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ISOTOPES AS TRACERS OF THE OCEANIC CIRCULATION: RESULTS FROM THE WORLD OCEAN CIRCULATION EXPERIMENT

(Abstract)

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During the past decades, natural and anthropogenic isotopes such as tritium (^{3}H), radiocarbon (^{14}C), ^{3}He, or the stable isotopes of water have been used in studies of the dynamics of natural systems. Early applications of tracers to studies of the ocean were directed at determination of circulation patterns and mean residence times of specific water masses, as well as estimates of mixing coefficients. These exploratory studies suggested that tracers can add significantly to our understanding of the oceanic circulation. In order to fully exploit this potential, the first global tracer study, the GEochemical Ocean SECtions Study (GEOSECS), was launched. From the GEOSECS results it was immediately apparent that very close coordination of tracer programs with physical oceanography studies is required for full utilization of tracer data.

During the 1980s plans for the World OCean Experiment (WOCE) were developed. As part of its Hydrographic Program (WHP), especially during the one-time survey, a set of tracers were measured on a global scale with unprecedented spatial resolution (both lateral and vertical). The original plan included a larger number of tracers (CFCs, $^{3}H/^{3}He$, ^{14}C, ^{39}Ar, stable isotopes of water, helium isotopes, ^{228}Ra, ^{90}Sr, ^{137}Cs, ^{85}Kr) than could actually be measured systematically (CFCs, $^{3}H/^{3}He$, ^{14}C, $H_2{}^{18}O/H_2{}^{16}O$, helium isotopes). Nevertheless, the resulting data set, which presently is under evaluation, exceeds those obtained from pre-WOCE tracer studies by a wide margin.

In this contribution, we describe the existing WOCE data set and demonstrate the type of results that can be expected from its interpretation on the basis of a few selected examples. These examples include: (1) the application of tritium and ^{3}He to studies of the ventilation of the upper waters in the Pacific Ocean, (2) the spreading of intermediate water in the Pacific and Indian oceans as derived from the distribution of ^{3}He, and (3) the evaluation of global ^{14}C maps with respect to the bottom water circulation in the Pacific Ocean. Although most of the presented results are preliminary, they demonstrate the potential of the WOCE tracer data set for obtaining insights into the oceanic circulation that were not possible on the basis of pre-WOCE data sets.