Southern California's marine monitoring system 10 years after the National Research Council evaluation

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ABSTRACT - In 1990, the National Research Council (NRC) published two in-depth assessments of marine environmental monitoring effectiveness. The first of these, *Managing Troubled Waters*, provided a national perspective and the second, *Monitoring Southern California's Coastal Waters*, examined the specifics of monitoring design and implementation in a densely populated, highly urbanized coastal region. The reports include explicit recommendations about the need for greater regionalization of monitoring efforts, supported by greater standardization of field, laboratory, and data analysis methods. They also identified the need for centralized data management and for greater flexibility in the language of standard discharge permits, flexibility that would permit discharge agencies to more readily participate in regional monitoring and research programs. Other recommendations identified a need for the U.S. EPA (EPA) and the National Oceanic and Atmospheric Administration (NOAA) to focus on creating a national monitoring program structured as a network of coordinated local and regional efforts. Finally, the NRC emphasized the need for better reporting and for periodic review of monitoring's relevance to management concerns. In this article, we use southern California as a test case to assess progress made in implementing the NRC's recommendations. We review progress made on each recommendation and discuss the features of the regulatory and management climate that contributed to or impeded this progress. We also consider whether, and to what extent, the NRC's recommendations remain relevant in the present context.

INTRODUCTION

Ten years ago, the National Research Council (NRC) prepared two documents reviewing the effectiveness of marine monitoring programs, a national assessment (NRC 1990a) and a more detailed look at programs in southern California (NRC 1990b). Both documents found numerous deficiencies in overall monitoring systems, as well as in the design and implementation of individual programs, and both documents made recommendations for improvement. In particular, the southern California assessment found that there was a minimum of $17 million per year of ongoing effort in the late 1980s, a number which was refined and updated by Schiff *et al*. (2002a) to $31 million per year in 1997. The bulk of monitoring is carried out by dischargers, most notably municipal wastewater dischargers. The NRC review found that despite the large expenditure, marine monitoring was spatially restricted, with 70% allocated to localized discharge permit monitoring and much of the remainder to selected historic trend sites. As a result, less than 5% of the area of the Southern California Bight (the coastal region between Point Conception in the north and the U.S.-Mexico international border in the south) was monitored. Effort was inconsistent, using different indicators and field and laboratory methods, and with data stored in incompatible data formats. Because there was no institutional mechanism for integrating or reporting findings, these deficiencies prevented a coherent assessment of the state of the Bight as a whole. They also made it extremely difficult to compare localized patterns and trends to the regional background. Together, these deficiencies severely limited the ability to use marine monitoring data in management decision making.

To address these shortcomings, the NRC reports made a series of recommendations. In this article, we use southern California as a test case to examine the extent to which these recommendations have been addressed 10 years after they were published. We then discuss factors underlying the monitoring system's successful response to these recommendations and identify next steps in the system's ongoing evolution, which has included a shift from a primary emphasis on single large discharge points to more of an ecosystem perspective.

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RECOMMENDATIONS AND PROGRESS

Recommendation #1: Establish A Regional Monitoring Program

The NRC studies identified that a large amount of monitoring was being conducted in southern California, but that most of it was local and disconnected. It was impossible to make regional assessments and to place local patterns and trends in a regional context. A major recommendation was to establish a regional monitoring program, with standardized field, laboratory, and data management methods, and with a process for analyzing and integrating results on a regional scale. The recommendation focused on three major areas: (1) sediment condition; (2) water quality and public health at swimming beaches; and (3) contaminant input sources. It is worth noting that a later NRC report on coastal wastewater management (NRC 1993) also stressed the value of integrating regional monitoring more fully into the management process.

Southern California's monitoring entities have been especially responsive to this recommendation, with the latest and most direct aspects of an evolving regional monitoring program being two regional surveys facilitated by the Southern California Coastal Water Research Project (SCCWRP). The first survey was conducted in 1994, involved 12 organizations, and focused on fish and sediment quality (Hashimoto and Weisberg 1998). The second (Bight'98) was conducted in 1998, involved 62 organizations, and extended beyond the first survey in three ways: (1) it extended inshore to include an assessment of bays, harbors, and port areas, (2) it extended southward to include Mexican waters between the U.S.-Mexico international border and Ensenada, and (3) it added a shoreline microbiology component. Both surveys focused on estimating the spatial extent of perturbation and used stratified random sampling designs to achieve this objective.

The results of these studies (Schiff 2000, Schiff and Allen 2000, Bergen *et al.* 2000, Noble *et al.* 2000) enabled scientists and managers, more completely than ever before, to map the extent of perturbations in a variety of indicators. These efforts were unique to the region in their use of common metrics and data collected from the entire region, not just from around individual discharge points. This enabled managers to assess relative degrees of perturbation at different locations and to begin tracking trends against an accurate description of the regional background.

These regional efforts focused on an assessment objective. However, success in that effort was entirely dependent on the achievement of regional methods standardization, which was accomplished in several ways and built on earlier efforts to standardize benthic sampling gear and invertebrate taxonomy. First, methods manuals were developed during the regional program and have since been adopted as required procedures for facility-specific monitoring. Second, training exercises were conducted. Third, quality assurance protocols were implemented in which each participating organization had to demonstrate competency prior to collecting data for the regional survey. Quality assurance involved field audits of onboard activities, as well as blind samples to assess competency in benthic infaunal identification (Ranasinghe *et al.*, 2002), chemistry (Gossett *et al.*, 2002), toxicology (Bay *et al.*, 2002 volume), microbiology (McGee *et al.* 1999), and fish identification. While these exercises demonstrated the considerable differences in laboratory performance that were anticipated by the NRC review, the intercalibration exercises provided a means to resolve these differences.

Standardization extended beyond data collection to include data management, as the project required data sharing among the more than 40 organizations that collected or processed samples. This was accomplished through a set of standardized data transfer protocols. While successful on a project basis, this did not meet the larger NRC goal of creating centralized data bases that make data available from all of the ongoing programs. The State Water Resources Control Board has attempted to build from the standardized data transfer protocols to create their Surface Waters Information Management (SWIM) data base.

While Bight'98 represents the most visible regional monitoring advance since the NRC report, there have been several other movements towards regionalization. Within San Diego County, more than 10 dischargers are contributing funds toward a set of quarterly regional kelp monitoring overflights. The Minerals Management Service has organized a Bight-wide network of organizations that monitor the rocky intertidal zone. It has developed consistency in data collection methods among programs, identified spatial gaps that must be filled to complete the regional picture, and created a regional data sharing scheme. The Southern California Wetlands Recovery Program was formed as a cooperative effort of 17 state and federal organizations to integrate wetlands acquisition and restoration activities. It is now developing an integrated regional monitoring program to assess their

progress towards specific goals. While these other efforts are still in their early stages and have not yet reached their full potential, they represent substantial progress toward fulfilling the NRC recommendation.

Recommendation #2: Increase the Flexibility Of Monitoring Programs

The NRC evaluation pointed out the segregation in monitoring efforts among government, academic, and discharger groups and argued that the perceived dichotomy between research and monitoring was artificial. This dichotomy is based on the assumptions that monitoring is a routine and relatively uncreative activity best performed by discharge agencies, while research is best carried out by academic scientists at research institutions. Program designs based on these assumptions, and on the consequent division of labor among government, academic, and discharger entities, reduce needed flexibility and hamper cost-effective planning and utilization of monitoring resources. They impair the ability of scientists at discharge agencies, who often know the most about the affected environment, to pose and address important new questions. It also ignores the fact that monitoring is not always a straightforward, routine activity but often requires input from specialists not found in discharge agencies (e.g., physical oceanographers, toxicologists, and statisticians). The NRC evaluation recognized that many questions can best be addressed by a combination of focused research and monitoring. This recommendation focused specifically on improving the ability of monitoring organizations to participate in regional monitoring and research activities and on better integrating the efforts of government, academic, and traditional monitoring entities.

There has been considerable progress in responding to the spirit of this recommendation, although not necessarily in the way the NRC panel envisioned at the time. The mechanisms of resource exchange and more broadly written National Pollutant Discharge Elimination System (NPDES) permits enable resources and expertise to be accessed and combined in many more ways than previously. In addition, the new NPDES permits (described more fully below) enable the discharge monitoring programs to be used as focal points for bringing expertise from a variety of sources to bear on questions that encompass traditional elements of both research and monitoring. Improved information about spatial and temporal patterns of impact and about the relative contribution of different sources of perturbation and contaminant input essential for the Integrated Coastal Management approach described in NRC (1993).

The most direct advance has been the concept of "resource exchange," in which regulatory agencies that issue discharge permits allow dischargers to trade a portion of their ongoing ambient site-specific monitoring requirements for an equivalent amount of monitoring in the Bight-wide regional surveys facilitated by SCCWRP. This was the primary resource used to "fund" these regional surveys. The regulatory agencies' intent in allowing this flexibility was to allow participation at minimal incremental cost (i.e., cost-neutrality).

While largely successful, there were unanticipated costs that rendered the resource exchange less than cost-neutral for dischargers. Most of the additional costs were associated with quality assurance and intercalibration exercises necessary to develop comparability among participating organizations. For several dischargers, particularly with regard to processing chemistry samples, the cost of meeting quality assurance goals exceeded the cost of sample processing in the study itself. There were also considerable unrecovered costs associated with planning, data analysis, and interpretation and synthesis, which are always more time consuming when conducted as part of a cooperative, multi-organizational effort. Most participants, however, believed that the increased knowledge and staff education gained through participation in all these activities offset the extra cost of the time invested.

While resource exchange to accomplish regional surveys is a good example of increased regulatory flexibility that yields more effective monitoring, the regional surveys are static, intermittent events. Even greater progress towards the NRC recommendation is exhibited in the monitoring permit issued to the Orange County Sanitation District (OCSD) in 1998, which divides their monitoring obligations into three components: (1) core monitoring, (2) regional monitoring, and (3) special studies. Core monitoring consists of the basic site-specific monitoring necessary to address individual discharger limits and impacts. It is mostly conducted in the immediate vicinity of the discharge and focuses on small-scale spatial effects and trends analysis. Regional monitoring provides the information necessary to make assessments over large areas and represents institutionalization of the resource exchange that was conducted in an *ad hoc* manner for the first two regional surveys. Special studies are focused short-term research efforts intended to help managers understand core or regional monitoring results, or to address unique

issues of local importance. It represents an opportunity for the discharger to adapt its program, cooperatively with the regulators, on an annual basis to address issues of concern. Collectively, these represent a significant advance from the typical historic permit, in which a comparable amount of effort was focused entirely on the core program, without the flexibility to address regional or shorter-term research questions.

Orange County Sanitation District is the only organization to have yet received this kind of progressive permit, but there is movement toward adopting this framework throughout southern California. SCCWRP has been tasked by its Commission, which includes all of the permit-granting water quality regulatory agencies in southern California, to develop a model monitoring program for ocean dischargers. Their recommendations mimic the three-pronged permit issued to OCSD, with the idea that such a permit approach is responsive to management questions about the processes leading to impacts and adaptive to the results of both research and monitoring (Schiff *et al.* 2002b). Ongoing permit negotiations for other dischargers are beginning to follow this model.

Recommendation #3: EPA And NOAA Should Provide Guidance

The NRC evaluation recognized that marine monitoring in southern California and throughout the country was excessively dominated by primarily local (i.e., in the vicinity of the discharge) concerns. In contrast, both EPA and NOAA had direct experience with conceiving, planning, and implementing larger monitoring programs of both regional and national scope. The NRC therefore recommended that these agencies provide guidance and direct assistance in developing regional monitoring programs, and perhaps a national network of such regional programs. The EPA was an effective partner in helping to establish southern California's regional monitoring program. The EPA's national office, primarily through their Environmental Monitoring and Assessment Program (EMAP), provided considerable assistance in creating the program's technical underpinnings. The primary assistance was in helping to focus the local questions around which to design the program and then in developing a design that would meet these objectives. This turned out to be a successful two-way interaction, as the local needs for enhanced stratification and nested levels of stratification for different indicators caused EMAP to reconsider their national design approach (Stevens *et al.* 1997). EMAP also provided assistance in developing field and data management manuals. While most of the organizations participating in the regional surveys had their own manuals and procedures in these areas, EMAP's experience in merging efforts across programs proved invaluable.

EMAP also provided seed money for the first regional survey. While local organizations outspent EMAP almost 8 to 1, the EMAP contribution proved valuable when and where individual organizations were incapable of certain types of sampling or analysis and contractor support was needed to fill the gaps. Interestingly, EMAP provided no financial assistance for the 1998 survey, but by that point such external support was no longer necessary. The proof of concept that EMAP invested in during the first survey was sufficient to generate additional and ongoing local support for subsequent efforts. This investment turned out to be a valuable one in return for EPA, as the skills that developed in southern California served as a launching point for EPA's subsequent west coast monitoring initiative in 1999.

In contrast, NOAA played no significant role in developing southern California's regional program. NOAA made some cash contributions to California's Bay Protection and Cleanup Program to conduct targeted sampling of Los Angeles Harbor and San Diego Bay during the last decade, but this contribution contrasted with EPA's approach in two ways. First, EPA allowed the local programs to define questions of interest. Second, EPA placed priority on investing in developing the local expertise needed for program continuity. NOAA's interaction seemed more motivated by the opportunity for cost-effective acquisition of data that NOAA needed for their own assessment purposes, rather than on providing guidance and developing the lasting relationship advocated by the NRC. As a result, the parameters and methods chosen for the regional surveys differ slightly from those used by NOAA nationally. Furthermore, NOAA's National Ocean Data Center data bases do not yet include the extensive regional survey data, or those from the routine surveys conducted by most of the regional survey participants. The principal NOAA contribution to the success of the regional programs was the chemistry intercalibration exercises they co-sponsor with the National Institute of Standards and Technology. Although subsequent local intercalibration exercises were necessary to enhance comparability (Gossett *et al.* 2002), the procedures

developed by NOAA served as a guide to the local group.

This disparity in the two agencies contributions to regional monitoring in southern California during the mid to late 1990s is in contrast to their respective contributions to other similar efforts at other times and places. For example, EMAP's Estuaries component, in one of the program's first efforts, tried to impose a standardized design in the mid-Atlantic region, without focusing on local questions that could have encouraged support and participation by local and regional participants. This resulted in more resistance and a much less collaborative atmosphere than characterized the southern California experience. In contrast, NOAA has a long history of local involvement in studies in east coast estuaries. Their participation in the CalCOFI Program helped create and sustain a world-class large-scale research and monitoring program, and data from NOAA's Status and Trends Program and data syntheses prepared by the agency's National Ocean Service helped provide an important basis for understanding contaminant patterns and impacts in southern California (e.g., Mearns *et al.* 1991). In understanding the two agencies respective contributions to regional monitoring in southern California, it is important to understand, first, that the EMAP program had matured to the point where it realized the long-term benefits of collaboration with local parties and, second, that EMAP expenditures increased after 1990 while those for NOAA's contaminant monitoring efforts decreased.

Recommendation #4: Enhance Communication With Users

The NRC evaluation recognized that even superlative monitoring serves no useful purpose unless and until the results are communicated effectively to a range of user communities. These include primarily managers, scientists, and the general public. The NRC therefore recommended that a variety of methods be used to summarize results and apply them directly to decision contexts.

Most historic monitoring data have been used primarily for site-specific decisions, such as for 301h waivers. This regulatory framework has a limited audience. In contrast, the more public-friendly nature of the questions asked in regional monitoring, particularly in the shoreline microbiology component (e.g., How safe is it to swim in the ocean?), led to extensive media coverage and requests for information by several of California's legislative committees. As a result, monitoring data are having a greater impact on key management decisions, such as greater focus on urban runoff as a source of shoreline bacteria, and have contributed to increased funding for initiatives to resolve such problems.

Regional monitoring also led to improved dialogue between regulators and dischargers on the goals of monitoring, the methods used to achieve these goals, and the ways in which monitoring data should be interpreted. When these kinds of issues are discussed in the context of regulators asking dischargers how to cooperatively build a regional program, the discussions take on a more positive tone than when dischargers initiate the discussion by disagreeing about facility-specific issues or requirements.

These discussions also included a broader array of organizations, including several non-profit environmental advocacy organizations that participated in Bight'98 by collecting, and in some cases, processing samples. As full partners in the process, these groups participated in the discussions about analysis and presentation of results. The honest discussions about data analysis and interpretation alternatives served to build a degree of trust among participants that has transcended the intermittent surveys. One positive example of this interaction is the greater sharing of data among public health agencies and non-profit environmental organizations that publish beach report cards, a collaboration that was based on a better understanding that both groups were serious about doing their jobs well.

The NRC recommendation also focused on breaking down barriers between academic researchers and routine monitoring entities. The regional surveys provide a tremendous opportunity for value-added participation by academics, as the cost for sample collection and processing of routine variables is already covered. Some researchers took advantage by, for example, adding viral measurements to the measurement of routine bacterial indicators (Jiang *et al.* 2001) and testing new biomarkers at the same time the large monitoring entities were collecting routine fish tissue chemistry measures. This still falls short of the NRC goal of continuing interaction outside of these one-time events. It is not clear whether continuing interactions outside of regional surveys will ever be the norm, given the different missions of the respective organizations. However, these fruitful experiences, combined with the increasing addition of special studies to routine monitoring

permits, provide a solid basis for expanding such value-added cooperation in the future.

FACTORS UNDERLYING THE EFFECTIVENESS OF THE SOUTHERN CALIFORNIA RESPONSE

In the context of regulatory and management policy making, 10 years is not a long time. Yet the monitoring and management systems in southern California have undergone significant changes in that time and their evolution is continuing. While, in hindsight, the NRC recommendations and the past decade's changes seem obvious and quite reasonable, the reality is that it is often very difficult to achieve fundamental change in long-standing compliance monitoring programs (Bernstein *et al.* 1999). Fear of undermining well-established compliance procedures, issues of organizational inertia, and the costs of coordination can also weaken tendencies toward regionalization (Bernstein *et al.* 1999, NRC, 1997).

The single most important reason for the changes in southern California was the NRC evaluation and the reports it produced. It alerted managers to inefficiencies and focused scientists towards improvement. It provided a neutral forum for participants and observers of the monitoring system to speak openly about its shortcomings. Newton's Law that a body in motion tends to stay in motion seems to apply equally well to permitted monitoring requirements, which tend to remain unchanged unless a catalyst such as the NRC reports serve to deflect their trajectory.

The second contributing factor was EMAP, which proved through demonstration projects on the east coast of the U.S. that large-scale regional programs were logistically feasible and could yield effective management information (Weisberg *et al.* 1993). EMAP also provided technical guidance in areas such as sampling design, field procedures, and data structures, based on their demonstration project experience. Finally, EMAP provided seed money which challenged the local monitoring entities to expend their own resources.

Third, there was a neutral local party to facilitate and coordinate regional monitoring. The Southern California Coastal Water Research Project (SCCWRP) is a nonprofit, local, marine research agency that is jointly administered by the four largest NPDES dischargers in the Southern California Bight and the five regulatory agencies that oversee those dischargers (Mearns *et al.*, 2001). Cooperation of the regulator and discharger communities was forged through their mutual participation in SCCWRP. The SCCWRP Commission, composed of senior management representatives from each participating agency, became a formal organizational body to receive, review, and respond to the results of the monitoring plans. A major strength of the SCCWRP Commission in this role is that the recipients of that information have the direct authority to implement management actions in response to the project results. SCCWRP staff also had the scientific skills to ensure that the project was completed. When other participating organizations could not undertake selected activities within their available resources, particularly in areas such as statistical design, database management, and report preparation, SCCWRP staff provided the technical expertise and personnel resources to conduct such tasks. Since SCCWRP is jointly administered by regulators and dischargers, their staff also provided non-partisan credibility in project development and interpretation of results.

Fourth, regulatory agencies provided the flexibility to allow discharger participation at minimal incremental cost. This flexibility should be commended because it runs contrary to typical regulator oversight behavior. Placing decisions about how to monitor largely in the hands of a regional planning group that included the dischargers themselves dramatically improved the development and acceptance of improved and standardized approaches. Concern was expressed that merging of programs would lead to a downward drift in quality to accommodate the least common denominator, with the least precise or least expensive approach being used. However, the opposite occurred. Many of the methods required in existing permits were outdated (e.g., requiring PCB Aroclors rather than PCB congeners), and the cooperative nature of the interactions provided the dischargers a forum for proactively improving their methods. Additionally, the mutual participation of dischargers and regulators in SCCWRP, as well as the trust exhibited by all parties in SCCWRP to ensure the technical adequacy and relevancy of the regional monitoring, added a comfort level to the regulator's decision to add flexibility.

Lastly, southern California had a series of previously developed networks that facilitated the additional interactions necessary to accomplish the regional survey (Bernstein *et al.* 1999). These long-term relationships among participants contributed to trust in each other's motives and to confidence in their joint problem-solving abilities. One example is

the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT) that was formed more than 10 years prior to enhance the quality of benthic infaunal analysis. Another example is that there are a limited number of academic institutions at which many of the environmental professionals in southern California have been trained. Thus, many participants have ties that predate their agency employment. As a result of these and other longstanding interactions, agency staff have parallel views of themselves as belonging to multiple communities, most notably ones focused on common problems and regional collaboration (Bernstein *et al.* 1999). These other identities served to soften boundaries when people from institutions with different missions were called upon to work cooperatively.

NEXT STEPS

The regional surveys have effectively responded to many of the NRC recommendations and have improved the efficiency and usefulness for managers of monitoring data. For example, the expansion of regional monitoring to include a broader range of habitats such as bays and estuaries, as well as a more extensive set of participants (e.g., from urban stormwater management programs) has laid the groundwork to address questions about a much wider set of sources and impacts. However, two shortcomings remain as the next roadblocks to the effective use of monitoring in a management context. The first is the need to address trends. The present regional surveys focus on status across a broad area at single points in time and the remaining annual monitoring is too site-specific to be the basis for ongoing regional planning. Managers have made it clear that they also need to know the trends in environmental condition before taking actions because a resource in poor but improving condition may not require further management action, whereas a resource in good but declining condition may require more immediate action. While repeated implementation of the regional survey eventually might provide such answers, managers cannot wait the extended period necessary to establish trends through this means.

Southern California has embarked upon two alternative approaches for meeting this need for more timely trend information. The first is not to rely entirely on probabilistic sampling for the regional effort. In Bight'98, 13 strategically selected sites that had been sampled periodically since 1977 as reference sites were included as sample sites. A second approach has been the use of coring at a subset of probability sites to assess trends in selected indicators through radiodated sampling strata (Zeng *et al.* 2001). While very expensive, this approach allows for two kinds of information that cannot be gathered through repeated sampling of selected historical sites: (1) spatially-based assessment of trends (i.e., what percent of the sediment in southern California has declining chemical concentrations, which is best done through probability-based designs), and (2) extending the analysis to preindustrial periods, rather than the shorter period from which the 13 historical sites were first measured.

Managers have also identified that they need to know the causes of problems in order to develop appropriate solutions. Cause and effect assessments will most likely have to be addressed through the special studies portion of the monitoring requirements or through cooperative relationships with academic researchers, but there have also been some interesting additions to the regional program that begin to address this issue. One of the additions has been the use of chemical markers that are indicative of contributions from specific sources, such as linear alkyl benzenes (detergent byproducts) which are markers for sewage sources (Zeng *et al.* 1998). Another strategy has been the use of multivariate pattern analysis to look for chemical signatures of plume tracks. While insufficient by themselves, these approaches begin to address the next management question and bring the monitoring community closer to addressing the management needs.

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