KEARNS & WEST

The Spatial Collaborative

California Marine and Coastal Geospatial Information Management System Scoping Study

Kearns & West and

The Spatial Collaborative

October 14, 2011

This report was prepared by Kearns & West and the Spatial Collaborative. It was funded by the California Ocean Protection Council and advised by the California Coastal and Marine Geospatial Working group (See Appendix H for Working Group members).

Kearns & West is a collaborative solutions and stakeholder engagement firm with offices in San Francisco, Washington, D.C., Portland, and Sacramento. Kearns & West has more than 25 years of experience conducting stakeholder, conflict, and information needs assessments; developing and implementing engagement and outreach plans; and designing and providing neutral third-party facilitation to support collaborative planning and decision-making processes in the water, coastal environmental, ocean, land use, and energy sectors.

Spatial Collaborative is geared toward scoping, evaluating, developing and implementing geospatial tools for collaborative decision-making. Our team includes geospatial developers, planners and marine scientists with experience in large-scale planning initiatives, including marine protected area planning in California, conservation zoning in England, and marine spatial planning in New Zealand. As a team, we help organizations evaluate their planning objectives, define and develop web-based applications that facilitate the use of geospatial information by non-technical users.

Contents

Executive Summary

California's shoreline and coastal waters are among its most valuable assets. Successful stewardship of these resources requires effective management and sharing of, and access to, scientific information, including geospatial information. In recent years, changes in computing power, available data, and software are enabling unprecedented uses of geospatial information for analysis and decision-making the world over. These new uses of geospatial information improve our understanding of our environment, enable more comprehensive and transparent planning, and help engage stakeholders across scales, and at speeds, that were previously impossible.

In California, geospatial data are currently housed in many different agencies and databases, using different standards for quality control and varying formats and spatial-temporal resolutions. This heterogeneity hinders agencies' abilities to collaborate and communicate effectively in their planning and permitting work. It also presents significant problems for conducting increasingly comprehensive marine and coastal ecosystem-based management, which requires sharing and integrating these data, as well as displaying the data in publicly-accessible formats to support decision-making processes.

In 2010, the California legislature and the Governor recognized this challenge and signed into law Assembly Bill 2125, which tasked the California Ocean Protection Council (OPC) with assessing how California coastal and marine-focused state agencies could better gather, manage, share and utilize geospatial information and technologies to manage the state's coastal and ocean environment. In early 2011, Kearns & West and the Spatial Collaborative were selected to conduct this assessment, resulting in this scoping study.

Key findings from the scoping study consultations include:

- All agencies report the need for a commonly accessible coastal and marine Information Management System (IMS) through which to access geospatial information and no existing California-based web atlas or geospatial information management system evaluated during this study addresses the complete set of features and requirements identified;
- The dominant use of geospatial information is by non-technical users using web mapping applications and Google Earth. Web services and "out of the box" software solutions can provide essential functionality for visualizing and more easily sharing data across organizations and agencies as well as inter-operate with other IMSs and databases;
- Previous experiences with distributed and centralized IMS architectures have shown strengths and weaknesses for each approach, depending upon data holder capabilities, and a hybrid approach could capitalize upon the strengths of both architectures; and
- Long-term staff support and funding are required to support an effective IMS. A Data Librarian and Data Diplomats could greatly enhance state inter-agency data sharing and maintenance of a coastal and marine IMS.

The resulting recommendations that emerged from these findings include[1]:

1. A California coastal and marine geospatial IMS should be searchable and viewable through a dedicated web atlas[2], with the ability to view, overlay, print, and/or download geospatial data in several formats, including through GIS web services within ArcGIS Desktop;

2. The architecture of the IMS should be organized with a hybrid approach, supporting both centralized and distributed data sources;

3. The IMS should have staff support through a data librarian and data diplomats; and

4. The IMS should be housed and funded in such a manner so as to enable it to be a long-term resource for California agencies.

[1] A complete description of the findings is included in Section 5, and more detailed recommendations are included in Section 6.
[2] Such a resource might also be referred to as a geospatial data atlas, data viewer, internet map service, web mapping application, web portal, or web viewer.

Section 1: Introduction

Scoping Study Goal and Organization

The goal of this scoping study is to identify the coastal and marine geospatial data priorities of California agencies and to outline the specific technical requirements for data management that are needed to support these priorities. This scoping study is intended to define and prioritize the functional requirements and workflows of state agencies for an ocean and coastal geospatial information management system that improves state agencies' capacities to share, access, download, and view these data.

Outline of document:

The scoping study is organized into the following six sections:

- **Section 1: Introduction**. This section outlines the goal and provides background context for the scoping study.
- **Section 2: Methods and Approach**. This section describes the consulting team's overarching approach to the scoping study and outlines the key steps in the analysis.
- **Section 3: Agency Assessment**. This section provides a summary of the current state of coastal and marine geospatial information and use among California agencies.
- **Section 4: Interoperability Assessment**. This section provides a summary of other information management systems within and outside of California that inter-operate with California coastal and marine agencies.
- **Section 5: Key Findings**. This section summarizes key findings from consultations with California coastal and marine resource agencies, as well as key interoperability findings from interviews with other leading data providers.
- **Section 6: Functional Requirements and Recommendations**. This section provides the consultant team's recommendations of key changes required to address the information management needs identified in earlier sections. This includes functional and compliance requirements of any new IMS. This section also addresses the feasibility of building a new system versus utilizing existing systems.

The Challenge

Coastal and marine geospatial data provide critical baseline information for making informed evaluations of, and decisions about, the uses and resources of the state's ocean and coasts. These data also enable agencies to effectively carry out mandates in the form of regulation and

permitting[3], as well as implementing environmental management policies to steward ocean and coastal resources for current and future generations.

Currently, these geospatial data are housed in various agencies and databases, using different standards for quality control and varying formats and spatial-temporal resolutions. This heterogeneity hinders agencies' abilities to collaborate and communicate effectively in their planning and permitting work. It also presents significant problems for conducting increasingly comprehensive marine and coastal ecosystem-based management, which requires sharing and integrating these data, as well as displaying the data in publicly-accessible formats to support decision-making processes.

The Context

A variety of efforts have been undertaken to date to address these challenges, including recent state investments; state, regional and federal policy initiatives; and other collaborative efforts in coastal and marine resource management. The Scoping Study's approach and resulting recommendations have been informed by the following.

Recent state investments

This scoping study emerges within the context of significant investments by the OPC and other California state agency partners over the past five years to improve marine and coastal ecological, physical, and socioeconomic data collection and the state's subsequent ability to carry out ocean and coastal protection laws and management decisions. Key investments have included seafloor mapping, coastal LiDAR data collection, and ecological and socio-economic data gathering to support marine protected area (MPA) planning and monitoring. These data can provide the best available information and science for informing permitting and regulatory decisions, as well as the planning, scoping, and stakeholder processes that precede these decisions. These data will also provide a baseline for subsequent adaptive management decisions that will be made in the face of a rapidly changing marine and coastal environment brought about by climate change, population dynamics, desalination and hydrokinetic energy development, and other changes.

Assembly Bill 2125 on the Use and Sharing of Geospatial Information

Assembly Bill 2125 (2010) states that "the OPC shall support state agencies' use and sharing of scientific and geospatial information for coastal and ocean decision-making, including marine spatial planning." Specifically, AB 2125 requires the OPC to do the following:

- Assess the needs of California's public agencies with respect to their abilities to gather, manage, use, and share information and decision-support tools relevant to ecosystem-based management in the coastal and ocean environment;

[3] Key environmental laws and management policies include: The California Coastal Act; the McAteer-Petris Act; the California Marine Life Management Act; the federal Coastal Zone Management Act; and the federal Oceans Act of 2000; the National Ocean Policy containing a Framework for Effective Coastal and Marine Spatial Planning (CMSP), as codified in President Obama's Executive Order 13547 for the Stewardship of the Ocean, Our Coasts, and the Great Lakes, July 19, 2010; and the Public Trust Doctrine.

- Subject to a determination of need, and in consultation with the relevant coastal or ocean management agency, increase the amount of baseline scientific and geospatial information that is available to agencies in a publicly accessible, electronic, and geospatial format;
- Support public agencies' collaborative management and use of scientific and geospatial information relevant to ecosystem-based management; and
- Help identify decision-support tools relevant to ecosystem-based management, and, where appropriate, support the adaptation of those tools or the creation of new tools to serve the state's needs.

The results of this scoping study will help the OPC to address several of these legislative requirements. By utilizing the results of this scoping study, California agencies can make their previous investments in data collection more relevant and available to agencies and others.

National Directive for Marine and Coastal Geospatial Planning

The need for improved access to and integration of coastal and marine spatial data is also a primary directive of the Executive Order No. 14547 signed by President Obama (July 2010) that adopted the Final Recommendations of the Interagency Ocean Policy Task Force and created the National Ocean Policy.[4] The Executive Order and Final Recommendations call for the development of coastal and marine spatial plans that build upon and improve existing federal, state, tribal, local, and regional decision-making and planning processes. The development of these regional plans will rely heavily on state and regional coastal and marine geospatial data. California will be working with Oregon and Washington to develop methods and agreements for sharing relevant data across state boundaries and in developing regional data products for the West Coast Region.

The Final Recommendations also call for the National Ocean Council to "begin the development of a national information management system and CMSP portal(s), adopt minimum data standards consistent with government-wide information quality standards, identify a Federal lead agency or entity to manage, implement, and update the CMSP portal(s), identify and begin development of any new standard tools or models needed for CMSP in all regions, and identify additional CMSP information and research needs." This scoping study is, in many ways, an initial effort by the State of California to begin developing a similar information management system. As both the state and national efforts may be working in parallel, the OPC and others should ensure regular communication with federal agency leads on the national system to ensure a consistent and inter-operable approach.

2009 Geospatial Information and Tools Workshop

In August 2009, the OPC, in collaboration with the California Ocean Science Trust, the National Oceanographic and Atmospheric Administration (NOAA) Coastal Services Center, the Center for

[4] *Final Recommendations Of The Interagency Ocean Policy Task Force July 19, 2010 (The White House Council on Environmental Quality).* http://www.whitehouse.gov/files/documents/OPTF_FinalRecs.pdf.

Ocean Solutions, and The Nature Conservancy, hosted a workshop titled "Collaborative Geospatial Information and Tools for California Coastal and Ocean Managers" at Stanford University. The purpose of the workshop was to assess agencies' current and potential capacities and needs to manage and share geospatial data, with the goal of identifying concrete recommendations for improving geospatial data management at the state level. Workshop attendees identified barriers to managing and sharing geospatial data among agencies and methods to overcome those barriers. The workshop's final report[5] identified a number of recommendations for improving geospatial information management and sharing, including coordinating state agencies' data management efforts; developing common data and metadata standards to facilitate the gathering and interpretation of data over time; and assessing data discovery and search tools for investment by the state of California.

At the 2009 workshop, California agencies identified a number of internal and external barriers to sharing and using geospatial data including: a lack of geographic information system (GIS) staff and expertise, insufficient information technology (IT) infrastructure, and inadequate funding. One way of leveraging capacity and overcoming infrastructure restraints that was discussed was to develop an interagency geospatial information sharing system that provides a user-friendly web interface for accessing coastal and marine geospatial data. California currently has several different web sites for environmental data; a few of these provide coastal data, but are generally short on marine data. Other sites that were operational at one time are now inactive, due to a lack of management and/or funding. This scoping study builds upon these findings to flesh out the features and requirements of just such an interagency geospatial information sharing system.

California Coastal and Marine Geospatial Working Group (CCMG-WG)

The 2009 geospatial information and tools workshop final report also recommended increased interagency coordination, as well as collaboration between agencies and the state's Geospatial Information Officer (GIO). In response, the OPC formed the California Coastal and Marine Geospatial Working Group (CCMG-WG) under the California GIS Council[6]. The CCMG-WG includes technical managers and users of coastal and marine geospatial data from the various California state agencies. The CCMG-WG seeks to facilitate the improved management, exchange, and analysis of geographic information to assist with the protection of California's coastal and marine resources, support environmental assessment efforts, and improve comprehensive planning in coastal and marine areas.

To date, the CCMG-WG has catalogued its top-priority data uses and needs, identified several data gaps, and reviewed numerous data management and decision-support tools. The CCMG-WG recently issued a resolution stating that California currently does not possess a coordinated statewide system for sharing and accessing geospatial data on coastal and marine resources, human uses, and existing and potential environmental conditions relevant to coastal and marine management. The resolution recommends that the state expediently fund a stakeholder scoping study and development of an online data-sharing network that allows for the efficient management, accessing, and downloading of coastal and marine geospatial information for the

[5] http://www.centerforoceansolutions.org/Spatial-Data-and-Tools/Workshop-2009/Geospatial_Report_Lo_res.pdf
[6] The Work Group members and the charter can be found here: http://www.opc.ca.gov/2011/04/coastal-and-marine-geospatial-data/

benefit of natural resource management agency staff, decision-makers, and potentially the greater public. This scoping study is the result of that CCMG-WG resolution and funding from the OPC.

Learning from the Development and Use of Existing Information Management Systems and Tools

In recent years, a number of government, academic, and private-sector groups have developed information management systems (IMSs) and decision support tools for geospatial data sharing, analysis, and presentation capabilities. These systems and tools have advantages and disadvantages that can serve to inform the type of information system that California develops. For example, many of these systems and tools incorporate open source data standards and web-based interfaces to provide accessible and user-friendly visual interfaces for understanding coastal and marine geospatial information. Other systems and tools incorporate visualization, mapping, and analysis tools to improve users' ability to participate in decision-making processes like the California Marine Life Protection Act (MLPA) Initiative.

The consulting team interviewed managers of several of the leading geospatial information management systems in California, in other states, and nationally. Summaries of, and recommendations from, these interviews are included in the Interoperability Assessment in Section 4.

Section 2: Methods and Approach

Overarching Approach to the Scoping Study

The consulting team's overarching approach to this scoping study consisted of the following key elements:

- Identifying use cases and target audiences;
- Characterizing current coastal and marine geospatial information management systems and work flows;
- Assessing the effectiveness of current systems in meeting agency priorities; and
- Identifying possible changes to better meet agency priorities.

Key Process Steps

To implement this approach, the consulting team pursued the following process:

1) **Conduct initial coordination with the California Coastal and Marine Geospatial Working Group (CCMG-WG).**

   The consulting team began by convening a meeting with the CCMG-WG. At this meeting, the consulting team presented its proposed project approach and timeline and received CCMG-WG input on a draft outline for the scoping study[7].

2) **Conduct initial interviews[8] with key geospatial IMS users and managers to better understand the California context and recent efforts.**

   To obtain a preliminary understanding of key challenges facing coastal and marine geospatial information management in the state, the consulting team conducted targeted interviews with a small number of data gathering and management efforts already underway[9]. The interviews included:

   - The California Environmental Resources Evaluation System (CERES),
   - The Monitoring Enterprise's Marine Protected Area Data Hub,
   - California Water Quality Monitoring Council's "My Water Quality" website, and

[7] See Appendix C for the project timeline.
[8] The consulting team took information provided during interviews at face value and did confirm all claims with additional background research or citation checks to ensure the accuracy of interviewees' statements. The consulting teams did research any conflicting statements that emerged from interviews.
[9] See Appendix D for the list of interview questions used for the above interviews and as the basis for supplemental interviews.

- The California Geological Survey's California Coastal Sediment Management Workgroup (CSMW).

3) Conduct an assessment of agency users

The consulting team conducted an assessment of agency users of coastal and marine geospatial information management systems. Key assessment steps included:

a) Researching the basic work flows by which different state agencies use geospatial information.

b) Convening workshops with small groups of state agency staff to discuss and ground-truth understandings of their data and information systems and uses[10]. This also included a meeting convened by the California Ocean Science Trust (OST) that brought together scientists and stakeholders to provide additional input on California coastal and marine geospatial information needs and priorities.

c) Conducting follow-up phone interviews with key agency staff to refine and confirm these characterizations. Consultations included agency GIS staff and project managers and decision-makers, and encompassed information content and management methods, data formats, spatial and temporal resolution, and metadata, as well as other topics of concern to the users[11].

The following agencies were included in the agency user assessment:

- California Coastal Commission
- California Department of Fish and Game
- California Department of Parks and Recreation
- California Geological Survey
- California State Coastal Conservancy
- California State Lands Commission
- California State Water Resources Control Board
- San Francisco Bay Conservation and Development Commission

4) Conduct an assessment of existing geospatial information management system operators

The consulting team conducted webinars with relevant information management system operators to assess approaches for interoperability[12].

Key system operators consulted included:

[10] See Appendix E for workshop participants.
[11] See Appendix F for a list of individuals who participated in the follow-up agency consultation calls.
[12] See Appendix G for a list of the questions discussed and individuals who participated in the interoperability webinars and subsequent follow-up consultations.

- Administrators of the Oregon and Washington Coastal Atlas systems.
- Managers of California-based geospatial data and data-management systems, such as those developing data and tools for seafloor mapping, climate change adaptation, sediment management, MPA monitoring, and other coastal and marine management issues.
- Administrators of federal applications, including NOAA Coastal Services Center's Multipurpose Marine Cadastre, NOAA's MPA Center, Managers of the Central and Northern California Ocean Observing System (CeNCOOS) and Southern California Ocean Observing System (SCOOS).

5) Prepare draft and final versions of the Scoping Study

To ensure that the Scoping Study document is meeting the interests and expectations of the OPC and the CCMG-WG, the consulting team produced iterative draft versions of the Scoping Study that were reviewed first by the OPC Project Team and then by the full CCMG-WG. The final version of this Scoping Study reflects the consideration of all feedback and input received from OPC Project Team and CCMG-WG members. This study will be reviewed by the California Coastal and Marine Geospatial Working Group, other members of California's public agency GIS community, Senior state agency staff, including the California Geographic Information Officer and senior staff at the California Technology Agency, and state policy makers, including the Ocean Protection Council and members of the Legislature.

Section 3: Agency Assessments

This section provides **s**ummaries of workflows and information management systems within California coastal and marine state agencies. This analysis also highlights barriers that inhibit use of geospatial data within agencies and data sharing between agencies.

The consulting team conducted a series of interviews and meetings to gather this information in order to understand these agencies existing geospatial information systems, how these systems support their work, and what challenges with these current systems are common across agencies. A summary table of the staffing and current geospatial technologies used by these agencies is included in Appendix J.

California Coastal Commission

Agency Objectives

The mission of the California Coastal Commission (CCC) is to "protect, conserve, restore, and enhance environmental and human-based resources of the California coast and ocean for environmentally sustainable and prudent use by current and future generations." The CCC plans and regulates the use of land and water in the coastal zone and issues permits for development activities (e.g., construction of buildings, divisions of land, and activities that change the intensity of land use or public access to coastal waters). The CCC is also one of two state agencies responsible for administering the Coastal Zone Management Act (CZMA), to ensure that federal activities and federally permitted projects (e.g., oil and gas leasing and military projects) are carried out consistent with California's Coastal Management Program.

Workflows

Mapping

Mapping public access and coastal zone jurisdiction is a very important and successful function of the CCC's Mapping / GIS Unit. The CCC uses coastal data acquired by or for local governments (e.g., parcels, roads, and ownership data) for the refinement of digital jurisdictional boundaries. CCC technical mapping staff use digital data and other hard copy sources to refine jurisdictional boundaries in an effort to make boundary determinations that clarify the location of the Coastal Zone and the CCC appeals and retained permitting jurisdictions. Occasionally, data collected by CCC staff for boundary descriptions of public access or open space easements are collected in AutoCAD Map 2000 and georeferenced in ArcGIS Desktop. This AutoCAD to ArcGIS step in the CCC staff workflow is somewhat of a "legacy issue," and staff are eager to move toward a system where a single tool is used to collect, georeference and store jurisdictional boundary information.

Planning/Permitting

The CCC also uses the California Coastal Records Project[13] to evaluate how the coastline has changed over time for planning, permitting and, in some cases, for enforcement. Images from the California Coastal Records Project are brought into image editing and presentation applications in order to create informational graphics and other project location visuals. These visuals, in combination with cartographic products generated by GIS staff, are used in a variety of ways that help inform the analysis in reports generated by CCC staff.

The CCC also works with offshore data, obtained from sources, such as project applicants, academic researchers, and state and federal agencies. Data gaps are common for the near shore environment (e.g., shallow, high wave energy locations) where data gathering is difficult. Additional data sources and themes include NOAA products from the Biogeography Branch and the Multipurpose Marine Cadastre, U.S. Geological Survey (USGS) products including digital orthophoto quadrants (DOQs), as well as fisheries data, essential fish habitat (EFH) data, biological data (e.g., kelp beds, whale migratory pattern), jurisdictional, navigational, geologic, hazards and infrastructure data. GreenInfo's protected area database[14] is used heavily, primarily for onshore information, as the offshore data are incomplete or out of date.

Coastal and offshore data are viewed online, in hard copy reports, or downloaded and stored locally as flat files (e.g., shapefiles and rasters). In some cases, data may be amended as a product of review and analysis work. These derived datasets are often informal drafts and are not typically available to the general public.

Permit applicants are a significant source of data for the CCC. During the completeness review of a coastal development permit application, CCC staff may issue requests for site- and/or project-specific geospatial information, including maps, surveys, and geospatial data layers. When this information is necessary for staff to carry out its analysis of a permit application under the Chapter Three policies of the Coastal Act, a permit application may not be deemed complete until it is submitted. Therefore the data burden is often the responsibility of the applicant. In some ways, this is not ideal as the data may be expensive and time-consuming for the applicant to collect and difficult for Commission staff to vet for the integrity, independence or robustness of the data.

Commission data shared with external sources (i.e., the public, applicants, and agencies) typically take the form of formal boundary determinations and staff reports/recommendations. Staff reports may include exhibits that contain the results of site specific surveys, maps, and geospatial information that is determined to be important for understanding the proposed project and/or associated Coastal Act consistency analysis. Currently, this information is most often shared by mailing paper copies, posting staff reports on the Commission website, or emailing raw data. In other cases, data are shared via digital media (e.g., Compact Discs, ftp site). CCC staff use an internal internet map service to display data but could potentially use the service to reveal data to external entities with the appropriate disclaimers. However, many staff do not currently make consistent use of the map service (internally or externally) due to design flaws, performance, and institutional resistance issues.

[13] http://www.californiacoastline.org/
[14] http:// www.calands.org

Data, Information Systems, and Tools

Human Resources

The CCC currently has 4 dedicated GIS staff.

Tools Used by the Agency

CCC staff use ArcGIS Desktop 9.3.1 and are soon upgrading to version 10. Technical mapping staff may also use AutoCAD Map 2000 on a limited basis to create boundary descriptions. Non-technical staff often use Google Maps, Google Earth, and the California Coastal Records Project, all of which they find extremely useful.

Information Management Systems

The CCC "internal" mapping service contains roughly 18 datasets (e.g., coastal access locations, coastal zone boundary) and is built on ArcIMS 9.2, which CCC is planning to upgrade to ArcGIS Server 10. This mapping service sits behind the CCC firewall, but the State Coastal Conservancy also has access to it for coastal access mapping such as planning for the California Coastal Trail.

There is also a mapping service that includes about 8 draft datasets with refined cadastral scale jurisdictional data for Commission district offices to review and interact. This service was intended as an internal review tool, and is used as such; until this tool is made publically accessible, local governments must rely on digital data requests, hard copy maps, and face-to-face interactions with CCC staff to discuss location-based issues and data.

Data are managed as flat files and some personal geodatabases on a single server. The mapping service is hosted on a second companion server. FTP (file transfer protocol) sites are used to provide data to the public.

The CCC is currently evaluating solutions to combine their Microsoft Access-based permit tracking system with geospatial data. One system, created by a company called Infor[15], is being installed in Marin County. The other system is from a company called Accela. Both offer an integrated permit, planning, and tracking system, and are proprietary, off-the-shelf systems. Both these systems move toward "citizen access" solutions, which would allow queries of the database and filing of applications on line. These permit tracking systems are still in the early development stages and are not expected to be completed for a couple of years.

Challenges

Permit Tracking: Analysts responsible for evaluating permit applications should be able to find and use relevant geospatial information on their own. This would allow for a more efficient permitting process and save resources for both applicants and the CCC. Currently, this is very

[15] http://www.infor.com

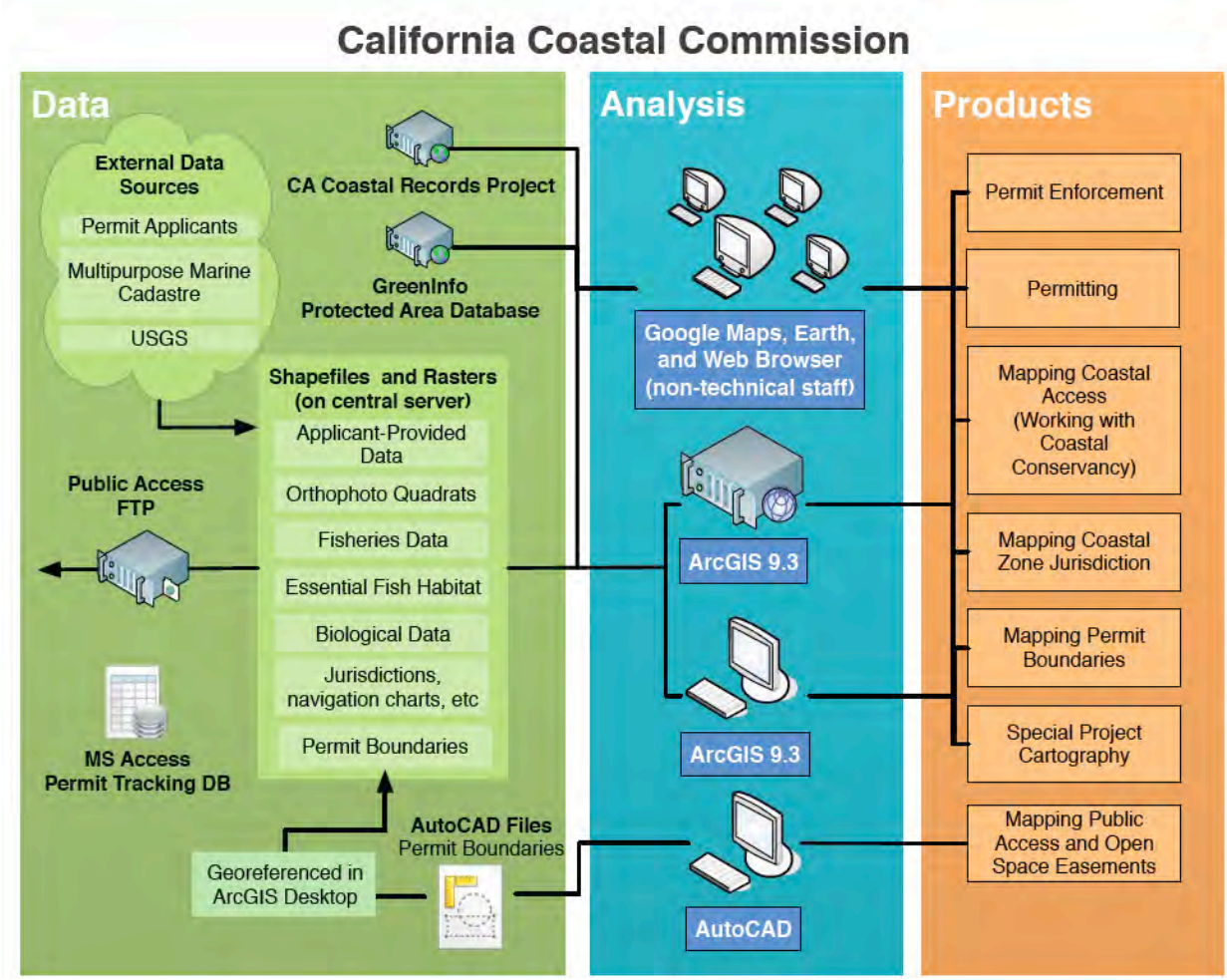
difficult to do. There is an internal permit tracking system that is based in Microsoft Access, and this is currently being upgraded to include geospatial information. As one interviewee stated, "Ideally, planners and analysts should be able to search through a geospatial database of permit actions and call up information that has been collected by any of the state agencies. Furthermore, the work that the CCC analyst does would make it back into this system."

Training: Training for non-technical staff to learn about using the internet mapping service and other geospatial tools would be very useful as a means of getting more CCC staff comfortable and adept at using these tools. The CCC is currently planning in-house training webinars to address this issue. Training for key staff was identified as one of the highest priorities.

Workflows: Another likely impediment to the widespread and consistent use of the internal map service and other existing external geospatial information tools is the fact that these tools have appeared in a more user-friendly, widely accessible format mostly in only the past five years. Many of the Commission staff began working before these tools were available and have developed workflows and habits that do not include use of these tools. The process of re-learning or adapting workflows to take advantage of these tools and information sources is a slow one and relies on willingness, interest, and available time/opportunity on the part of staff. Promoting and prioritizing workflow modernization for staff would likely help address this challenge.

Software: Although the CCC relies primarily upon Esri technologies and has the capacity for serving ArcGIS Server based web services internally. Some of the new web mapping features of ArcGIS Server 10 will be very useful to them, and it has been suggested that getting technical assistance with this would be helpful.

Data Management: Interviewees recommended that the State help to define a consistent methodology or data structure and a data management plan. CCC staff noted that leaving it up to the individual agencies helps agencies get their internal house in order, but, from a statewide perspective, this makes it hard to access and share information with stakeholders and users from other agencies. OPC could support this data management plan and try to integrate information not only within California but with Oregon and Washington. If this effort were to be undertaken, it could be met with resistance, but with time and collaboration the State could develop a robust, resilient data management plan and structure that would serve the needs of all coastal agencies and their stakeholders. The data management plan would essentially include a protocol for metadata, and defined roles and responsibilities within each agency. This would be key in a distributed data environment. CCC staff also noted a need for a process to manage and share information so that it is portable and easy to upload. In addition, there is a need for agreement on data quality objectives and the process by which agencies use, access, and assist with managing a statewide system over time.


California Coastal Commission
Data
External Data Sources
Permit Applicants
Multipurpose Marine Cadastre
USGS
CA Coastal Records Project
GreenInfo Protected Area Database
Shapefiles and Rasters (on central server)
Applicant-Provided Data
Orthophoto Quadrats
Fisheries Data
Essential Fish Habitat
Biological Data
Jurisdictions, navigation charts, etc
Permit Boundaries
Public Access FTP
MS Access Permit Tracking DB
AutoCAD Files Permit Boundaries
Georeferenced in ArcGIS Desktop
Analysis
Google Maps, Earth, and Web Browser (non-technical staff)
ArcGIS 9.3
ArcGIS 9.3
AutoCAD
Products
Permit Enforcement
Permitting
Mapping Coastal Access (Working with Coastal Conservancy)
Mapping Coastal Zone Jurisdiction
Mapping Permit Boundaries
Special Project Cartography
Mapping Public Access and Open Space Easements

California Geological Survey

Agency Objectives

The California Geological Survey's (CGS's) broader mission is to provide scientific products and services about the state's geology, seismology and mineral resources including their related hazards, which affect the health, safety, and business interests of the people of California. This agency is nestled within the California Department of Conservation (DOC). CGS uses geospatial data for three main purposes:

1. *Geologic mapping*. Geologic mapping is the basic data source for many different topics (e.g., habitat identification, seismic hazards analysis, minerals management). Habitat type and extent can usually be correlated to the underlying geology; CGS has an ongoing program with State Parks to map geologic hazards within coastal parks (e.g., lagoons and watersheds). CGS's geologic mapping also includes the landslide mapping program, a component of which is focused primarily along the coast; landslide boundaries occasionally extend into the ocean. Landslides are a major component of coastal erosion and are impacted by sea level rise.
2. *Seismic hazard assessments*. Seismic hazard assessments provide maps of geologic fault features and activity, and these assessments extend offshore. Marine data (e.g., marine bathymetry and 3-D subsurface data) are needed to identify the extent of active faults, which affects shaking and hazard zone analyses of onshore areas of concern. It is important that marine bathymetry and geologic information merge with terrestrial data for tsunami runup and hazard planning efforts. CGS is currently ramping up efforts with the California Emergency Management Agency (CalEMA) to understand tsunami effects in coastal areas for future planning.
3. *Mineral resources planning*. Mineral resources planning uses mapping to evaluate the location, types, and changes in mineral resources throughout the state. A key focal area relevant to coastal and marine issues includes sediment management, where improved understanding of the location and extent of viable offshore sand resources can assist in addressing sea level rise through coastal restoration efforts such as beach replenishment and wetlands protection.

Workflows

Mapping

CGS geospatial information work flows are organized around the production of a diverse suite of maps. These maps are used for both planning and permitting purposes by local agencies (i.e., city and county) as well as state agencies (e.g., Cal Fire, State Parks, CalTrans, the Department of Water Resources), businesses, and the public. Key maps include geologic maps, seismic source maps, landslide maps, earthquake probability maps, seismic shaking hazard maps, active fault hazard zone maps, tsunami runup and evacuation maps, landslide potential maps, erosion hazard maps, mineral resource maps, and watershed and wetlands restoration maps.

Current plans for sharing geospatial data include providing more access to and dissemination of data via the web. CGS plans to do this via greater exploitation of Google technology (e.g., display hazard data on an overlay of Google Earth). CGS hopes to further exploit web browser capability

(web interfaces) at the front end for borehole data entry (e.g., logging in data, capturing parameters).

There are other two services in which CGS is partnering to share data. One is a site called MyPLAN under development for the California Emergency Management Agency, which will enable browsing and download of GIS data for natural hazards. The site also will allow for overlay and generation of custom maps on a variety of base layers. The other is Cal Atlas under the Natural Resources Agency, which also makes natural hazards and geological GIS data available for browsing and download.

CGS has also been instrumental in the creation of the Coastal Sediment Management Workgroup's (CSMW's) geospatial data website, including obtaining and preparing coastal and marine data for display and download as well as browser development. The website is hosted by CERES using a server funded by the California Department of Boating and Waterways.

Data, Information Systems, and Tools

Human Resources

CGS has four dedicated GIS technical staff housed in the Forest and Watershed Geology Program. Most CGS staff are geologists, and most have some GIS training. A significant amount of training took place about a decade ago when CGS's GIS training budget was greater.

Tools Used by the Agency

The primary geospatial analytical tool used by CGS staff is ArcGIS Desktop 9.3 (though they are currently in the process of upgrading to version 10). CGS also uses a suite of related add-on tools, including ArcStereo and photogrammetry, which help them deal with large scale imagery. Open-source tools that they use include Grass (raster GIS), QGIS, and MOST (for tsunami modeling).

Other key analytical tools still in use include MapInfo (used by the Minerals Group) and GeoMedia (used for regional mapping and GIS analysis; both raster and vector). Some uses of GeoMedia are currently being converted to ArcGIS.

Additional analytical tools include HAZUS (natural hazard loss estimation software), SYSTAT (a high end statistical package), Rockworks (for geological analysis), ENVI (for remote sensing analysis), and Surfer (for spatial modeling).

CGS also uses Google Earth Pro for many purposes, including as a visualization tool for doing recon prior to going to field, for emergency response work (part of state emergency plan), and for posting data. Google Earth is an important tool for CGS. CGS also uses other webtools, including GeoMedia webmap and an ArcGIS webtool. CGS utilizes other imagery, such as that available through ESRI, California Department of Fish and Game, FEMA, and other GIS servers.

Finally, CGS has developed some in-house analytical tools, including Liquefy (for conducting liquefaction analyses) and a seismic hazard model (for conducting probabilistic analyses to create seismic shaking hazard maps).

Information Management Systems

Internal data are stored in two main databases. Active fault mapping data are stored in an Active Faults Database (QFaults3), which is a Microsoft Access database. Samples and borehole data are stored in a Seismic Hazard Zoning Borehole Database. This database uses Microsoft Access software to support public access and Oracle software for internal access. CGS is in the process of migrating from an Oracle database to a SQL (structured query language) database server.

Sources of Data/Information

CGS utilizes geospatial data from a number of different external and internal sources to support their mapping work. Key external data sources include USGS (e.g., topographic and bathymetric data), NOAA (e.g., remote sensing data), state agencies (e.g., coastal zone data from CCC, and bathymetric data in floodplains from DWR), Cal-Atlas (e.g., shoreline data), local agencies including local governmental building departments (e.g., jurisdictional data, borehole data), universities (e.g., tsunami research center of University of Southern California), the geotechnical consulting industry, and the U.S. Census Bureau (e.g., census data). CGS generally accepts available and relevant data from other state/federal Surveys, academia, etc.

Challenges

Access to Data: CGS staff described encountering difficulties, at times, in finding relevant data. Staff indicated their desire to be able to better communicate with other agencies about what would be good data to have; no clear mechanism currently exists for this, and this capability could lead to synergies between agencies. CGS staff are not adequately aware about which geospatial data are available at other agencies, because there is not comprehensive data sharing within California. There is no mechanism to find out if certain data even exist. To address this challenge, CGS staff recommended creating an efficient state coastal and marine data catalogue that would allow staff to identify and retrieve data, and where retrieval of data would also be spatially oriented (i.e., a mapping orientation would be used to retrieve data). This would help CGS find other data and would help make other agencies more aware of CGS data. Additionally, CGS staff recommended additional staff training on what existing geospatial information resources are out there and how to find them.

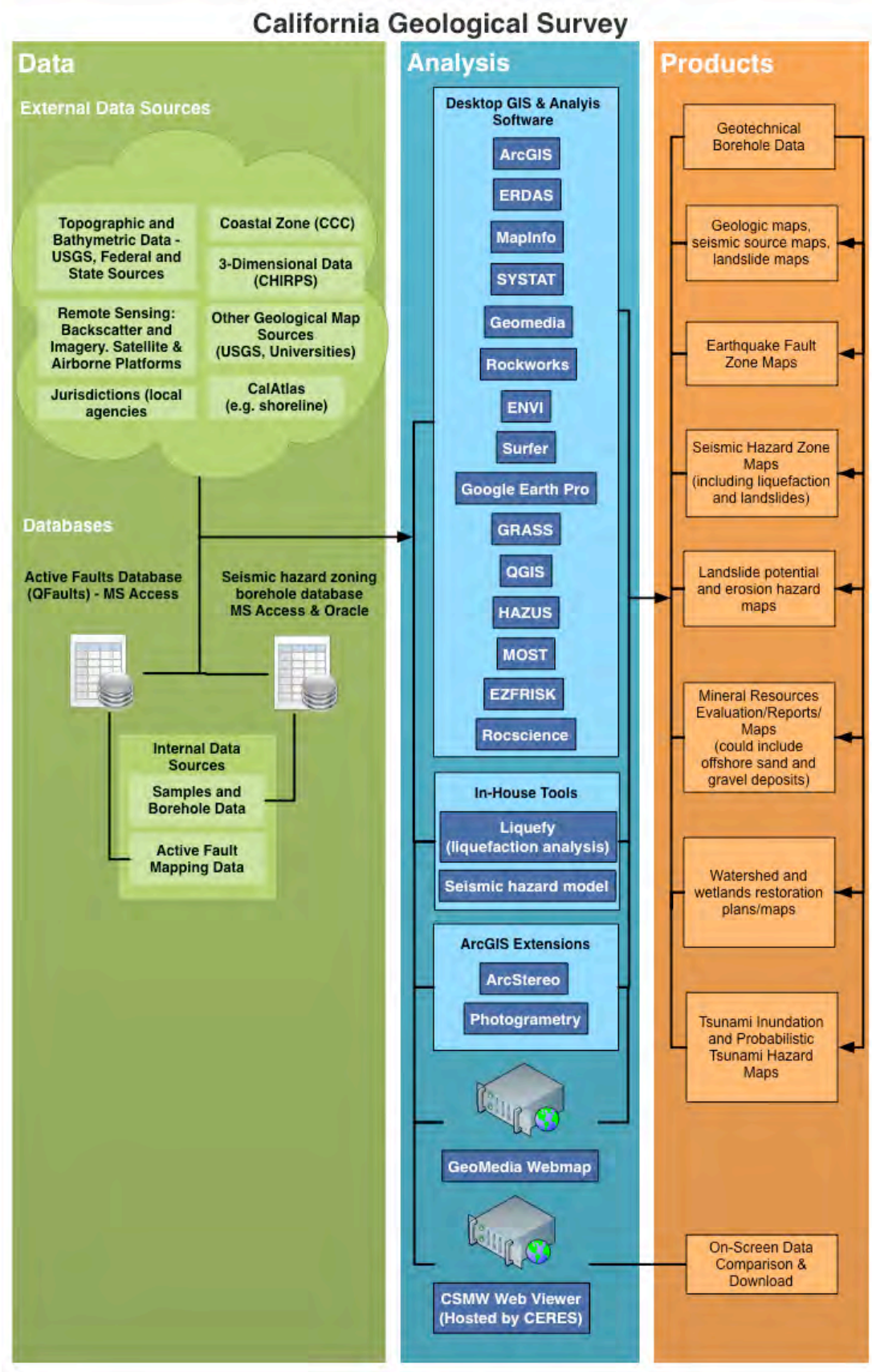
Sharing Data: CGS staff also described some challenges sharing data with other agencies or the public. In particular, with regard to CGS sharing of data through MyPLAN and Cal Atlas (described above), staff noted that it would be helpful to have data servers source-location based to optimize logistics of data maintenance and updating.

Restrictive Access to Information Technologies: CGS staff described impediments involving institutional constraints and bottlenecks, such as disagreements over what types of staff are authorized to use what types of software, and security restrictions imposed by the DOC Information Technology Unit. These restrictions were viewed as contributing to delays in accessing data and as impeding at times CGS's ability to serve their geologic and hazard maps to the public through the agency's webpage. For instance, staff do not load data into ArcGIS Server because they are not authorized to use ArcGIS Server to share data with other agencies or the

public. CGS staff suggested that they would benefit from increased access to open source technologies.

As a specific example, CGS has designed the Coastal Sediment Management Workgroup (CSMW) website and Webmapper. However, CGS could not get DOC authorization to host it on their server. CERES is now hosting the website for CSMW on behalf of CGS. This is problematic, however, because CGS GIS staff are currently not authorized by DOC to use the ArcGIS Server software to update or modify data or information on the CERES server. As such, the website has not been updated in 1.5 years, which has diminished the Webmapper's usefulness. The CSMW is looking for a way to improve this situation through a hosting agreement where someone else makes the upgrades or by finding other ways to piggyback on other agency data and tools.

Updating hardware and software to take advantage of currently available technology: CGS has been slow to upgrade hardware, partly due to budget constraints. Consequently, CGS has not kept up with the trend in software upgrades to migrate toward utilizing more and more system memory. CGS machines are presently limited to only 3 GB of memory using the 32-bit version of the Windows XP operating system. A 64-bit operating system would allow them to expand their machines' memory to 8 or 10 GB, thereby enabling more powerful and efficient geospatial data processing.


California Geological Survey
Data
External Data Sources
Topographic and Bathymetric Data - USGS, Federal and State Sources
Coastal Zone (CCC)
3-Dimensional Data (CHIRPS)
Remote Sensing: Backscatter and Imagery. Satellite & Airborne Platforms
Other Geological Map Sources (USGS, Universities)
Jurisdictions (local agencies
CalAtlas (e.g. shoreline)
Databases
Active Faults Database (QFaults) - MS Access
Seismic hazard zoning borehole database MS Access & Oracle
Internal Data Sources
Samples and Borehole Data
Active Fault Mapping Data
Analysis
Desktop GIS & Analyis Software
ArcGIS
ERDAS
MapInfo
SYSTAT
Geomedia
Rockworks
ENVI
Surfer
Google Earth Pro
GRASS
QGIS
HAZUS
MOST
EZFRISK
Rocscience
In-House Tools
Liquefy (liquefaction analysis)
Seismic hazard model
ArcGIS Extensions
ArcStereo
Photogrametry
GeoMedia Webmap
CSMW Web Viewer (Hosted by CERES)
Products
Geotechnical Borehole Data
Geologic maps, seismic source maps, landslide maps
Earthquake Fault Zone Maps
Seismic Hazard Zone Maps (including liquefaction and landslides)
Landslide potential and erosion hazard maps
Mineral Resources Evaluation/Reports/ Maps (could include offshore sand and gravel deposits)
Watershed and wetlands restoration plans/maps
Tsunami Inundation and Probabilistic Tsunami Hazard Maps
On-Screen Data Comparison & Download

Department of Fish and Game Marine Region

Agency Objectives

The California Department of Fish and Game's (DFG) Marine Region (DFG-MR) was established in 1997 with a mission to protect, maintain, enhance, and restore California's marine ecosystems for their ecological values and their use and enjoyment by the public through good science and effective communication. Its activities include fisheries and habitat management, environmental review, and water quality monitoring statewide.

Geospatial data are used for permitting, lease assessments, fisheries management, enforcement, long-term spatial planning and strategizing, and various other projects. MPA planning via the Marine Life Protection Act Initiative (MLPA Initiative) was a significant driver for using and sharing geospatial information by the DFG-MR from 2004 to 2011. Now that many MPAs are beginning to be implemented, the department will continue to gather information to support evaluation and adaptive management of these MPAs, and will provide data to support the design of any additional MPAs in the future.

Permitting examples include sport and commercial fishing permits, scientific collection permits, and environmental review for incidental take (e.g., dredging, bridge maintenance). Historically, the department has managed a variety of tasks (e.g., permitting, MPA planning) on an issue-by-issue basis. However, with a move toward ecosystem based management (EBM) and more comprehensive planning, DFG-MR will need to integrate information in a more comprehensive fashion.

Workflows

DFG-MR compiles and quality-checks information from many different sources, and seeks the best available data within the themes and types useful to the Department's work. Major information sources include private contractors, NOAA's bio-geographical assessments, and academic institutions. These data are sought on a project-by-project basis.

Marine Protected Area Monitoring

Going forward, MPA monitoring data will be extremely important to DFG-MR, and these data originate from a variety of sources, including non-governmental organizations (NGOs) (e.g., Reefcheck), state and federal agencies, and academic institutions. North Central Coast, Central Coast, and South Coast baseline monitoring Principal Investigators have been identified, and monitoring is underway and summarized in a 5-year review in the Central Coast and Channel Islands. Yet, DFG personnel report a great deal of difficulty discovering existing MPA monitoring data, as there is no centralized list of researchers, projects and data products. The MPA Monitoring Enterprise (monitoringenterprise.org) is currently working on a set of tools that includes a means to discover where, when, and what kinds of MPA monitoring data is being conducted in state waters, but the release date for these tools has not yet been specified.

MarineMap[16] is a web-based application used by DFG-MR and stakeholders involved with the MLPA Initiative as they designed and evaluated MPAs. Within MarineMap, users can (a) view and query spatial data layers pertaining to California state waters and the surrounding area, (b) draw prospective MPAs, (c) assemble MPAs into arrays or prospective MPA networks, (d) view reports on habitat representation and replication, MPA size and spacing, and economic impacts to fisheries, and (e) share prospective MPAs and arrays with other users. MarineMap significantly reduced the work demand on DFG-MR GIS specialists with respect to MLPA Initiative efforts for several reasons. Before MarineMap was designed for the MLPA Initiative, DFG-MR GIS specialists captured stakeholders' MPA designs using ArcGIS Desktop, an application that is not well suited for sketching spatial concepts and receiving immediate analytical feedback on the consequences of those designs (e.g., conservation value or economic impacts). After meeting with stakeholders, for example, GIS analysts would labor for three weeks to clean up and organize the spatial designs generated in stakeholder meetings, analyze them, and return reports to stakeholders. With MarineMap, iterations in design and evaluation took minutes rather than weeks. Stakeholders could work independently, without the aid of GIS specialists. Furthermore, as modifications to the designs were requested by the MLPA Initiative Blue Ribbon Task Force or the Fish and Game Commission, DFG-MR staff used MarineMap, rather than ArcGIS Desktop, because editing geospatial features was simple, analytical feedback was provided in real-time, and exporting shapes to KML (keyhole markup language) and shapefile formats met the needs of GIS specialists and non-specialists alike.

DFG-MR GIS specialists continue to condition and prepare data that were used in MarineMap. Although the planning phase that includes stakeholder involvement in the MLPA Initiative has concluded, the Fish and Game Commission is evaluating the MPA network proposal (and preferred alternative) developed in the North Coast Study Region. As such, MarineMap is still used for data visualization, proposal evaluation and, if necessary, proposal modification by the Fish and Game Commission. Furthermore, depending on how the MLPA implementation takes place for the San Francisco Bay Study Region, MarineMap may continue to be used there as well.

Compliance and enforcement of MPA regulations will also be facilitated by the use of geospatial information. DFG recently released an application for mobile phones that indicates the locations and regulations of MPAs in state waters[17]. However, DFG Enforcement does not have their own GIS unit and consequently rely on Marine Region staff.

Research Permitting

DFG issues permits for research within state waters, including MPA monitoring. There are two databases for scientific permits; one that is used for applications and another for reports (with very limited information). Ideally, these two databases would be combined, along with any number of relevant external databases to know what kinds of activities are happening in any given location.

Data that originate within DFG-MR include commercial fisheries catch data. These data are requested by external entities on a regular basis. Marine Recreational Fisheries ("recfin") data are

[16] http://northcoast.marinemap.org
[17] http://www.dfg.ca.gov/m/MPA/SelectManagementArea

also used for regulatory purposes but are protected by secure federal systems accessed by a "gatekeeper" at DFG with access rights.

Facility Siting Evaluation

Besides MPA monitoring and enforcement and research permitting, DFG-MR is responsible for evaluating energy siting permits, artificial reefs, dredging activities, aquaculture facilities, etc., to determine how these activities might impact habitats, fisheries and other resources. Knowing the cumulative impacts for all the activities in one area (e.g., within an MPA) is very important, but currently there is no single application that provides this information. In part, this is due to the fact that the data are distributed both within and outside DFG and are hard to locate. Ideally, there would be an application that allows one to examine the cumulative impacts of any given management decision. Although a prototype of such an application was developed at UCSB (impacts.marinemap.org), there is currently no production-level application that may be used by DFG-MR staff for the purposes of examining cumulative impacts.

When working on a development or permitting project, new data are often collected by staff or permit seekers. There is no common data repository for these data and they often go unused after the project is complete. For example, Pacific Gas and Electric Company (PG&E) proposed a wave energy pilot project off the Humboldt coast and, consequently, the company conducted a variety of studies (e.g., fish trawls, sea bird surveys, marine mammal surveys) to assess its potential impacts. These data belong to PG&E and company officials have offered to share them. Site-specific data such as these can be useful to unrelated projects, and ideally they would be stored in a common location. Unfortunately, there is no current structure to store such data products.

Data, Information Systems and Tools

Human Resources

DFG-MR has four dedicated GIS staff--one full time employee (FTE) and three temporarily funded by MLPA and the Marine Life Management Act (MLMA)—and the Bio-geographic Data Branch has about 20 GIS staff FTEs at headquarters for support. Approximately twelve biologists also use ArcGIS Desktop, which is licensed via DFG-MR's offices.

Tools Used by the Agency

Most DFG-MR staff use Google Earth, Google Maps and MarineMap very frequently. Dedicated GIS staff use ArcGIS Desktop. Although staff have used MarineMap extensively to support the MLPA Initiative, it has limited use beyond that planning process and cannot be easily modified for new purposes without extensive programming. By the same token, some DFG personnel have argued that new tools should be developed such that either: (a) they can be easily maintained by existing DFG staff (i.e., they use ESRI-based technologies and are not likely to develop and support the necessary skill set "in-house" to maintain the open-source based MarineMap), or (b) there is a funding mechanism in place to develop them "in-house." Otherwise, tools such as MarineMap are likely to go unused after outside contractors have concluded their work.

In some cases, in-house technology development and data management efforts are hampered by IT policies or staffing. For example, while DFG has copies of ArcGIS Server 10, they are still running version 9.3 due to "bureaucratic licensing issues and a bottleneck with IT staff."

The Bio-geographic Information and Observation System (BIOS) is a web-based mapping system designed to enable management, visualization and analysis of biogeographic data collected by DFG and partner organizations[18]. Primarily, BIOS contains terrestrial data, but a newer version that also contains Marine Region data, is scheduled to be released in October of 2011. The focus of this new application will be MPA planning and monitoring. A future version that contains Rockfish Conservation Areas at a finer resolution is expected to be released shortly thereafter. All of these web-based applications are designed to be data viewers, with no statistics, analytics or reporting of any kind.

In our interviews with DFG staff, many respondents stressed the need for a "MarineMap-like" tool that is very easy to use and, at its core, allows users to visualize and download coastal and marine geospatial information. Staff stressed that tools that are not "dead simple" will go largely unused. Ideally, the tool would also have analytical and reporting functions that would be developed on a project-by-project basis. It was also suggested that this tool would include access to relevant peer reviewed literature that was tied to a place-based search function.

Information Management Systems

The vast majority of DFG's information infrastructure (i.e., hardware, software, data and applications) serves terrestrial management needs, although it supports the DFG-MR on a project-by-project basis. Some infrastructure is managed at the Bio-geographic Data Branch and DFG-MR's Monterey Office also hosts a centralized library.

In support of the MLPA Initiative, DFG-MR data are replicated to the University of California Santa Barbara (UCSB) Marine Science Institute, where they are stored in an ArcSDE geodatabase and made accessible via ArcSDE services, and where shapefiles are stored in a web-accessible directory and published as KML via MarineMap. MarineMap, and the associated SDE (spatial database engine) database, will be supported by UCSB until December 31, 2011. To maintain MarineMap for California beyond this date, additional funds will be required for developers outside DFG to update the application as needed.

There is a trend toward centralization with the BIOS system (which includes 500 data layers) and a new direction statewide toward centralization of data. DFG requires that all data and metadata be stored in the BIOS library. Although BIOS contains marine and coastal data, it is not synchronized with Marine Region databases (although a small subset of BIOS data are also contained within MarineMap, these data are not synchronized). The catalog contains DFG and partner data and is harvested by the State CERES and U.S. Geological Survey NBII catalogs. Furthermore, because it is reportedly difficult to use, the Marine Region essentially does not use data stored in BIOS despite the fact that it has been designated as a central data repository for the rest of the agency. Most of the DFG-MR staff noted that BIOS is difficult to use and provides very limited relevant information. Consequently, it is difficult to find and distribute marine geospatial information throughout the agency.

[18] http://bios.dfg.ca.gov/

Data in BIOS, and the upcoming related viewers that include Marine Region data, are published as data services (e.g., WMS, WFS, KML, and ESRI Map Services) that may be consumed by third-party applications, such as ArcGIS Online.

In the near future, DFG-MR will require heavy use of MPA monitoring data. There is some question about where these data will be stored and distributed and DFG-MR is currently discussing options with the MPA Monitoring Enterprise. Although BIOS is the likely candidate for storing some spatial data useful in the adaptive management of MPAs, it is unlikely to contain all DFG-MR monitoring data, as many of these datasets are not appropriate for a spatial database. That is, the spatial component of monitoring data is only one element to consider when evaluating candidates for a database. Any database that stores DFG-MR monitoring data should be able to record that spatial component. However, geospatial databases (such as the ArcGIS Server "geodatabase" that powers BIOS) are only appropriate to consider when the geospatial component of data (e.g., habitat maps) is the central attribute of interest.

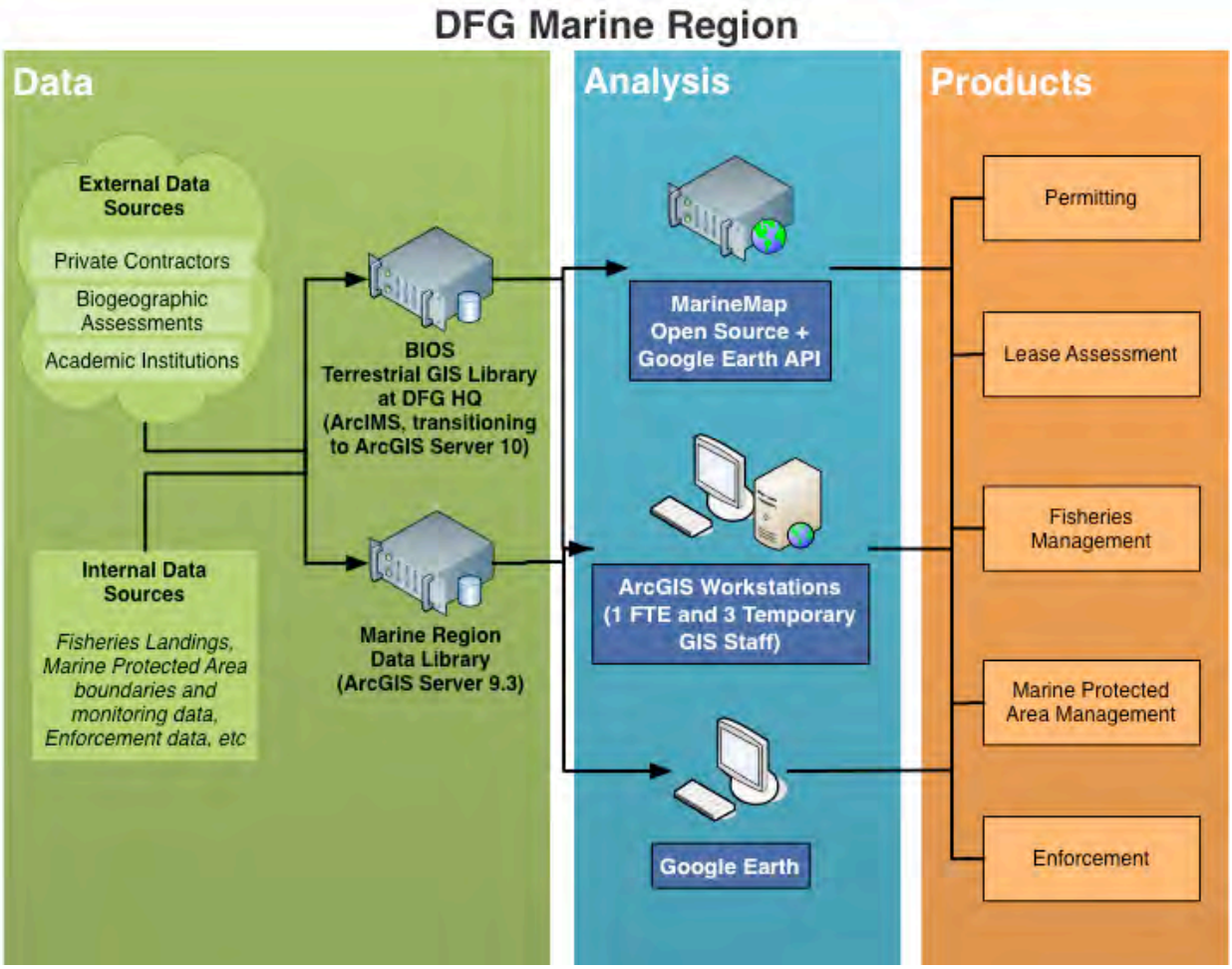
Challenges

Coordinating MPA Monitoring Data: MPA monitoring research conducted by DFG-MR scientists may or may not overlap geographically with research conducted by other researchers, such as those funded by the MPA Monitoring Enterprise. To better coordinate research efforts, the location of DFG-MR monitoring research (and associated attributes such as activity, time, etc.) should be captured in a spatial format so that it may be compared with the location of monitoring research supported by other entities. For example, the Monitoring Enterprise will be publishing the location and type of supported research in the form of a KML layer on their new web site[19]. There is an immediate need to coordinate the MPA monitoring research efforts by DFG-MR with those funded by other entities to avoid duplication of efforts or incompatible research protocols. Although DFG is part of the project management team for the MPA baseline monitoring programs, additional tools for coordination have been requested.

Need an Improved Interface for BIOS: According to many of those interviewed, the interface to BIOS is overly complex and not intuitive for non-specialist users. Improvements to the interface and hands-on training for staff would increase the likelihood that non-technical users would use BIOS.

Need Clear Links to Pertinent Studies: Several staff also expressed an interest in having "instant access" to peer reviewed studies that pertain to coastal geographies. For example, one planner wanted to know where in state waters research has been conducted on sea urchins and then read the relevant articles related to that research. Although is it technically feasible to georeference documents of this sort, it was acknowledged that a single repository for literature would be challenging given copyright issues.

[19] http://monitoringenterprise.org


DFG Marine Region
Data
External Data Sources
Private Contractors
Biogeographic Assessments
Academic Institutions
Internal Data Sources
Fisheries Landings, Marine Protected Area boundaries and monitoring data, Enforcement data, etc
BIOS Terrestrial GIS Library at DFG HQ (ArcIMS, transitioning to ArcGIS Server 10)
Marine Region Data Library (ArcGIS Server 9.3)
Analysis
MarineMap Open Source + Google Earth API
ArcGIS Workstations (1 FTE and 3 Temporary GIS Staff)
Google Earth
Products
Permitting
Lease Assessment
Fisheries Management
Marine Protected Area Management
Enforcement

Department of Parks and Recreation

Agency Objectives

The California Department of Parks and Recreation (State Parks) manages more than 270 park units, the largest and most diverse natural and cultural heritage holdings of any state agency in the nation. State Park units include underwater preserves, state beaches, recreation areas, wilderness areas and more. State Parks is responsible for managing almost one-third of California's coastline and manages the state's coastal wetlands, estuaries, beaches and dune systems.

Workflows

Planning

State Parks is involved in planning and implementing coastal restoration projects, predicting the impacts of climate change (including sea level rise and accelerated erosion), identifying parks that are most vulnerable to change, and creating master plans for each park. State Parks uses geospatial data to map the distribution of exotic species, beach grass, changes in beach profiles, planned changes to infrastructure, and coastal restoration (e.g., removing European beach grass). There is a limited amount of LiDAR data for some of the beaches that were used to generate digital elevation models (DEMs). LiDAR data are also important for dune and forest restoration by, for example, evaluating the changes in beach and backbeach profiles over time, evaluating erosion, wave impacts and flooding potential but analyzing these data can be slowed consequence of existing staff work flows. Some multi-spectral products used for vegetation mapping were collected in cooperation with the U.S. Fish and Wildlife Service (USFWS) and the Bureau of Land Management (BLM).

Data, Information Systems and Tools

Human Resources

There are less than ten GIS analysts within State Parks who are responsible for assisting others, including wildlife biologists and foresters, who need to use and understand geospatial information. There are three individuals at the agency responsible for developing the boundaries data throughout the State Parks. Data are created as CAD (computer aided design) files and are transformed into GIS layers for use by other individuals in the department. There is also an individual at USFWS who was been contracted to work on geospatial data analysis pertaining to dune restoration. In addition, there are service centers and organizations with specialty concentrations (e.g., archeology) that provide GIS services to State Parks on a recharge basis. There are also many staff-level scientists within State Parks that have varying degrees of GIS expertise.

Tools Used by the Agency

State Park GIS analysts use ArcGIS Desktop. Some are outdated (e.g., ArcView version 9.1), while others are currently upgrading to version 10. The entire department also has "unlimited access" to ArcGIS Desktop 9.1 by way of Citrix terminal services that connect to a single server with a shared, map drive containing Parks data. However, this access of ArcGIS Desktop through terminal services results in reduced functionality, processing time, and other limitations.

AutoCAD is used to generate spatial information used at the "project level", such as designing and putting into digital record Parks assets and structures.

Information Management Systems

The Unit Data File (UDF) is a document library with approximately 12,000 records that includes planning documents, environmental impact reports, and archeological site information. At one time this was a customized ArcIMS application but recently they have implemented the GeoPortal Extension of ArcGIS Server. The purpose of the UDF is to consolidate relevant and critical documents for archival and research purposes. The GeoPortal Extension generates a spatial rendition of the footprint (e.g., a bounding box) for the record such that one can execute a spatial search for records. Importantly, the UDF only provides records of the data - not the geospatial data layers themselves. Consequently, there is a gap in the data hosted at the district level and those potentially available statewide.

Interviewees suggested that State Parks could benefit from an application like Cal-Adapt[20] that allows resource managers to view, analyze and download geospatial data.

There are enterprise- and personal-geodatabases scattered throughout the State Park departments. Some of these databases are co-managed with the National Park Service while other geodatabases have been developed to run district-wide.

Sources of Data/Information

State Parks relies upon many other agencies for data. Coastal LiDAR data are obtained through a cooperative between the Army Corp of Engineers and the California Coastal Conservancy. National Aerial Photography Program imagery comes from the U.S. Department of Agriculture by way of the USGS. The California Natural Diversity Database hosted at the California Department of Fish and Game is used to some extent. The BLM and California Department of Water Resources provide bathymetric data. Cooperative agreements exist between the BLM Coastal National Monuments, DFG and State Parks regarding the custody of resources in offshore rocks and islands and, consequently, relevant data are exchanged between these agencies.

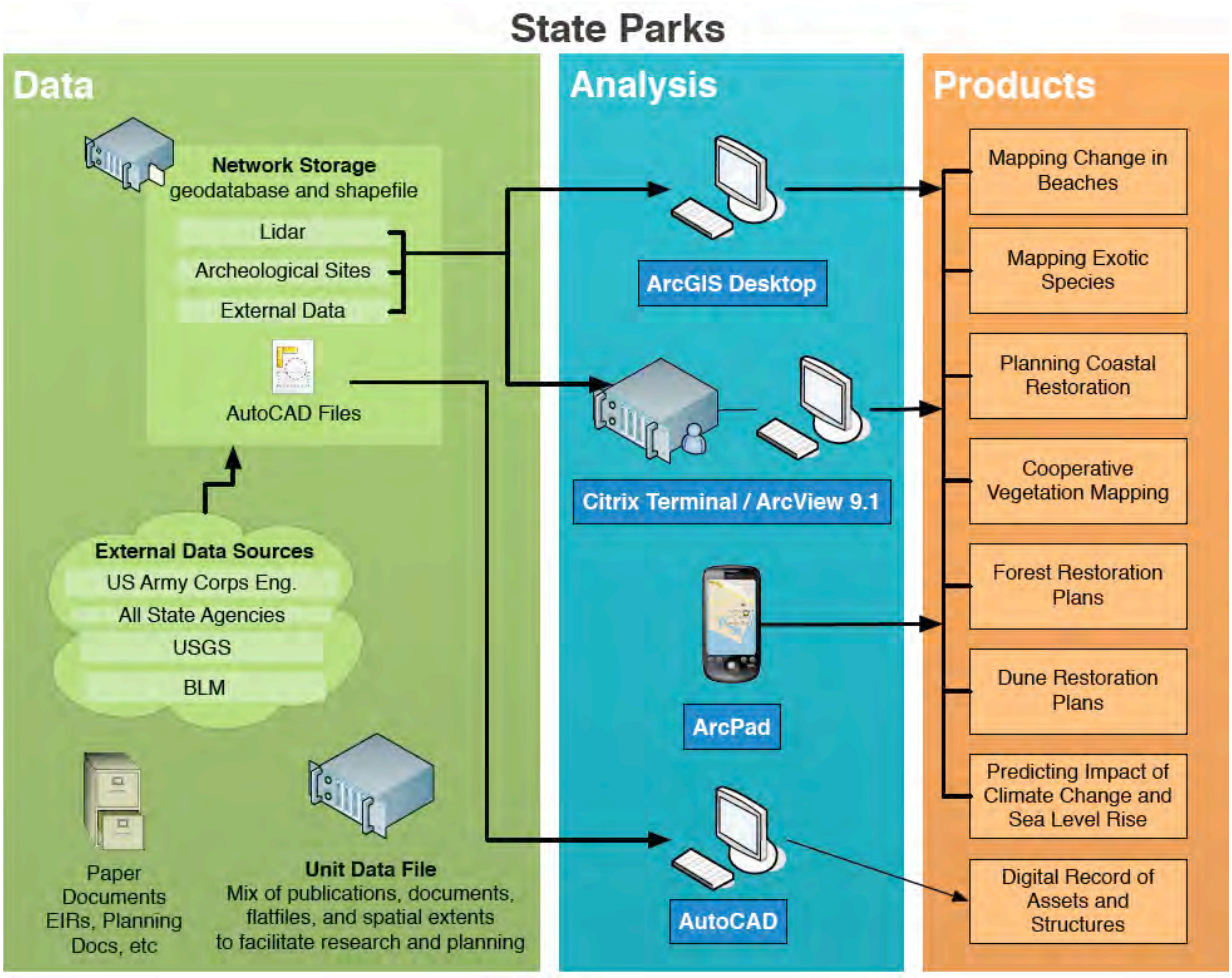
[20] http://cal-adapt.org/

Challenges

Limited funding and technical support: Individual State Park districts have varying degrees of funding and support. Generally speaking, the lack of dedicated support staff and GIS specialists is the most significant challenge to those working in the coastal and marine region. Existing staff are "dramatically overloaded" with work.

Limitations to data sharing and management: There is no FTP site for sharing data. Some data (e.g., LiDAR) are shared with entities (e.g., the Save the Redwoods League and the National Park Service) and, consequently, those data are hosted by partners. Other data (e.g., forest data) are intentionally kept internal until requested so that they are not abused. Data sharing occurs via email or CD/DVD.

Agency personnel expressed an interest in a centralized system for the management of coastal and marine geospatial data and metadata. It was suggested that the USGS national map model is only effective at the local level. State Parks could contribute a few modest datasets and these are already housed at the Natural Resources Agency.



San Francisco Bay Conservation and Development Commission

Agency Objectives

The Bay Conservation and Development Commission (BCDC) was established as a state agency in 1965 by the McAteer-Petris Act in order to help preserve San Francisco Bay from indiscriminate filling. Since that time, BCDC's role in the Bay Area has expanded to include overseeing all public and private development within 100 feet of the shoreline, ensuring public access to the shoreline and waters, coordinating shoreline restoration projects (e.g., salt ponds and wetlands), and planning region-wide responses to other emerging issues relevant to San Francisco Bay (e.g., adaptation to sea-level rise due to climate change).

BCDC is organized into several distinct units, including Planning, Permitting, Dredging and Sediment Management, and Enforcement. The Planning Unit is responsible for conducting planning studies, research, and periodic amendments to the San Francisco Bay Plan, Suisun Marsh Protection Plan and other BCDC plans. The Permitting Unit is responsible for ensuring that development in and along the San Francisco Bay is compliant with BCDC regulations, the Bay Plan and other BCDC policies. The Dredging and Sediment Unit works with federal, state and local partners to manage dredging and disposal activities in the Bay Area. Finally, the Enforcement Unit evaluates BCDC permits and activities in and along the Bay to assess if they are in violation of existing permit conditions and BCDC regulations, and, if they are, issues penalties of various kinds depending upon the violation.

Workflows

Planning

The Planning Unit undertakes diverse planning studies, which require research, data, and analysis. Because BCDC is a relatively small agency, it relies mostly upon data provided by other local, state and federal agencies as well regional non-governmental partners. For most studies, BCDC planners are able to use ArcGIS for simple overlay analysis and mapping, such as showing the location of a permitted development relative to the location of other assets. At times, planners have used ArcGIS to conduct more advanced spatial analysis, such as determining if existing Priority Conservation Areas are located along the shoreline and if they are at an elevation that would allow for species or habitat response to climate change.

As BCDC's planning responsibilities have become more comprehensive, its need for acquiring data from more sources and for conducting more advanced spatial analysis has increased. For the regional airport systems plan, for example, planners needed regional information across a variety of sources, including from local governments, other regional agencies, and state and federal partners. Other more comprehensive planning processes include ecosystem-based management approaches for San Francisco Bay. For plan amendments for specific projects, the Planning Unit's data needs are similar to the needs of the Permit Unit.

One example of a current major BCDC planning project is the Adapting to Rising Tides (ART) project. A key component of this is a Federal Highway Administration-funded project researching the projected sea-level rise impacts upon transportation infrastructure from Emeryville to Union City. The data for this study (e.g., shoreline typologies, parks, contaminated lands) have been

difficult to secure from the various federal agencies, local governments, and nonprofits that have them, as the data are not consistently in searchable databases, and planners then have to call the data providers to determine where they can go to access them.

BCDC served as a beta-testing group for Cal-Adapt[21], California's climate change research data portal, and tested the tool with local government partners. They found that it was great to have one place to go with lots of data, reports and maps. This information representing projected climate changes provokes questions for planning research (e.g., sea-level rise at particular locations, changes to water resources relative to the Bay) and guides the kind of policy changes that should be explored. BCDC planners also appreciated the peer review of the research on the site, including the site's inclusion of citations identifying the sources of each aspect of the research. Cal-Adapt has helped streamline the data consumption to data analysis process for the planning unit.

Planning staff expect that they will need to increasingly develop and provide geospatial data for projects, both for internal and external audiences, over the next 5-10 years. They anticipate BCDC will need to host an externally facing website where people can access and download data.

Permitting

The Permitting Unit primarily uses a combination of information provided by permit applicants (some electronic and some hardcopy), the Bay Resource Agency Tool (BayRAT), and data provided by partners and relevant agencies. BayRAT is a web-based decision support tool developed by BCDC planning staff to support planning, permitting, and other work by staff throughout the agency. By combining BayRAT and hard copy permit information, permit analysts are able to find historic permit information for a particular geography. Through the data layers in BayRAT, analysts can assess potential impacts of a proposed project upon different shoreline types, public access to the Bay, priority use areas, particular waterways jurisdictions, previously developed fill areas, natural resources and other shoreline assets of interest. If analysts need more information about permits for a particular parcel, they reference information in BayRAT to find the appropriate hard copy permit file to gain a better understanding of specific details associated with the permit.

Because the information in BayRAT is limited, analysts often rely upon the information provided by the application to conduct their permit analysis. If the applicant is not providing the most accurate data, then this lack of information could be reflected in the resulting permit. However, staff find that the information is reasonably accurate after an analyst has an opportunity to review it.

The Permit Unit has been trying for years to get a permit tracking system established, which would include an electronic log for permits and place information in a geospatial format for use within BayRat. The barriers to setting up this kind of system are that it would require additional funding and would be very time-intensive to get the current hard copy permit information entered in.

[21] http://cal-adapt.org/

Dredging and Sediment Management

The Dredging and Sediment Management Unit primarily uses BayRAT for analysis of dredging permits to see if they are consistent with the Bay Plan. In addition to the data available within BayRAT, analysts also get information on sediment types, dredging, and other data from the Army Corps of Engineers and other partner agencies of the Coastal Sediment Management Workgroup, which they can view in ArcGIS or in an online map viewer provided through the workgroup (coastalsediment.resources.ca.gov).

This Unit works closely with other state and federal agencies through the Long Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region (LTMS) Program to coordinate dredging planning and permitting. The LTMS program enables clear points of contact for addressing data sharing needs of the partner agencies, including historical information from the Army Corps Dredging database.

This Unit works with many different agencies that also track sediment types affecting San Francisco Bay. In partnership with these agencies, Dredging and Sediment Management Unit staff are able to get spatial information such as shapefiles delineating where mudflats, marshes, and wetlands are located, as well as information on how sediment dynamics are going to affect those areas. USGS is the primary agency that identifies sediment erosion areas.

Enforcement

The Enforcement Unit ensures that permit holders are complying with the rules and regulations required by BCDC permits. Consequently, it relies upon many of the same tools and information that the Permit Unit utilizes. In addition to these, Enforcement Analysts also update information on a particular permitted site with data gathered from their field visits.

Data, Information Systems and Tools

Human Resources

At BCDC, all GIS-related tasks, including cartography, data processing, and hardware maintenance, are handled by one FTE, a Coastal Planner / GIS Analyst (running ArcGIS Server 9.3.1). The GIS Analyst also supervises one to two interns that help him with GIS data or analysis tasks.

Tools Used by the Agency

All Commission staff use Apple computers and primarily use BayRAT to access spatial information. BayRAT, now in its 2nd version, is an ArcGIS Server based web-map. All data accessed through BayRAT is static and updated quarterly, if not more frequently. The information is organized by permit number, and there are sometimes multiple permits for a particular site. BayRAT includes a clip function to identify an area of interest in order to find permit information

within that geography. The parcel numbers for sub-tidal data in BayRAT now show public and private ownership, based upon the work of a NOAA Coastal Fellow.

For the next version of BayRAT, staff would like for it to be faster, more efficient, and to have a more intuitive design. They would also like for the permit tracking system to be linked to BayRAT, and there are plans and funding proposals out for this feature.

When staff need to conduct more robust geospatial analysis tasks than they are able to through BayRAT, they use one of four PC workstations with ArcGIS Desktop 9 installed.

Finally, staff use a variety of externally hosted web-mapping applications including Google Earth. For example, when permit staff are assessing shoreline conditions (e.g., riprap along the shoreline, what's next to a property, etc.), they will open windows for BayRAT and Google Earth and compare the data in side-by-side screens.

Information Management Systems

All BCDC internal data are stored as shapefiles, in raster format, and in personal geodatabases on a single server. The Coastal Planner/GIS Analyst oversees the maintenance of four GIS workstations, which are most often used by BCDC planners. BayRAT includes links to DFG's BIOS database (which is accessed frequently), San Francisco Estuary Institute's wetland tracker, and the Department of Toxic Substances Control's Envirostor database. Additional key data providers for use in the ArcGIS workstations include consultants, Bay Area counties, Metropolitan Transportation Commission, Association of Bay Area Governments, East Bay Regional Parks, CalTrans, US Fish and Wildlife Service, Army Corps of Engineers, National Marine Fisheries Service, NOAA, USGS, USEPA, and others.

After an internal legal review process, BCDC internal data, such as permit information, can be shared on a case-by-case basis with external audiences through email, FTP, mailing CDs, mailing external hard drives, or copying paper-based files. Staff can share internal geospatial data easily.

Challenges

Looking forward, BCDC staff realize that the current geospatial infrastructure will need to be improved upon to meet their needs. Some of the challenges with the current configuration include:

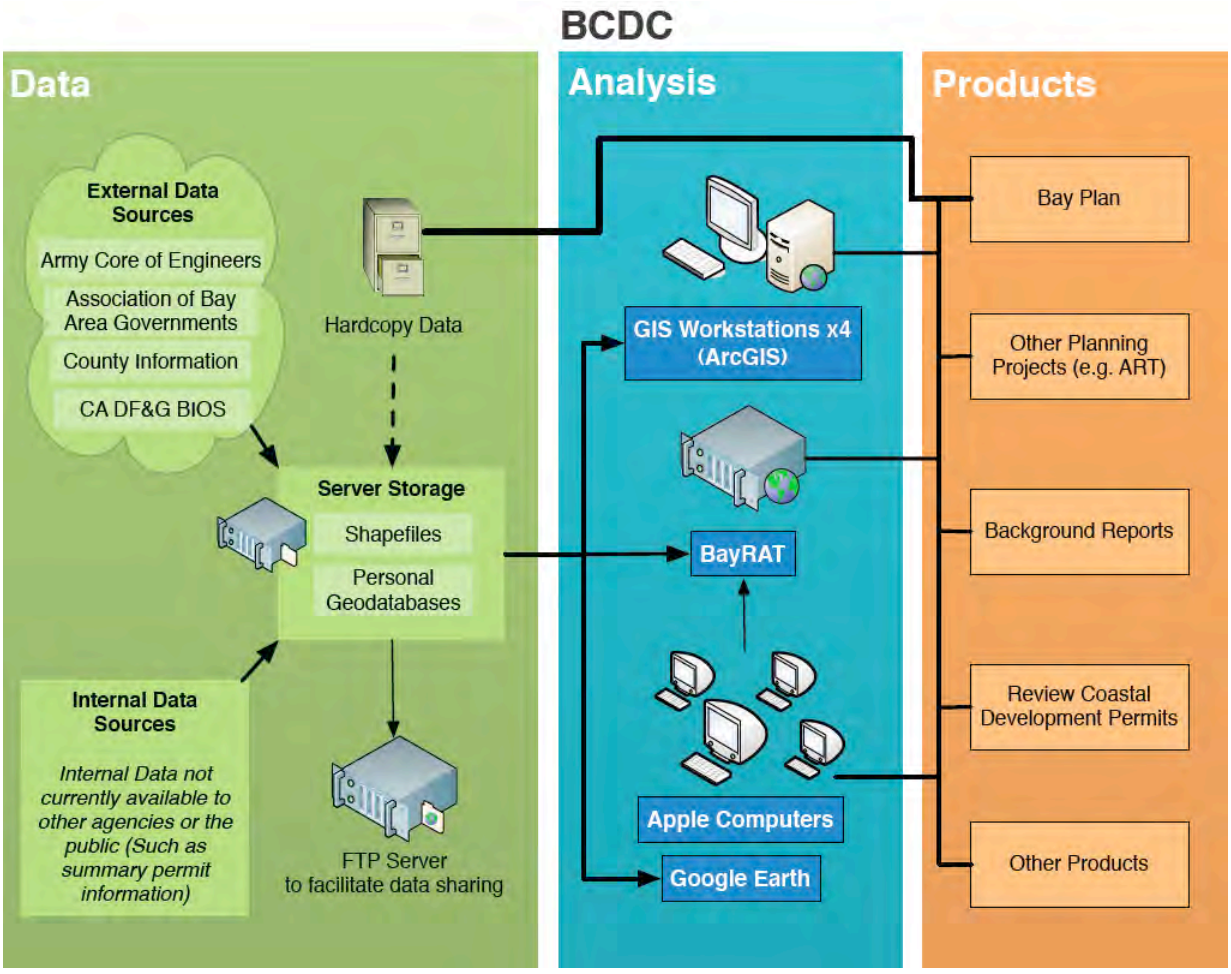
Finding and using data from many different sources. When staff need to pull together new geospatial information for use in a planning study or other project, they often don't know where the available information is, if it's valid, what the meta-data standards are for it, what scale it is appropriate for, what projection it is in, etc. They find that current data portals aren't comprehensive or completely appropriate for the type of work BCDC is engaged in (for example, they find DFG's BIOS database to be very hard to navigate), although NOAA is starting to create portals they think will help going forward.

Delays resulting from inaccessibility to data from other agencies. Because BCDC staff are so often dependent upon other agencies for data, the responsiveness of these other agencies can

dictate their workflows at times. Related to this is the time difference between whether or not the providing agency has a comprehensive data source or if staff have to go to multiple agencies for information (e.g., going to USFWS, DFG, and Audubon for data on the same bird species).

Lack of time to access additional geospatial information within the permitting process. The permit review process does not always allow time for additional data acquisition and analysis by the permit analyst, beyond reviewing information provided by the permit applicant. As a result, the value of additional geospatial information or more advanced analytical tools is not always readily apparent for permit analysts.

The agency's reliance upon Macs when ArcGIS is Windows-based. This set-up works for permitting, most of the time, because the Permit Analysts primarily rely upon BayRAT. For any visualization or analysis beyond the capabilities of BayRAT, staff have to download data for use at a GIS workstation. As a result, the workstations are most often used by staff or interns who are building datasets, and the analytical tools available in ArcGIS are underutilized. The availability of more sophisticated web based tools is a growing and important trend worldwide, so the Mac environment may become less of a challenge in the future.



State Coastal Conservancy

Agency Objectives

The California State Coastal Conservancy (SCC) uses a variety of methods to purchase, protect, restore, and enhance coastal resources and provide access to the shore. Through its grant-making and projects, the SCC works to: protect and improve the quality of coastal wetlands, streams, watersheds and near-shore waters; build trails and stairways by acquiring land and easements; revitalize urban waterfronts; purchase and hold environmentally valuable coastal and bay lands; and protect coastal agricultural lands.

Workflows

Planning

Projects at the SCC are virtually all conducted in partnership with other state and federal agencies (e.g., California Coastal Commission, Department of Fish and Game, USGS), local governments, or NGOs. Consequently, the SCC relies heavily upon project partners to provide geospatial information and maintain project archives. The geospatial information used to support regional planning (e.g., determining upland habitat and subtidal restoration goals) is generally managed and hosted by its non-profit partners.

Parcel line maps are crucial to work performed by SCC staff, but the mechanisms for accessing these data and the quality of the data are highly variable from county to county. Some data are publically available while others require a subscription. Some parcel datasets are statewide but are rarely at a resolution that is required at the project level. Parcels are used to examine easements or acquisitions for conservation or restoration projects.

LiDAR data are very promising, as they provide the kind of resolution that is useful to the SCC when reviewing project proposals. With LiDAR, for example, one can glean information about the kinds of soil that will be moved in a wetland restoration project. Other kinds of topographical information, such as most digital elevation maps (DEMs), are rarely at a resolution high enough to make informed project decisions.

Data, Information Systems and Tools

Human Resources

The SCC does not employ any GIS technicians, though about eight staff have some GIS proficiency. There are currently only three licenses for ArcGIS 10 owned by the SCC. In this sense, the SCC is fairly "lean" and partners with other state agencies when necessary. The GIS work performed within the SCC is confined to simple cartography (or the examination of maps) but not geoprocessing or analysis.

Tools Used by the Agency

The California Coastal Records Project and Google Earth are the primary geospatial tools used by staff at the SCC.

Information Management Systems

The SCC provided some funding for the development of, and now uses, the California Protected Areas Database[22], which was developed by GreenInfo Network. Likewise, the SCC has helped build and pay for the development and hosting of a geodatabase for the Coastal Commission. This includes maps of parcels, a coastal trail and general information on the coastal zone.

The SCC has mapped all agency projects in a web-based application where one can click on a particular project and get a picture and description of that project. This application was developed by GreenInfo and runs on OpenLayers.

There is an internal internet map service that the California Coastal Commission helped develop but it isn't used because it lacks a simple user interface designed for non-specialists. The SCC provided the hardware and software for this project. The mapping service includes coastal counties, basic parcel information, location of the coastal trail and watersheds.

The SCC has an information management system that includes a project database that tracks all of the projects they are working on. Although this information includes coordinates for project sites, the database is not geospatial--i.e., it's not a "geodatabase," and other spatial information is very limited. This database is a combination of a Microsoft Access front end with a Structured Query Language (SQL) Server back end. Most geospatial information, including land surveys and habitat maps, are not stored in any centralized way. Although there is currently an effort to expand the SCC's information management system, this does not include geospatial information.

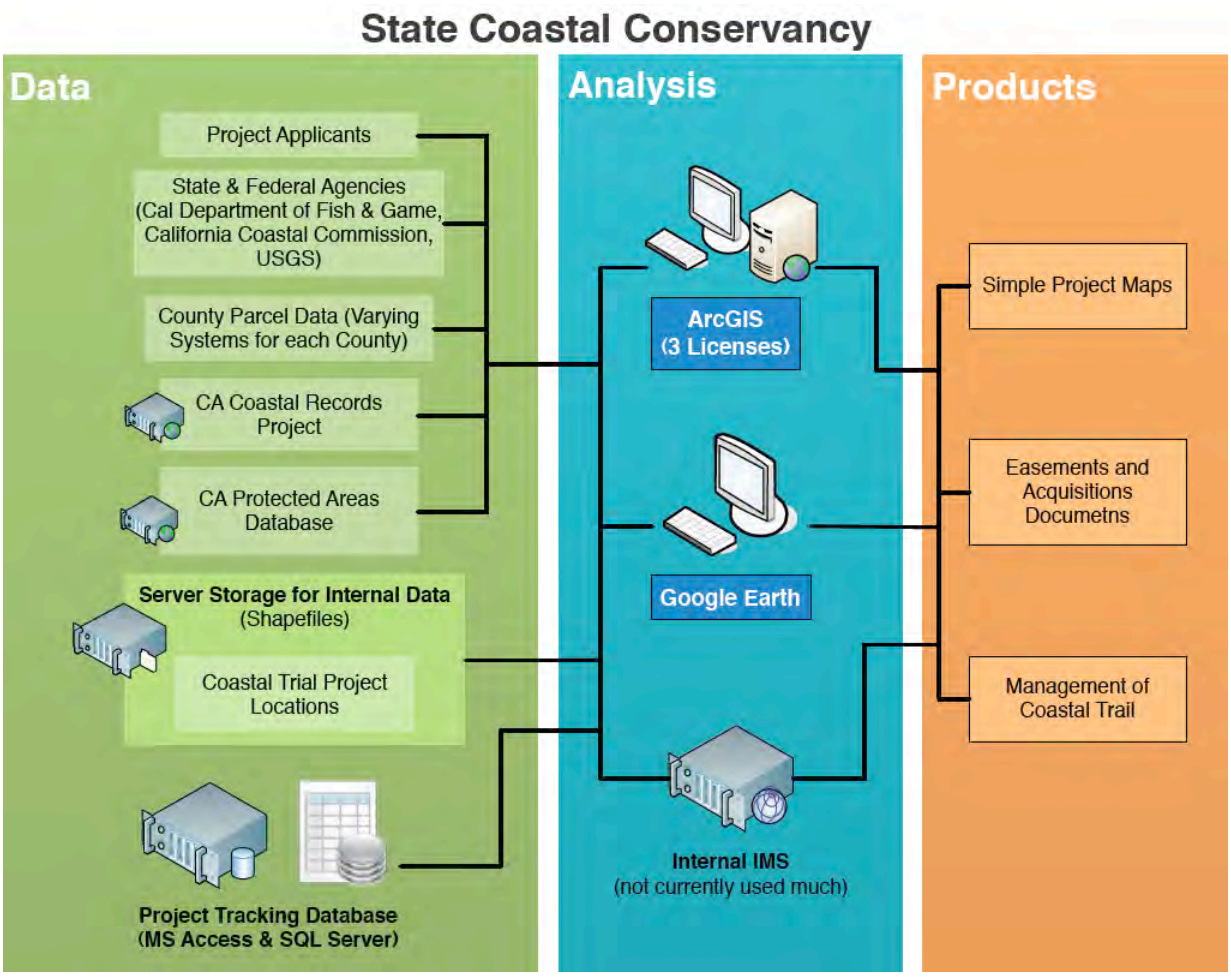
The SCC maintains a good record of the California Coastal Trail, and currently this exists only as a shapefile on a desktop computer.

Challenges

Training on Simple Tools: The SCC does not need additional GIS specialists to accomplish their work. Rather, the SCC needs some additional training, described as a "half-day GIS camp" for project managers to gain some GIS proficiency. In particular, SCC staff could benefit from experience with simple GIS tools such as Google Earth and web-based tools designed for the non-specialist.

Data Quality and Availability: Parcel maps, which the SCC depends on for much of their work, vary in precision and resolution from county to county. Furthermore, some data are freely available while others (e.g., Los Angeles County) require a subscription.

[22] http://www.calands.org


State Coastal Conservancy
Data
Project Applicants
State & Federal Agencies (Cal Department of Fish & Game, California Coastal Commission, USGS)
County Parcel Data (Varying Systems for each County)
CA Coastal Records Project
CA Protected Areas Database
Server Storage for Internal Data (Shapefiles)
Coastal Trial Project Locations
Project Tracking Database (MS Access & SQL Server)
Analysis
ArcGIS (3 Licenses)
Google Earth
Internal IMS (not currently used much)
Products
Simple Project Maps
Easements and Acquisitions Documetns
Management of Coastal Trail

State Lands Commission

Agency Objectives

The California State Lands Commission (SLC) provides stewardship of the lands, waterways, and resources entrusted to its care through economic development, protection, preservation, and restoration. SLC consists of four divisions.

The Division of Environmental Planning and Management ensures compliance of the State Lands Commission with the provisions of the California Environmental Quality Act (CEQA), and provides analytical staff services (policy and technical) to the members of the Commission, it's Executive Officer and the line programs.

The Land Management Division has primary responsibility for the surface management of all sovereign and school lands in California. This responsibility includes the identification, location, and evaluation of the State's interest in these lands and its leasing and management.

The Marine Facilities Division was given pollution prevention and response authority by the Lempert-Keene-Seastrand Oil Spill Prevention and Response Act of 1990. To support this responsibility, the division carries out inspections and develops regulations such as the Marine Oil Terminal Engineering Standards. *The Ballast Water Management for Control of Nonindigenous Species Act* of 2000 added management of invasive species to the Marine Facilities Division's responsibilities.

The Mineral Resources Management Division manages the use of energy and mineral resources of more than 160 oil, gas, geothermal, and mineral leases covering more than 153,000 acres of state-owned lands. These leases include activities in the waters of the Santa Barbara Channel and off Los Angeles County and Orange County. The Division's goals are to ensure public safety, protect the environment, and maximize revenue.

Workflows

CEQA Review for Leases

Development projects planned for state lands require a lease from the State Lands Commission. This includes structures such as piers, buoys, offshore oil, and gas development within state waters. Detailed information on activities and developments within leased lands collected by surveyors are stored in hardcopy and drafted in computer aided design (CAD) systems by the Land Management Division when leases are negotiated.

The Commission uses geospatial information extensively to comply with CEQA and develop mitigation measures and lease conditions. This is done primarily through the use of environmental impact reviews coordinated by the Division of Environmental Planning and Management. Geospatial analyses and data are compiled by the SLC, contractors, and lease applicants. Two staff members in the division have GIS expertise to facilitate this process. While some data layers are maintained in house, most data are gathered in support of each review and are not stored in a single database. These data are synthesized into products, such as maps, for use by Commission decision makers. These products can also be used to facilitate planning by

other statewide efforts. Providing digestible data products for use in decision-making is a key concern for Division of Environmental Planning and Management staff.

Managing Oil, Gas, and Geothermal Leases

The Minerals Resource Management Division manages oil, gas, and geothermal leases. The division makes limited use of GIS, solely as a visualization tool for creating maps of leases, engineering flow diagrams, and geological maps. The Division posts these lease maps on their website in pdf format using ArcGIS. Leases go through review processes at the Land Management Division and the Division of Environmental Planning and Management, where geospatial data is used to inform decisions. Analytical tools for processing geospatial have been used to identify state lands that are suitable for leasing; this workflow is no longer practiced. When spatial data are utilized, outside sources include lease applicants, the California Geological Survey, and the California Department of Conservation.

Invasive Species Management

Geospatial data are also used by the Marine Facilities Division to assist in efforts to prevent marine invasive species via commercial ship ballast water and vessel fouling. The division maintains a database that stores the source of incoming ships, their destination within state waters, and where ballast water exchanges have taken place. It contains as many as fifteen thousand records per year. Ship operators submit this information via fax, and it is entered into the database by Marine Facilities Division staff. From these data, biannual maps and reports are created and used to enforce restrictions on where ballast water exchanges can take place in relation to state waters. The Marine Facilities Division is also pursuing more aggressive regulation, which would involve sampling ship ballast water directly for invasive species. Ship operators would be required to install treatment systems on ships, and SLC would regulate the density of these organisms that can be in ballast water exchanged in state waters. The current information system is to be expanded to include this information.

Data, Information Systems and Tools

Human Resources

The SLC currently has limited staff solely dedicated to working in GIS and each of the divisions have varying degrees of GIS capacity and expertise.

Tools Used by the Agency

The SLC primarily uses a combination of ArcGIS software, Access databases, flat files and personal geodatabases on desktops or on shared network storage to manage and access data. Google Earth and KML files are also used and is more widely used by agency staff. Different divisions rely on centralized IT services to manage shared network storage and ArcGIS installations. Installations

of ArcGIS are generally kept up to date, with staff interviewed all indicating that they are running version 10 of the software. Geospatial data is managed on a project-by-project basis within these shared drives rather than a centralized database.

Information Management Systems

Lease boundaries are developed or provided by lease and permit applicants as CAD files and stored on the Land Management Division's shared network drive. These data are managed using AutoCAD. The Land Management Division also stores detailed lease information in the Application Lease Information Database (ALID). The Land Management Division relies on AutoCAD and does not use geospatial tools, although there is some desire to make use of ArcGIS to fulfill their tasks.

The Division of Environmental Planning and Management makes extensive use of GIS using ArcGIS 10, ArcExplorer, and Google Earth. The division has undergone a process to compile and derive point locations and other attributes of leases from ALID into shapefiles for use in ArcGIS for planning purposes. This information is also used alongside satellite imagery in the Google Earth desktop application to look for non-leased facilities. Currently staff is working to link coastal lease GIS datapoints to coastal photographs from the California Coastal Records Project. The Division of Environmental Planning and Management utilizes data layers stored as flat files (shapefiles) on a shared network drive. These data layers include lease locations, a shipwrecks database, the California Natural Diversity Database from the Department of Fish and Game (updated monthly), hydrographic data, county layers, and data layers provided by lease applicants and contractors as part of environmental impact review processes.

Within the Marine Facilities Division, geospatial information is accessed and managed on local desktop machines using ArcGIS 10 with the Spatial Analyst Extension. Staff environmental scientists use their local desktop storage to manage shapefiles, which include cadastral and physical data such as world exclusive economic zones (EEZ) and state boundary layers, bathymetry, and world land layers. Shared network stores are not utilized for managing data due to storage limitations. An Access database is used to store data on the location of ballast water exchanges. This database is hosted on a server within the division, and is subject to serious quality of service issues where access may be suspended for a period of days. These data must be manually transferred into ArcGIS by analysts to create maps and other data products, due to the non-spatial nature of Microsoft Access. Data from this database is usually shared among other agencies and interested parties as a spreadsheet. There are plans for further development of these systems to allow ship operators to enter data into this database using a web interface, allow database access by offsite inspectors, expand the database schema, and support better integration with ArcGIS. These plans are funded but subject to a lengthy approval process and dependent on SLC IT infrastructure capacity.

The Minerals Resources Management Division has access to three licenses for ArcGIS 10, which are used sparingly. For the most part data are managed outside of GIS, within Access databases or flat files. When utilizing GIS, staff rely on shapefiles stored typically on local desktop machines due to limited space on network storage.

Challenges

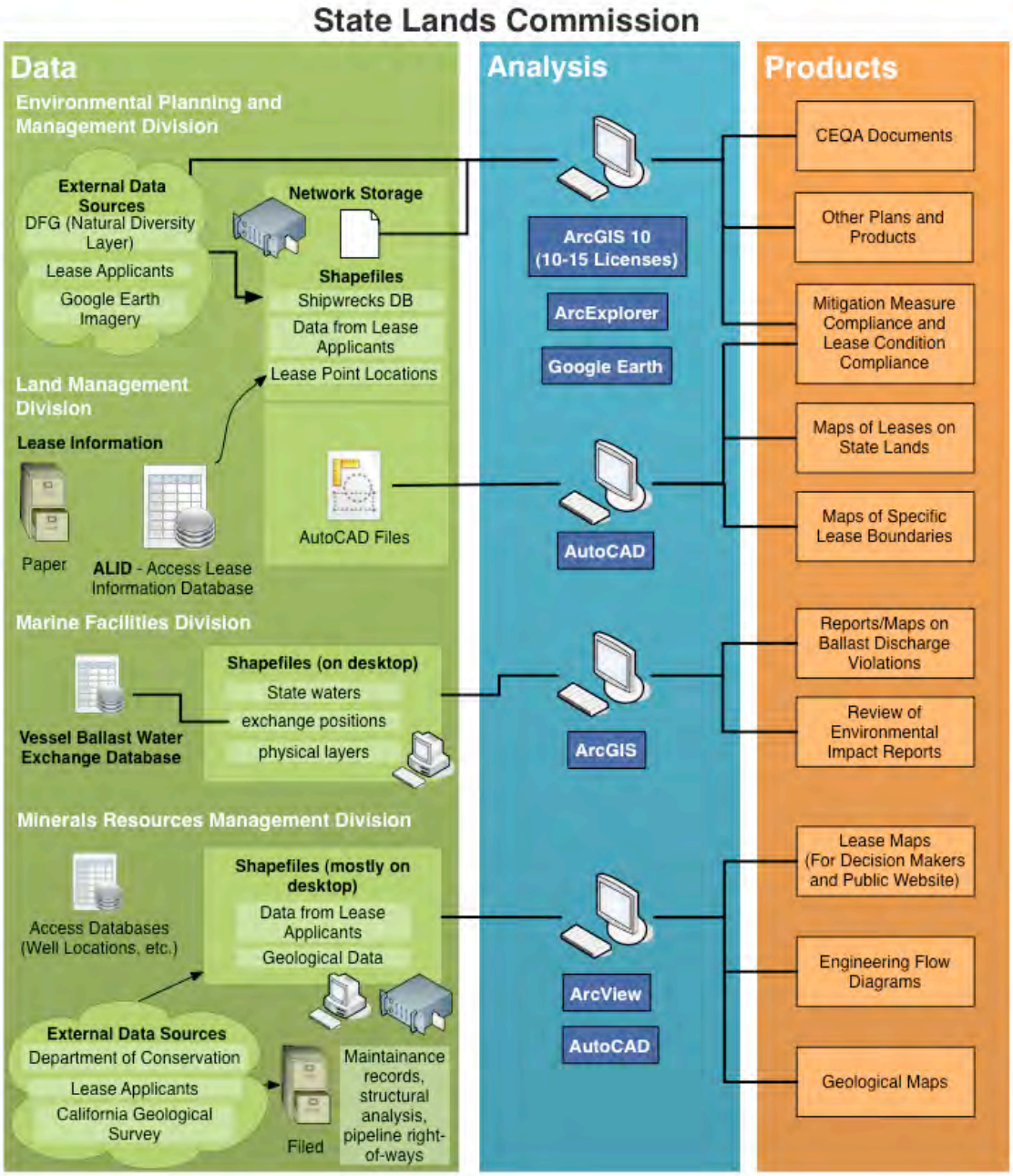
Lack of Sufficient Funding: One of the most critical challenges for the SLC is a lack of funding for GIS activities within the agency. The Division of Environmental Planning and Management hosted a GIS group to assist ongoing efforts involving geospatial information within the agency. This group was disbanded in 1999 due to budget cuts, reducing opportunities for shared intellectual and IT resources. Each division within the agency has geospatial data users, but their activities and data operate within the limited scope of their division or project.

Need a Large Centralized Database: As a consequence of lack of resources, the Division of Environmental Planning and Management relies extensively on contractors to gather and assess data, construct models and geospatial analyses, and develop products in support of environmental impact reviews and planning efforts. This process, and the provision of data by lease applicants, generates a large volume of useful geospatial information. Unfortunately the SLC does not have the necessary IT infrastructure to manage all of this data in a centralized geospatial database. It cannot be effectively used for future projects, or shared with other agencies. Existing server infrastructure is limited in storage space, subject to outages, and policy limitations affect the timely use of software. Creating such a database would require additional funding and personnel. SLC staff indicated that in the absence of such funding, it would be desirable to have access to such hosting infrastructure provided by the OPC. Similarly, the Minerals Resources Management Agency has an abundance of geospatial and engineering data generated in response to leases and provided by lease applicants. Staff expressed a desire to proactively manage these data inside a centralized, geospatial database to support future uses. Here too there is a lack of the necessary resources to effectively do so. Staff identified a need for dedicated and responsive database administrators to manage these data and policies that make available the necessary software to utilize them.

Many other agencies interviewed for this study identified a need for geospatial data on SLC leases and jurisdictional boundaries. There are significant challenges to creating such a dataset. Like most California agencies, these data are spread over a variety of formats and information systems. Lease boundaries are stored in CAD files by the Land Management Division, but the Division of Environmental Planning and Management is in the process of creating their own derived dataset containing the point locations of leases for use in ArcGIS. The differing resolution and formats of these datasets support divisional efforts well, but could result in data management problems. They also may not be in the appropriate format and detailed enough for outside efforts such as the MLPA Initiative. Recent lease information is stored within ALID, but many leases are still described within paper records. Jurisdictional boundaries are also subject to varying environmental conditions, such as the current state of navigable State waters. This sort of information is typically evaluated on a project-by-project basis. Developing a statewide dataset would require substantial investment and would be necessarily subject to caveats.

Difficulty Finding External Data: While interviewed staff felt current agency objectives were met by existing datasets, staff identified a need for simpler ways to find and access data from outside sources. High Frequency Radar data on ocean currents, Marine Protected Area and National Marine Sanctuary boundaries, raw LiDAR, and Environmentally Sensitive Habitat Areas were among the datasets identified. Data from the Department of Fish and Game are also currently utilized but are infrequently updated. Beyond these specific datasets, SLC staff were supportive of the concept of a coastal and marine data atlas, as well as a "data librarian" who could guide them towards data that were useful for a particular purpose. Interviewees also felt

that data diplomats within each agency that help facilitate data sharing outside their agency was a good idea, but that necessary financial incentives would have to be in place to make such a program successful.



State Water Resources Control Board

Agency Objectives

The California State Water Resources Control Board (Water Board) was established in 1967 to support and coordinate decision making on water quality and water quantity issues in the state. The Water Board allocates water rights, adjudicates water right disputes, develops statewide water quality control plans, establishes water quality standards, and guides the nine Regional Water Quality Control Boards, which have jurisdiction over the major watersheds of the state.

The Water Board is organized into several divisions, including Administrative Services, Financial Assistance, Water Rights, Information Technology, and Water Quality. The Division of Water Quality includes two branches: Ground Water Quality and Surface Water Regulation. The Division of Water Quality also includes the Ocean Unit, which "is responsible for the development and updating of statewide water quality control plans, policies, and standards involving marine waters."

The Water Board also has an Office of Information Management and Analysis, which houses the Surface Water Ambient Monitoring Program (SWAMP) Unit and supports the California Water Quality Monitoring Council. SWAMP coordinates all water quality monitoring conducted by the State and Regional Water Boards. The California Water Quality Monitoring Council (Monitoring Council) was established by the California Environmental Protection Agency (Cal/EPA) and the California Natural Resources Agency in order to integrate and coordinate the water quality and related ecosystem monitoring, assessment, and reporting conducted by the two agencies.

Workflows

Planning

The Water Board undertakes a wide variety of planning efforts to ensure the state complies with the federal Clean Water Act and additional state-level regulations. Planning that is most relevant to this Scoping Study is included in the water quality control plan for the ocean waters of California, called the California Ocean Plan, in accordance with section 303(c)(1) of the federal Clean Water Act and section 13170.2 of the California Water Code.

This plan is developed by the Water Board's Ocean Unit and regulates point source discharges into the open ocean, but does not regulate discharges into bays (the Enclosed Bays and Estuaries Plan addresses this issue). These discharges include those regulated under the National Pollutant Discharge Elimination System (NPDES), such as stormwater, wastewater, commercial vehicle discharges (e.g., cruise ships), and industrial discharges. The data on these pollution sources and amounts is collected from information the Water Board has collected directly, as well as permit and monitoring information the State Water Board has received from the regional water boards.

As part of the 2009 Ocean Plan, the Ocean Unit staff created several maps showing NPDES Discharge Outfalls, Vessel No Discharge Zones, Marine Protected Areas (MPAs), Enclosed Bays and Estuaries, and Areas of Special Biological Significance (ASBSs or marine managed areas that are not MPAs), as well as Regional Water Board and County boundaries. For the ASBSs, the Ocean Unit has a GIS layer showing the location of each storm drain outfall in these areas.

Some of these data were also utilized in the MLPA Initiative process to support MPA planning. Beyond this example, other California agencies typically do not request these data and may not know the Ocean Unit has it. The Ocean Unit works with many other agencies (e.g., the California Coastal Commission), but geospatial data has not been a focus of this work to-date. The Southern California Coastal Water Research Project (SCCWRP) is often contracted to collect ocean water quality data for the Ocean Unit, such as the map of NPDES discharge locations. The Ocean Unit also updates a statewide GIS layer delineating where boats launch to collect mussels, as these are used as an indicator of water quality along the coastline.

A current planning project for the Ocean Unit is establishing a no discharge zone for the whole coastline for large commercial vessels (this is a proposed rule by the USEPA). Another is supporting a debris policy that is in development, which seeks to reduce the amount of trash that makes its way into the ocean. Both of these projects involve a Water Board GIS analyst, who is conducting a variety of geospatial analyses to support policy development.

Permitting

The State and Regional Water Boards issue permits for a variety of different types of discharges into waterways (most permits are issued at the regional level). Of most relevance to ocean issues are permits issued under NPDES, Vessel Discharge permits, and storm water permits issued to cities. NPDES permits cover point sources of pollution throughout the state. Information on these permits is housed in the NPDES Regulatory and Compliance Database and tracked in the California Integrated Water Quality System Project (CIWQS). The CIWQS system provides permit and order tracking, inspection tracking, self-monitoring report tracking, management of violations and enforcement activities, reporting of regulatory information both internally and externally, and billing information tracking.

Monitoring

Water quality monitoring is a core component of the Water Board's work and the Board has put a lot of resources into supporting data collection and management in this area. In order to coordinate the water monitoring activities of the State and Regional Water Boards, the State Water Board created the Surface Water Ambient Monitoring Program (SWAMP). Whereas permits focus on the amount of pollutants to be discharged by each point source emitter, the monitoring programs assess to what extent the sum total of these and other discharges are below or exceed the Total Maximum Daily Load (TMDL) for pollutant concentrations in "Impaired" water bodies. TMDLs are established by the state, and the USEPA requires that the state ensure pollutant concentrations do not exceed them. The SWAMP database was created in order to collect monitoring data on ambient water quality to assess whether these water bodies were meeting TMDL and other regulatory requirements. SWAMP is designed to share geospatial data with USEPA's national Water Quality Exchange database (formerly called STORET). Because the SWAMP database is used for regulatory decision-making, it has a high requirement for data quality.

Building upon SWAMP, the State has recently established the California Environmental Data Exchange Network[23] (CEDEN), in order to serve as a data-exchange network not only for SWAMP data, but also for citizen monitoring groups, regional programs, regional boards, and multiple state agencies. CEDEN will serve as the common system to capture and distribute all of the various forms of water quality data in standardized formats, but it is not trying to bring all of these data into a single system. Currently, most of the data that is available through CEDEN is from the SWAMP dataset (e.g., chemical and physical data). It will soon have biological, invasive species, marine debris, and other types of data related to fresh and saltwater water quality.

The metadata for the CEDEN system will be in the California Environmental Resources Evaluation System (CERES) established format. The SWAMP program has had an elaborate set of data standards, and most of their data sources follow the SWAMP template. CEDEN has taken a sub-set of the SWAMP template standards to serve as the minimum standards for the much broader types and sources of data that will be in CEDEN, including who collected the data, when, where, what quality assurance protocols were used to collect the data, and others. While CEDEN will require data providers to meet this minimum threshold, they will also encourage people to do better than those minimums in order for the data to be more valuable for more applications over time. CEDEN will become the California conduit for sharing data with USEPA's Water Quality Exchange database. To effectively inter-operate with this and other national databases, CEDEN is trying to make sure that their data can work with, and can be pulled out of, the federal system.

CEDEN pulls data from four regional data centers throughout the state (California State Water Resources Control Board, Moss Landing Marine Laboratories, San Francisco Estuary Institute, and the Central Valley Data Center), with each center focusing collecting data on a particular geographic area. These data centers do not house the data, but serve as a conduit between the people collecting the data and getting the data into a centralized CEDEN database. The data centers provide one-on-one interactions with data providers to help them structure and import their data into CEDEN. The regional data centers are currently funded with money from the Water Board from bond funds. In the future, the data centers will need to have a mechanism to become self-supporting.

Finally, the Water Board has recently created a new database for water quality assessment, called the California Water Quality Assessment Database (CalWQA). It is the repository for the state's Clean Water Act Section 303(d) pollutant impaired water body information. It links to other databases, such as SWAMP, by using the water quality monitoring or discharge information in those other databases to assess whether a water body is listed as "impaired" by a particular pollutant.

Data, Information Systems and Tools

Human Resources

The Ocean Unit has partial use of one GIS analyst, who also supports two stormwater permitting units of the Water Board. The GIS analyst is professionally trained in GIS, and the Ocean Unit also relies on student assistants who can work part-time. For advanced mapping or geospatial

[23] http://www.ceden.org/

analysis projects beyond the capabilities of their GIS analyst, the Ocean Unit staff work with the SWRCB's Office of Information Management and Analysis.

The Water Board's Office of Information Management and Analysis (OIMA) has provided staff support to develop many of the geospatial information systems used by the agency. Their office currently consists of 2.5 FTEs. Their staff are very experienced (i.e., 6-7 years of experience in GIS enterprise technology), and additional staff have been added to other offices of the Water Board to support CEDEN and many of the other data platforms.

According to interviews both within and outside of the Water Board, the capacity and tools that the Water Board has created are robust. The staff are adept at creating leading edge, enterprise-wide technologies and maintaining the technical infrastructure. Their ability to quickly create new data analysis and mapping tools has been improving, both because of more experienced staff and because other Water Board staff have begun to utilize better methods to collecting data. This has resulted in organized and high quality data that then enable better tools. OIMA has provided web-based tools to staff for entering records that have largely automated the process for quality assurance and quality control (QA/QC).

Tools Used by the Agency

GIS professionals at the Water Board utilize ArcGIS Desktop and ArcGIS Server versions 9.3 and version 10, depending upon which office they are in. The customized web mapping applications mentioned earlier were created using Esri or Google technologies.

Information Management Systems

OIMA staff and others at the Water Board have created a variety of different geospatial information management systems and tools to support their work. None of these have been explicitly created to meet the needs of the Ocean Unit, but the Ocean Unit uses several of them in the course of their planning and analysis. The Ocean Unit's GIS data are stored in their section's office. While the Water Board has a GIS library, there is no formalized process to ensure that the Ocean Unit's data are stored there.

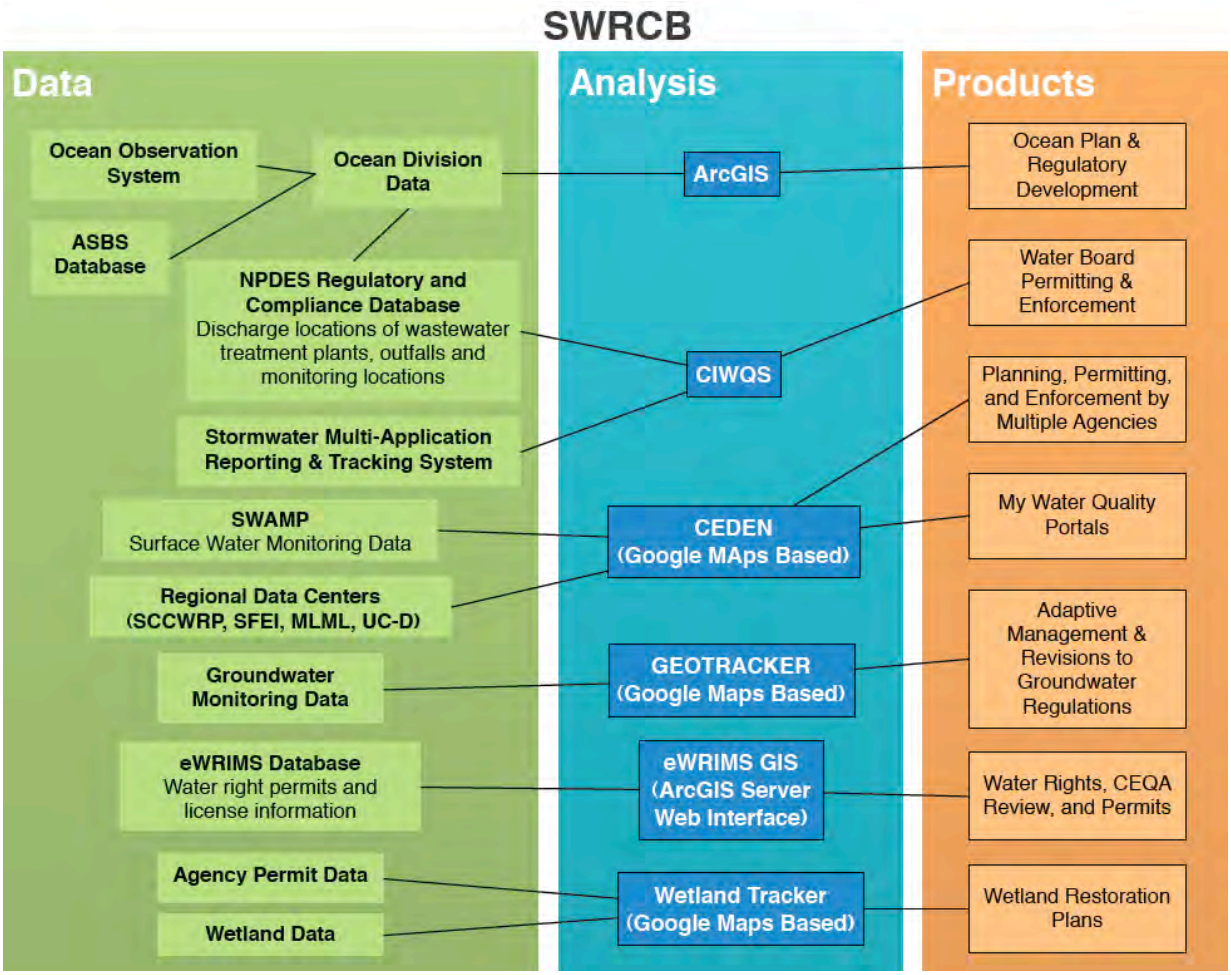
Challenges

The complexity of the Water Board's structure (with nine regional boards) creates challenges in sharing information across different parts of the organization and between the State Water Board and regulated entities. Confusion also arises from the divisions between staff and regulations that address surface water and those that address groundwater.

Funding: The greatest limiting factor in creating robust geospatial information systems for the Water Board is the lack of staff available to create and maintain these systems, as well as the lack of funding for collecting and maintaining data. CEDEN, for example, relies upon bond funding for its regional data centers, and the *My Water Quality* site (see Section 4) is mandated by legislation but does not have a long-term budget for developing the issue-specific portals.

Upgrading: The diversity of software and systems across the Water Board also creates technical challenges in making older systems work with the new. Effectively communicating the need to plan and pay for these upgrades to stakeholders who put a lot of human and financial resources into the existing systems is challenging.

Training: The Water Board has a basic GIS course, which is focused on ArcMap and ArcExplorer, through their training academy. However, they could use a data collection training to help staff understand how to get data from the field into a format usable for GIS systems (e.g., geocoding, field data collection). Doing this well is critical for everything else the Water Board wants to do with technology afterward. Providing training on the data and web services that are currently available may also help improve staff's use of these tools and support for developing custom tools within the agency.



Section 4: Interoperability Assessment

This section provides a summary of other information management systems both within and outside of California that may inter-operate with California coastal and marine agencies. California should consider the lessons learned from these geospatial information management system operators as it takes steps to improve its own systems for sharing coastal and marine geospatial data.

Relevant California Geospatial Information Management Systems

The consulting team interviewed the leaders of four natural resource-focused geospatial information projects in California to understand their systems, development and information management strategy, structure, and current capacity and resources.

California Environmental Resources Evaluation System

The California Environmental Resources Evaluation System (CERES) is an office established within the California Natural Resources Agency (Resources Agency) that works to facilitate access to a variety of California environmental data. The staff at CERES have created a variety of tools and resources, including an environmental information clearinghouse for the State of California (California Environmental Information Clearinghouse, or CEIC), a geospatial data library (Cal-Atlas), and map server services for the Resources Agency. CERES also hosts a web-based library for the discovery of and access to ocean and coastal data and information (California Ocean and Coastal Environmental Access Network or CalOCEAN). CERES has 7 full time staff, including several developers. Half of their staff are state civil service employees and half University of California-Davis employees.

Based upon external interviews and the consulting team's own evaluation, Cal-Atlas currently has a relatively complex interface and appears to be designed for use by GIS technicians (users are able to download raw data) rather than end users of geospatial information. Cal-Atlas is being updated to adopt the easier interface of the California Strategic Growth Council data library. CERES has also provided several geospatial visualization systems for other agencies as necessary (e.g., MyPlan, CA Now, and others).

The foundational technology used to implement these different CERES projects could support and interoperate with a new coastal and marine-focused geospatial IMS. These tools, in many cases, rely on web services published using ArcGIS Server, which could be consumed by an IMS developed using ESRI or open source technology. The Resources Agency Atlas/Map Server[24] provides an interface to discover these web services that are used by Resource Agency GIS users.

Additionally, CERES has the staff and infrastructure necessary to support the central data repository envisioned in the technical requirements listed in Section 6. The Department of Water

[24] http://atlas.resources.ca.gov/

Resources and the Natural Resources Agency are in the process of developing a modern Tier 3 datacenter (i.e. a server farm with redundant capacity, multiple uplinks, and backup power in order to guarantee 99.982% availability of the infrastructure) with the support of the State Technology Agency. Development of this datacenter in coordination with the State Technology Agency could enable CERES to more quickly and cost-effectively support new projects. CERES also has experience working with multiple data providers in a collaborative manner. In service of an initiative of the California Strategic Growth Council, CERES has been facilitating a four-agency[25] collaboration to facilitate geospatial data sharing. This project has involved building a geospatial data portal that relies on web services hosted by the participating agencies, as well as working with data stewards within some agencies to centralize datasets for those agencies lacking the capacity needed to serve their data to others. This model could be replicated to support the data sharing effort envisioned in the Section 6 of this report.

CalOCEAN

CalOCEAN was created in 1997 to provide a discovery and access to ocean and coastal data and information[26]. The site consists of directories of links to data sources organized by different points of entry (e.g., by the relevant state agency, data type, geographic area, or other categories). Many of the links to data holdings are no longer operational and the search feature on the site does not function.

CalOCEAN has not been updated for quite some time (e.g., the homepage has not been updated since 2006) and is not actively managed. If CalOCEAN were fully functional, it could provide a valuable mechanism to search for coastal and marine data holdings by category and metadata. However, it implements only a small subset of the features and requirements listed in the section of this Scoping Study on Functional Requirements and Recommendations (Section 6). CalOCEAN can serve as a useful model as a directory of spatial data providers, but would not serve as an extensible basis for the scope of a geospatial information management system described in Section 6. The information cataloged in CalOCEAN should be pulled into any new geospatial IMS that is developed.

The primary lesson that should be learned from the CalOCEAN experience is that without dedicated and long-term staffing and resources, any geospatial IMS effort will struggle to stay relevant to the needs of ever evolving coastal and ocean agencies.

The MPA Monitoring Enterprise's Ocean Spaces Site

The MPA Monitoring Enterprise was established in 2007 as a program of the California Ocean Science Trust to lead the scientific monitoring of the newly established Marine Protected Areas (MPAs) in California state waters. This monitoring will support adaptive management of these MPAs over time.

[25] The California Strategic Growth Council is a collaborative effort of the California Business, Transportation and Housing Agency, the California Health and Human Services Agency, the California Environmental Protection Agency, and the California Natural Resources Agency.
[26] http://ceres.ca.gov/ocean/abstract.html

As part of this work, the Monitoring Enterprise has been developing a new community platform called OceanSpaces, which will build a community of scientists and stakeholders involved in MPA monitoring around a common source of information - the objective, impartial, scientific information to serve as the basis for MPA management and decision-making. The site will include the ability to form communities of shared interest (e.g., for a particular MPA and/or for a particular ecosystem or human use), present monitoring information and evaluations spatially, and provide data for download and use offline.

The focus of OceanSpaces on community and social tools and functions offers an interesting opportunity to pilot a new approach for sharing data and networking diverse user communities, existing databases and websites. A coastal and marine IMS could incorporate a similar component to support data sharing across particular sub-groups of the California coastal and marine community. This community feature could be a logical extension in a future version of a coastal and marine geospatial IMS. Additionally, if CERES or another agency were to serve as the central data repository of the coastal and marine geospatial IMS, then the Monitoring Enterprise could interoperate with this system to share data.

My Water Quality Website

The California Water Quality Monitoring Council (Monitoring Council) has been leading an effort to create the new "My Water Quality" site[27]. While many previous environmental information efforts have focused on creating large databases with standardized data in order to meet a wide variety of needs, the Monitoring Council has focused on providing a limited set of data to users focused on answering key public-oriented questions, such as "Is it safe to swim today?" Several different such questions are addressed by different portals on the website, with workgroups of experts creating each of these portals and ensuring the quality of the data involved.

There are currently three working portals: 1) safety of swimming in coastal waters (e.g., bacterial indicators of contamination and how that translates into safety), 2) safety of eating fish and shellfish (e.g., bioaccumulated pollutants, lake and reservoir monitoring), and 3) an ecosystem health portal focused on wetlands. There are geospatial data presented in all three of these portals and there are tailored systems behind the portals to collect and organize that data.

The Monitoring Council has assembled theme-specific workgroups focused on these particular areas of water quality information, and each is responsible for developing a web portal for its theme. The workgroup that is most relevant to marine issues is focused on the aquatic ecosystem health of coastal and marine habitats. That workgroup has not yet been assembled.

The workgroups are responsible for QA/QC of data that go into their portals. Two of the workgroups (Safe to Swim and Safe to Fish) are using SWAMP and CEDEN stored data, and therefore can rely upon the existing SWAMP data protocols. The Safe to Swim workgroup found that the data they needed were not being provided rapidly enough to support the goals of the portal. They created a new database called Beach Watch[28] and worked to make sure that the local health agencies could use it and, therefore, could submit their data more frequently. They will

[27] http://www.cawaterquality.net
[28] http://beachwatch.waterboards.ca.gov/BeachWatch/index.jsp

soon be switching the Safe to Swim portal over to rely upon the Beachwatch database supported through CEDEN.

Given that this system is reliant upon a diversity of data sources and is a multi-agency collaborative effort, it can serve as a model for how to organize and manage data in the envisioned geospatial coastal and marine IMS. This is particularly true for how the effort is organized using workgroups with representatives from each of the participating agencies – an idea like our data diplomats described in Section 6.

California Geological Survey's California Coastal Sediment Management Workgroup Spatial Data Website

The Coastal Sediment Management Workgroup (CSMW) is a federal-state collaborative effort established to coordinate implementation of Regional Sediment Management throughout the state. Co-chaired by the Natural Resources Agency and the US Army Corps of Engineers, one of the resources created by the CSMW is the Coastal Sediment Management Spatial Data website called WebMapper[29]. The site was built by CGS for the CSMW using ArcServer and is hosted at CERES on a server purchased for such use by a CSMW member agency (California Department of Boating and Waterways).

The site hosts a variety of spatial information designed to inform sediment management decisions, such as critical beach and cliff erosion areas, potential on- and off-shore sediment sources to address the erosion, bathymetry, coastal retention structures, jurisdictional boundaries (e.g., coastal zone, state waters, state parks, MPAs), coastal and near shore species/habitats of concern, sea level rise inundation zones, coastal geology, and ESRI World Imagery and Street Maps as backdrops to this spatial information. All layers have been re-projected as necessary to conform to a common reference layer (i.e., "coastline"). The spatial data was collected from other agencies or developed during CSMWs development of littoral cell-based Coastal Regional Sediment Management Plans, is stored on a CSMW "page" within CalAtlas, and can easily be downloaded for desktop analyses. The viewer has a suite of standard visualization tools available (e.g., pan, zoom, measure) as well as direct access to the appropriate California Records Project photos for the specific coastal location of interest.

The participating agencies have found the WebMapper to be very helpful in creating a common picture of sediment-related issues along the coast and near shore. To increase the WebMapper's usefulness to a broader range of users, CSMW recently conducted a "GIS User Survey and Needs Analysis Study" to identify, amongst other things, what measures were needed to improve the WebMapper's capabilities and support. The survey looked at many issues common to this survey carried out in this study, and results were provided to the OPC team and contractors. CSMW finds it will be challenging to develop these improvements and maintain the WebMapper because CGS staff no longer have authorization to utilize the ArcServer software, and CERES security protocols require that their staff "place" the upgrades on the server themselves. Because of these maintenance issues, CGS and CSMW are currently unable to get new data into the WebMapper or to improve efficiencies. CSMW is currently exploring options to resolve these issues, including further development efforts with CERES, and would be interested in being an integral part of a

[29] http://coastalsediment.resources.ca.gov/

more broadly supported data atlas that would promote finding and viewing of additional data that could further the ability of coastal sediment managers to make well-informed decisions.

Relevant Non-California Agency Geospatial Information Management Systems

The consulting team conducted a series of meetings and interviews with the managers of other major coastal and marine-focused geospatial information management systems along the west coast to understand their systems and key requirements for a California agency system to be able to interoperate with them.

NOAA MPA Center

NOAA's MPA Center develops and hosts several key datasets relevant to this study. Two datasets pertain to MPAs: 1) a data layer that displays shipping lanes, military closures, and the like that prohibit extractive activities, and 2) the authoritative MPA layer for the entire US. Additionally, the MPA Center develops and hosts an Ocean Uses Atlas[30] that displays human uses of the ocean (e.g. sailing, offshore oil and gas, recreational dive fishing, motorized boating, commercial benthic fishing) in state and federal waters of the coast of California.

MPA center web-based data viewers use the ESRI web APIs (Application Programming Interfaces). Thus, data could be consumed from a California-based system if it provided web services that can be used by those systems (ArcGIS REST API or WMS). Conversely, data could be consumed and utilized in a California-based system were it to support the web services hosted by the ArcGIS Server implementations at the MPA center. These include WMS (Web Map Service), WFS (Web Feature Server), and the ArcGIS REST (Representational State Transfer) API.

NOAA Multi-purpose Marine Cadastre

The NOAA Multi-purpose Marine Cadastre (MMC) is a GIS-based marine information system for U.S. waters, providing authoritative geospatial data and information. Data include jurisdictional boundaries and limits, federal geo-regulations, federal agency regions, human use data, physical and oceanographic data, marine habitat and biodiversity, navigation and marine infrastructure. These data are exposed through a web-based viewer based on the ArcGIS Server Flex API and through a data registry, a listing of useful authoritative data sources with links to the original data source.

The MMC project team supports the use of web services for sharing data across repositories. While data is periodically harvested from original sources to drive the MMC, they view this as a temporary solution. They plan to restructure their architecture in the future to a more distributed system relying upon web services hosted by authoritative data sources that can be utilized to drive web based viewers and decision support tools such as the MMC. This would allow these data providers to update their data and have those changes propagate to other tools in real time. For a California data portal to interoperate with the MMC, it would need to provide data through

[30] http://www.mpa.gov/dataanalysis/atlas/

services such as the ArcGIS REST API and WMS. Similarly, a regional data portal could consume data from the MMC and it's sources through this system architecture.

Oregon Coastal Atlas

The Oregon Coastal Atlas[31] includes maps of estuaries, rocky and sandy shores, beach water quality, beach morphology, ocean "areas" (e.g., coastal zone, estuaries), human use, physical, biological and hazards data. The Oregon Coastal Atlas provides several web-based map viewers to visualize spatial data, using open source server technology.

The Oregon Coastal Atlas creates and consumes catalog services for the web (CSW), which are used to publish and discover metadata for data holdings. If the California-based geospatial IMS creates metadata services and publishes them as CSWs, it may be interoperable with search tools provided within the Oregon Coastal Atlas.

Washington Coastal Atlas

The Washington Coastal Atlas includes the shoreline public beach access points, biological and habitat features, physical and regulated features, modifications, jurisdictional delineations, transportation features, background imagery and satellite imagery. One of the most used datasets is oblique photos of the shoreline over multiple years. Data are drawn from disparate sources and used to create local ArcGIS Server-based services (i.e., WMS and KML).

There is interest in drawing data from live services (e.g., WMS services from other coastal atlases) but this isn't being done much now. The State of Washington is also developing an ESRI Geoportal Server to support CSWs to integrate with the International Coastal Atlas Network. The long-term strategic goal of ICAN is to facilitate the development of distributed, digital, coastal atlases. By participating in ICAN by way of WMS or CSW, the Washington Coastal Atlas could potentially increase the discoverability and use of their geospatial data.

Major Remote Sensing Data Repositories

There are several research entities that are collecting, storing and disseminating remote sensing data, which are often large, high-volume datasets in a variety of formats. The Golden Gate LiDAR project is developing LiDAR, hyperspectral, and aerial photography datasets for three counties in the San Francisco Bay Area (Marin County, San Francisco County, and San Mateo County). These will be synthesized into one and two meter DEM models for the San Francisco Bay Area. The Southern California Beach Process Study (SCBPS) is similarly collecting LiDAR data from Mexico to Long Beach, and is sponsored by U.S. Army Corps of Engineers and the California Department of Boating and Waterways. USGS, the OPC, and San Francisco State University are involved in mapping the seafloor off of California and creating datasets describing the physical morphology of the California seabed using backscatter and multibeam data that are synthesized into geological maps, bathymetric DEMs and habitat classification models. The Seafloor Mapping Lab at

[31] http://coastalatlas.net

California State University—Monterey Bay, which specializes in high-resolution acoustic remote sensing for coastal habitats, publishes their data as Fledermous, DEMs, shaded relief (GeoTIFFS), shapefiles and KMZs.

The challenge in all of these cases is providing adequate, redundant storage for large, high-volume datasets. For example, the Golden Gate LiDAR project has no web viewer at this time. It would like to serve the data over the web, but this is challenging due to the size (16TB) of data. There are plans to host products such as the DEMs through the USGS National Map. The Southern California Beach Process Study has a website that visualizes where surveys have been done through interactive maps. Users can also view elevation charts along a transect line within coverage areas, and access metadata. The website will soon include a link to download the data.

The USGS hosts its data and products on various project websites, and through the National Geophysical Data Center. Users can download data typically as grids, xyz files, DEMs, TIFFs, or Shapefiles. While this method may not be as sophisticated as some web services-based approaches, it is easy to find complete raw datasets, and the USGS hosting infrastructure is robust and fast. The National Center for Airborne Laser Mapping has taken a similar approach, hosting grid files within downloadable compressed archives. A KML is available that provides an easy, visual way to view datasets and their coverage.

California Ocean Observing Systems (SCOOS and CeNCOOS)

The Southern California Ocean Observing System (SCOOS) and Central and Northern California Ocean Observing System (CeNCOOS) collect, analyze and disseminate a very broad suite of ocean remote sensing information and models used to inform a host of management decisions. Valuable time-series data include sea surface temperature, chlorophyll, air temperature, salinity, and currents. Most of these data are made available via FTP sites and web-based portals[32]. Some of these data are statewide in scale, while others are more regional. SCOOS and CeNCOOS personnel interviewed showed a strong interest in integrating their data products into a California coastal and marine geospatial IMS.

Many products derived from SCOOS and CeNCOOS data (e.g., models) are not advertised; those who obtain and use them do so by contacting SCOOS- or CeNCOOS-affiliated scientists to explore what is available. As such, these organizations provide a gateway to scientists who may advise interested parties on new methods, approaches or data products that may be useful to planning and permitting.

[32] See http://sccoos.org/interactive-map/ and http://www.cencoos.org/sections/products/index.html

Section 5: Key Findings

Key Findings from Interviews with California Agency Users

All agencies report the need for a coastal and marine data atlas. One of the greatest challenges that many agencies face is finding reliable, high-quality coastal and marine data outside their agency. Efforts such as CalAdapt[33] are helping to provide this for specific issues (e.g., data for climate change impact planning); however, there is aneed for a more comprehensive and integrated, and easily accessible mechanism for discovering, visualizing, and downloading diverse datasets. Most interviewees favor a distributed architecture for this atlas, yet most agencies don't have the resources necessary to host their data with reliable web services for access by a common atlas. Furthermore, most interviewees cited the need for a single point of discovery to common geospatial datasets.

While CalOCEAN was ostensibly created to address this issue, no interviewees mentioned it when asked if there are any current resources that they use to meet this need. This is largely because CalOCEAN has not been promoted or regularly maintained because of a lack of funding, and it does not have a public interface accessible to most users.

There is significant use of geospatial information by non-technical users using non-GIS tools. While most of the coastal- and marine-focused agencies we met with and interviewed have one or more dedicated GIS staff, a significant number of geospatial information users are not using ArcGIS or other desktop GIS tools. Instead, they are using a wide variety of web-based data viewers and analytical tools, either provided by other agencies or custom-made for their agency (e.g., BayRAT, CalWQA). These web-based tools provide a specialized subset of information and functionality geared towards the planning and permitting tasks these non-technical users require. Still others, especially decision makers and those less familiar with online mapping and tools, rely on paper maps.

ESRI and Google technologies are ubiquitous. GIS staff overwhelmingly use ESRI desktop and server products, while non-technical staff use web applications developed using ESRI software and/or Google Earth and Maps mashups. Many of the ESRI products are outdated due to lack of resources to support upgrades, and policies in place that prevent staff from migrating to newer systems. Non-technical users prefer the web-based tools and Google Earth, although they may still need training in order to utilize them effectively.

Long-term staff support, such as a Data Librarian and Data Diplomats, could greatly enhance state inter-agency data sharing and maintenance of a coastal and marine IMS. Through consultations with state agencies, the concept of a Data Librarian emerged, who would

[33] See description of CalAdapt in the BCDC agency assessment.

administer the coastal and marine data atlas and assist agency staff, and potentially the public, in finding coastal and marine geospatial data. The Data Librarian would also serve as the primary state-wide contact for nongovernmental and industry data providers who need help identifying the standards and formats they should provide data in for state agencies to best be able to utilize them. The Data Librarian, combined with "Data Diplomats" at each agency, would enable much more cohesive data sharing and access across the state (these roles are described in Section 6).

Permit information often resides in outdated technologies (i.e., in hardcopy or Access databases), which create barriers to accessing permit information and sharing information across agencies or with the public. Several state agencies (e.g., BCDC, CCC) have plans and are seeking funding to create new permit database systems that they would like to link to mapping applications. The information provided by permit applicants is not easily accessed by other agencies that may have jurisdiction over the same area. The public currently has to contact multiple agencies to identify permit requirements and historic information for a given area, with dramatically different ease of accessing this information. As one interviewee described, "Ideally, planners and analysts should be able to search through a [web-based] geospatial database of permit actions and call up information that has been collected by any of the state agencies. Furthermore, the work that the permit analyst does would make it back into this system."

Agency staff are largely focused on internal acquisition and use of information to fulfill their agency's regulatory mandates. There is currently little funding or staff support to enable robust data sharing with other agencies, either to support planning or permitting. Given this, agencies that are reliant upon data provided by others are at the mercy of those data providers, which often delays workflows and decisions. There is no centralized coastal and marine geospatial information portal. Barriers to sharing data among these agencies would be greatly reduced with a single, well-staffed and supported coastal and marine IMS.

There is currently no interest in building a single universal analytical tool to be used by multiple agencies. Because the goals and objectives of each of these agencies are so diverse and specific, their analytical needs are likewise very agency-specific. There does not appear to be a demand or resources for a single web-based application that would be used by state agencies to support complex analysis of geospatial data or to specifically address agency objectives. That said, a centralized marine geospatial information management system would be the first and essential step to creating more comprehensive tools in the future. The development of an IMS would require the provisioning of data using standard web services. These web services could serve as basic infrastructure for the visualization of data, acting as a building block to support the development of agency-specific tools by the agencies themselves, or by an inter-agency development group.

Agency-specific tools could be developed by an inter-agency software development group. This group could create tailored tools for specific agency needs and leveraging resources and experience from across agencies. Many interviewees supported this concept, provided that the

tools do not force a one-size-fits-all interface or design. Such capacity could be served by CERES, or a new development group supported by the OPC, or a collaborative interagency work group of developers (such as within the California GIS Council) led by the GIO. The California GIO has also mentioned the concept of a "CalGEO App Store" that would enable private developers to build applications that use state data could be another approach to address this need.

Many agencies have a need for outreach and training support so that agency staff can learn about, and how to use, a coastal and marine data atlas, if one is created, and relevant analytical tools. Many agency staff that have an established workflow routine do not have the time or desire to actively seek out new tools and technologies, even though these resources could improve the speed and/or quality of their work. Training on the resources available in California and how to incorporate these data and tools into their workflows, could be a standard part of new hire orientation and agency staff continuing education requirements. An inter-agency "Tools Ambassador" could track what geospatial analysis tools are available and relevant to coastal and marine agencies, and provide periodic trainings for California agency staff on how to incorporate these tools into their work.

Key Interoperability Findings from Interviews with Other Leading Data Providers

Through interviews with a variety of organizations with large coastal and ocean geospatial data holdings (see Appendix G), we found that their information management systems have the following attributes that are key to consider when designing a California coastal and marine geospatial information management system:

There are existing metadata catalogs that can be built upon in any new IMS. Many of the leading coastal and marine data providers have established metadata catalogs that use nationally- and internationally-established standards for their metadata. California should work to adhere to core metadata standards that have been established through these systems and can add any additional metadata requirements that are necessary in addition to these. Designers of any new IMS for California should assume that state agencies will adhere to existing metadata standards when creating data and recording its existence in catalogs.

Discoverability of California data (i.e., being able to find relevant data you were previously unaware of) is a very important feature for any new IMS. Finding authoritative sources of coastal and marine geospatial information is a challenge that must be addressed by multiple strategies. An atlas can provide a useful central data location, but search tools are needed to help users find that portal in the first instance, as well as the data within the portal. An investment in good metadata can be further leveraged if that content is used to support the discoverability of data. Standard catalog search tools based on the CSW OGC (Open Geospatial Consortium)-Standard can be used to support search across metadata catalogs from desktop GIS as well as web-based tools. Special attention must also be paid to standard search engine optimization strategies that will ensure data are well represented in web search engines. Most

agency users of geospatial information don't have specialized training in geospatial technology, so web search engines will be the most important mode of discoverability compared to catalog search services. An atlas should also have a spatial query tool so that users can find data and information that is available for a particular geography.

Web services enable easier data sharing with other organizations and agencies as well as more seamless co-operation with other IMSs and databases. Several of the leading west coast data providers have established web services to easily share their data with others. The California coastal and marine geospatial IMS should be able to easily pull data through many of these services and should provide a similar service for these other organizations. The most relevant standards in use are WMS, the ESRI-developed ArcGIS Server REST API, and KML. These standards allow for applications to be built upon data hosted within each data provider's own systems, ensuring timely updates and avoiding duplicate data repositories. These web services could allow a California coastal and marine geospatial IMS to interoperate with existing efforts such as the web-based viewer developed for the Coastal Sediment Management Working Group and the Monitoring Enterprise's OceanSpaces. Such viewers could in the future be developed to directly consume data from the IMS web services.

Previous experiences with distributed and centralized architectures have shown strengths and weaknesses for each approach, depending upon data holder capabilities, and a hybrid approach could capitalize upon the strengths of both architectures. The data providers interviewed have a mix of distributed and centralized architectures. Most are working to establish distributed systems; however, they are limited by the technology available at each of their constituent sources. For example, the Multipurpose Marine Cadastre utilizes the web services of data providers when available, but more often must centralize data within the Cadastre, as many data providers do not have the necessary infrastructure to host web services (e.g., the State Lands Commission).

There are many high volume datasets (e.g., LiDAR, seafloor mapping, Ocean Observing System data) that have unique data handling and storage requirements, and may require reformatting to serve through a web-atlas. These data contain many billions of records and occupy terabytes of storage space. While storing such data volumes is increasingly feasible, they are not insignificant. For example, hosting 1 Terabyte of data in a cloud hosting[34] environment (Amazon Web Services) costs 154.00 per month as of September 2011. More importantly, transferring such large quantities of data over the Internet is infeasible. If the California coastal and marine geospatial IMS were to provide these types of data, then hardware and bandwidth requirements would need to increase substantially. Synthetic data products can be more manageable and valuable for end users, and so a phased approach is recommended for data provision with smaller volume data products being incorporated first and higher volume datasets being provided as hardware and bandwidth to support them are secured. Indeed, the National Center for Airborne Laser Mapping has been successful in providing grid products rather than raw

[34] Cloud hosting or cloud computing are terms to describe having data or applications hosted on remote servers (i.e. on the internet) rather than an onsite server or desktop.

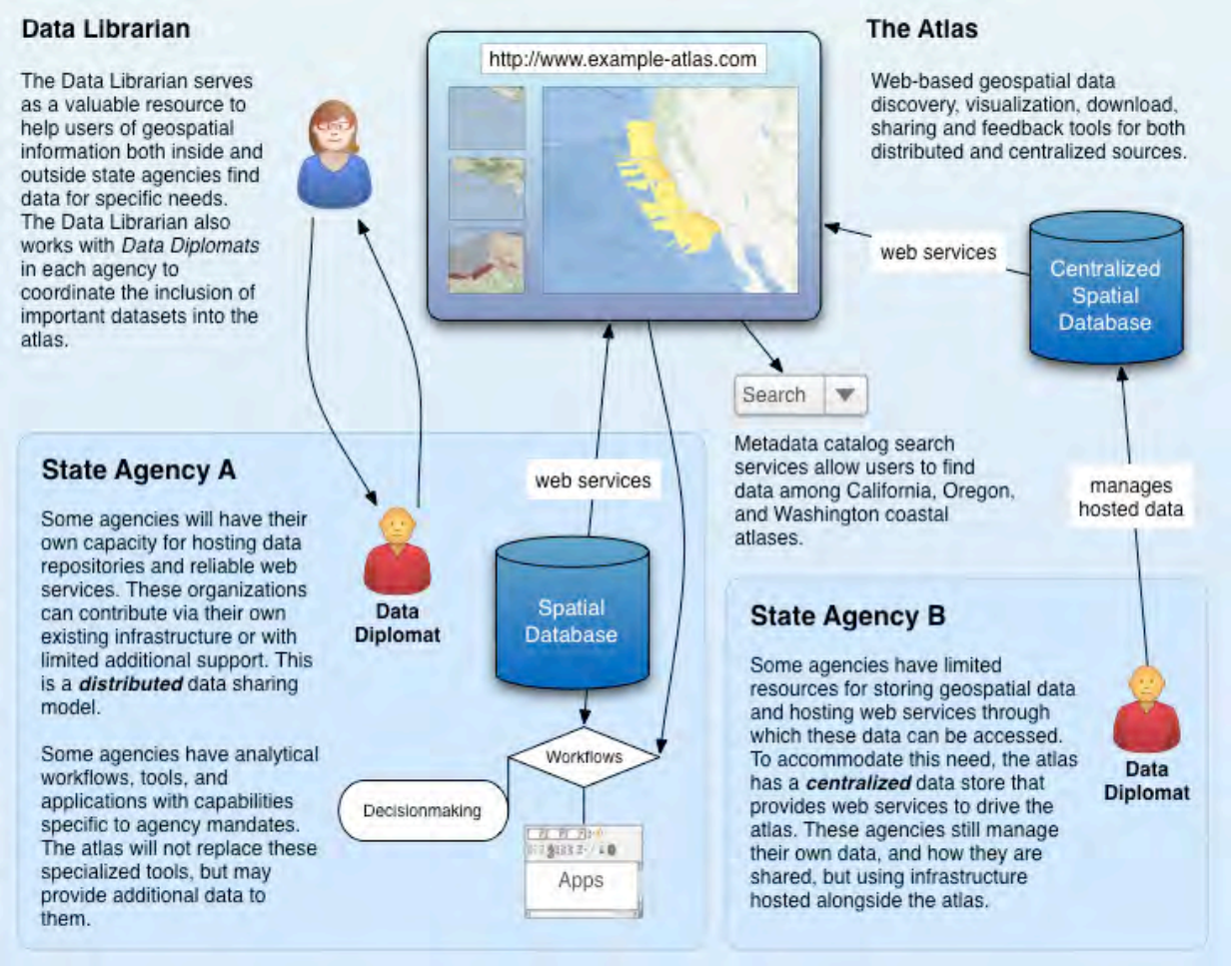
xyz data to users. These data are also binned into grid cells so they can be downloaded incrementally at reasonable file size. A process will need to be established to determine and prioritize which synthetic products will be most valuable.

The Ocean Observing System networks have existing web-atlases that function well and can serve as models for a California atlas. The ocean observing system networks have developed specialized web applications for visualizing and disseminating oceanographic data. These applications are heavily customized to provide a richer visualization environment than can be achieved using standard spatial data viewers. They represent a significant investment on the part of these organizations. Any new information management system would be best served by providing simple visualization of these datasets and linking directly to the OOS atlases to support more complex visualization needs.

Section 6: Functional Requirements

Summary Overview Diagram of Recommendations

The primary recommendation of this study is to develop a web-based information management system (IMS) to access, download and view coastal and marine geospatial data. A web-based IMS would fulfill the need for a central point of access for California coastal and marine geospatial information that was a strongly articulated by virtually all of the California agencies in the scoping study. A full traceability matrix for the features of this system is provided in Appendix I. The basic organization of this system is summarized in the diagram below; a more detailed description of the functional requirements follows.



Functional and Compliance Requirements

The requirements for this system are organized into four components, with two potential software architectures at their core.

1. Hybrid Architectural Approach, Supporting Both Centralized and Distributed Data Sources

Key Requirements:

1.1 The information management system should reflect the varying capabilities of state agencies to host spatial databases, tools, and web services, and interoperate with existing efforts to distribute coastal and marine geospatial information.

1.2 Agencies with existing, compatible infrastructure and staffing to support geospatial databases and web services can and should share data with the IMS utilizing those existing resources;

1.3 Agencies that do not have access to existing infrastructure and staffing to support such data stores and services should be provided centralized, high quality hosting infrastructure for their geospatial data by means of the IMS.

1.4 Maintenance of this system's hosting infrastructure should be provided by dedicated IT services, although all data management an d access control would continue to be conducted by agency staff.

1.5 This system of centralized hosting with distributed ownership and control could be supported by either traditional server infrastructure or by "cloud computing" environments.

Both the California Geospatial Working Group and interviewees expressed a preference for distributed management and hosting of data. Distributed architectures have several important advantages. Data managers can maintain their data within their organization's existing infrastructure without interrupting existing systems. Distributed architectures also reduce the duplication of data across systems, because the data is not being copied into a central server with periodic updates from the data provider. Data duplication is even less of a problem when the distributed architecture relies upon web services from each of the provisioning entities. Such data streaming through data portals and other tools by way of web services ensures timely updates are propagated across the network.

Distributed architectures also have significant disadvantages relative to centralized data stores. The reliability, speed, and quality of the system depend upon the capabilities of each distributed data source (i.e., it is only as strong overall as its weakest link). This requires that each agency host web services using the same standards with up-to-date hardware and software. In a centralized architecture, one organization can take responsibility for hosting, staffing, and developing systems with a focus on high availability and quality of service. In a distributed scheme these costly resources must be duplicated among agencies.

As already noted, many users of geospatial data are not experts in technology and benefit from easy to use, high-quality, web-based tools. Efforts to develop such tools using a distributed

architecture across many organizations have been met with limited success due to the challenges involved in pulling data from data sources distributed among varying organizations.

	Distributed	Centralized
Advantages	Utilizes existing systems	Achieves efficiencies through a centralized data maintenance effort
	Reduced data duplication	Homogenous software environment simplifies interoperability
	Timely updates	
Disadvantages	Requires costly redundant infrastructure and staffing	May slow timeliness of data updates
	Requires aligned interests of all participants	Data duplicated among centralized database and agency systems
	Few success stories	

One example of a hybrid approach is the Multipurpose Marine Cadastre. While promoting the use of distributed web services, and utilizing them when available, most of the data used in the Cadastre is duplicated and hosted centrally to ensure a high quality of service. Despite this challenge, the Cadastre has served as an effective data portal by ensuring that appropriate infrastructure and staffing are available to manage data in a centralized manner when a decentralized approach is insufficient.

The Consulting Team recommends taking a similar hybrid approach to system architecture with the California coastal and marine geospatial IMS. Where data are reliably available from existing systems through compatible web services, data need not be centralized within the IMS. The IMS would simply utilize these services to provide an interface to discover, view and query these data. For example, both the Department of Fish and Game BIOS system and the CERES California Resources Agency Atlas/Map Server provide data hosted as web services using the ArcGIS Server REST API. These hosted map services could be used to visualize and query these layers in a map viewer application as part of an IMS without duplicating those data within the system.

For agencies that cannot or do not wish to build such technical capacity internally, a centralized database should be made available to them that is supported by dedicated IT personnel as part of the IMS. One of the main disadvantages of a centralized architecture is the potential for that system and its operators to become a bottleneck, preventing the timely updating or provisioning of new data. For a centralized database to be effective, it must meet the needs of agency data providers first and foremost.

To address this issue, a system of centralized hosting but distributed data management should be utilized. While dedicated staff will see to the maintenance of the hardware and software driving the IMS, management of data within it should be entirely the responsibility of agency personnel. Agency personnel would be responsible for deciding what datasets go into the system, access control settings, and update schedules. The Data Librarian can support these activities, but

ultimately agencies have accounts on the IMS that allow them full control over their data. The IMS centralizes complex hardware and software support while distributing data stewardship, and in this way acts much like a cloud computing service.

2. *Ability to View, Print, and/or Download Geospatial Data in Several Formats*

Key Requirements:

2.1 The IMS should have multiple tools to support data search and discoverability, including;

> 2.1.1 A high-speed web-based data search tool for identifying available and relevant data based on the contents of stored metadata.
>
> 2.1.2 Tools to identify a geographic area of interest to further refine search criteria and define data download extent.
>
> 2.1.3 Consideration of search engine optimization techniques to ensure datasets can be found using common web search engines (e.g., Google, Bing).
>
> 2.1.4 Provision and consumption of catalog services (CSW) to support data search across other geospatial data management systems, such as the Oregon and Washington Coastal Atlases.

2.2 The IMS should enable basic overlay analysis and data visualization within a web-based interface and print these overlay maps with standard cartographic elements (i.e., compass, legend, etc.);

2.3 The IMS should allow users to develop views of geospatial information (maps) that they can then share links to. These maps would allow them to set the map extent, visible data layers, and comments. This functionality covers two important use cases:

> 2.3.1 Users can contact data providers to ask questions, providing a link to a map highlighting an area of interest related to the query.
>
> 2.3.2 Working groups can develop and share maps with a subset of data from the IMS geared towards topics of interest. These maps could be used rather than developing costly data viewers of their own.

2.4 Data hosted within the IMS would be available for download in both open and industry-standard data formats for use with dominant open-access and proprietary (i.e., license-based) analysis software, such as Google Earth and ESRI products.

2.5 IMS data will also be available through web services and APIs for third party data access and use in applications. Access through web services will ensure near instant propagation of data updates and reduce data duplication. These same services can be utilized by desktop tools, such as ArcGIS.

Given that most agency users of geospatial data are not proficient in ArcGIS Desktop, the IMS should be structured in such a way so that most users who simply need to conduct overlay analysis can do that from within a web application. Nearly all interviewees cited a need for very

easy to use, web-based tools to support these features. A subset of those users are likely to download the data as a KML file for use in Google Earth, and a further subset are likely to download the data for use in desktop GIS tools such as ArcGIS Desktop.

3. Staff Support through a Data Librarian and Data Diplomats

Key Requirements:

3.1 A centralized coastal and ocean Data Librarian will:

> 3.1.1 Help coastal and marine agency geospatial data users find data necessary to support their particular planning and permitting projects;
>
> 3.1.2 Work with all agencies who are providing data to the IMS to provide QA/QC of these data and to facilitate regular duplication and centralized hosting of these data;
>
> 3.1.3 Work with federal agencies, the state GIO, and relevant partners (e.g., the Oregon and Washington Data Atlases) to ensure that data in the IMS conform with emerging state and national standards for environmental datasets and that hardware meets state technology requirements;
>
> 3.1.4 Oversee any contractors who build data visualization tools for the IMS to ensure that the tools are designed in such a way as to meet the needs of agency users.

3.2 Data Diplomats at each agency will:

> 3.2.1 Serve as the QA/QC steward for any existing data their agency provides to the IMS;
>
> 3.2.2 Ensure that new data are collected in a manner that is easily shared with the IMS (e.g., by ensuring appropriate meta-data are included, QA/QC protocols are followed, data formats are compatible, etc.);
>
> 3.2.3 Provide periodic trainings within their agency on how to use the IMS.

These two roles, a Data Librarian and Data Diplomat, have been broadly supported in meetings and interviews with California agency staff. One of the greatest challenges facing coastal and ocean planners is finding relevant and useful geospatial data to support planning on emerging issues. While an IMS will be able to partially address this, it will be impossible to contain all data that may be necessary for coastal and ocean permitting and planning in the IMS, as the amount of data is large and varied, the issues are dynamic, and the state of the science is continually in flux. A central staff person can supplement the IMS with creative problem solving for meeting users' data needs and, like a reference librarian, can ensure that emerging data needs are incorporated into the IMS over time.

The Data Diplomat role was initially recommended in the 2009 Workshop Report on *Collaborative Geospatial Information and Tools for California Coastal and Ocean Managers*. This role is essential in order to ensure that data produced by agencies can be effectively shared with others through the IMS and that the system meets the needs of planners and analysts within their agency. Data Diplomats would need to be provided dedicated time and resources to fulfill this

role. The role and responsibilities of this role could be adapted from the Data Stewards established to help data sharing between the agency members of the California Strategic Growth Council.

4. Permanent Location for the IMS

Key Requirements:

- 4.1 The IMS should be housed within an organization that has the staff and hardware capacity, as well as long-term funding, necessary to support it.
- 4.2 The host organization for the IMS should be one in which its mission is aligned with providing high-quality customer service to other California agencies who will rely upon it. If the IMS is tangential to the mission of the organization, then internal support for it, as well as the morale of its staff, may suffer over time.
- 4.3 The hardware necessary for the IMS could either be provided through servers at the organization or through a cloud-computing environment.
- 4.4 The host organization should have progressive IT policies that support the rapid utilization of new technology.

Comparable services in other states have been housed within agencies, by inter-agency organizations, and by non-profit organizations. The most appropriate location for an IMS is outside the scope of this study, but will be addressed through follow-on work by other consultants.

Feasibility Assessment: Building a New System versus Utilizing Existing Systems

Adapting existing geospatial information management systems to fulfill the needs of a statewide marine geospatial IMS is, at first glance, an attractive option because of the cost-savings implications. However, no web atlas or geospatial information management system evaluated during this study addressed the complete set of features and requirements identified. These deficiencies were related mostly to the software used to search, visualize, and discuss geospatial data by end users. Many systems lacked easy to use interfaces and data visualization capabilities (e.g., CalAtlas), or were overly focused on a specific purpose (e.g., My Water Quality Portal). Any existing system would require substantial investment in the creation of these new features and possibly a redesign of the user interface to meet the needs of non-technical agency line staff.

As identified in the following section, software packages are available to create systems to manage the full life cycle of geospatial information. In the past 24 months, products such as ArcGIS Online and GeoNode have emerged that facilitate not only the management and basic visualization of geospatial data, but also collaborative sharing of geospatial data through user groups and feature easy to use web interfaces. These software applications can be effectively used "out of the box", with less software development effort required to support them previous versions of these products. For this reason, it is likely to be more feasible to adopt one of these new, modern systems than to add functionality to an existing system.

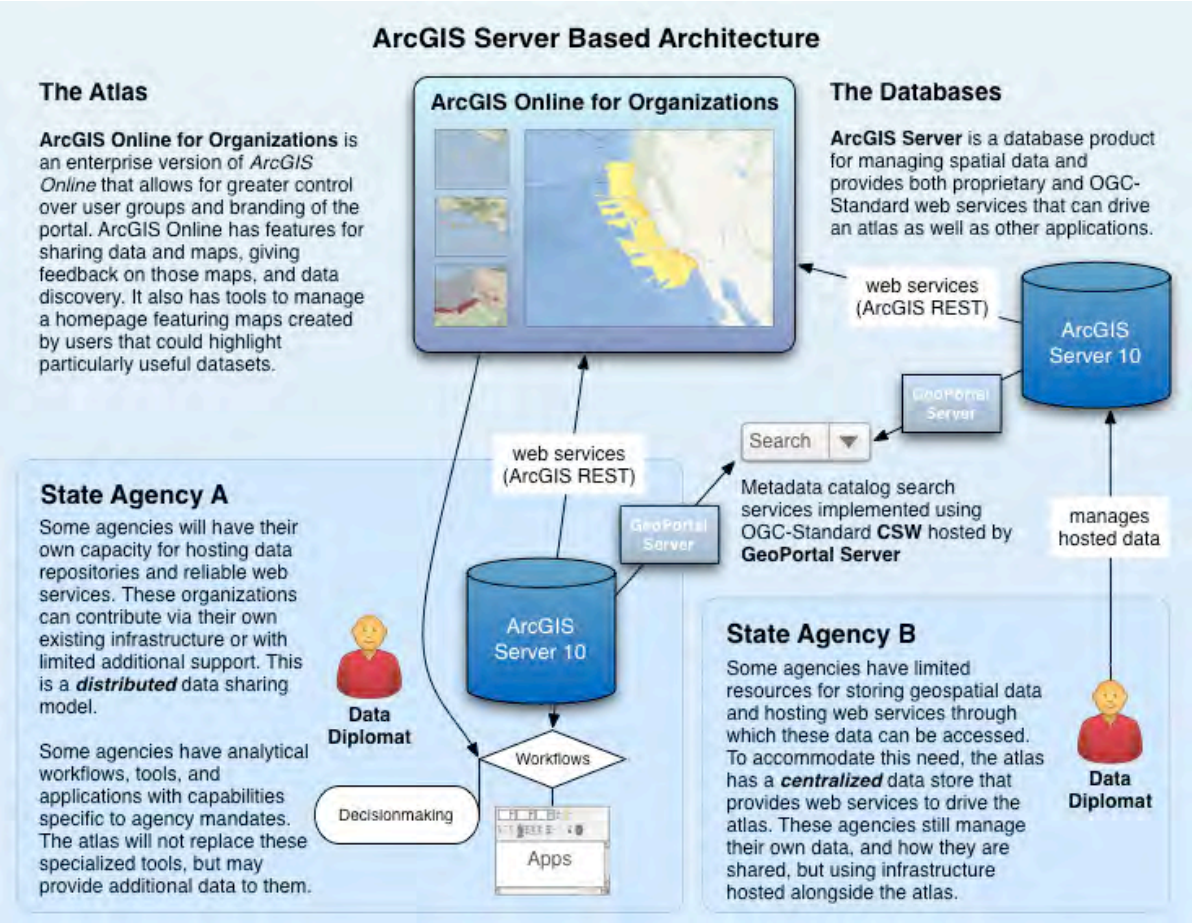
Beyond software, server infrastructure and IT staff support will be necessary for the IMS to function effectively. The California State Technology Agency has developed policies to encourage the centralization of IT services and infrastructure. The California Natural Resources Agency has worked with the State Technology Agency to create a modern new datacenter and this datacenter could provide the infrastructure necessary to house the coastal and marine IMS. The coastal and marine IMS would benefit from regular upgrades to the Resources Agency system given its large number of users.

Alternatively, the IMS could be hosted effectively on a cloud-computing platform such as Amazon Web Services or, possibly, ArcGIS Online. It could also be hosted at an academic institution in the state with sufficient infrastructure and capacity to serve this function. It will be vital that whatever organization hosts the IMS meet the key requirements listed in Section 4. The question of appropriate institutional structures will be addressed in greater detail by follow-on work by other consultants.

Evaluation of Potential Architectures

The hybrid architecture recommended by this study could be created in either Esri-based or GeoNode-based software platforms. This section describes how they could each be structured.

1. *ESRI-Based Architecture*

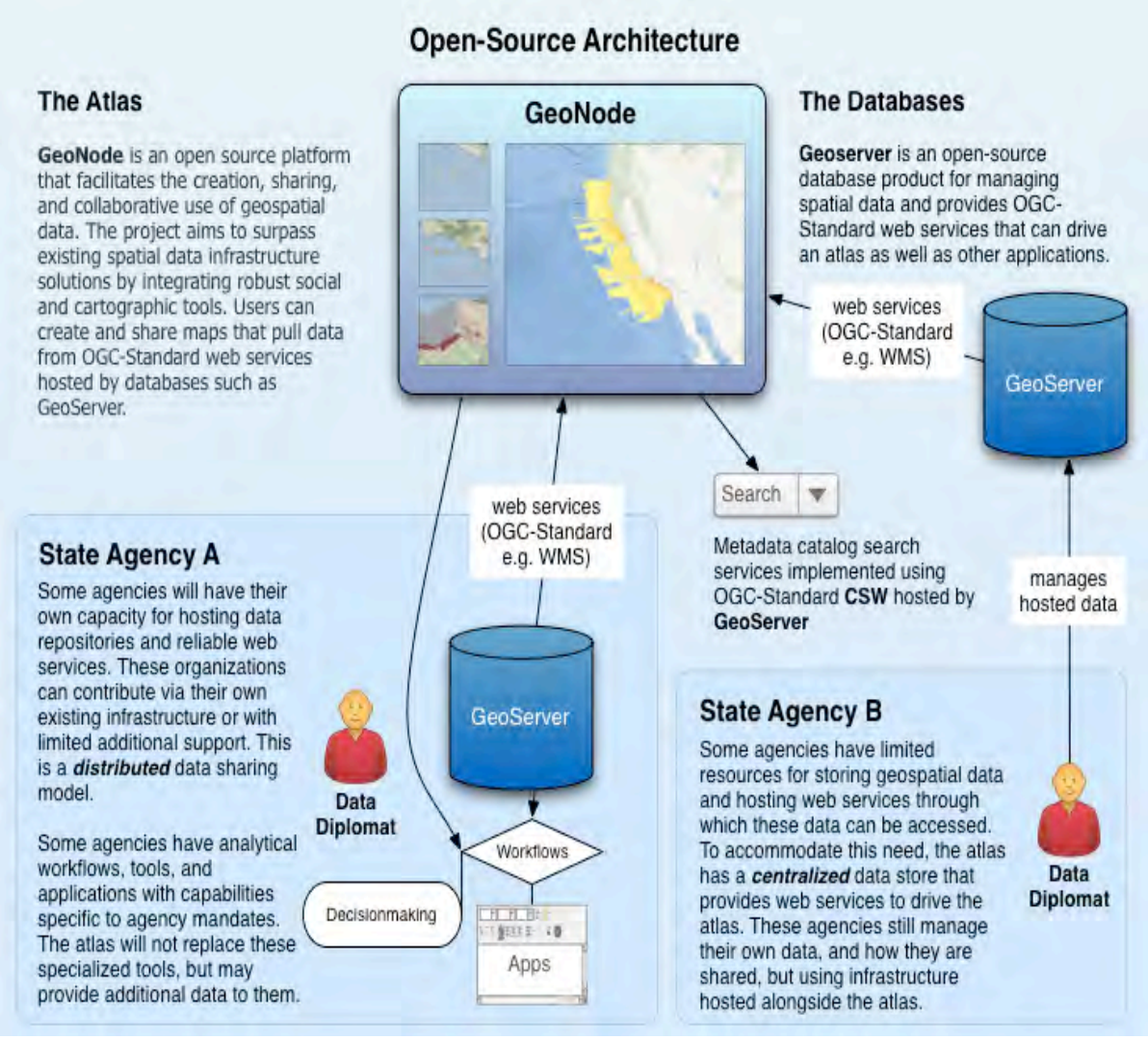


An ESRI-based IMS takes advantage of ArcGIS Server 10 technology in use at many state agencies. Agencies utilizing this technology can publish web services using the ArcGIS Server REST API as well as OGC-Standard services such as WMS, WFS, and KML. These web services can be used in numerous applications, including an IMS. ArcGIS Online for Organizations is a forthcoming product from ESRI that enables organizations to deploy a customized instance of ArcGIS Online. ArcGIS Server instances can be registered with ArcGIS Online, allowing users to search through data holdings in a distributed network, and from them create maps that can be shared and commented on by other users.

These tools can be used in decision-making processes, as well to evaluate and give feedback on data quality. Using ArcGIS Online for Organizations, the IMS could carefully manage access control between state agencies as well as with regard to the general public. As part of the IMS infrastructure, a deployment of ArcGIS Server 10 could be hosted to support the centralized data-sharing model alongside the distributed architecture. This server would host the same kinds of web services to the IMS. Interoperability between other coastal atlases in Oregon and

Washington would be facilitated with the availability of OGC-standard CSW services that enable searching of metadata catalogs. These services could be provided by the open source GeoPortal Server product that integrates with ArcGIS Server. Implementers of GeoPortal Server have cited difficulty in deploying the technology, so a more detailed evaluation of CSW implementations would be necessary during the design phase of an IMS.

2. *Open Source (GeoNode) Based Architecture*



An open source architecture looks quite similar, with differing components, to an ERSI-based system. GeoNode is an open source product that interacts with web services produced by databases such as GeoServer and offers users the ability to search through data holdings, share maps, and comment on these maps and data sources. GeoServer provides robust tools for managing geospatial data, much like ArcGIS Server. GeoServer can also host CSW services for searching through metadata catalogs. As open source projects, these tools can be heavily customized to meet the specific needs of California state agencies. Nearly all state agencies have substantial investments and training in ESRI products however, so a customized open source

solution would require significant investment in system development and more importantly development and training at the agency level. An open-source solution provides the opportunity to develop a more custom tailored and user-friendly system, but at higher cost and much more difficult interoperability challenges. As the ESRI solution appears sufficient if not superior for enabling cross-agency data sharing, this investment may not be appropriate.

Regardless of the choice between an Esri-based or GeoNode-based solution, arge, high-volume datasets (e.g., LiDAR) will require storage and dissemination solutions that exceed many other typical marine geospatial data. As the per-unit cost of storage drops, this will become less of an issue. Dissemination of these data, however, requires fast hardware and high bandwidth that are atypical for many locations. As mentioned earlier, CERES appears to have the staff and hardware infrastructure required to host and disseminate LiDAR and other high-volume datasets.

Considerations for Long-term Operational Sustainability of the System

For the IMS and its supporting staff to demonstrate a clear added value over time, they will need to collect data on the benefits derived to the participating agencies, stakeholders, and the broader public from providing these services. Potential benefits that should be measured include:

- Shortened time spent by staff on discovering data for their planning studies and permit evaluations;
- Improved quality of planning products through the integration of additional and more current information, as well as through the increased ease of, and time for, conducting geospatial analysis; and
- Reduced cost for hosting geospatial data at smaller agencies that rely upon the IMS for geodatabase hosting.

To ensure that the IMS has the capacity necessary to sustain itself long-term, it should be funded through longer-term (e.g., five-year) contributions by the participating agencies (or by some other means of funding). The participating agencies will need to perceive the previously mentioned added value of this system for them to desire to renew their support. This both incentivizes the host organization to ensure high-quality customer service and creates a sense of ownership over the IMS by the contributing agencies.

The Data Librarian and Data Diplomats for the IMS should be comprised of technically savvy staff who have in-depth (i.e. five or more years) experience within California agencies and with coastal and marine data. The Data Librarian should be funded at a level commensurate with a senior-level research librarian. The Data Diplomats will need to have time budgeted to perform this role and established performance metrics that are included in their staff evaluations.

Additional Emerging Concept: A California Inter-Agency Permit Database

Numerous state agencies have either already created, or hope to soon create, a database system for their permit information that replaces their current paper-based processes and is usable with geospatial tools. The state could coordinate this effort to create an inter-agency permit database system that would improve efficiency of the permit process within agencies, enable agencies to

access permit applicant information that was previously provided to other agencies, and enable developers to have one portal for submitting state permit information.

Such a system is outside the scope of this study, but would be immensely valuable to permitting agencies, businesses, and the public. Undertaking this project would require a major investment of time and resources, which are challenging to envision in the current fiscal climate. As this information has an important spatial component, it could be developed as a new set of functionality within the IMS or as a separate database that interoperates with the IMS via web services.

Appendices

A) Glossary of Selected Terms
B) List of Acronyms
C) Project Timeline
D) Interview Questions
E) Attendees at June 9-10, 2011, Agency Workshops and June 8, 2011, OPC Science Advisory Team Meeting
F) List of Supplemental Agency Consultations
G) Questions and Participants From Interoperability Consultations
H) Geospatial Workgroup Members
I) Traceability Matrix
J) Summary Table of Agency GIS Staffing and Current Geospatial Technologies

Appendix A: Glossary of Selected Terms

Atlas	A web-based collection of maps. An atlas is one component of a geospatial information management system (IMS).
Application (short for application software)	Computer software designed to help the user to perform specific tasks.
Application programming interface (API)	A particular set of rules ('code') and specifications that software programs can follow to communicate with each other.
ArcGIS	A software suite consisting of a group of geographic information system (GIS) software products produced by Esri.
Cadastral map	A map that shows the boundaries and ownership of land parcels.
Catalog services for the web (CSW)	Defines common interfaces to discover, browse, and query metadata about data, services, and other potential resources.
Centralized system	A system in which information is routed through and key functions are concentrated in one or more major central hubs.
Cloud computing	The delivery of computing as a service rather than a product, whereby shared resources, software, and information are provided to computers and other devices as a utility (like the electricity grid) over a network (typically the Internet).
Database	An organized collection of data for one or more purposes, usually in digital form. It implies that the data is managed to some level of quality (measured in terms of accuracy, availability, usability, and resilience).
Data portal	A gateway to data or information.
Data store (short for operational data store)	A data storage unit, often in the form of a database, designed to integrate data from multiple sources for additional operations on the data.
Data viewer	A software framework for visualizing geospatial data.
Desktop	Refers to use through a desktop computer.
Distributed system	A system of multiple autonomous information management systems that communicate through a network.
Geospatial	Refers to data with a spatial component, usually with reference to the surface of the earth.
Geographic information system (GIS)	A system designed to capture, store, manipulate, analyze, manage, and present all types of geographically referenced data. In the simplest terms, GIS is the merging of cartography, statistical analysis, and database technology.
Information management system (IMS)	Any system of software and hardware that facilitates the storage, organization, and retrieval of information within a computer system.
Internet map service	Provide maps through the Internet usually as images.
Interoperability	A property referring to the ability of diverse systems and organizations to work together (inter-operate).
Keyhole markup language (KML)	A programming language used for expressing geographic annotation and visualization within Internet-based, two-dimensional maps and three-dimensional Earth browsers

Mashup	A web application that combines data and/or functionality from more than one source.
Metadata	Data providing information about certain pieces of data, such as: means of creation of the data, purpose of the data, time and date of creation, creator or author of data, standards used.
Open geospatial consortium (OGC)	An international voluntary consensus standards organization in which more than 400 commercial, governmental, nonprofit and research organizations worldwide collaborate to develop and implement open standards for geospatial content and services, GIS data processing and data sharing.
Open source (or open access)	Describes practices in production and development that promote access to the end product's source materials
Proprietary	Refers to products that are licensed under exclusive legal right of the copyright holder.
Raster	Refers to a type of image or graphic made up of grid of pixels, commonly referred to as a bitmap.
Server (or web server)	A computer or device on a network that manages network resources.
Structured query language (SQL)	A standardized query language designed for managing data in relational database management systems. Its scope includes data insert, query, update and delete, schema creation and modification, and data access control
System	Refers to an information management system
Tool	Refers typically to a web application
Web application	An application that is accessed over a network such as the Internet.
Web browser	A software application for retrieving, presenting, and traversing information resources on the World Wide Web.
Web feature server (WFS)	Provides an interface allowing requests for geographical features across the web using platform-independent calls
Web map service (WMS)	A standard protocol for serving georeferenced map images over the Internet that are generated by a map server using data from a GIS database
Web portal	A web site that functions as a point of access to information in the World Wide Web. A portal presents information from diverse sources in a unified way.
Web server	Can refer to either the hardware (the computer) or the software (the computer application) that helps to deliver content that can be accessed through the Internet
Web services	A software system designed to support interoperable machine-to-machine interaction over a network, such as the World Wide Web.
Web viewer	A web based data viewer for visualizing geospatial information.

Appendix B: List of Acronyms

ALID	Application Lease Information Database
API	Application Programming Interface
ART	Adapting to Rising Tides
ASBS	Areas of Special Biological Significance
BayRAT	Bay Resource Agency Tool
BCDC	San Francisco Bay Conservation and Development Commission
BIOS	Bio-geographic Information and Observation System
BLM	Bureau of Land Management
CAD	Computer Aided Design
CalEMA	California Emergency Management Agency
Cal/EPA	California Environmental Protection Agency
CalOCEAN	California Ocean and Coastal Environmental Access Network
CalWQA	California Water Quality Assessment Database
CCC	California Coastal Commission
CCMG-WG	California Coastal and Marine Geospatial Working Group
CD	Compact Disc
CEDEN	California Environmental Data Exchange Network
CEIC	California Environmental Information Clearinghouse
CeNCOOS	Central and Northern California Ocean Observing System
CERES	California Environmental Resources Evaluation System
CEQA	California Environmental Quality Act
CGS	California Geological Survey
CIWQS	California Integrated Water Quality System Project
CMSP	Coastal and Marine Spatial Planning
COS	Stanford University Center for Ocean Solutions
CSC	Coastal Services Center
CSMW	California Coastal Sediment Management Workgroup
CSW	Catalog Services for the Web
CZMA	Coastal Zone Management Act
DEM	Digital Elevation Model
DFG	California Department of Fish and Game
DFG-MR	California Department of Fish and Game Marine Region
DOC	California Department of Conservation
DOQ	Digital Orthophoto Quadrant
DVD	Digital Video Disc
EBM	Ecosystem Based Management
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
ESRI	Economic Systems Research Institute
FEMA	Federal Emergency Management Agency
FTE	Full Time Employee
FTP	File Transfer Protocol
GIO	Geospatial Information Officer
GIS	Geographic Information System
IMS	Information Management System

IT	Information Technology
KML	Keyhole Markup Language
LiDAR	Light Detection and Ranging
LTMS	Long Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region
MLMA	California Marine Life Management Act
MLPA	California Marine Life Protection Act
MMC	Multi-purpose Marine Cadastre
MPA	Marine Protected Area
NGO	Non-Governmental Organization
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
OGC	Open Geospatial Consortium
OIMA	California Water Board Office of Information Management and Analysis
OPC	California Ocean Protection Council
OST	California Ocean Science Trust
PG&E	Pacific Gas and Electric Company
QA/QC	Quality Assurance/Quality Control
REST	Representational State Transfer
RFQ	Request for Qualifications
SCC	California State Coastal Conservancy
SCCWRP	Southern California Coastal Water Research Project
SCOOS	Southern California Ocean Observing System
SDE	Spatial Database Engine
SLC	California State Lands Commission
SQL	Structured Query Language
SWAMP	Surface Water Ambient Monitoring Program
TIFFS	Tagged Image File Format
TMDL	Total Maximum Daily Load
UCSB	University of California Santa Barbara
UDF	Unit Data File
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WFS	Web Feature Server
WMS	Web Map Service

Appendix C: Project Timeline

2011	April	May	June	July	August	September
Engagement	Project Kick-off Meeting with CCMG-WG members	Initial Background Interviews with Key Users	Agency User Consultation Meeting Follow-up Consultation Interviews with agency users	Interoperability Assessment Webinar Follow-up Consultations with system operators	Additional Consultations as needed	Document Review Meeting with CCMG-WG
Document Development	Develop Annotated Table of Contents	Revise Annotated Table of Contents	Draft Sections from User Consultations	Begin preparing initial draft	Transmit initial draft to CCMG-WG for review Revise based on CCMG-WG comments	Prepare Final Scoping Document

Appendix D: Interview Questions

Background

1. What is your title and role in your organization? What is your experience with regard to geospatial information systems?

Current experience with geospatial information management systems

2. How does your organization currently use geospatial data and/or information management systems?
    a. Please describe how your agency's geospatial information is organized – is there a central database(s) within the agency, if so what server software is it running? How many ArcGIS licenses does your agency have / how many GIS FTEs do you all have?
    b. Does your agency have a tool(s) (such a web-mapping tool) that you have developed for geospatial data viewing or analysis? Was this developed in-house or through a contractor?
    c. Who uses the above mentioned tools and who uses ArcGIS Desktop? Is there overlap (i.e., do some use both)?
3. What are the main strengths of the current configuration?
4. What are the weaknesses? What is the system not able to do (i.e. retrieve certain data, process permits efficiently, conduct certain types of analysis, etc.) that is of high priority?

Integration with other State Agencies

5. What other state agencies do you rely upon the most for data for planning or permitting? What federal agencies? What non-governmental sources (e.g., academia, private contractors, etc.)?
6. Are there short- and long-term plans for further developing your agency's geospatial information management systems or tools?

Advice for our information management system scoping study

7. If the state were to create a data atlas for coastal and marine geospatial data, what key features and functionality do you think would be most valuable for your agency? Would it be best structured as a centralized, decentralized, or hybrid-type system (explain)?
8. Are there key capacities within your agency that need to be strengthened to effectively make use of coastal and marine geospatial information in decision-making? E.g., More training on existing geospatial information resources? Training on web-based geospatial tools? More GIS training? More experienced GIS staff hires? Better access to key software?
9. Here's who we've spoken with from your agency [review user meeting attendees and interviewees]. Have we missed any key people who would have important insights on this topic?

Appendix E: Attendees at June 9-10, 2011, Agency Workshops and June 8, 2011, OPC Science Advisory Team Meeting

June 9 (Sacramento) – Agency User Workshop

Leo Anguiano, SWRCB
Christina Cairns, NOAA CSC
Clif Davenport, CGS
Laura Engeman, OPC
Rebecca Gentry, Cal OST
Eric Gillies, SLC
Mike Bell, SLC
Steve Goldman, DFG
Jeff Kapellas, SWRCB
Tom Lupo, DFG
Pam Rittlemeyer, OPC
Paulo Serpa, DFG
Steve Steinberg, SCCWRP/CEDEN
Chris Wills, CGS

June 10 (San Francisco) – Agency User Workshop

Bob Batha, BCDC
Matt Armsby, COS
Greg Benoit, CCC
Carolyn Box, BCDC
Christina Cairns, NOAA CSC
Allison Dettmer, CCC
Tim Doherty, BCDC
Laura Engeman, OPC
Rebecca Gentry, Cal OST
Lindy Lowe, BCDC
Aaron McGregor, OST
Pam Rittlemeyer, OPC
Cassidy Teufel, CCC

June 8 OST meeting (San Francisco)

Matt Armsby, COS
Brian Baird, Natural Resources Agency
Kenneth Coale, OST-SAT
Christina Cairns, NOAA CSC
Mark Carr, OST-SAT
Aimee David, Monterey Bay Aquarium
Tim Doherty, BCDC
Laura Engeman, OPC
Kaitlin Gaffney, Ocean Conservancy
Jocelyn Herbert, Resources Legacy Fund Foundation
Tegan Hoffmann, Blue Earth Consulting
Karen Garrison, NRDC
Sam Johnson, OST-SAT
Rebecca Gentry, Cal-OST
Gabriela Goldfarb, Consultant
Jaime Jahncke, PRBO
Meghan Jeans, COS
Emily Knight, Cal-OST
Skyli McAfee, Cal-OST
Aaron McGregor, Cal-OST
Karen McLeod, OST-SAT
Mark Moline, OST-SAT
Leila Monroe, NRDC
Steven Murray, OST-SAT
Erin Prahler, COS
Pam Rittelmeyer, OPC
Emily Saarman, UC Santa Cruz
Linda Sheehan, Coastkeeper
George Shillinger, COS
Mary Small, OPC
Anna Weinstein, Audubon
Meredith Williams, San Francisco Estuary Institute

Appendix F: List of Supplemental Agency Consultations

Agency User Interviews:

California Coastal Commission
Al Wanger
Dan Carl
Jon Van Coops
Mark Delaplaine
Tom Luster
Carl Schwing

California Geological Survey
Bill Short

Department of Fish and Game:
Brian Owens
Jason Vasquez
Vickie Frey
Becky Ota

Department of Parks and Recreation
Isaac Perlman
Jay Harris
Paul Veisze

San Francisco Bay Conservation and Development Commission
Wendy Goodfriend
Jamie Michaels

State Coastal Conservancy
Mary Small
Abe Doherty
Peter Jarausch

State Lands Commission
Cy Oggins
Eric Gillies
Michael Bell
Lynn Takata
Richard Greenwood

State Water Resources Control Board
Dominic Gregorio

CEDEN
Steve Steinberg

Appendix G: Questions and Participants From Interoperability Consultations

Questions

Understanding your system:

- Scope / purpose of your atlas?
- Funding required, timeline for development?
- Current staffing, server, and other needs?
- Centralized / Decentralized / Hybrid?

How a New, OPC Hosted, California Atlas could / should best inter-operate with your system:

- Will you want your system to draw data from a new California atlas?
    - If so, are there standards it should be enforce to effectively share data with your system?
- Does your atlas serve information that may be harvested? What are the standards?
- Other requirements?

Data Diplomat

- Do you have a staff person like this? 1 FTE? More / less?
- Other roles / functions that this person fills?

Interoperability Consultation Participants

Oregon and Washington Coastal Atlases
Oregon: Andy Lanier, Tanya Haddad
Washington: Liz O'Dea, Kathy Taylor, Darby Veeck

University of California – San Diego
John Helly

NOAA Multipurpose Marine Cadastre
Dave Stein
Brian Smith
Adam Bode

NOAA Marine Protected Area Center
Mimi Diorio

Ocean Observing Reps and Hosts of Large Data Holdings
Samuel Johnson
Rikk Kvitek
Ellen Hines
Lisa Hazard (SCOOS)
Tom Wadsworth (CeNCOOS)
Heather Kerkering (CeNCOOS)

Appendix H: Geospatial Workgroup Members

- Matt Armsby – Law Fellow, Stanford's Center for Ocean Solutions
- Greg Benoit – Coastal Program Analyst, CA Coastal Commission
- Christina Cairns – Coastal Management Specialist, NOAA CSC
- Clif Davenport – Senior Engineering Geologist, Dept of Conservation
- Tim Doherty – Coastal Planner, BCDC
- Laura Engeman – Project Manager, OPC
- Rebecca Gentry – Program Associate, Ocean Science Trust
- Eric Gillies – Environmental Program Manager, State Lands Commission
- David Harris – Director, CERES
- John Helly – UCSD, Scripps, San Diego Super Computer
- Peter Jaraush – Project Manager, State Coastal Conservancy
- Aaron McGregor – Program Associate, Ocean Science Trust
- Tim Reed – GIS Analyst, Gulf of the Farallones
- Pam Rittelmeyer – Program Associate, OPC/OST
- Paulo Serpa – GIS Analyst, DFG
- Steven Steinberg – Director, CEDEN
- Cassidy Teufel – Coastal Program Analyst, CA Coastal Commission

Appendix I: Traceability Matrix

This Traceability Matrix aligns the features described in Section 6 with interviewees and meeting participants would requested this type of feature.

Feature	Feature	Requester
1.1, 1.2	Interoperability with distributed data sources *	Steve Goldman (DFG), Jeff Kapellas (SWRCB), Paulo Serpa (DFG), Steve Steinberg (CEDEN), Greg Benoit (CCC), Cassidy Teufel (CCC), Mimi Diorio (NOAA), John Helly (UCSD), Dave Stein (NOAA), Lisa Hazard (SCOOS), Al Wanger (CCC), Mary Small (SCC)
1.3, 1.4	Availability of centralized database	Eric Gillies (SLC), Cy Oggins (SLC), Mary Small (CCC), Dave Stein (NOAA), Mimi Diorio (NOAA), Paulo Serpa (DFG), Greg Benoit (CCC), Rikk Kvitek (CSUMB), Clif Davenport (CGS)
2.1.1	Search via metadata	Eric Gillies (SLC), Paulo Serpa (DFG), Greg Benoit (CCC), Tim Doherty (BCDC), Jeff Kapellas (SWRCB), Steve Steinberg (SCCWRP), Mimi Diorio (NOAA), Tanya Haddad (Oregon Coastal Atlas)
2.1.2	Scoping searches to geographic area of interest	Tim Doherty (BCDC), Brian Owens (DFG), Eric Gillies (SLC), Paul Veisze (State Parks)
2.1.3	Search engine optimization **	Mimi Diorio (NOAA), Lindy Lowe (BCDC)
2.1.4	Web catalog services	Lindy Lowe (BCDC), John Helly (UCSD), Tanya Haddad (Oregon Coastal Atlas)
2.2	Data visualization (overlay analysis) and printing **	Eric Gillies (SLC), Paulo Serpa (DFG), Greg Benoit (CCC), Wendy Goodfriend (BCDC), Jeff Kapellas (SWRCB), Steve Steinberg (SCCWRP), Cassidy Teufel (CCC), Mary Small (Conservancy), Clif Davenport (CGS), Isaac Perlman (State Parks)
2.3	Map sharing **	Lindy Lowe (BCDC), Paulo Serpa (DFG)
2.4	Data available for download in multiple formats	Lindy Lowe (BCDC), Lynn Takata (SLC), Paulo Serpa (DFG), Greg Benoit (CCC), Al Wanger (CCC), Peter Jarousch (SCC)
2.5	Data available as web services	Dave Stein (NOAA), Mimi Diorio (NOAA), Andy Lanier (Oregon Coastal Atlas), Lisa Hazard (SCOOS), Steve Goldman (DFG)
2.1, 2.2	Simple and intuitive web-based interface *	Mary Small (SCC), Jason Vasquez (DFG), Cassidy Teufel (CCC), Tim Doherty (BCDC), Allison Dettmer (CCC), Brian Owens (DFG), Al Wanger (CCC)
3.1	Data librarian *	Greg Benoit (CCC), Cy Oggins (SLC), Lindy Low (BCDC)
3.2	Data diplomats *	Greg Benoit (CCC), Cy Oggins (SLC), Lindy Low (BCDC), Tom Luster (CCC), key recommendation from 2009 “Collaborative Geospatial Information and Tools for California Coastal and Ocean Managers Workshop” report.
4.1	Requires host with appropriate staff and hardware capacity	Richard Greenwood (SLC), Tom Lupo (DFG), Dave Stein (NOAA), Jeff Kapellas (SWRCB), Mary Small (SCC), Steve Steinberg (CEDEN), David Harris (CERES)

4.2	Host should have mission aligned with providing high-quality customer service	Mimi Diorio (NOAA), Dave Stein (NOAA), Jeff Kapellas (SWRCB), Mary Small (SCC), Steve Steinberg (CEDEN), David Harris (CERES), Richard Greenwood (SLC)
4.3	Hardware could be hosted servers or a cloud-computing environment **	David Harris (CERES)
4.4	Host organization should have progressive IT policies	Mimi Diorio (NOAA), Dave Stein (NOAA), Jeff Kapellas (SWRCB), Mary Small (SCC), Steve Steinberg (CEDEN), David Harris (CERES), Richard Greenwood (SLC), Eric Gillies (SLC), Lynn Takata (SLC), Clif Davenport (CGS)
Not listed	Permit tracking database	BCDC, Coastal Commission
Not listed	Interagency software development group **	
	* Identified in most interviews and group discussions, list of requesters only representative	
	** Inferred from problems and objectives identified in interviews	

Appendix J: Summary Table of Agency GIS Staffing and Current Geospatial Technologies

X = Current version in use * = Upgrade planned

State Agencies

State Agency	Dedicated GIS Staff	ArcGIS Desktop 9.x	ArcGIS Desktop 10	ArcGIS Server 9.1-9.2	ArcGIS Server 9.3	ArcGIS Server 10	Open Source Servers	Google Earth	Custom Web Viewers, Esri Based	Custom Web Viewers, Google Maps Based	Custom Web Viewers, Open Source	Access Databases
CCC	4	x	*	x		*		x	x			x
CGS	4	x	*					x	x		x	x
DFG-MR	4 (20 FTEs at headquarters)	x	x		x	x		x	x	x		
DPR	10	x (through a Citrix terminal)	x (GIS analysts only)		x				x			
BCDC	1	x			x			x	x			
SCC	0	x			x		x	x			x	
SLC	1		x	?		x		x (Pro version Only)				x
Water Board	1 in Ocean Unit (2.5 FTEs at OIMA office)	x	x		x	x			x	x		

Other IMSs for a California IMS to Interoperate With

Affiliation	Dedicated GIS Staff	ArcGIS Desktop 9.x	ArcGIS Desktop 10	ArcGIS Server 9.1-9.2	ArcGIS Server 9.3	ArcGIS Server 10	Open Source Servers	Google Earth	Custom Web Viewers, Esri Based	Custom Web Viewers, Google Maps Based	Custom Web Viewers, Open Source	Access Databases
SCOOS								x		x		
MMC	25	x	x		x	x						
Oregon Coastal Management Program	1	x					x	x		x	x	x