are organisms that actively enter the trap while looking for food or shelter and are subsequently killed by the preservative. For decades, they were mainly considered as contamination for carbon flux analyses. However, the swimmer community composition from sediment traps can be a valuable dataset and the idea of treating the data as a "window to the deep sea", rather than a problem, has become more popular in recent years.

First, swimmers can be used as indicator for ecosystem change. Because of their relatively short life span, they respond quickly to environmental changes. For example, scientists from the Alfred Wegener Institute and the University of Bremen, Germany, worked with sediment traps to explore how increasing temperatures of Arctic waters affect amphipod community patterns, which was published last year in *Frontiers in Marine Science.* They found that higher water temperatures impacted the amphipod community and lead to a more frequent occurrence of the North Atlantic species *Themisto compressa* relative to Arctic species. Second, we still lack understanding of deep-sea biodiversity and its seasonal and inter-annual dynamics. Sediment traps offer an opportunity to study this environment over an extended time and allow the detection of short- and long-term changes. For example, Italian researchers of the Polytechnic University of Marche and Stazione Zoological Anton Dohrn, Italy, found that different groups of deep-sea taxa dominate the four studied oceanic basins of the Mediterranean Sea and significantly change in their abundance and community structure over time. Third, swimmer data can provide more information on carbon flux. As mentioned, the organisms feed and fragment sinking detritus, which in turn enhances microbial remineralisation and affects the carbon flux. Therefore, different species compositions impact the carbon flux regime. Sediment traps allow a direct comparison of particle carbon estimates and swimmer composition data, as both are collected in the same sampling cup over the same time frame. This is expected to lead to a better understanding of carbon transport in the Southern Ocean.

Like every other method, using sediment traps for swimmer data collection comes with biases. For example, it remains difficult to distinguish swimmers from zooplankton carcasses. While swimmers actively enter the trap and should not be included in carbon flux estimates, zooplankton carcasses died in the water column above the sediment trap and are part of the passive carbon flux. With fresh samples, we use



A selection of swimmer found in the SOTS sediment traps: a pteropod, two amphipods, a decapod, a polychaete and isopods.

staining methods to distinguish live from dead zooplankton, for example with the stain neutral red for crustacean zooplankton, but because the traps are deployed for a year until recovery, these methods are not available. Second, species of gelatinous plankton, such as jellyfish, siphonophores and salps, are difficult to be identified in the samples. While this way of data collection is less intrusive than sampling with zooplankton nets or Continuous Plankton Recorders, specimens are still easily damaged due to their fragile nature. Additionally, large-sized zooplankton, such as pyrosomes, are under-sampled, because of the coarse mesh (~2 cm) on top of the traps. This is a technical necessity to avoid the entry of fish or other large organisms, which might then succumb to the preservatives deployed in the collection cups and block the turning of the trap time series carousel mechanism.

Despite the mentioned biases, swimmer data collected by sediment traps are a valuable addition to our knowledge on Southern Ocean carbon flux and deep-sea biodiversity. This taxonomic data should be used more widely for as it also allows to track climate change effects in the oceanic ecosystem. Future changes at SOTS and in other parts of the subantarctic zone, for example increasing temperature as the result of the southward extension of the East Australian Current, will likely affect carbon uptake by and transport in the Southern Ocean. The analysis of the year-round and long-term swimmer dataset closes the seasonal gaps in ocean observation data and will improve our understanding of the marine carbon cycle.

Australia's Integrated Marine Observing System (IMOS) is enabled by the National Collaborative Research Infrastructure Strategy (NCRIS). It is operated by a consortium of institutions as an unincorporated joint venture, with the University of Tasmania as Lead Agent. Details of the deep-sea moorings at SOTS are available via the Integrated Marine Observing System (http://imos.org.au/). For more information on mooring and carbon flux at SOTS see for example Trull, T. W. et al. (2010). The Australian Integrated Marine Observing System Southern Ocean Time Series facility. OCEANS'10 IEEE SYDNEY, *1–7 or Wynn-Edwards et al. (2020). Particle fluxes at the Australian Southern Ocean Time Series (SOTS) achieve organic carbon sequestration at rates close to the global median, are dominated by biogenic carbonates, and show no temporal trends over 20-years. Frontiers in Earth Science 8 (2020): 329.*