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Editorial

Interpretations of biogeochemical processes from the US JGOFS Bermuda and Hawaii time-series sites

From humble beginnings and modest vision, the Hawaii and Bermuda time-series stations have proven to be among the most visible and important accomplishments of the Joint Global Ocean Flux Study (JGOFS) era. These stations have provided unique views of seasonal to decadal scale variability in biogeochemical processes. They have contributed to fundamental changes to the basic paradigms of the ocean biogeochemistry and have helped shape what is now referred to as interdisciplinary oceanography. The JGOFS time-series programs have provided an important social change for how marine scientists collaborate, share data and ideas. Most importantly, these stations are now set to endure beyond JGOFS as these scientific values become important components of the next generation of biogeochemical research hypotheses and projects.

The two US stations, the Bermuda Atlantic Time-Series Study (BATS) and the Hawaii Ocean Time-Series (HOT) both commenced sampling in late 1988, and over the ensuing 12 years, have created unparalleled datasets. These were joined by a five-year French JGOFS effort off Kergulen Island in the Southern Ocean and the ongoing German–Spanish effort near the Canary Islands in the Northeastern Atlantic Ocean. Following the lead of these and other studies, a virtual armada of ocean biogeochemical time-series research programs has been initiated in many regions of the World Ocean.

The idea of an ocean time-series was clearly not invented by JGOFS. The two US stations are built on previous efforts in the same areas to provide decadal time-scale context for their research. Ocean Weather Stations, coastal hydrographic stations, and marine biological laboratories provided early time-series of physical, chemical and occasional biological features. The California Cooperative Fisheries Investigation (CalCoFI) and similar efforts built interdisciplinary ocean time-series around fisheries management issues. The Longhurst–Hardy plankton recorder survey is a unique window into the time and space variability of plankton in the North Atlantic. The ever-increasing number of satellites has also created invaluable time-series of the ocean-surface properties while sediment and ice cores are used to provide essential time-series data for contemporary oceanographers.

The most important contribution made by the US JGOFS time-series stations has been the increased understanding and resulting paradigm shifts that have arisen from the long-term nature of the experiments and the co-location of so many different measurements. We have an emerging understanding of the response of the oceans to climate variability and the impacts of that response on the carbon cycle. Previous assumptions of a steady-state oligotrophic gyre are now obviously invalid, as substantial ecosystem shifts exist on a variety of time scales. Our understanding of

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nutrient dynamics has changed greatly. The assumption of constant Redfield ratios for nutrients is now seen to be incorrect, and these ratios are observed to change in response to a range of dynamical processes. Researchers have shown that nitrogen fixation has a central place in the productivity and nutrient cycles of both the North Pacific and North Atlantic. These are just a few of the achievements, items of increased understanding and shifting paradigms that can be credited at least in part to JGOFS time-series studies.

The US JGOFS time-series programs are likely to be the most comprehensive, inter-decadal set of biogeochemical observations ever collected. They also have been the focus of over 100 other complementary investigations by a diverse spectrum of marine scientists. The principal investigators of the US JGOFS stations have spent considerable effort making these stations, ship- and shore-based facilities, and most importantly the core time-series data, available to interested investigators regardless of country or funding. These "ancillary projects" gain the value of the comprehensive measurement program and, in turn, expand the basis of understanding available to all investigators.

This volume is the second special issue of *Deep-Sea Research Part II*, *Topical Studies in Oceanography* to focus on the US JGOFS time-series stations. It includes recent results that, like the first volume (*Deep-Sea Research*, *Part II*, Vol. 43, Nos. 2–3), cover a full range of disciplines and scientific questions. These contributions build upon both the core time-series and the many ancillary investigations. As these time-series grow longer, the types of questions that can be addressed also expand. With a decade of data, interannual time-scales become more tractable and we get our first glimpses of the exciting new understanding and altered paradigms that await on the decade time-scale. Core data from the time-series programs are now and have been since their initiation available via the world-wide web at hahana.soest.hawaii.edu/hot/hot.html for HOT and at www.bbsr.edu/cintoo/bats/bats.html for BATS. This volume includes a CD-ROM with many ancillary data sets that we hope will further expand the utility of the time-series data sets. The types of ancillary data included on the CD-ROM span satellite to microscopy imagery.

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