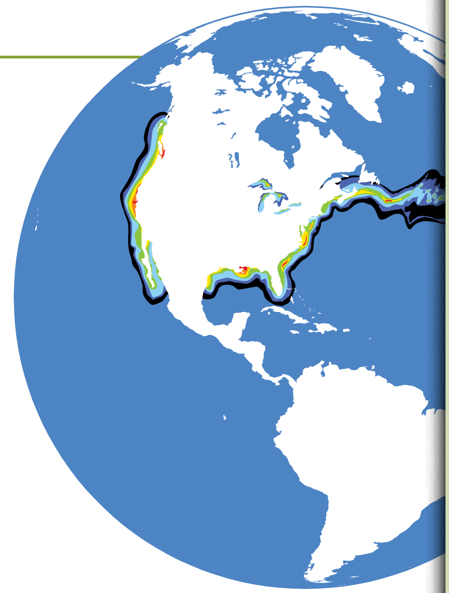
INTRODUCTION



BY RICHARD A. JAHNKE,
MICHAEL R. ROMAN,
AND KENNETH H. BRINK

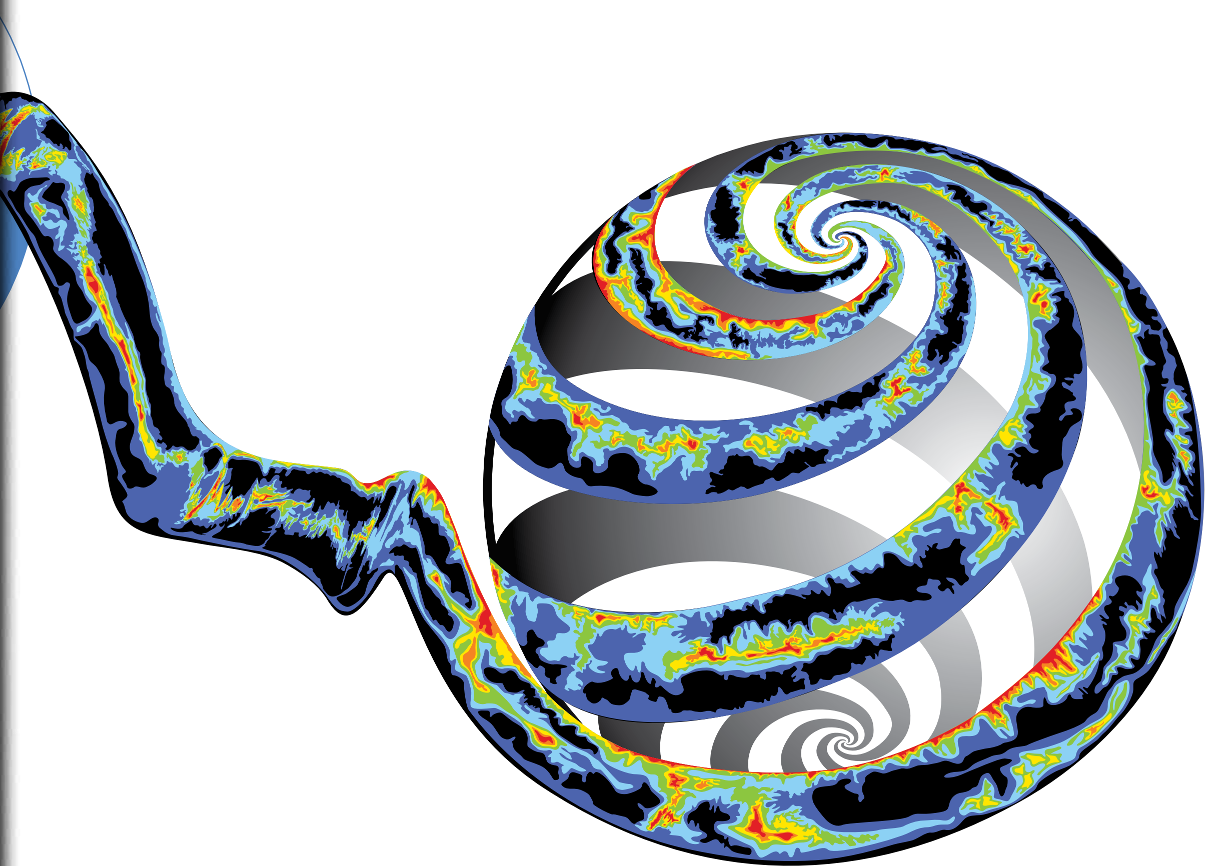
Coastal Ocean Processes Program

Advancing Interdisciplinary Research and Technology Development

Coastal ecosystems provide major research challenges because of the diversity of their environments and habitats and their high spatial and temporal variability. The magnitude of mass exchanges and organism populations, and the proximity of coastal systems to human populations, necessitate an improved understanding of these ecosystems. Because of the complexity and, in many cases, interdependency of interactions, significant advancement requires a holistic, interdisciplinary approach.

To meet these research challenges, the Coastal Ocean Processes (CoOP) program has promoted interdisciplinary coastal research for nearly two decades. Developed through a series of community workshops (cf. Brink et al., 1990, 1992), CoOP was organized around physical forces and boundaries that control ecosystem character and cross-margin transport of materials. It was recognized at the inaugural workshop that to understand the extremely diverse and variable coastal ocean requires a strategic framework. Simply put, it is not possible to study all coastal regions on all required scales. The organizing assumption defining the CoOP strategy has been that a finite set of dominant processes controls the basic characteristics of coastal environments. These processes occur in different mixtures at different locations and at different times, resulting in the observed variability of coastal ecosystems. CoOP's goal has been to promote process-oriented research at selected locations that differ in their relative mix of controlling processes. Integration of individual observations provides fundamental insight into coastal processes and process interactions applicable to many coastal settings.

Within the strategic framework and emphasizing technology development, CoOP has conducted a series of focused research projects in coastal regions where forcing factors controlled the character and transport processes to differing extents (Roman, 1998). CoOP's interdisciplinary projects have examined the effects of physical forcing on inner-shelf larval transport, air-sea momentum fluxes, episodic transport in the Laurentian Great Lakes, wind-driven transport in coastal Oregon and northern California waters, and buoyancy-dominated transport effects of the Columbia and Hudson Rivers. CoOP's final research projects, which are still underway, focus on the



dynamics of interactions and material exchanges with the seafloor, a dominating factor that differentiates open-ocean and coastal ecosystems.

A majority of CoOP's projects have completed their field and analysis phases, and results are published throughout the oceanographic literature. Although the final CoOP projects will not be out of the water until the end of 2008, project scientists have already begun to report individual discoveries. The manuscripts following this introductory article provide a mixture of retrospection, synthesis, and highlights of the discoveries and advances made through the individual research projects. The articles provide a window to view CoOP and a point of entry for those seeking further information. Below, we provide a history of the program, its philosophy, organization, and the lessons learned in nearly two decades of promoting and conducting interdisciplinary coastal research.

A BRIEF HISTORY

The CoOP program found its voice in a 1990 workshop populated by coastal oceanographers seeking an alternative to disciplinary compartmentalization in the funding and conduct of coastal research (Brink et al., 1990). The vision established and maintained throughout CoOP's existence was to promote fully integrated, interdisciplinary, coastal ocean research in order "to obtain a new quantitative understanding of the processes that dominate the transports, transformations and fates of biologically, chemically and geologically important matter on the continental margins" (Brink et al., 1992). Three elements were considered crucial to success: process studies, modeling, and long time series. The strategy was to conduct a series of focused research efforts at locations that differed significantly in the mix of fundamental controlling processes, such as the magnitude of wind-driven or buoyancy-driven transport. Although physical forcing processes or boundaries were used to provide the differentiating framework for each location, the research focused on interdisciplinary aspects and interactions within each coastal ecosystem.

Before CoOP's inception, coastal research was predominantly organized and conducted within oceanographic disciplinary groups. Although this approach improved our understanding of specific phenomena, such as tides, that can be solely defined within a single discipline, less progress was made in the study of complex phenomena that represent major challenges in coastal research, such as the occurrence and consequences of harmful algal blooms or the biological productivity of buoyant river plumes. CoOP research projects, on the other hand, have been proposed and conducted by interdisciplinary research teams. For each project, the research community was engaged through a CoOP-sponsored open workshop. Subsequently, research teams self-organized around a single proposal, ensuring disciplinary integration of the project.

CoOP has been a broad community effort. The CoOP Scientific Steering Committee (SSC) was comprised of three representatives each from the five major oceanographic disciplines (physical, chemical, biological, and geological oceanography and marine meteorology), with individuals serving three-year, staggered rotations. Over CoOP's lifetime, this disciplinary balance was maintained on the SSC with service from 78 individuals representing 51 institutions in 26 states and Canada. During the normal rotation of SSC members, a principal investigator (PI) from each project was entrained to report on progress and seek guidance when needed. This structure allowed for a minimalist CoOP Program Office that has, since 1994, facilitated and promoted research for 159 PIs (from 51 academic and research institutions in 22 US states and Germany), maintained a periodic newsletter, convened nine open workshops for community input, and published ten program office reports.

Richard A. Jahnke *(rick.jahnke@skio.usg.edu) is Professor, Skidaway Institute of Oceanography, Savannah, GA, USA. He served as Chair of the CoOP Scientific Steering Committee (SSC) from 2000–2008 and was an SSC committee member from 1995–1998.* **Michael R. Roman** *is Professor and Director, Horn Point Laboratory, University of Maryland, Cambridge, MD, USA. He served as CoOP SSC chair from 1993–1999 and was an SSC committee member from 1990–1993 and 1999–2001.* **Kenneth H. Brink** *is Senior Scientist, Woods Hole Oceanographic Institution, Woods Hole, MA, USA. He was instrumental in the creation of CoOP and was Chair of the SSC from 1990–1993 and a member of the SSC from 1993–1998.*

LESSONS LEARNED

Three aspects of CoOP's organizational structure and their influence on the resulting research projects warrant highlighting here: the mode and timing of integration for interdisciplinary research efforts; the review and duration of projects; and the integration of technology development into the research projects. The CoOP strategy for ensuring integration of interdisciplinary research required interested researchers to self-organize into interdisciplinary teams, typically of 8–12 PIs, who competed for support by submitting a single, integrated research proposal. This strategy had a variety of benefits. Integration occurred at the conceptual phase of the project and was self-imposed, in contrast to programs that have attempted to develop interdisciplinary research by evaluating individual PI proposals and then assembling large teams, imposing working partners, and attempting to integrate across disciplines after ideas have been reviewed. Here, interdisciplinary teams were required to be developed as proposals were written so that science plans were evaluated as complete, integrative efforts. Successful disciplinary integration is reflected in the balance of researchers supported. Over the program's lifetime, physical and biological oceanographers each comprised approximately one-third of CoOP PIs, with marine meteorologists and chemical and geological oceanographers comprising 10–15% each.

CoOP projects have been small enough that major initiatives could fund more than one group for each research area. Although each project is different, in general, this situation fostered healthy competition, both during the proposal development period and during project execution. It has facilitated comparative studies, because individual teams selected different locations for study. Medium-sized teams operated efficiently, with the flexibility to self-monitor and self-regulate, and to adapt research directions as results dictated. The success of these medium-sized, interdisciplinary research teams derived significantly from an agency review and funding process tailored to these integrated proposals. The moderate size of the projects also allowed sufficient flexibility to facilitate coordination among funding agencies. Although the National Science Foundation (NSF) was generally the lead agency, the Office of Naval Research and the National Oceanic and Atmospheric Administration have been significant partners, providing financial support for individual projects and coordinating internal research programs with CoOP projects, greatly expanding the breadth of research performed.

Most CoOP projects were supported in five-year funding cycles. Although the specifics were tailored by each group, this duration permitted an initial ramp-up phase to ready equipment and develop prototypes of new instrumentation; a field observation phase usually of sufficient duration to follow at least two annual cycles; and a ramp-down phase to compile, analyze, and publish initial results. Although funded at a reduced level, this latter phase has proved to be very important. In addition to promoting timely publication of initial results and the development of synthetic understanding, this phase accelerated the availability of field data to support a very productive modeling effort. However, the five-year funding footprint was insufficient to realize one of CoOP's original three elements: long time series.

An added benefit of the establishment of these medium-sized, self-regulating project teams is that it freed the SSC to function in an advisory role, to focus on strategic program direction, and not to manage details of individual projects, because all relevant disciplines were included at inception. One obvious example is the role the SSC and Program Office played in the early planning for the coastal component of the Ocean Observatories Initiative (Jahnke et al., 2002, 2003), which arose well after establishment of CoOP.

CoOP's NSF support has been provided through the Ocean Technology and Interdisciplinary Coordination (OTIC) Program within the Integrative Programs Section of the Division of Ocean Sciences. As such, there has been a strong and well-coordinated link between CoOP research programs and the development and implementation of new technologies. An important aspect of this emphasis has been to incorporate technology development into field research programs to ensure immediate feedback between engineering design and science requirements. The willingness of the OTIC program managers to fund novel and not-quite-off-the-shelf measurement tools to address recalcitrant questions in challenging coastal environments provided an exceptional opportunity for CoOP researchers.

PERSPECTIVE FOR THE FUTURE

As the CoOP Program comes to an end, a reflection on lessons learned is instructive not only to coastal scientists but also to the broader oceanographic community. CoOP benefited significantly from the development of a coherent research strategy at inception that provided a critical framework to keep the program coordinated as it progressed. This underlying strategy has ensured that individual projects all contributed fundamentally to the central program goal. Synthesis of the results from all the projects holds the promise to collectively advance understanding to a greater extent than the individual projects themselves could do.

The formation and use of medium-sized, interdisciplinary research teams have proven to be extremely effective means to conduct complex interdisciplinary research. Integration of thinking among the individual subdisciplines at the inception of each project was a critically important step in conducting these complex efforts. Additionally, these teams have been flexible in adapting to and securing funding from multiple sources, certainly a strength in these challenging times.

The success enjoyed by CoOP is also attributed to NSF's establishment of a proposal review and funding structure that was tailored specifically for complex, interdisciplinary research questions that were the focus of CoOP projects. Furthermore, NSF program managers understood the importance of technology development for making new observations and supported and encouraged implementation of new instrumentation within individual research projects. The existing high-quality data sets await the thorough synthesis and modeling effort that will lead to a coherent interpretation of the individual process study results.

Marine science is moving toward greater integration of traditional disciplines and complex research strategies that meld ship-based measurement, Internet-available observatory data, assimilative and traditional modeling syntheses, and geographically dispersed researchers. The CoOP organizational model serves as a valuable starting point to meet the challenges of twenty-first century marine research.

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