MY WATER QUALITY
OCEAN PORTAL ROADMAP

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ABOUT THIS DOCUMENT

The California Water Quality Monitoring Council (WQMC) was established by the Secretaries of the California Environmental Protection Agency and the California Natural Resources Agency to maximize the efficiency and effectiveness of existing water quality and associated ecosystem monitoring, and to ensure that collected data are maintained and available for use by decision-makers and the public.

A first step by the Monitoring Council was the creation of an online platform for intuitive, streamlined access to water quality information – called My Water Quality, within the Monitoring Council website. The Monitoring Council has identified ocean and coastal waters as a key theme area for development within this website. However, the potential scope of an ocean theme area within the My Water Quality platform is enormous and it has been unclear how to prioritize questions or areas of focus. In addition, the breadth of existing data and data systems is very large and there are many different options for development of this system.

To meet the call for this new ocean theme that will help to bridge the domain divide between water quality and ocean resource management, the California Ocean Science Trust led a scoping process involving members WQMC Ocean Ecosystem Workgroup and other focal matter experts to identify:

1. Focal areas or questions within the ocean realm that bridge the water quality and marine resource monitoring communities, will provide useful information for a broad audience, and build upon existing projects and programs; and
2. Cost-effective development options that effectively leverage existing investments in web-based platforms and data sharing tools.

This document represents the findings of this collaborative and partnership-based process, charting a clear path forward towards an achievable, cost-effective content and technical development strategy for an ocean-themed component of the My Water Quality website.

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INTRODUCTION

This report describes a roadmap to guide the efforts of one or more California Water Quality Monitoring Council (Council) workgroups in developing ocean data web portals that will provide a single, coordinated point of entry to programmatic information, data, assessment results, and supporting information. These web portals are intended to be organized around easily understood questions that enable validated, credible data and information to be delivered in ways that directly meet users' highest-priority decision-making needs on specific issues of statewide concern. The portals should ideally be designed and implemented by multi-party, collaborative workgroups able to identify and help overcome the often entrenched institutional impediments that hamper the coordination across programs that is key to improved information access. As described more fully in the Council's foundational documents (CWQMC 2008, 2010), this offers the best chance of overcoming challenges posed by the diversity of monitoring and assessment programs, the volume and variety of data they produce, and the number of databases and data systems in which they are stored.

The scoping group that produced the roadmap identified a number of core goals the web portals, and their development and implementation process, should address, including:

- Support decision making by providing targeted data and information needed by key audiences in government, the public, and the science community
- Promote integration of water quality and marine resources monitoring, assessment, and management across institutional boundaries
- Promote collaboration among multiple programs to coordinate monitoring, standardize data, and produce credible information products
- Improve the quality and efficiency of monitoring and assessment programs, as well as the efficiency of tasks that depend on ready access to ocean data and information
- Direct users toward the highest quality information and promote transparency of data gathering, analysis, and assessment methods by documenting the source(s) and credibility of data and information products
- Support longer-term resource management and planning by providing efficient access to necessary information

The first of the six goals above is primary, with the remaining five goals contributing to portals' ability to effectively support decision-making.

The scoping group identified the Council's California Wetlands Monitoring Workgroup (CWMW) as a significant effort that meets these core goals and could therefore serve as a model for the ocean data workgroup efforts. It deserves explicit emphasis that the workgroups are intended as the core mechanism that initiates and sustains the collaboration needed to achieve improvements to program coordination and data access; portal development is therefore one, but not the only, product of that collaboration. The CWMW focuses on shared regulatory drivers and decision-making needs; includes representatives of state, federal, and local agencies as well as NGOs; has developed and promoted the use of standardized monitoring and assessment frameworks; has helped produce important products to support decision making; and has improved transparent, web-based access to credible raw data and assessment tools.

While the Council's Wetlands web portal primarily includes information developed by the CWMW, other Council portals (e.g., Rocky Intertidal Coastal Habitat, Safe to Eat Fish, Safe to Swim) illustrate another key element of the scoping group's recommended approach, namely that the ocean data web portal(s) avoid reinventing wheels by duplicating information readily available elsewhere. They should instead provide organized access to other sources of credible and authoritative information, where they exist, to free users of the burden of navigating the ever-increasing thicket of websites, portals, published literature, data archives, and other information. Much as Virgil guided Dante through the underworld, protecting him from danger and revealing invaluable insights, the ocean data portal(s) should take users by the hand to lead them to specific, highly credible information pertinent to their specific questions and decision-making needs.

The roadmap presented below defines several assumptions and guiding principles based on past experience in developing information needed by decision makers. It describes a sequence of logical development phases that allow technical development and institutional coordination to be mapped onto management priorities and frameworks. While fully achieving the core goals listed above will require focused effort sustained over a period of time, the roadmap also recognizes that valuable information for most key issues is available now, providing it is well organized and coordinated. Thus, the scoping group recommends a phased approach to take advantage of currently available information resources, and this report highlights potential initial steps to this end. The phases are constructed to provide needed information at each stage of portal development while at the same time motivating and supporting essential collaboration and coordination among related programs and data sources. The development phases are designed so that they can be accelerated or extended depending on the maturity of a specific issue and the availability of resources.

The scoping group then identified ten priority issues directly relevant to resource management and policy making and selected three of these issues (ocean acidification (OA), the relationship between protected areas and water quality, and harmful algal blooms (HABs)) as case studies for more detailed examination to illustrate how the core goals could be achieved. As described further below, these case studies were selected to represent issue areas with different existing circumstances including political momentum, technology assets, and decision-making frameworks. These drivers will most likely shift over time, and the roadmap is designed to accommodate prioritization of different issues. For example, marine debris has emerged as a priority issue across agencies, subsequent to the selection of the initial three case studies.

In addition to describing the roadmap's purpose and content, it is important to describe what it does not include. The roadmap does not include many aspects of a formal scope of work, including a clear and narrow purpose statement, functional and technical requirements, explicit development steps, costs, and outcomes/outputs. Instead this roadmap is intended to make the case for and help guide the more detailed work of one or more issue-specific workgroups charged with creating and then implementing the actual scopes of work for web portal development. There is an important reason for this: It would have been inappropriate and counterproductive for the scoping group to usurp what should be a core function of the workgroups. As explained more fully below, successful program coordination and portal development efforts depend on the committed involvement of decision makers and other stakeholders whose first-hand input will be organized through issue-specific workgroups. For the scoping group to do more than provide guidance, illustrative examples, and a starting framework would undermine such involvement and inhibit workgroups' ability to account for policy and management relevance and urgency, resource availability and existing assets, and capacity. This roadmap therefore stops short of defining the specific content and structure of any individual ocean data portal.

BACKGROUND

The California Water Quality Monitoring Council was formed in 2007 in response to California State Senate Bill 1070 (Kehoe) that required the California Environmental Protection Agency (CalEPA) and the California Natural Resources Agency (Resources) to jointly address significant problems related to the coordination and efficiency of water quality and ecosystem monitoring and access to data and assessment products. As the Council diagnosed these problems:

> But California's water quality information system is defective. Because current monitoring programs were developed at different times, to address a variety of site-specific issues, or to fulfill different statutory or regulatory compliance mandates, there are inconsistent monitoring objectives and methods to collect and assess the data, making it impossible to integrate data from different studies to develop valid information for decision making. And there is no single user-friendly place to access the data, which means that the feedback necessary to improve the effectiveness of monitoring programs is often lacking. There is a tremendous opportunity for improvement. (CWQMC 2010, p. 7)

The Council submitted recommendations to the two agency secretaries in 2008 (CWQMC 2008) and a comprehensive ten-year strategy in 2010 (CWQMC 2010), which, together, have provided the basis for the several web portals developed to date.

In 2012, Council staff and several stakeholders involved in ocean monitoring and assessment undertook to establish an ocean health workgroup to develop a web portal design. After achieving a certain amount of progress, this effort came to a halt due to the complexity of issues surrounding ocean data management and assessment as well as to a lack of focused institutional and financial support. Around the same time, the California Ocean Protection Council (OPC) commissioned an external evaluation of the state's ocean observing (i.e., monitoring and assessment) capabilities (Bernstein et al. 2011). One of the evaluation's key findings was that the state lacks mechanisms for coordinating the wide range of ocean data gathering efforts and for integrating them to produce information needed by decision makers. In parallel, California has completed the first scientifically designed network of marine protected areas in the nation, and has developed an innovative monitoring program to assess the performance of the MPA network relative to broad ecosystem protection goals. State and private investments in MPA monitoring have significantly advanced California's capacity and technology assets to coordinate and integrate ocean ecosystem data to inform natural resource management. However, there remains a challenge, and opportunity, to link the ecological and socioeconomic focused MPA monitoring data collection with water quality, ecosystem and physical oceanographic data collection occurring under water quality mandates. These efforts have created an opportunity to use the Council mandated workgroup process and data portals to advance this coordination.

California Ocean Science Trust (OST) empaneled a small scoping group (Appendix 1) to develop a roadmap to identify challenges, opportunities, and alternative pathways toward addressing these coordination and integration challenges. The scoping group's charge was not to make concrete decisions about web portal content or structure or to solve technical problems and institutional constraints, but to provide useful guidance that would direct the formation and activities of one or more permanent Council workgroups to pursue implementation and resolve such issues with broad stakeholder input.

ASSUMPTIONS AND GUIDING PRINCIPLES

The scoping group identified a number of assumptions and guiding principles that underlie the roadmap's phasing, the central role played by a decision-centric, question-driven approach in organizing and prioritizing information, and recommendations about the desired functional capabilities of ocean data web portals and their relationship to other portals.

ORGANIZE AROUND DECISIONS AND CORE MOTIVATING QUESTIONS

Challenges related to finding, accessing, and then integrating environmental and resource management information and data to make high priority decisions are well known and are discussed specifically in the context of water quality and aquatic ecosystems in the Council's reports to the agency secretaries (CWQMC 2008, 2010). Simply loading raw datasets into online data portals (Figure 1), even with some degree of organization, does not solve these challenges for two principal reasons. First, it does nothing to prioritize key datasets or to improve their resolution, certainty, and credibility. Nor does it highlight the most credible and useful programmatic and background information. Second, it assigns to the user the tasks of identifying the most appropriate data, evaluating data quality, subsetting and integrating data, and then performing condition assessments. Where assessments do exist, the warehouse approach still leaves users with the task of judging the relative value of competing assessment approaches. The warehouse approach also fails to provide incentives for data gathering programs to improve their coordination, develop comparable methods, develop more widely applicable and authoritative assessment tools, and sustain these interrelated efforts over time.

Figure 1. The warehouse scene from Raiders of the Lost Ark, a common visual metaphor for the difficulty of finding needed data and information in the large volumes of data produced by multiple monitoring and assessment programs. Source: http://codelikethis.com/lessons/learn_to_code/warehouse.jpg.

Attempting to resolve these challenges simply by applying more powerful technical tools (e.g., larger servers, or more sophisticated search, data subsetting, and data visualization tools) will not directly address the information and data access problem because it is not driven by end users' perspectives and decision-making needs. For example, an earlier in-depth evaluation of the HABs issue for the OPC (Bernstein et al. 2011) identified a number of key management decisions that were then framed as questions (Table 1). Together, these provided a means of identifying and organizing information sources and data gaps. Data and information portals that are organized to deliver information to targeted audiences in ways that directly address key questions are more likely to meet their needs for timely and authoritative information. They are also more likely to incentivize improvements to monitoring and assessment systems and help them adjust their focus as knowledge improves and management concerns shift in response.

Table 1. Example decisions related to HABs and the information needed for decision making framed as questions. Excerpted and adapted from Table A.2.7 in Bernstein et al. (2011).

Decision category	**Management decision or activity**	**Ocean information needed for decisions**
Public health: CA Dept. Public Health	Open/close commercial shellfish growing and harvesting / recreational shellfishing to assure that shellfish are safe for human consumption.	Do domoic acid and PSP toxin concentrations in shellfish exceed safe limits?
	Issue public health advisories and warnings	Is there a threat to human health? What areas are at risk and how long will the risk persist?
Marine wildlife health: CA F&W, marine wildlife rescue organizations	Determine potential HAB impacts on living marine resources and ecosystems	Are animal mortalities due to HABs?
	Focus watch efforts and recovery resources for rapid response to strandings	What is the probability of HAB formation in a specific location and time? What is current location, spatial extent, and future movement of bloom? When will the HAB dissipate?
	When to release wildlife back to environment	What are current phytoplankton levels and community composition? Are toxic species present? What is current location, spatial extent, and future movement of bloom? When will the HAB dissipate?

For example, Case Study 1 (Marine Protected Areas and Water Quality) illustrates how specific questions about the impacts of pollutant discharges on resources in protected areas helped prioritize and guide the identification and integration of diverse datasets from southern California, including 1) protected

area boundaries, 2) resources within protected areas, 3) commercial and recreational fish catch data, 4) surface current modeling of discharge plumes, and 5) pollutant concentrations in discharge plumes. These questions guided not only the data access effort, but also the development of needed intermediate assessment products such as indices of fishing pressure and pollution intensity. It also served to highlight a key data gap in other areas of the state, namely accurate data on discharge flows required to estimate pollutant loads to the coastal ocean.

IDENTIFY AND DIRECTLY ENGAGE TARGET AUDIENCES/USERS

The current Triennial Review of the Council's workgroups and portals highlights the importance of integrating these efforts into the ongoing work of agencies and other governmental entities in ways that directly engage their staff at the outset and improve the accuracy, timeliness, and efficiency of their work. This requires the early and active engagement of key audiences and the delivery of data and information that keeps them involved by meeting their high priority decision-making needs. Portals that were designed independently, without input and engagement from target audiences, and without direct links to their priority decision-making needs have been less successful in attracting users and sustaining support. In contrast, the CWMW was initiated in response to shared regulatory requirements to report on wetlands status and restoration efforts. The clear benefits available from collaboration and coordination provided the incentive for the many parties to continue to invest time and resources in an often challenging process over time.

Even where information needs have not yet been fully codified in regulation, a nexus with pending decisions and key interest groups is crucial. For example, the synthesis of Marine Protected Area (MPA) and Areas of Special Biological Significance (ASBS) monitoring information with water quality monitoring (Case Study 1) can inform the respective management programs and enable them to address questions about the effects of pollution on living marine resources. As another example, ocean acidification (OA) (Case Study 3) is an issue of emerging concern that has been identified as a priority by multiple entities within California, including the Ocean Protection Council, the West Coast Governors' Alliance on Ocean Health, the Water Boards, and some fisheries and discharger groups. In response, the Ocean Science Trust convened the West Coast Ocean Acidification and Hypoxia Panel to build a new knowledge base that explicitly addresses decision makers' science information needs and advances understanding of these complex issues.

Engaging target audiences from the outset is critically important to prevent closed design loops in which portals are designed *by* those with technical expertise *for* others with technical expertise, without the outreach and scoping needed to attract, engage, and usefully inform decision makers and other affected stakeholders. Thus, within the concept of a single, global point of entry (discussed below), the scoping group identified three types of audiences that will typically be best served by specific sorts of data and information:

- Level 1: High level policy makers and ocean stakeholders (e.g., public, media, business) that require higher-level summary and programmatic information
- Level 2: Agency and NGO managers who require issue specific information and assessment results
- Level 3: Agency, NGO, and academic scientists who require detailed process-level scientific data and results

MEET TECHNICAL AND INSTITUTIONAL CHALLENGES TOGETHER

Meeting decision makers' and other users' need for relevant, reliable, and timely data and information requires far more than simply providing access to the extensive universe of available datasets, websites, and publications. As successful data integration and access efforts demonstrate (e.g., the CWMW, climate change modeling, international disease outbreak monitoring), this also requires overcoming institutional barriers to sharing data, as well as to the development of standardized data collection and QA/QC methods, coordinated study designs, consistent assessment frameworks, and collaborative reporting procedures. This is because agencies and other actors typically act independently to meet their individual mandates (the infamous "silo" problem). Such actions, by themselves, are not sufficient to address statewide problems and answer questions about the status of resources or to support more comprehensive prioritization and efficient decision making. Thus, both explicit and implicit institutional priorities often limit the willingness or ability to share and coordinate information across institutional boundaries, as described in Davenport et al.'s (1992) classic paper Information Politics.

For example, the CWMW's progress over the past few years illustrates the consistent effort needed to negotiate common goals for a State of the Wetlands report, along with the data sharing, methods standardization, and data analysis/assessment protocols needed to provide a credible and sustainable basis for this and future statewide assessments. Within the CWMW, an equal or greater amount of time was spent negotiating issues related to differing perspectives and definitions of "wetland," competing regulatory and reporting requirements, data quality standards, and divergent philosophies about access to data as about technical methods. Similarly, the collaborative California Current Acidification Network (C-CAN) focuses, among other things, on developing a standard set of monitoring methods needed to produce reliable data on the extent and magnitude of OA that is comparable across all programs. Thus, simply moving existing program descriptions and datasets to a web portal will not, by itself, create the needed coordination and establish a reliable foundation for informing decision makers and the public. It is only when needed information has been identified and the institutional challenges to creating that information have been clarified that the wide universe of potential technical solutions can be narrowed down to a set of realistic, appropriate alternatives.

The CWMW's efforts also illustrate the danger of addressing technical or institutional challenges independently of each other. Technical solutions to data access, credibility, and integration, even if elegant technically, are not likely to be implemented without institutional support. Conversely, attempts to foster institutional communication and collaboration in the abstract have no focus or traction unless they are grounded in the specifics of programmatic and technical details.

DEVELOP AND IMPLEMENT PORTALS IN PHASES

While websites can be created relatively quickly, careful thought and planning effort is required to design portals that effectively present priority decision-making information to key target audiences. Additional effort is necessary to develop the technical coordination needed for broader data integration and assessment, and to overcome institutional barriers to such coordination. There is thus a significant difference (Table 2) between a website that simply provides links to a series of datasets or data sources and one that presents the most credible data and information organized to meet decision-making needs and in doing so promotes valuable coordination across multiple monitoring and assessment programs.

Table 2. Taxonomy of generic data portal categories based on their structure and function. Other types of portals (e.g., Open Channels, OceanSpaces) foster engagement in the science policy process with features and functions in addition to data management, display, and analysis. Examples listed here are illustrative only and not an exhaustive list.

Portal category	Portal characteristics and/or capabilities
Data catalogues	• Collection of data sets and links to data sources • May be sorted by category • May have simple search function • Examples: West Coast Ocean Data Portal
Data portals	• Data organized by thematic areas or questions related to decision making, public concerns • Data products in support of specific decision needs • Simple interactivity, e.g., turn map layers on and off, select datatypes or sites and display on map • Metadata • Structured stakeholder participation • Data policies and standards, particularly for QA/QC • May support online community discussions • Examples: CA Water Quality Monitoring Council, PISCO, Northeast Ocean Data, OceanSpaces, CA Dept. Fish and Wildlife MPAs, CalFish, Carbon Dioxide Information Analysis Center
Analysis and assessment portals	• All data portal characteristics, plus… • Targeted data integration • Targeted assessment tools • Ability to run more complex comparisons and analyses • Ability to stream real- or near-real-time data • Examples: CCAMP, SCCOOS, CenCOOS, SCAMIT BRI Calculator, EcoAtlas

Given this range of portal types, purposes, and capabilities, it will be essential for the ocean data portal workgroups to carefully define a realistic and concrete set of portal functions, capabilities, and products and describe how these can be developed and expanded as needed. Rather than following a one-size-fits-all, predetermined development path, portal functions must be tightly linked to management frameworks and decision needs for each key issue, and to the monitoring and assessment programs that produce authoritative information. Past experience in a wide range of arenas demonstrates that phased development approaches are most effective in circumstances, such as this, where requirements are somewhat fluid and where the institutional infrastructure is not fully established. Phased development will thus ensure that portal capabilities and products remain appropriately matched to the management context and do not lag or outstrip available information and tools. For example, the management framework for protected areas and water quality (Case Study 1) includes a mix of statewide and regional/local spatial scales, with the primary emphasis for now on the regional scale. Thus there may not be the need for intensive statewide coordination of assessment approaches and information products that there is for instance for OA (Case Study 3), an issue that requires a more spatially extensive set of monitoring and management approaches.

The scoping group therefore outlined a phased approach (Table 3) to web portal development that could be implemented to the degree needed to meet decision needs and at a pace determined by the amount of resources and the availability of credible and coordinated data and assessment products. Thus, any particular portal development effort could skip phases that have already been completed, combine phases that are at a similar development stage, or stop at an intermediate phase once decision-making needs are adequately addressed. A phased process yields two important benefits. First, it allows time for workgroups to coalesce, conduct needed outreach, and take advantage of available data, information, tools, and web-based information sources. Second, it allows workgroups to choose appropriate interim or final endpoints that include only those functions needed to successfully meet decision-making needs.

Table 3. Idealized web portal development phases that include aspects of both portal and larger program evolution. All phases are envisioned to provide ready access to information of all types directly useful in decision making. Movement from one phase to another will depend on the degree of institutional collaboration needed to support technical coordination. Some phases may be skipped or combined based on the level of existing development. Each phase is assumed to include some or all elements of preceding phases.

Phase	Information and/or capability	Programmatic aspects	Portal aspects
Phase 1	Access to program description and loosely organized data and information	• Identify core management questions and decision-making information needs • Create workgroup, identify audiences, build relationships • Describe current management/regulatory frameworks and goals • Describe current monitoring programs and sampling networks • Identify range of validated and unvalidated data, data products, reports, literature	• Present core management questions/decisions and related information needs • Access information one dataset or product at a time from original sources
Phase 2	Access to management questions and related validated data and information	• Ongoing outreach to decision makers, other users • Identify opportunities for institutional and technical coordination • Select screened and validated authoritative data and data products that meet specific QA/QC criteria	• Access data transparently from sources through distributed database system • Organize access in terms of decision needs, management questions
Phase 3	Coordinated indicators, monitoring methods, QA/QC standards, assessment endpoints, and reporting	• Ongoing outreach to decision makers, other users • Improve institutional linkages • Develop coordinated programs and methods • Produce authoritative information products targeted at core questions through coordinated assessment program(s)	• Ability to search for and access subsets of validated data (e.g., through map polygons or search filters) and eventually integrate them into customized datasets for specific assessments • Full integration of coordinated monitoring and web-based assessment products into regulatory and management processes

	• Automate production of key integrated data products and assessment reports	algorithm • Ability to present real-time data streams and assessment results as appropriate • Automate key assessment and reporting functions

It is important to note that the portal development phases outlined in Table 3 include a parallel focus on both program integration (e.g., identification of authoritative data, coordinated monitoring methods and indicators) and on technical portal capabilities such as data access, integration, and assessment. Both programmatic information as well as technical data products are essential to audience engagement and decision making and both can and should be given appropriate emphasis and visibility within the resulting portal. Progress toward these goals can be tracked in part with the monitoring program performance benchmarks defined by the Council (CWQMC 2010, Table 2).

The CWMW and Case Study 2 (Harmful Algal Blooms) provide useful illustrations of how these phases can help participants understand and organize complex development efforts. The CWMW has worked through many of these steps over a period of years, beginning with efforts to standardize the definition of wetlands and how they are mapped and then proceeding through the development of coordinated assessment methods and report products. The OPC evaluation of ocean observing systems (Bernstein et al. 2011) described the availability of some information on the frequency and extent of HAB blooms from current monitoring networks and also highlighted the need for a predictive modeling and assessment capability based on three-dimensional biological-geochemical models. This work is currently underway in parts of California and its outcome will in turn help inform revisions to monitoring programs.

IDENTIFY A GLOBAL POINT OF ENTRY TO ORGANIZE ACCESS TO DATA AND INFORMATION

There is currently a wide array of websites and data portals focusing on ocean data at the local, regional, statewide, and larger scales (see Table 2). Some are program-or issue-specific while others cast a wide net to include as broad a range of information and data types as possible. In addition, existing data portals include an extensive variety of search and access capabilities and many such portals make little or no mention of data resolution or QA/QC issues. This situation all too frequently leaves key audiences with the responsibility for searching for relevant information, often one dataset or data/information product at a time, across multiple platforms, and it does not provide critical insights about the reliability and utility of data and/or information for different purposes. Even where a platform contains much of the data a user might need, datasets by themselves do not answer questions. Thus, the majority of ocean data portals have not crossed the divide between unorganized data on the one hand and validated and prioritized information useful to decision makers on the other.

Effective portals solve this problem by providing a single, global point of entry to priority data, information, and assessment tools needed to address core management questions. As illustrated by the Council's Safe to Swim portal, this should involve providing active links to other portals, databases, and websites rather than creating redundancies by duplicating information. In fact, an essential feature of effective portals is that they avoid reinventing wheels by using existing data, information products, tools, websites, and webpages, as long as their credibility and validity can be documented. Users' confidence in the credibility of these resources can be enhanced by ensuring the transparency of such pass-through links.

While the actual technical approach can vary and should be defined by the workgroups, it is feasible to structure management questions, related information products, and therefore the portal design to fit the requirements of each audience. For example, the Council's Safe to Swim portal illustrates one possible approach in which links to research, monitoring programs, raw data, and reports are provided

on the portals' home page. An alternative might be to design separate entry pages for each of the three audiences.

The specific approach taken to the design of a portal's page layout and structure, its presentation of information and its methods for accessing and integrating information, as well as its means of linking to other portals are decisions that should be made by each workgroup. The scoping group believes strongly that user communities, as part of the workgroup process, should be directly involved in decisions about where portals should be hosted and/or which technical and design approaches are best suited to support the phased development process outlined in Table 3. The scoping group did, however, identify a number of effective portals that illustrate various features it might be desirable to consider when constructing the ocean data portal. The scoping group also noted that technology itself is not a magic bullet that can replace the need for effective engagement with stakeholders, careful articulation of questions, and consistent efforts to overcome institutional boundaries to coordination and integration of diverse data and information sources. Finally, the scoping group emphasized three core principles for the effective use of technology in structuring portals and making decisions about their capabilities:

- Incorporate flexibility to allow for future adaptability and expandability as knowledge improves, decision requirement change, and the issue evolves
- Be aware of and avoid attractive dead ends that could close off future options
- Ensure that portals' presentation of data and information can be tuned to the needs of different audiences, either by addressing their questions directly or by providing links to, for example, underlying raw data

PORTAL DEVELOPMENT ROADMAP

The scoping group created an initial roadmap consisting of a set of priority issues, a generic pathway to program coordination and portal development, and three case studies that illustrate in more detail how the roadmap could be implemented. The case studies position specific events on a five-year timeline on the assumption that ongoing efforts would be continued and expanded. Timelines for other issues could be similarly developed.

PRIORITY ISSUES

The scoping group identified a number of issue areas that are of concern to state managers and other stakeholders and are also good candidates for a portal designed to improve access to data and information and promote coordination of monitoring methods and assessment approaches (Table 4). The scoping group required that candidate issues be topics or problems that bridged natural resource management (through California's Resources Agency) and water quality management (through CalEPA and the state Water Boards).

All 10 issues currently have some type of web-based information access infrastructure. While some are more developed than others, none currently include the range of portal capabilities and program coordination envisioned by the scoping group (Table 3) as necessary to support effective decision making. Table 4 briefly describes these issues, organized in rank order of priority based on the criteria in Table 5.

Many of these issues are included in the broad, systematic evaluation of current portals included in Appendix 3 of Council (2008). In addition, detailed descriptions of management decision information needs/sources and monitoring capabilities and gaps for five of the 10 issues are included in Appendix 2 of Bernstein et al. (2011), the OPC's evaluation of California's ocean observing capabilities.

Table 4. The 10 priority issues identified by the scoping group as candidates for coordinated portal development. Information on each issue is drawn from the program and portal assessments in two Council reports (Council 2008, 2010), the OPC report on California's ocean observing systems (Bernstein et al. 2011), other readily available sources such as program websites, and discussion among the scoping team members and with experts in several issue areas. Issues are presented in the rank order shown in Table 5, which summarizes the results of a qualitative prioritization exercise. Opportunities are shown below only for the top four priorities. To avoid repetition, a major opportunity for all issues is to develop a global point of access to available authoritative data and information. Such opportunities currently exist for each of the 10 priority issues.

Issue	Current status and rationale	Opportunities
Protected areas (ASBSs and MPAs) and water quality discharges	• Detailed evaluation of discharges in OPC report provides basis for portal design • Separate monitoring programs and databases exist for water quality, MPAs, ASBSs • Monitoring programs and data access are coordinated regionally • Established QA/QC protocols identify authoritative data • Assessment thresholds and tools for some water quality parameters provide basis for assessment tools; additional assessment tools (e.g., fishing pressure index, reef health index) for protected area resources under development • Structural differences in monitoring programs to meet conservation (MPA) or mitigation (ASBS) goals lead to different data analyses, but data collection approaches overlap somewhat • Southern California pilot integrated assessment of MPA/ASBS resources, fishing pressure, contaminant impacts from discharges provides framework for wider integration • Ocean Protection Council priority provides impetus	• Improve regional coordination of resource and water quality monitoring/assessment • Provide wider access to integrated assessment tools • Promote coordinated assessments at regional scale • Assess protected area effects on fish stocks and fisheries
Ocean acidification (OA)	• Emerging state priority, with potentially large implications for some stakeholders, provides impetus • West Coast Governors Alliance on Ocean Health priority provides additional impetus • NOAA Ocean Acidification Program and national research plan provides guidance	• Identify common set of questions to guide research and monitoring • Support development of standardized methods • Catalyze development and integration of monitoring networks and assessment

Issue	Current status and rationale	Opportunities
	questions • Data and authoritative background information readily available from separate sources • Developing monitoring, QA/QC, and assessment methods provide basis for coordination and integration	
Harmful algal blooms (HABs)	• Detailed evaluation in OPC report provides basis for portal design • Well known human and wildlife health impacts • Statewide monitoring network with some web access • Emerging collaborative/coordination effort, e.g., NOAA & remote sensing • National NOAA HAB program provides context and some guidance • Southern California pilot to develop 3D biological-geochemical model	• Improve linkages to water quality and oceanographic data • Strengthen link to other ecosystem issues • Improve predictive and tracking capability
Marine debris	• Detailed evaluation in OST report provides basis for portal design • Emerging state priority and stakeholder interest provides impetus • CA legislation provides some regulatory drivers • West Coast Governors Alliance interest provides additional impetus • NOAA National Marine Debris Program information clearinghouse provides context • USEPA data sources on trash generation and disposal useful in assessment • Local and regionally coordinated monitoring and special studies provide starting points for improving coordination • Initial local efforts to develop portals provide starting points, but data widely distributed across separate sources, e.g., MS4 monitoring, beach cleanups, marine surveys, municipal/industrial waste streams	• Improve methods standardization and coordination • Improve coordination of terrestrial, freshwater, and marine monitoring and reporting • Develop coordinated reporting and data access capabilities
Swimming safety	• Existing Council portal provides statewide beach assessment results • Well-developed management/regulatory frameworks identify priority information products • Standardized monitoring, QA/QC, and assessment programs produce authoritative data • Data management system in place but requires streamlining • Active R&D efforts to improve monitoring tools, e.g., near real-time monitoring and notification, strengthen need to improved reporting and	

Issue	Current status and rationale	Opportunities
	information access	
Seafood consumption safety	• Existing Council portal provides statewide assessment results and a logical home for additional data and information • Well-developed management/regulatory frameworks identify priority information products • Standardized monitoring and assessment programs produce authoritative data • Coordinated statewide monitoring for coasts, rivers/streams, and lakes/reservoirs through SWAMP solves the coordination problem • Data management system exists but could be improved to streamline data submission and retrieval	
Anadromous fishes	• Detailed evaluation in OPC report provides basis for coordination and portal design • Well-established and coordinated monitoring and assessment programs for freshwater and marine populations provide starting point for needed additional coordination • Limited interaction between freshwater and marine programs and data highlights institutional barriers to integrating data on upstream and ocean conditions • Monitoring, QA/QC, and assessment methods well established and identify authoritative data • Data on different populations/areas readily available in separate databases • Key data gaps include models relating both upstream and ocean condition to survival and growth, and improved monitoring of smolts	
Oil spills	• Detailed evaluation in OPC report provides basis for coordination and portal design • Well-developed federal and state regulatory and management framework identifies authoritative data • Assessment tools and decision-making information well defined and produce key information products • Unresolved technical and institutional concerns limit use of some real-	

Issue	Current status and rationale	Opportunities
	time monitoring data and highlight opportunities for coordination • Data gaps related to baseline characterization of ecosystem status, subsurface plume tracking provide focus for improved monitoring and assessment	
Industrial facility siting (e.g., wind/wave energy, desalination plants)	• Detailed evaluation in OPC report provides basis for coordination and portal design • Some statewide background information (e.g., wave energy potential) available as a starting point • Lack of widespread collection of or access to needed site-specific baseline information (e.g., detailed inshore bathymetry) focuses need for improved monitoring and data access capabilities • Lack of agreed-on assessment tools (e.g., facility impacts on wave energy and shorelines, saline plume) highlights opportunities for coordination	
Fisheries	• Evaluated in Council (2008) • Well established federal and state regulatory/management regimes • Standardized monitoring, QA/QC, and assessment methods • Data readily available in multiple state and federal databases	

The prioritization results (Table 5) include a relative level of concern (which includes political motivation) across key audiences, with emerging issues generally ranking higher largely because of their uncertainty and lack of access to authoritative information that directly addresses key questions. The second criterion judges the relative level of effort needed to improve program coordination and create a global point of entry to authoritative information, taking into account the complexity of the issue, existing technical assets, and the current level of coordination within and among programs. The opportunity criterion assesses the relative current level of interest in pursuing efforts to improve program coordination and access to information. For example, while the level of interest in the status of anadromous fishes is high due to the tenuous long-term status of salmon and steelhead populations, there is less active interest at the moment in moving beyond existing institutional and information management frameworks. Similarly, the current availability of the Council's Safe to Swim portal and Heal the Bay's statewide beach report card scores has lessened the urgency of streamlining the existing information management procedures and data access capabilities.

Table 5. Summary results of the issue prioritization exercise, following qualitative methods used in Council (2008, 2010) and using information sources described for Table 4. For each criterion, lower numbers represent a higher priority. The overall priority is the simple average of the individual ratings on three separate criteria.

	Prioritization Criteria			
Issue	**Level of concern**	**Level of effort**	**Opportunity**	**Overall priority**
Protected areas and water quality	1	2	1	1.3
Ocean acidification (OA)	1	2	1	1.3
Harmful algal blooms (HABs)	1	2	1	1.3
Marine debris	1	2	2	1.7
Swimming safety	2	2	2	2.0
Seafood consumption safety	2	1	3	2.0
Anadromous fishes	1	3	3	2.3
Oil spills	2	3	3	2.7
Industrial facility siting	3	3	3	3.0
Fisheries	3	3	3	3.0

STRATEGIC APPROACH TO ISSUES

The scoping group built on the strategic program development approach outlined in the Council's 10-year Comprehensive Monitoring Program Strategy (Council 2010) that highlights the fundamental role played by issue-specific workgroups. These workgroups are the venue that brings key decision makers and other target audiences together with the monitoring and assessment specialists for the conversations needed to identify priority decisions and articulate management questions, highlight needed information, and address the institutional hurdles to improved program coordination and data access.

Figure 2 illustrates the importance of programmatic support for these issue-specific workgroups. Such programmatic support would include elements such as maintaining key relationships, providing funding, and establishing an information technology infrastructure. At the level of individual issues, Figure 3 shows the parallel progression through the four development phases (Table 3) of design efforts devoted

to the portal itself and to the monitoring and assessment programs that produce the validated data and information accessed through the portal.

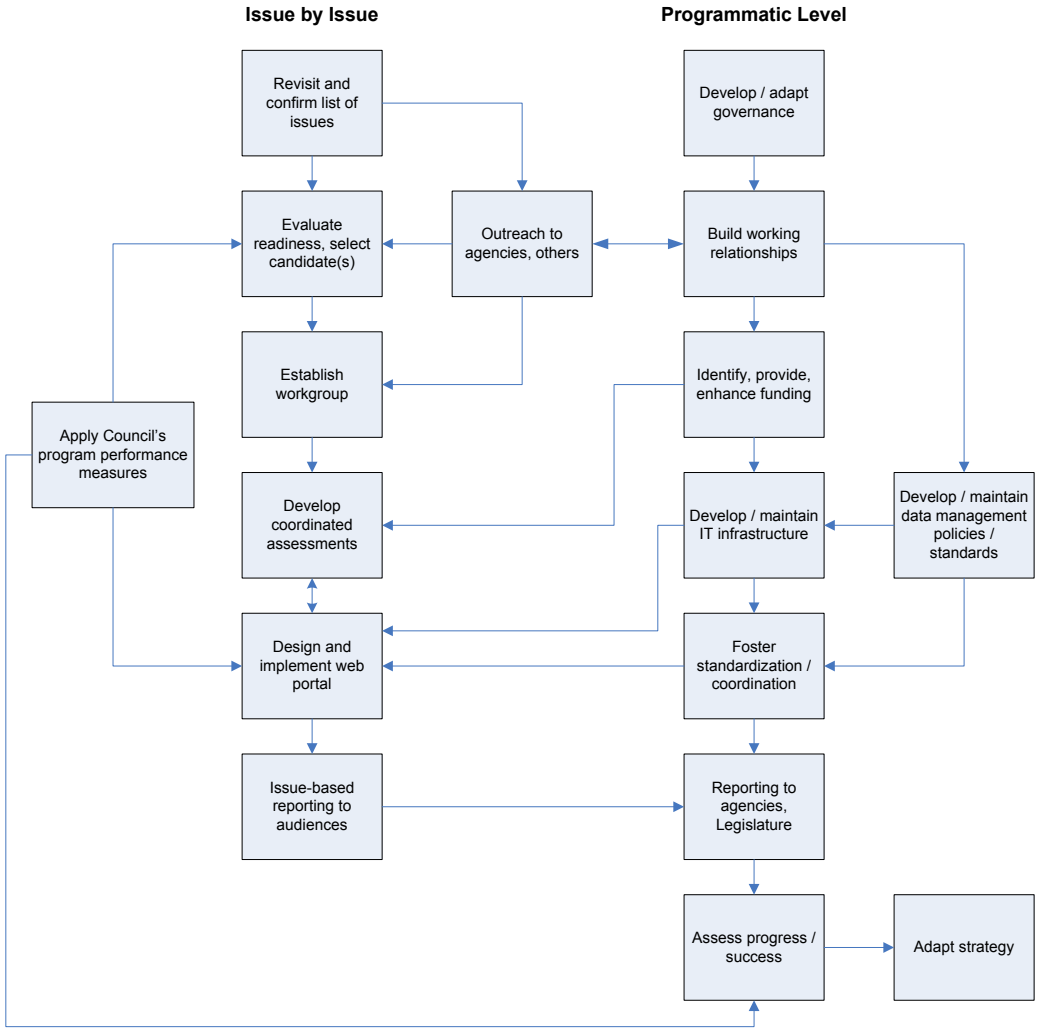

Figure 2. An overall strategic program development approach consisting of issue-specific efforts and the broader programmatic support needed for issue-specific workgroups to function effectively. Adapted from Figure 8, Council (2010).

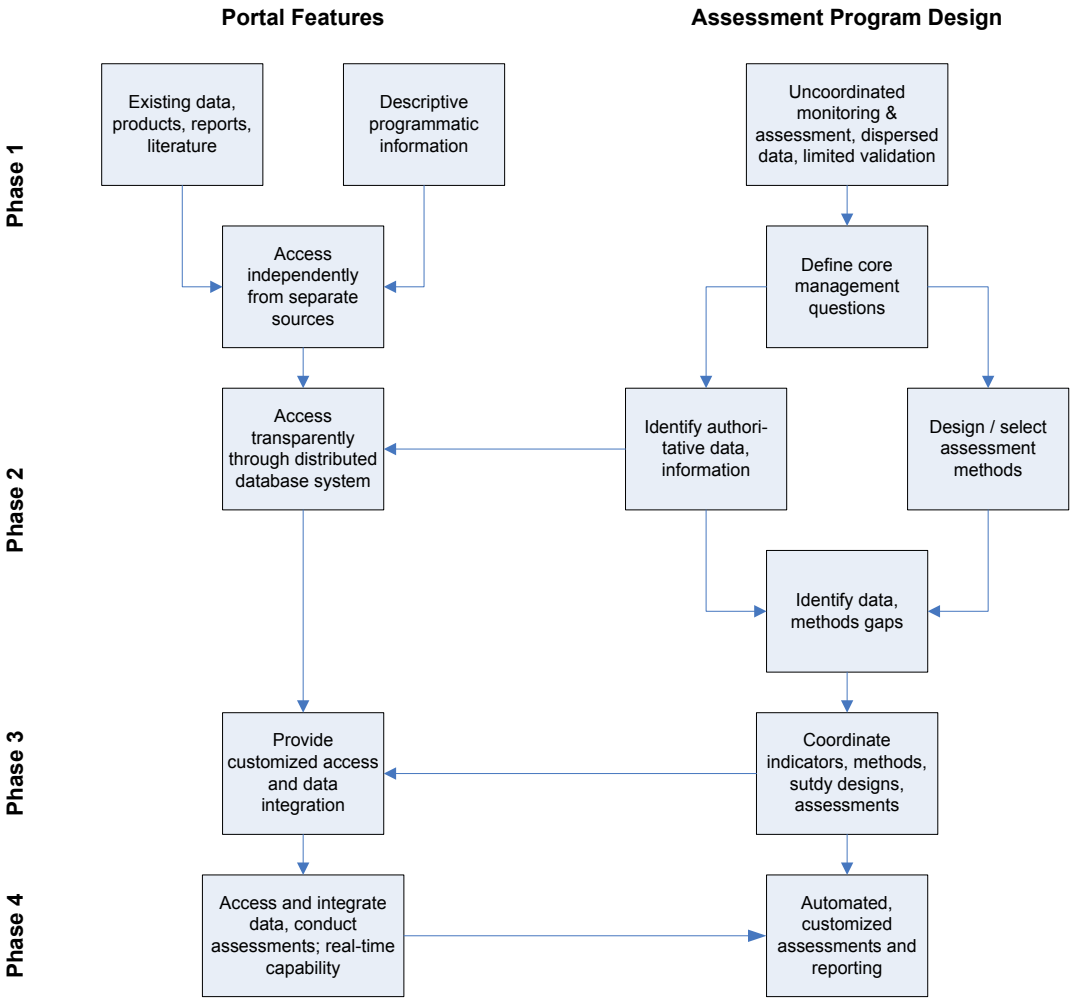

Figure 3. Parallel efforts, in each of the four main design phases defined in Table 2, devoted to developing the web portal and the monitoring and assessment programs that produce information accessed through the portal.

MANAGING PROGRESS

While each workgroup will have concerns specific to its own issue, workgroups should be created and managed within an overall governance structure that ensures accountability and coordination across the various workgroups. This is needed to prevent the workgroups from simply adding another layer to the existing thicket of data and information resources without improving users' ability to access authoritative information to support decision making. Figure 4 is based on the process used to manage the Council's existing workgroups. An overall Oceans Workgroup will be essential, given the close interrelationships between various ocean issues and the data and assessment tools involved in each. For example, Bernstein et al. (2011) noted that both three-dimensional biological-geochemical models and integrated inshore-offshore current models were essential to multiple issue areas. Similarly, access to common key datasets is integral to multiple issue areas. The ability to efficiently provide timely and authoritative information to decision makers rests in part on the workgroups' ability to coordinate these and other technical efforts across multiple issues. This in turn will depend on collaboration across

institutional boundaries. One important role of the Oceans Workgroup will thus be to identify the most critical institutional boundaries and bring them to the attention of the Council (or other managing entity) for resolution. Another role to be shared by the Council and the umbrella Oceans Workgroup is the periodic evaluation of individual workgroup efforts, using the Council's metrics in Table 2 of Council (2010) as a starting point.

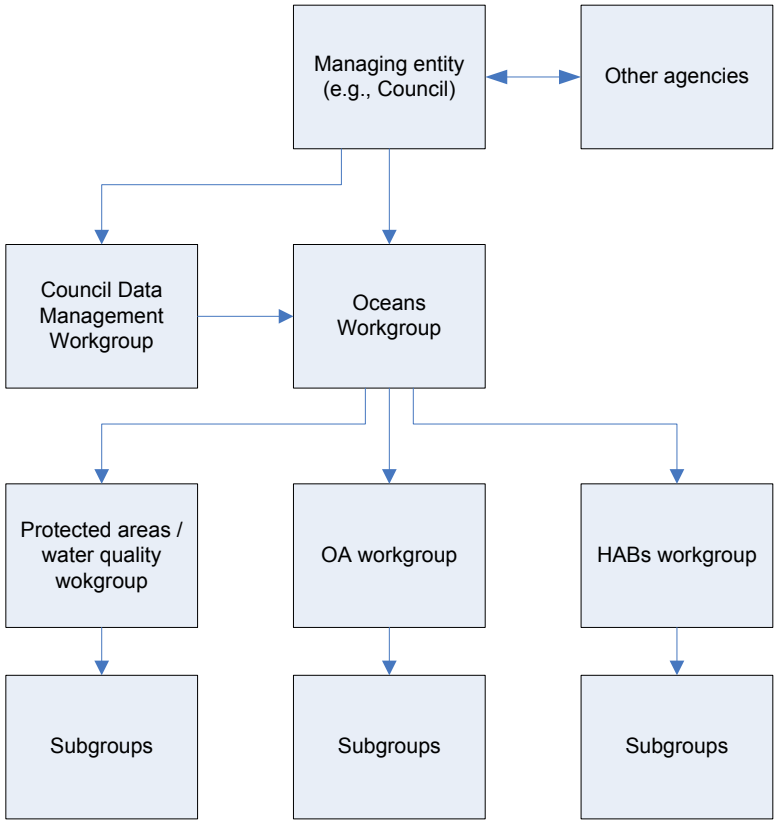

Figure 4. Generic governance structure for the issue-specific workgroups.

CASE STUDIES

The scoping group selected three of the 10 priority issues from Table 4 to illustrate how web portals could be constructed to act as a catalyst and organizing framework for workgroups, institutional integration, and the development of more coordinated and sophisticated monitoring and assessment approaches. The case studies are intended to illustrate potential opportunities for empaneling workgroups and creating data portals and the scoping group fully expects that the workgroups would use the case studies as a starting point for their own information gathering and planning. In particular, workgroups are likely to choose different portal structures and/or information dissemination features depending on users' needs and preferences, which will differ from issue to issue.

The case studies also illustrate ways in which authoritative information can be identified and presented in data portals, irrespective of an issue's current phase of development. For example, the OA issue is at

an early stage of maturity yet there is substantial data and information available now that could be packaged to address some decision-related questions.

The three cases include:

- Case Study 1 (Protected Areas and Water Quality) is defined by well-developed management questions, regulatory and management structures, ongoing monitoring that is relatively well coordinated, and active efforts to develop more integrated assessment approaches
- Case Study 2 (HABs) is defined by clear management and regulatory procedures for human and wildlife health, ongoing and coordinated monitoring of a few key parameters, but a less well developed data management and assessment infrastructure; however, there are active efforts to improve predictive modeling tools that would expand the scope of management capability
- Case Study 3 (OA) is defined as an emerging issue, with a growing level of concern and management attention but no agreed on regulatory framework and with monitoring and assessment methods still in flux

The three case studies differ in terms of the maturity of their management frameworks, the degree of coordination across related monitoring and assessment programs, and the development of more sophisticated assessment approaches. However, there is enough existing information for each to move directly into Phases 1 and 2 in the first year of development and begin organizing and providing access to useful data and information. Progress through the subsequent phases will depend on users' needs and the availability of resources but will also be constrained by the time needed to complete modeling and research efforts required for the more advanced assessment tools in Phases 3 and 4.

Table 6. Timeline for completing development phases for the three illustrative case studies.

Year	Phase	Activity
1	1 – 2	Create workgroup, identify core management questions, identify currently available relevant data and which is authoritative, define current data access capability, create portal to present available authoritative data and information, conduct outreach to decision makers, the public, and agency staff
2 – 3	2 – 3	Expand portal capabilities to improve data access and integration, develop and publish additional QA/QC standards, expand program coordination, continue development of broader integrated assessment framework and tools, continue outreach
3 – 5	3	Expand portal abilities to access distributed data from global point of access, implement portal abilities to subset and integrate data and information from multiple authoritative sources, continue development of broader integrated assessment framework and tools, continue outreach
5 – 10	3 – 4	Continue and maintain program coordination; expand and refine portal capabilities to access, subset, and integrate data and information from multiple sources; automate ability to run integrated assessment, continue outreach

CASE STUDY 1: MARINE PROTECTED AREAS AND WATER QUALITY

This case study focuses on understanding and improving the efficacy of protected areas limiting fishing (MPAs) and limiting discharges (ASBSs). Coastal discharges from wastewater treatment plants, storm drains that outlet on the coast, and streams and rivers contribute a variety of pollutants to the nearshore ocean. These pollutants could impact organisms, foodwebs, and larger ecological communities through a variety of lethal and sublethal impacts. The potential for such impacts concerns protected area managers as well as those responsible for assessing and reducing the discharge of pollutants to marine ecosystems. Calibrating relative investments in the protected area types requires improved understanding of ecosystem response to both types of protection, separately and combined, and in the face of varying levels of potential threats (i.e., pollutant discharges) from outside protected area boundaries. However, understanding ecosystem response in this context has been difficult until recently because distinct management regimes, monitoring programs, and databases hampered the necessary motivation, data integration, and analysis. Increased interest and funding, along with improved databases and modeling and assessment tools, have made this issue ripe for focused attention and portal implementation.

In general, there are several key sources and types of information involved in answering questions about the relationship between water quality and resources within protected areas:

- Programmatic information, e.g., legal and management frameworks, maps, descriptions of monitoring and assessment efforts
- Core data and assessment results from:
  - MPA monitoring coordinated by the MPA Monitoring Enterprise and Ocean Science Trust and conducted by a range of academic, agency, tribal, and citizen group organizations
  - ASBS monitoring conducted by local NPDES permittees
  - MS4 (stormwater) monitoring of discharges and ambient coastal water quality
  - POTW (treatment plant) monitoring of discharges and ambient coastal water quality
  - Coordinated regional monitoring programs (e.g., Bight, CCLEAN)
- Ancillary data needed for assessment of potential impacts, such as:
  - Nearshore and offshore coastal currents
  - Indices of oceanographic conditions (e.g., El Niños, Pacific Decadal Oscillation)
  - Commercial and recreational fishing pressure
  - Other external drivers such as rainfall and local land use

As described below, much of this data and information is produced and managed separately by distinct programs but there is some overlap and a number of functional relationships, both formal and ad hoc, that vary from place to place in the state.

Management/regulatory interest and framework. The two major categories of protected areas (MPAs and ASBSs) are managed by the California Department of Fish and Wildlife (of the California Natural Resources Agency) and the California State Water Resources Control Board (of CalEPA), respectively, under separate legislative mandates. The Marine Life Protection Act defined the framework for creating MPAs while sections of the California Ocean Plan defined ASBSs. The primary focus of these mandates, and their implementing regulations, naturally reflect the different missions of the two agencies. MPA management is concerned with the status of living resources and the limitation of extractive activities within the several categories of MPAs. ASBS management, in contrast, concentrates on regulation of

coastal discharges in order to maintain natural water quality within each ASBS. Water quality, the other major piece of the puzzle, is also managed by the State Water Resources Control Board and its Regional Water Quality Control Boards. The focus of water quality monitoring and management is on tracking trends in compliance with Ocean Plan standards, pollutant loads to the coastal ocean, and impacts on traditional indicators of biological impact such as benthic and some fish communities.

Monitoring and assessment programs. Extensive monitoring and assessment programs currently exist and provide a solid foundation for the workgroup's efforts at program coordination and portal design. These are briefly identified above and the following Table 7 summarizes the existing degree of internal coordination within each program.

Table 7. Preliminary summary of existing degree of internal coordination for the major monitoring programs and other data sources relevant to the assessment of potential water quality impacts on protected areas.

Data/information type	**Level of coordination**
Core monitoring and assessment programs	
MPA monitoring	• Coordinated statewide design implemented by single entity • Some collaboration with regional partners, e.g., Bight Program
ASBS monitoring	• Coordinated statewide design implemented by local permittees
MS4 stormwater monitoring	• Diverse designs implemented by local permittees • Some overlap with ASBS monitoring
POTW treatment plant monitoring	• Different designs implemented by local permittees • Coordination at regional level • Some overlap with MPA and ASBS monitoring
Coordinated regional monitoring programs	• Coordinate many but not all relevant data types • Some (e.g., Reef Check) collaborate directly with MPA, Bight, and others
Ancillary data	
Nearshore and offshore coastal currents	• Coordinated statewide
Oceanographic indices	• Coordinated entire west coast
Commercial and recreational fishing	• Coordinated statewide
Other external drivers	• Level of coordination depends on data type and source • Ranges from statewide to regional to local to uncoordinated

In general, the major monitoring programs exhibit a high degree of internal coordination of their monitoring designs and methods at the regional and statewide scales. However, there is much less coordination across programs, with the result that specific indicators, QA/QC requirements, spatial and temporal sampling intensity, and data formatting can be inconsistent from one program to another.

Despite the presence of well-developed monitoring programs that independently examine MPAs, ASBSs, relevant control areas outside protected areas, and various aspects of water quality, there has until

recently been little focused effort on direct examination of potential water quality impacts on marine resources. An ongoing integrated assessment effort in southern California, initiated by the Ocean Science Trust in collaboration with SCCWRP and taking advantage of the timely opportunity presented by Bight '13, illustrates the potential of such efforts, along with their challenges and the essential role to be played by the workgroup. The assessment includes a pollutant index based on estimates of pollutant loads from coastal discharges and probability distributions of coastal plumes (Figure 5), an index of fishing pressure based on long-term records of recreational and commercial catch (Figure 6), and a newly developed index of resource status within and outside of protected areas.

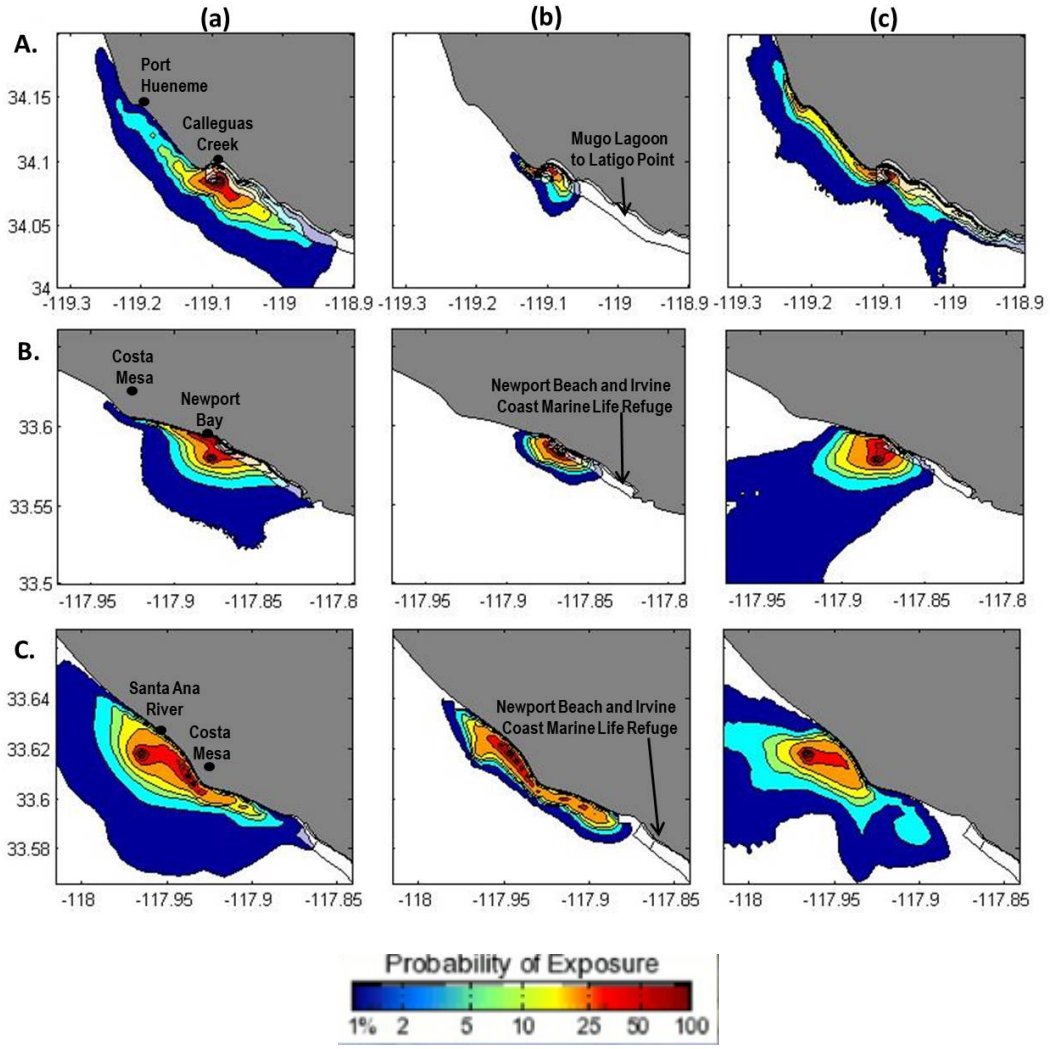

Figure 5. Illustration of the use of coastal discharge flow and coastal current data to produce probability exposure maps for a series of discharges and nearby protected areas in southern California. The figure is organized by rows for (A) Calleguas Creek, (B) Newport Bay, and (C) Santa Ana River. Additionally, each column represents a different temporal model run including (a) annual, (b) the February 22, 2008 storm event, and (c) the December 15, 2008 storm event. Local ASBS are also displayed in all figures and defined in column (b). The X-axis is longitude and the Y-axis latitude. Colors represent probability of plume exposure as indicated at the bottom of the the figure. These probability exposure maps are then

combined with estimates of pollutant loads for each discharge to derive a pollutant index for each protected area. From Figure 3, Rogowski et al. (2014).

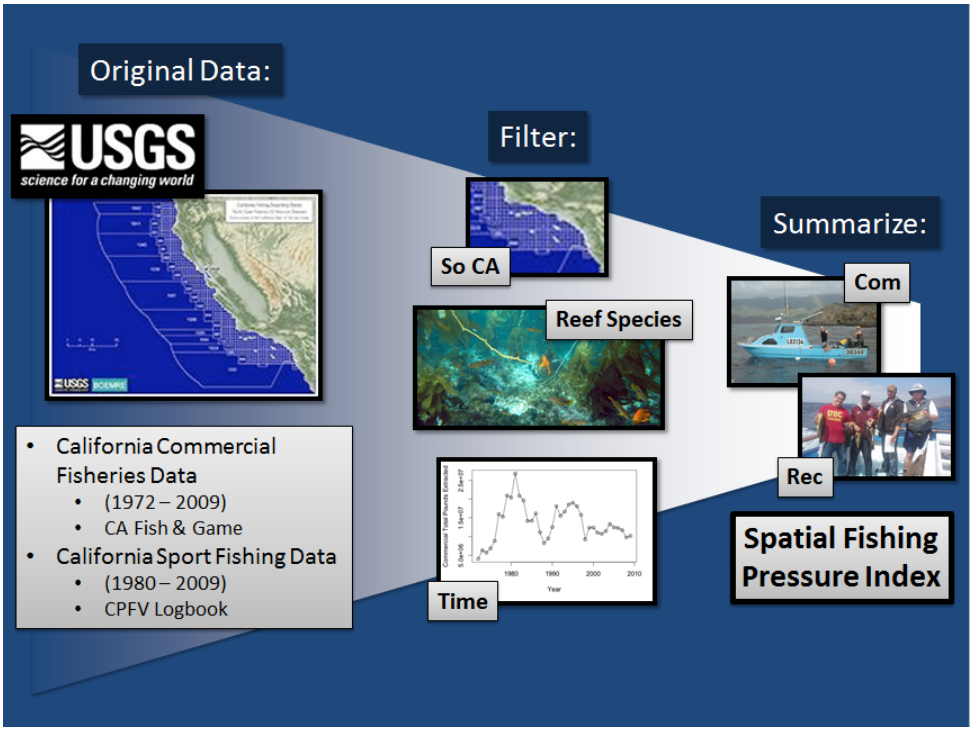

Figure 6. Schematic of the data integration and synthesis steps involved in producing an index of fishing pressure on protected areas in southern California. From Update on Fishing Pressure Index presentation by SCCWRP, Ocean Science Trust, and Occidental College Vantuna Research Group, March 2, 2014.

Access to data and information. The types of data and information described above are readily available from a range of authoritative sources (Table 8). However, these separate sources are not well integrated at present and users face the challenge of finding, accessing, and integrating data on their own if they wish to address the core questions related to this case study. In addition, as Table 8 indicates, analogous data can reside in different databases, depending on the specific type of permitted discharge. The State Water Resources Control Board has established an ultimate goal of using the California Environmental Data Exchange Network (CEDEN) as a central repository and access point for most if not all ambient monitoring data, but has experienced funding and technical difficulties that have delayed its full implementation. As a result, many permittees are submitting data in a standardized format to their respective Regional Water Boards for eventual inclusion in CEDEN. Despite its intended scope, CEDEN is not envisioned to include key programmatic information (e.g., permits and assessment reports) and some discharger self-monitoring data, particularly for POTWs, continues to be submitted to the California Integrated Water Quality System (CIWQS) and there is as yet no functional crosswalk between these two systems.

This brief summary of data management and access challenges within a single agency is compounded when it is extended to encompass the wider range of actors and data sources involved in the protected area/water quality issue (Table 8). Thus, the integrated assessment currently being conducted in southern California (see preceding subsection) faced a large challenge in identifying, validating,

accessing, and integrating data and data products (e.g., plume modeling results) from several independent sources. This emphasizes the critical role to be played by the workgroups, one of whose central functions is to identify essential needs for coordination across the range of data gathering and assessment programs.

Table 8. Preliminary summary of data sources for the data types needed to answer questions about the potential impacts of water quality on marine protected areas.

Data/information type	**Source(s)**
Programmatic information	
MPAs	OceanSpaces, Dept. of Fish and Wildlife website
ASBSs	State Water Resources Control Board website
Other programs	Variety of websites
Core data and assessment results	
MPA monitoring	Ocean Science Trust – OceanSpaces
ASBS monitoring	State Water Board – SWAMP, eventually CEDEN Local databases
MS4 stormwater monitoring	Local databases, eventually CEDEN
POTW treatment plant monitoring	State Water Board – CEDEN, CIWQS Local databases
Coordinated regional monitoring programs	Local databases, some to CEDEN
Ancillary data	
Nearshore and offshore coastal currents	SCCOOS and CenCOOS websites
Oceanographic indices	SCCOOS and CenCOOS websites
Commercial and recreational fishing	Dept. of Fish and Wildlife
Other external drivers	Variety of websites

Opportunities for coordination and portal development. This case study provides significant and immediate opportunities to empanel a workgroup and develop a web portal that would organize and improve access to the substantial amount of existing data and information on this issue. This could be achieved relatively rapidly with visible payoffs to the range of programs' participants as well as to managers and the public.

In addition, the workgroup would be ideally positioned to improve the coordination across now-separate monitoring and assessment efforts and to rationalize and extend efforts now underway to expand the scope of existing monitoring and assessment. Because the majority of these efforts have mature study designs and data management systems and are already regional or statewide in nature, their inclusion in a web portal initiative would readily be seen as a logical step and one that would increase the efficiency and decision-making effectiveness of their respective programs.

Potential workgroup members would include representatives of existing monitoring programs and the state and regional management/regulatory agencies that oversee them, key audiences for this

information, and data managers now responsible for managing the separate data streams. A preliminary set of suggested workgroup members might include:

- Management agencies
  - State Water Resources Control Board
  - Department of Fish and Wildlife
  - Regional Water Quality Control Boards
  - NOAA Fisheries
  - Ocean Protection Council
- Monitoring and assessment entities
  - MPA monitoring Enterprise/Ocean Science Trust
  - MS4 stormwater programs (CASQA)
  - POTW treatment plant programs (CASA)
  - Regional monitoring (SCCWRP, Reef Check)
  - Fish catch monitoring (Department of Fish and Wildlife)
  - Oceanographic data (SCCOOS and/or CenCOOS)
- Conservation, public interest, and user entities
  - Heal the Bay
  - California Waterkeeper organizations
  - Commercial and recreational fishing organizations
- Data management and portal design
  - Council data management workgroup
  - Ocean Science Trust
  - SCCWRP

Key initial focus areas for the workgroup could include:

- Identify and provide centralized access to key programmatic information and to existing authoritative data sources
- Raise the visibility of current efforts to improve coordination and integrated assessments (e.g., regional ASBS monitoring, integrated assessment in southern California)
- Reconcile differences in study design, indicator selection, and monitoring intensity across programs
- Define QA/QC approaches needed to validate authoritative data sources
- Identify and prioritize key data gaps related to small POTWs, recreational fishing, pollutant loads in river and stream discharges, and nearshore plume dynamics
- Continue the development of assessment approaches and thresholds for living resources and for overall integrated assessments
- Extend assessments of protected area effects in reef habitats to soft bottom habitats

CASE STUDY 2: HARMFUL ALGAL BLOOMS (HABS)

This case study focuses on the tracking and prediction of HABs and the management of the associated health risk for both human and wildlife consumers of seafood. A detailed summary of HABs management, monitoring, and assessment programs, and decision makers' information requirements is included in Bernstein et al. (2011) and much of the following information is drawn from that source. However, recent efforts initiated through the HAB Monitoring and Assessment Program (HABMAP) have

substantially improved coordination across the research and management entities involved in this issue, directly addressing prerequisites established by NOAA for the allocation of federal resources to developing a coastwide HAB predictive capability similar to those created for other regions of the county.

HABs occur in almost all aquatic environments worldwide and can cause widespread effects on water quality, marine foodwebs, aquaculture operations, and human and wildlife health. The direct causes of HABs remain uncertain, but they have increased in frequency in recent years, particularly along the west coast of North America. Their potential threat to human health, as well as their documented role in causing large-scale mortalities of marine mammals, fish, and sea birds, has resulted in a number of international, national, and regional programs to track HABs' extent, better understand their causes, and develop a predictive capability.

In general, there are several key sources and types of information involved in answering questions about the potential impacts of HABs on human and wildlife health, and on marine ecosystems:

- Programmatic information, e.g., legal and management frameworks, descriptions of monitoring and assessment efforts
- Core data and assessment results from:
  - California Department of Public Health (CDPH) monitoring of plankton populations
  - CDPH monitoring of sport and commercial shellfish
  - CenCOOS and SCCOOS monitoring of toxin concentrations and distribution
  - CDPH monitoring of human health events
  - Wildlife rescue groups' monitoring of wildlife toxic events
- Ancillary data needed for improved predictive tools
  - Oceanographic conditions (winds, waves, temperature, currents)
  - Plankton distribution (remote sensing)
  - Nutrient inputs and distribution

Management/regulatory interest and framework. There are four major decision categories related to HABs:

- Public health
- Water quality
- Marine wildlife surveillance and rescue
- Coastal business operations, primarily aquaculture and desalination

No single agency has the scope of responsibility and expertise needed to fully address all four types of decisions. CDPH has authority to manage issues related to public health and can issue quarantines and closures of both recreational and commercial shellfish fisheries and conducts a series of monitoring and reporting programs (see next subsection). While there are no existing ocean water quality regulations related to HABs, there is growing concern that nutrient loading from POTWs and stormwater discharges may contribute to phytoplankton blooms, including HABs (e.g., Figure 7). If further research documents the validity of such concerns, then regulatory action under the California Ocean Plan could be taken by the State Water Resources Control Board or the various Regional Water Quality Control Boards. There is no formal management framework specifically related to HABs impacts on wildlife and marine wildlife surveillance and rescue is conducted by a network of independent rescue centers. Dense HAB blooms

can affect coastal tourism and can significantly affect desalination operations that employ reverse osmosis by fouling pretreatment membranes. There are also concerns about the ability of various drinking water treatment methods to remove algal toxins.

Because of their increasing severity and their potential impacts on human health and marine ecosystems, HABs has for several years been a priority for state, regional, and national organizations. These include the California Ocean Protection Council (OPC 2012), the West Coast Governors' Association (Gregoire et al. 2008), and NOAA, all of which call for improved HAB monitoring, tracking, and forecasting capabilities to protect coastal resources, businesses, and public health. At the international level, the
International Oceanographic Commission and UNESCO support the GEOHAB program.

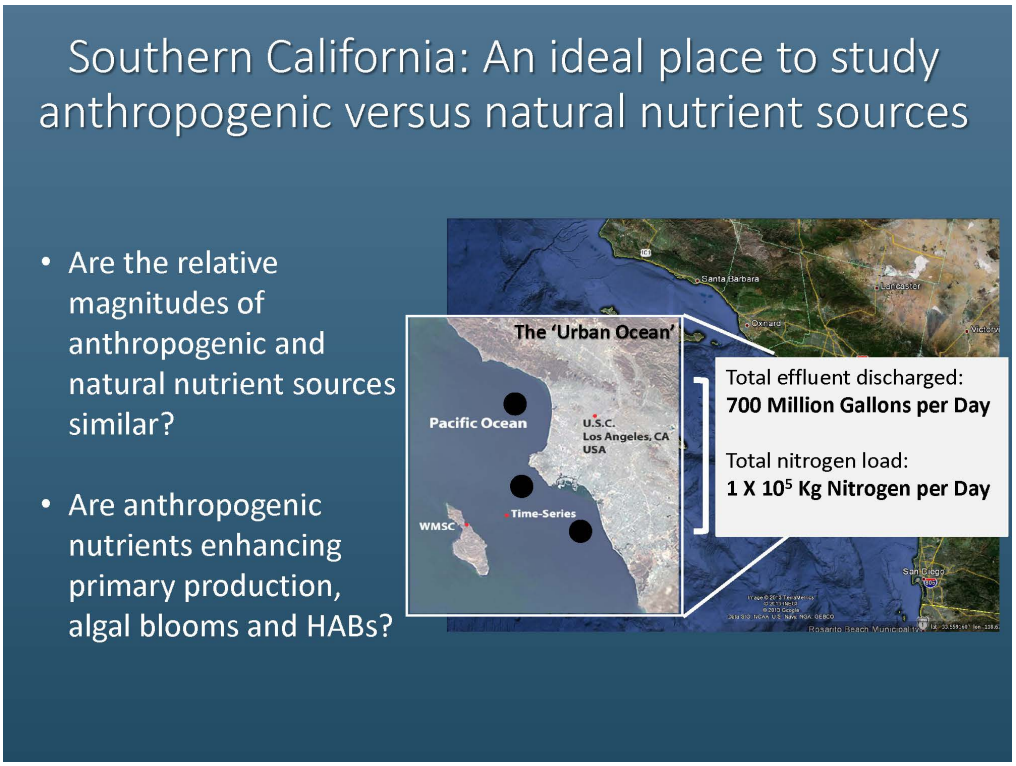

Figure 7. Illustration of the types of management questions motivating current HAB research and assessment (Howard et al. 2013).

Monitoring and assessment programs. Several core monitoring and assessment programs currently exist and provide a solid foundation for the workgroup's efforts at program coordination and portal design. These are briefly identified above and the following Table 9 summarizes the existing degree of internal coordination within each program. A central piece of these existing efforts is the statewide volunteer monitoring program organized by CDPH that tracks HAB species abundance and distribution at a network of ocean monitoring stations throughout the state (e.g., Figure 8). Additional monitoring and reporting is well coordinated with the exception of monitoring of wildlife toxin events. However, monitoring is focused primarily on Paralytic Shellfish Poisoning due to *Alexandrium spp.* and Amnesic Shellfish Poisoning due to *Pseudo-nitzchia spp.* Other toxins and illnesses are poorly monitored if at all.

Table 9. Preliminary summary of existing degree of internal coordination for the major monitoring programs and other data sources relevant to the assessment of HABs potential impacts.

Data/information type	Level of coordination
Core monitoring and assessment programs	
CDPH monitoring of plankton populations	• Coordinated statewide design managed by single entity
CDPH monitoring sport, commercial shellfish	• Coordinated statewide design implemented by single entity
Toxin concentrations and distribution	• Coordinated statewide design implemented by partner entities
CDPH monitoring of human health events	• Coordinated statewide reporting to single entity
Wildlife rescue groups' monitoring of wildlife events	• Alerts via phone, email, listserve • No coordinated monitoring or reporting
Ancillary data	
Oceanographic conditions	• Coordinated entire west coast
Plankton distribution (remote sensing)	• Coordinated entire west coast
Nutrient inputs and distribution	• Coordinated regionally

HABMAP acts as a central coordinating entity for all monitoring and assessment activities, which has contributed significantly to the progress toward a statewide predictive capability. In particular, HABMAP has benefited from a 2010 HABs workshop that identified and prioritized managers' and researchers' information needs and defined a series of steps over a three year period that formed the basis for a regional, collaborative workplan. In addition to the monitoring efforts described in Table 9, researchers in the region are actively developing pilot versions of working HABs predictive tools as proof-of-concept for more intensive development efforts to follow.

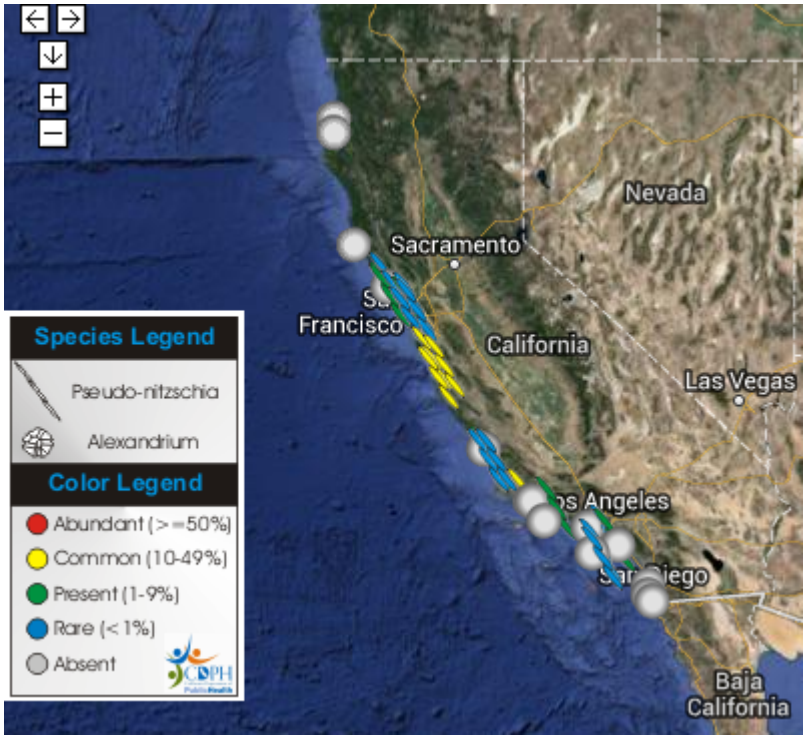

Figure 8. Example monitoring results for the third week of March, 2014, for the volunteer toxic phytoplankton monitoring program managed by the California Department of Public Health. This map displays relative abundance of *Pseudo-nitzchia*, responsible for domoic acid, and *Alexandrium*, responsible for the PSP toxins. (source: http://www.cdph.ca.gov/HealthInfo/environhealth/water/Pages/Toxmap.aspx)

Access to data and information. Much of the relevant monitoring data is readily accessible through HABMAP and the SCCOOS and CenCOOS websites and the OOS websites also provide access to oceanographic and remote sensing data. Wildlife rescue groups gather data on toxic events and provide real-time notices to the HABMAP monitoring and research community. However, there is no verified and readily accessible database of wildlife mortalities due to toxic events and this prevents larger-scale and longer-term assessments of patterns and trends in HAB impacts on marine organisms. The HAB issue is thus characterized by a relatively well organized set of databases, some of which provide links to each other's information. However, there is as yet no single global point of access for relevant information and data.

Opportunities for coordination and portal development. Because of the existing level of coordination among monitoring and assessment efforts, the presence of functioning data portals, and the clear understanding of users' information needs, this case study provides significant opportunities for making quick progress on the goals outlined by the scoping group. For example, the earlier OPC evaluation (Bernstein et al. 2011) created a visual overview (Figure 9), supported by detailed appendix tables, of the specific categories of data, intermediate data products, and assessment results needed to support priority decisions. Because these monitoring and assessment programs have mature designs and are already regional or statewide in nature, their inclusion in a web portal initiative would be a logical next step that would make this information more available to a broader audience, thus raising the profile and utility of HABs data and information. In addition, a collaborative workgroup would provide a venue for improving reporting and archiving of wildlife data and for coordinating nutrient monitoring data statewide, in collaboration with other programs such as those focused on OA and nutrient impacts in estuaries (State Water Resources Control Board's Nutrient Numeric Endpoints project).

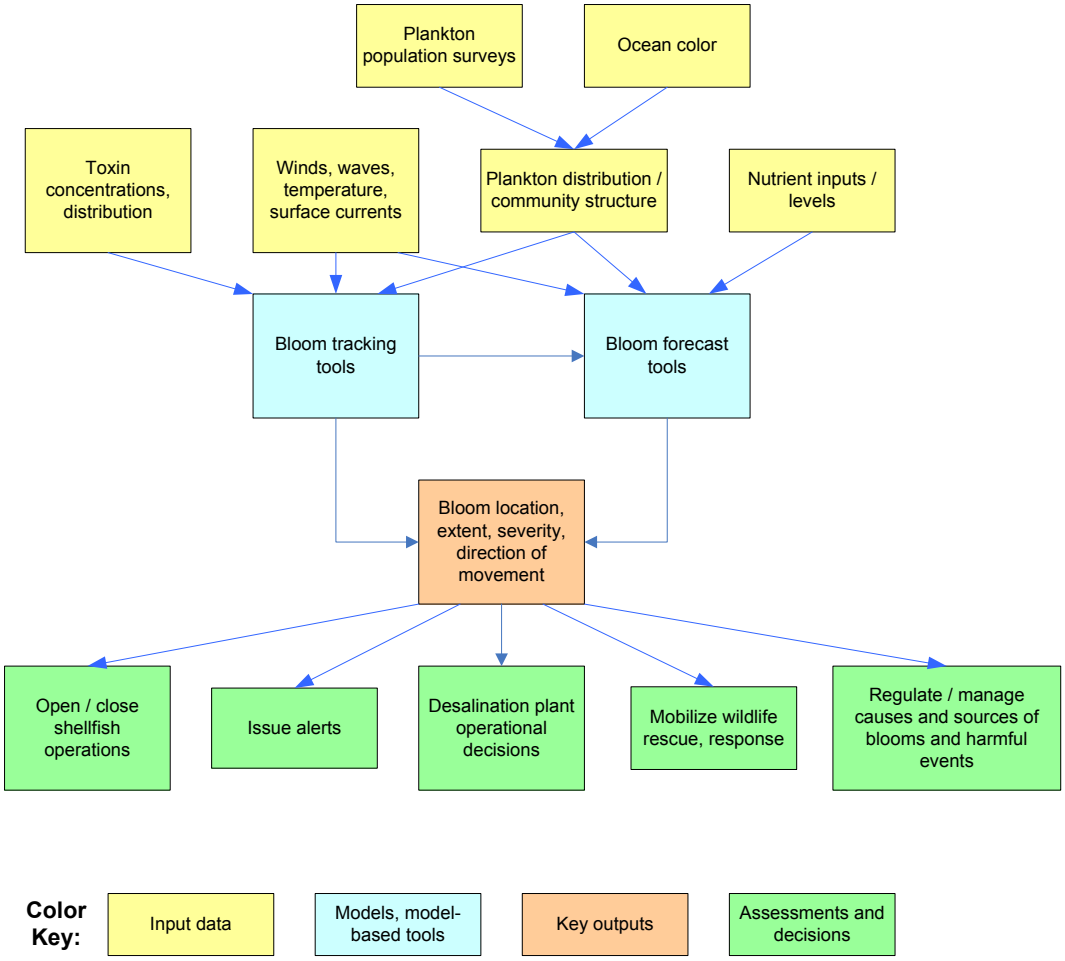

Figure 9. A schematic illustration of how ocean data, models, and tools can inform key aspects of decision making related to HABs. Note that multiple decisions flow from one primary set of information outputs. From Figure 6.2, Bernstein et al. (2011).

Potential workgroup members would include representatives of existing monitoring and assessment programs, the state and regional management/regulatory agencies that oversee them, key audiences for this information, and data managers now responsible for managing the separate data streams. A preliminary set of suggested workgroup members might include:

- Management agencies
  - California Department of Public Health
  - State Water Resources Control Board
  - Ocean Protection Council
- Monitoring and assessment entities
  - California Department of Public Health
  - Wildlife rescue groups
  - MS4 stormwater programs (CASQA)

  - POTW treatment plant programs (CASA)
  - Regional monitoring (SCCWRP, CCLEAN)
  - Oceanographic data (SCCOOS and/or CenCOOS)
  - Researchers and modelers
- Conservation, public interest, and user entities
  - Heal the Bay
  - California Waterkeeper organizations
  - Commercial and recreational shellfish organizations
- Data management and portal design
  - Council data management workgroup
  - Ocean Science Trust
  - SCCWRP
  - HABMAP

Key initial focus areas for the workgroup could include:

- Identify and provide centralized access to key programmatic information and to existing authoritative data sources
- Raise the visibility of current efforts in order to improve programmatic support (e.g., pilot predictive models)
- Improve coordination of nutrient monitoring statewide and create coordinated reporting and archiving function for wildlife toxic event data
- Define QA/QC approaches needed to validate authoritative data sources
- Identify and prioritize key data gaps related to additional toxins and wildlife impacts
- Continue the development of predictive modeling tools and extend pilot efforts statewide

CASE STUDY 3: OCEAN ACIDIFICATION (OA)

This case study focuses on the monitoring, research, and impact assessment involved in improving understanding of OA and identifying and evaluating potential management responses to this emerging issue. OA is at an earlier stage of evolution than the other two case studies and provides opportunities to organize and prioritize background information for several audiences who are still learning about the issue, as well as to improve coordination across multiple related efforts. Additional opportunities exist to incorporate needed new measurements into existing monitoring programs and to develop modeling tools to improve predictive assessment capability.

OA refers more accurately to changes to the ocean's carbonate chemistry rather than more narrowly and simply to reduced pH. It stems from global production of CO_2 and its uptake into the world's oceans and is therefore a global issue. However, local inputs of nutrients that lead to plankton blooms, eutrophication, and hypoxia can exacerbate the problem (Figure 10), as can upwelling of water high in CO_2. OA thus first came to widespread public attention in the Pacific Northwest, an active upwelling zone, where "acidified" waters caused severe impacts on shellfish fisheries. The global nature of the problem and its potential to create severe impacts on marine foodwebs have catalyzed a number of international, national, and regional initiatives to develop more comprehensive monitoring and assessment networks.

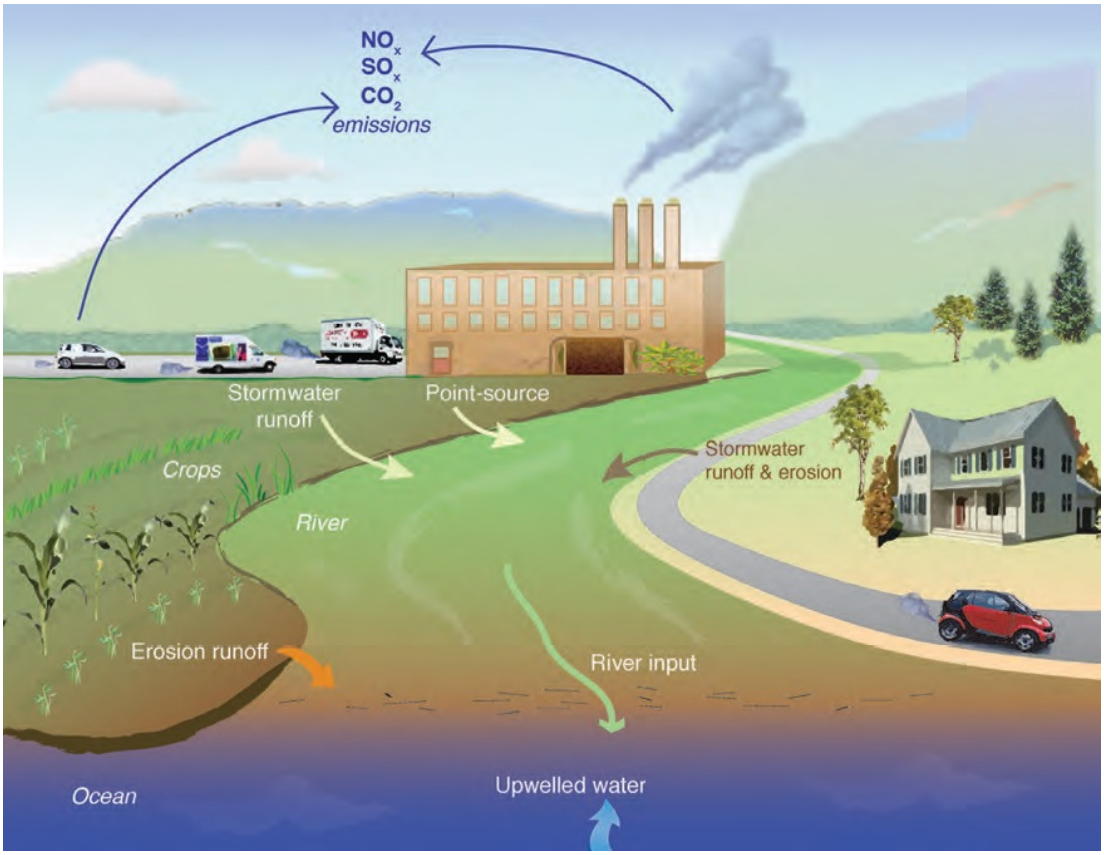

Figure 10. Conceptual illustration of the sources that contribute to OA, including upwelled seawater rich in CO_2, atmospheric emissions, and local terrestrial inputs. Taken from Figure 2 in Washington State (2012).

In general, there are several key sources and types of information involved in answering questions about the potential impacts of HABs on human and wildlife health, and on marine ecosystems:

- Programmatic information, e.g., legal and management frameworks, descriptions of monitoring and assessment efforts, basic descriptions of OA, its potential impacts, and potential management responses
- Core data and assessment results from:
  - CenCOOS and SCCOOS moorings, gliders, and shore stations
  - California Cooperative Oceanic Fisheries Investigations (CalCOFI) monitoring of the California Current
  - NOAA's Pacific Marine Environmental Laboratory (PMEL) monitoring along the west coast
  - Ocean Margin Ecosystems Group for Acidification Studies (OMEGAS) moorings and intertidal monitoring
  - Bight Program and coastal discharger monitoring in southern California
- Ancillary data needed for improved predictive tools
  - Oceanographic conditions (winds, waves, temperature, currents)
  - Impacts on shellfish and other marine organisms
  - Nutrient inputs and distribution

Management/regulatory interest and framework. At present, there is no active regulatory regime for OA. However, there is the potential that changes in ocean pH could be regulated by the State Water Resources Control Board under the California Ocean Plan. If nutrient inputs from coastal discharges are shown to cause or contribute to OA impacts, then these could also be regulated under the same management regime, with potentially large economic impacts on coastal dischargers if they are required to dramatically reduce nutrient loading to the coastal ocean.

More broadly, a number of management agencies and research entities that focus on ocean ecosystems and/or fisheries have a growing interest in OA, driven by concerns that OA could disrupt marine food chains. These entities include OPC, the State Water Resources Control Board, the West Coast Governors' Association, NOAA, USEPA, and a number of international organizations such as the International Atomic Energy Agency (IAEA).

Monitoring and assessment programs. A number of monitoring program exist and their number and scope is expanding. These are briefly identified above and each exhibits a high degree of internal coordination. Because OA measurement methods are still developing, the degree of standardization and coordination across programs is less than in the other two case studies and programs measure somewhat different indicators or aspects of the carbonate system. However, the California Current Acidification Network (C-CAN) and NOAA's Integrated Ocean Observing System (IOOS) are focused directly on identifying validated methods that can form the basis for a more broadly coordinated monitoring network. In addition, a recently published strategic plan for federal monitoring and research (NSTC 2014) provides additional guidance for regional efforts.

There is extensive communication and collaboration among the OA research and monitoring community, although no single entity within California has emerged to play a central coordinating role. Research efforts that bring together several partners, such as the effort to develop a three-dimensional model to predict the effects of coastal nutrient discharges on hypoxia and OA, funded by OPC, Center for Ocean Solutions, and the David and Lucile Packard Foundation, are accelerating the development a more integrated OA community regionally. Internationally, an emerging governance structure for the Global OA Observing Network (Figure 11) provides a larger context for regional and national monitoring and assessment efforts.

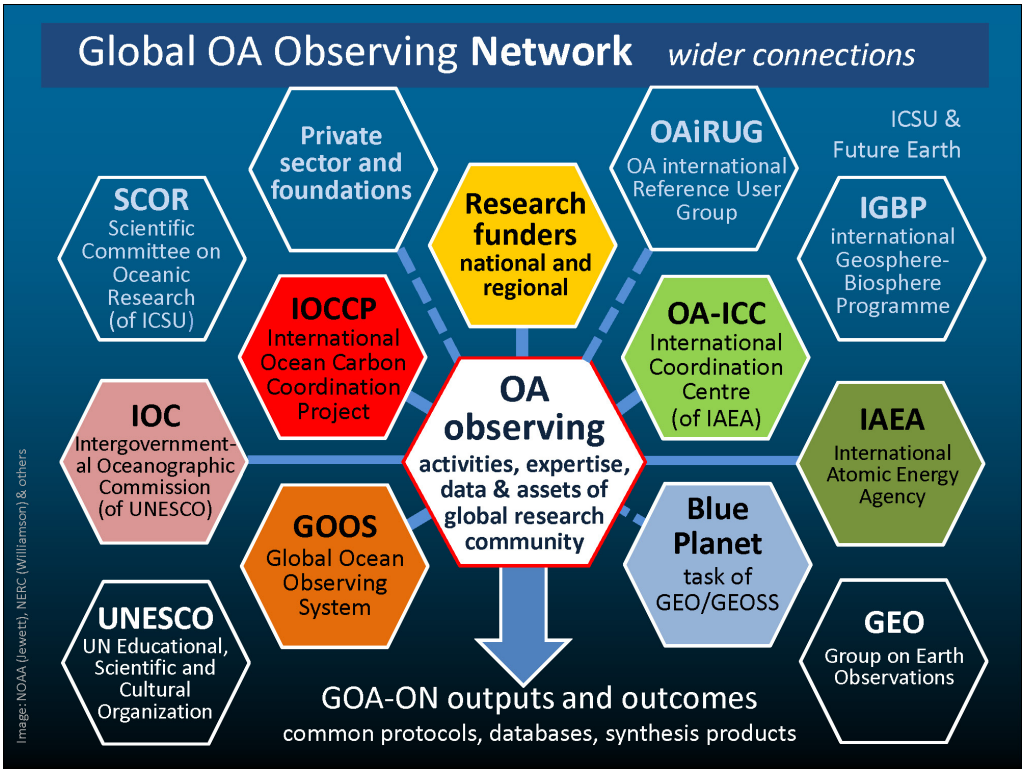

Figure 11. The primary international entities responsible for coordinating activities of the Global OA Observing Network. (source: http://www.pmel.noaa.gov/co2/GOA-ON/)

Access to data and information. Websites for the several monitoring programs described above that focus directly on OA are all linked to directly from the CenCOOS and SCCOOS websites and their data are available from those individual websites. However, there is as yet no coordinated single point of access for all information and data, which must still be obtained program by program. For example, a number of ogranizations, both governmental and nongovernmental, have produced reliable summaries of the OA issue for decision makers and other ocean stakeholders. However, there is no global point of entry to this information that also serves to distinguish it from a large amount of much less reliable information that is equally available.

An updated list of OA monitoring assets for the west coast is under development by the OPC but has not yet been published. In addition, nutrient loading data from coastal dischargers is available from regional monitoring programs in the Southern California Bight (Bight Program) and a portion of the central California coast (CCLEAN) but there are substantial data gaps for the remainder of the coastline. The Global Ocean Acidification Observing Network's interactive map of OA monitoring resources (Figure 12) is an example of the type of coordinating effort underway from a number of directions.

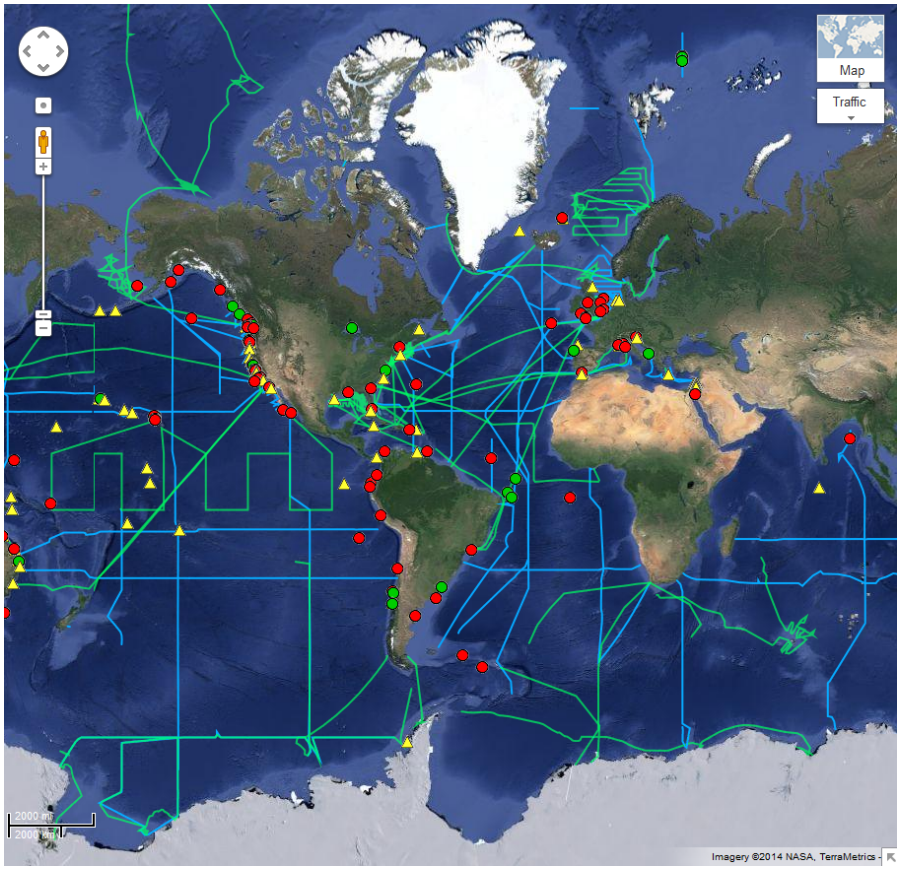

Figure 12. Interactive map of OA monitoring resources from the Global Ocean Acidification Observing Network. (source: www.pmel.noaa.gov/co2/GOA-ON/)

Opportunities for coordination and portal development. Key questions are emerging from decision makers and other audiences as this issue gains wider attention. For example, the West Coast Ocean Acidification & Hypoxia Science Panel has recently published a summary of decision makers' information needs (http://westcoastoah.org/) and specific management and research questions are solidifying as OA's potential impacts become clearer. As the amount of data and information increases, these questions will provide an organizing framework for the audiences who are still learning about this issue. Even though impact assessment and predictive tools are not as developed as for the other two case studies, there is nevertheless a pressing need for a web portal that would identify and prioritize authoritative information about the nature, causes, extent, and potential severity of OA, as well as about potential management responses. Because this information continues to evolve rapidly, the collaborative workgroup for this issue could play a critically important role by periodically updating the programmatic and descriptive information essential to educating decision makers and other ocean stakeholders.

Potential workgroup members would include representatives of existing monitoring and assessment programs, the state and regional management/regulatory agencies that oversee them, key audiences for this information, and data managers now responsible for managing the separate data streams. A preliminary set of suggested workgroup members might include:

- Management agencies

  - State Water Resources Control Board
  - NOAA (e.g., PMEL)
  - Ocean Protection Council
- Monitoring and assessment entities
  - Oceanographic data (SCCOOS and/or CenCOOS, CalCOFI, OMEGAS)
  - Methods development (C-CAN)
  - MS4 stormwater programs (CASQA)
  - POTW treatment plant programs (CASA)
  - Regional monitoring (SCCWRP, CCLEAN)
  - Researchers and modelers
- Conservation, public interest, and user entities
  - Heal the Bay
  - California Waterkeeper organizations
  - Commercial and recreational shellfish organizations
- Data management and portal design
  - Council data management workgroup
  - Ocean Science Trust
  - SCCWRP

Key initial focus areas for the workgroup could include:

- Identify and provide centralized access to authoritative programmatic and background information for key audiences
- Improve coordination of nutrient monitoring statewide
- Support continued development and dissemination of best monitoring methods and related QA/QC standards
- Support continued development of predictive modeling tools and assessment capabilities
- Improve access to data, including coordination with coastwide, national, and international networks

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APPENDIX 1: SCOPING GROUP MEMBERS

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