Part II

SYMPOSIUM OF THE CALCOFI CONFERENCE

LAKE ARROWHEAD, CALIFORNIA

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THE CALCOFI SAMPLING PROTOCOL AND TIME SERIES, POINT/COUNTERPOINT

What are the CalCOFI data? What was measured? How often? And where? What exactly was Wib Chapman referring to when he so often said that the California Current was the most intensively sampled piece of ocean in the world? And what do we know of its physics and its inhabitants as a result of this effort?

As the CalCOFI program approached its fortieth birthday, a symposium was convened at the 1987 CalCOFI Conference to discuss these questions. The following three papers were part of the proceedings.

In the first paper I attempt to place the CalCOFI effort in the larger context of the collapse of the sardine fishery. Scientific attention had been directed toward this fishery, once the largest in the world, since 1915. The vagaries of recruitment compounded by society's tendency to overexploit were generally recognized as coconspirators in the demise of the sardine. The CalCOFI program augmented ongoing work and marshalled additional resources to distinguish the relative influences of exploitation and the environment on the production of fish. The primary sampling tools employed at sea were the plankton net and the hydrocast bottle.

The CalCOFI data set is not homogeneous. The sampling protocol was changed several times throughout the history of the program, producing uneven temporal and spatial sample densities. I describe these sampling regimes and attempt to set them in the context of the dramatic emergence of the northern anchovy population and the response of the program's organizers.

In the next paper Joe Reid reviews the contributions of CalCOFI from the viewpoint of a physical oceanographer. Analysis of the CalCOFI data confirmed earlier descriptions of the California Current as offshore southward flow balanced by a countercurrent and upwelling. The CalCOFI surveys, when combined with large-scale surveys of the North Pacific, established broad correlations between circulation, nutrients, and zooplankton. The CalCOFI data also revealed seasonal fluctuations, aperiodic events, and eddies.

Reid notes that CalCOFI's intent was to relate variations in the circulatory pattern to changes in the biota. The first decade, however, was monotonously invariant, offering little opportunity for comparison. The steady decline in the numbers of sardines, which had started in the early 1940s, continued through this period. On the other hand, zooplankton abundance was correlated with the strength of the California Current. This correlation continued through the 1957–58 El Niño (the first major oceanographic event to be observed by the CalCOFI program) as well as through subsequent cold- and warm-water periods.

In the final paper Paul Smith and Geoff Moser review the contributions of CalCOFI from the viewpoint of biological oceanographers. Analysis of ichthyoplankton from surveys bracketing the 1957–58 El Niño revealed biogeographic patterns that moved in concert with major changes in the circulatory patterns. Recruitment to pelagic fish populations was shown to be autocorrelated over several years; trends in population abundance were shown to be autocorrelated over several decades. Contrasted with long-term temporal correlations, changes in population abundance do not appear to be concordant over the geographic range of the population.

Smith and Moser also note that recruitment to the northern anchovy population is much more variable than the anchovy's reproductive output, suggesting that prerecruit predation may control population growth. In this regard the multispecies nature of the CalCOFI data holds great potential.

With computer-aided analytical tools, trophic relationships can now be teased from the CalCOFI data set. The data, previously available only as atlases and research reports, have recently been assembled into a computer data base, and a series of ichthyoplankton data reports have been published. The data base can also be accessed through the CalCOFI On-Line Data System, making it possible for any researcher to explore the extent of the ichthyoplankton and hydrocast data, review the sampling methodology, and extract desired subsets of the data.

Still to be addressed is the future of the CalCOFI sampling program and how the sampling design can be improved to address current research questions. What should be measured, with what techniques, how often, where, and why? Would it be appropriate to develop high-speed plankton sorting and identification techniques (e.g., species-specific DNA probes, antibody assays [ELISA], and image analysis)? Would it be useful to use satellite imagery to describe the dynamics of primary production? Should we sacrifice spatial resolution and species precision for insight into temporal dynamics? And, most promising of all, should we investigate the use of genetic tools to describe population structure and the spatial dynamics of recruitment?

Whether we call it "biodynamics of the sea" or "the ecosystem approach," the essence of biological oceanography is to link the physics of the ocean with biological processes. Unfortunately, there are appallingly few demonstrations of this linkage. Walter Munk tells us that physical oceanographers are just now beginning to measure things on a scale that reflects the ocean's true variability; the implication is that biological oceanographers must do the same in order to make any sense of the world. Some linkages may prove irrelevant to the prediction of population growth. Lasker's elegant demonstrations that successful feeding by larval fish is dependent on a stable mixed layer was offset by the conclusion that survival through the larval stage was not the sole determinant of recruitment. But until we extrapolate from the individual animal and its ambit to the population and its habitat, we will be relegated to simple (and sometimes misleading) correlations between physical and biological variables.

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